



NMRA DCC Reference Manual
For
QSI Quantum[®] 3, 2, and 1
Equipped Locomotives

Version 5.2.0
For Firmware Versions 7, 8 and 9
5-August-2015

New in DCC Reference Manual Version 5.2.0

Added Reverser Type to CV51.3
Added CV52.20 Sniffer Valve Volume and CV116.20 Sniffer Valve Balance
Added CV52.41 Reverser Volume and CV116.41 Reverser Balance
Added Head End Power to CV53.
Added CV55.1.1 Horn Type and CV55.1.2 Alternate Horn Type
Added CV55.1.10 Horn Reverb Amount
Added CV55.1.11 Horn Reverb Distance
CV55.3.6 Bell Ring Period: each unit represents 0.01 second.
Added CV55.3.7 User-defined Bell Metallurgy
Added CV55.5.SI Dynamic Brakes Fans
Added CV55.8.SI Cooling Fans
Added CV55.76.SI Mars Light Strobe with Horn
Added CV55.76.5 Mars Light Strobe Hold Time
Added CV55.80.SI Rear Mars Light Strobe with Horn
Added CV55.80.5 Rear Mars Light Strobe Hold Time
Added CV55.104.2 Automatic Front Marker Lights2 Config
Added CV55.104.3 Automatic Front Marker Lights3 Config
Added CV55.104.13 Front Marker Lights2 Max Intensity
Added CV55.104.14 Front Marker Lights3 Max Intensity
Added CV55.106.2 Automatic Rear Marker Lights2 Config
Added CV55.106.3 Automatic Rear Marker Lights3 Config
Added CV55.104.13 Rear Marker Lights2 Max Intensity
Added CV55.104.14 Rear Marker Lights3 Max Intensity
Added CV55.122.21 Firebox2 Min Intensity
Added CV55.122.22 Firebox2 Max Intensity
Added CV55.122.23 Firebox2 Mid Intensity
Added CV55.122.27 Firebox2 Ramp Up Time
Added CV55.122.28 Firebox2 Ramp Down Time
Added CV56.36.0 Consist Address Active for F13-F20
Added CV56.36.1 Consist Address Active for F21-F28
Added CV115.5.0 Dynamic Brakes Fans Port
Added CV115.8.0 Cooling Fans Port
Added CV115.104.1 Front Marker Lights2 Port and CV115.104.2 Front Marker Lights3 Port
Added CV115.106.1 Rear Marker Lights2 Port and CV115.106.2 Rear Marker Lights3 Port
Added CV120.10.0 Bell Hold Time
Added CV127.0.SI User-defined Horn Component Volume
Added CV127.40.SI User-defined Alternate Horn Component Volume
Added CV128.0.SI User-defined Horn Component Balance
Added CV128.40.SI User-defined Alternate Horn Component Balance
Added CV130 User-defined Horn Component Pitch
Added CV131 User-defined Alternate Horn Component Pitch
Added CV133.1.0 Locomotive Type
Added CV133.2.0 Chuff Intensity
Added CV135.PI.SI Upon Stopping Scenario Configuration

New in DCC Reference Manual Version 5.1.0

Added descriptions of F13...F28 default features to section 1.
Added CV51.16 Atmospherics Level
Added CV52.30 Air Dryer Volume and CV116.30 Air Dryer Volume Balance.
Added CV52.47 User Recorded Sound Effect2 Volume and CV116.47 User Recorded Sound Effect2 Volume Balance.
Added CV52.50 Verbal Feedback Volume and CV116.50 Verbal Feedback Volume Balance.
Added new features to CV53:

“Engine Room Lights”
“Engine Room2 Lights”
“Shut Down”
“User Recorded Sound Effect2”
“Calibrate BEMF to SMPH”

Added CV55.3.6 Bell Ring Period
Added CV55.13.1 Air Dryer Minimum Interval and CV55.13.2 Air Dryer Maximum Interval
Added CV55.21.1 Low Idle Timeout.
Added CV55.92.19 OHBL Pulse 2 Max Intensity
Added CV55.96.19 Rear OHBL Pulse 2 Max Intensity
Added Prime Beacon X4 effect to OHBL (CV55.92.SI) and Rear OHBL (CV55.96.SI).
Added Strobe Light (Double Pulse) effect to OHBL (CV55.92.SI) and Rear OHBL (CV55.96.SI).
Added CV55.109.12 Truck Lights Max Intensity.
Added CV55.109.17 Truck Lights Ramp Time.
Added CV55.113.12 Step Lights Max Intensity.
Added CV55.113.17 Step Lights Ramp Time.
Added CV55.120.12 Engine Room Lights Max Intensity.
Added CV55.120.17 Engine Room Lights Ramp Time.
Added CV55.128.0 bit 6 Trip Odometer Readout.
Added CV56.0 bit 2 Antialiased BEMF Measurements
Added CV56.1 QSI System Configuration 1.
For 2 byte CV's (CV56.7.0-1, CV56.24.0-1, CV56.25.0-1, and CV56.26.0-1)
 Added instructions to program high byte first, then low byte for verbal acknowledgment.
 Corrected examples.
Added CV58.5.0-1 Trip Odometer
Added CV58.10.0-1 Power Conversion Stopping Distance
Added CV58.20.0-1 BEMF to SMPH Calibration Distance
Added CV115.109.0 Truck Lights Port
Added CV115.113.0 Step Lights Port
Added CV115.120.0 Engine Room Lights Port
Added CV115.121.0 Engine Room2 Lights Port
Changed CV118.PI Individual Sound Pitch Shift to CV118.PI.SI
Added CV127.PI.SI Component Sound Volumes.
Added CV128.PI.SI Component Sound Balance Controls.
Added CV129.PI.SI Diesel Motor Configuration

New in DCC Reference Manual Version 5.0.2

Added CV 6 V-Mid.
Added Bell Actuator Sound enable to CV51.2 Special Sound Effects Enable.
Added CV51.3 Special Sound Effects Enable.
Added CV51.14 System Volume Balance.
Added CV51.15 System Pitch Shift.
Added CV51.20 Motive State Change Warning Signals.
Added several new CV52.PI Individual Sound Volumes.
Added several new CV53 Feature Identifiers.
Added default CV53 feature to output mappings for outputs 15...30.
Added CV55.12.SI Spitter Valve Configuration.
Added CV55.70.0 bit 7 Gas Turbine Transition Light Behavior
For all lights:
 Added CV55.PI.17 Light Ramp Up Time.
 Added CV55.PI.18 Light Ramp Down Time.
Added CV56.6 Speed Step 1 Delay
Added CV56.7.SI SMPH/BEMF Ratio
Added CV56.8 BEMF Offset
Added CV56.14 Chuffs Per Wheel Revolution
Added CV56.26.SI Scale Wheel Diameter
Added CV115.PI.SI Feature to Port Mapping.

Added CV116.PI Individual Sound Volume Balance.
Added CV117.PI.SI Individual Sound Selection
Added CV118.PI Individual Sound Pitch Shift.
Added CV120.PI.SI Ready to Move Scenario.

New in DCC Reference Manual Version 4.6.1

Added hoot/fancy ending to CV55.154.SI Grade Crossing Horn Signal.

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Digital Command Control Explained

Digital Command Control (DCC) is the standard adopted by the National Model Railroad Association (NMRA) in 1994¹ to allow compatible operation of all locomotives and Command Stations regardless of manufacturer.

DCC differs from Analog control in that DCC applies full voltage to the track at all times and controls the speed and functions of different locomotives by addressing each locomotive separately using assigned locomotive ID numbers. Because each locomotive can be addressed separately, you can independently control speed, lights, and sounds on different locomotives on the same powered track.

DCC provides features and opportunities that are usually not available under conventional Analog Control², but does require you to commit to a new and more complex operating system.

All Quantum equipped locomotives operate using NMRA DCC control. The three most common locomotives are Steam, Diesel and Electric, although others, such as trolleys, powered commuter cars, subways, etc. can be operated under DCC as well.

Quantum equipped locomotives have been designed to operate directly out of the box under NMRA standards for either conventional Analog DC operation or Digital Command Control. There are no switches in the locomotive that need to be set to select the type of control system. The Quantum System responds directly to the type of signal on the track.

1 The Electrical and Communication Standards were adopted by the NRMA in Portland OR in July, 1994. The basic Recommended Practices (RP's) were accepted in 1995 in Atlanta Georgia and the Service Mode RP's were established in 1996.

2 Quantum systems use an advanced Analog control system called QARC™ (Quantum Analog Remote Control) Technology that does provide many of the same features available in DCC. See the Quantum Analog Reference Manual for details.

This Manual

This manual is divided into seven parts:

- The first section summarizes how to operate your Quantum equipped locomotive in DCC. Read this and you will quickly have your locomotive up and running.
- The second section summarizes the programming of Configuration Variables (CV's). Read this when you are ready to customize your locomotive's operation.
- The third section describes in detail NMRA standard CV's supported by Quantum equipped locomotives. Skim over this to get a general idea of what it contains. You will often refer to it when you want to solve a particular problem.
- The fourth section outlines in excruciating detail the NMRA standard CV's that assign outputs to function keys. Normally you do not have to be concerned with these CV's, but sometimes this section is important, for example if you ever have to configure your locomotive to operate with a DCC controller having a small number of function keys.
- The fifth section describes in detail CV's that are unique to Quantum equipped locomotives. Skim over this to get an idea of the degree of flexibility built into Quantum decoders. Refer to this section whenever you want to customize volume levels, change the features that are assigned to function key outputs, configure the behavior of these features, or tweak your locomotive's running performance.
- The sixth section describes in detail additional NMRA standard CV's that you may find useful if you want to fine-tune your locomotive's running performance.
- The seventh section describes additional CV's unique to Quantum 3 equipped locomotives.
- The appendices describe operation with different DCC Digital Command Stations, troubleshooting and Applications Notes.

Most operations of Quantum equipped locomotives, such as turning the Bell on and off, changing direction, blowing a Horn or a Whistle, are the same across all locomotive types. Special operations for different types of Quantum equipped locomotives are described in the Operation Manuals that come with the locomotives. Any special features included in this Reference Manual will be described in sidebars or notes.

Please Note

This reference manual completely describes all features currently available in DCC when operating a Quantum equipped locomotive that has version 7, version 8, or version 9 firmware. If your locomotive has version 6 or earlier firmware, use the Quantum DCC Reference Manual Version 3. To determine the firmware version read the contents of CV 7 (In Ops Mode, set CV 64 to 7 and hear verbal response).

Many of the new features described in version 5.1 of this manual are available only with version 8 or version 9 firmware that runs on Q3 decoders.

For the most up-to-date information about which CV's are supported by the version of firmware in your decoder, refer to the "VersionXCVSsupport" files in the Files section of the QSIindustries Yahoo Group:

<http://groups.yahoo.com/group/QSIindustries/files/>

Although reading the first section, "Locomotive Operation in DCC", will allow you to begin operating your Quantum locomotive immediately, the purpose of this manual is not to teach you how to use DCC. We assume that you already have the working knowledge and experience to operate the different DCC features and program CV's. If you are just getting started in DCC, there are several books listed in the appendices to instruct you in the operation of DCC layouts, turnouts, accessories, programming Configuration Variables (CV's), etc.

1 Locomotive Operation in DCC

1.1 Getting Started

Although DCC operation can be very complex, it does not have to be. Your Quantum locomotive is factory configured to operate the common and more popular features. The following brief instructions will get you up and running quickly.

To start operating your Quantum equipped locomotive immediately:

- 1) Select locomotive number 3
- 2) Set your controller to 128 (preferred) or 28 (acceptable) speed step range³
- 3) Start your locomotive by turning up the throttle

1.2 Basic Throttle and Direction Control

When you turn up the throttle, the locomotive starts moving and produces sounds appropriate to its moving state. The Headlight, Mars Light, and Reverse Light change intensity depending on the direction of movement.

When you reduce the throttle setting to zero, the locomotive comes to a complete stop and automatically enters Neutral. You will hear special background sounds appropriate to its resting state. If the locomotive was moving forward, the Headlight (or operating Mars Light) dims when it stops and enters neutral. This was common practice for prototype locomotives under Rule 17⁴. You will hear a Short Air Let-off whenever the locomotive enters Neutral.

If you leave your Steam locomotive in Neutral for at least 25 seconds and then slowly turn up the throttle, the locomotive plays Cylinder Cocks sounds as it starts moving. The Cylinder Cocks sounds automatically terminate after 16 repetitions or when the locomotive reaches a speed greater than 12 smph.

The direction of your locomotive changes when you press the direction key. If the locomotive was moving at the time you pressed the direction button, the locomotive slows at a speed determined by the deceleration setting in CV 4, come to a complete stop and then accelerates in the other direction as determined by the CV 3 acceleration setting. CV 3 and CV 4 are described in the section "Programming Configuration Variables".

Locomotive Directional States

Quantum locomotives have four distinct Directional States:

Forward (FWD): If the locomotive is set to the Forward Direction and is moving, it is in the "Forward" state.

Neutral from Forward (NFF): If the locomotive is set to the Forward Direction, and the throttle is turned down to zero speed step and the locomotive is stopped, it will be in a Neutral State called "Neutral from Forward".

Reverse (REV): If the locomotive is set to the Reverse Direction and is moving, it is in the "Reverse" state.

Neutral from Reverse (NFR): If the locomotive is set to the Reverse Direction, and the throttle is turned down to zero speed step and the locomotive is stopped, it will be in a Neutral State called "Neutral from Reverse".

³ If you set your controller to 14 speed-step operation without reconfiguring your Quantum system to the same speed steps in CV 29, your Directional Lighting will not operate correctly.

⁴ Rule 17, followed by prototype railroads, states: The headlight will be displayed to the front of every train by night, but must be dimmed or concealed when a train turns out to meet another and the entire train has stopped clear of main track, or is standing to meet trains at the end of double track or at junctions.

1.3 Throttle Control Modes

There are four ways your locomotive can respond to your throttle.

- **Standard Throttle Control (STC):** Under STC, the percentage of full power applied to the motor is directly related to the throttle setting (speed step). Since the power to the motor is constant for a given throttle setting, the locomotive's speed varies depending on the load. The locomotive may easily stall at low speeds from minor gear binding, turnouts, and curves.
- **Calibrated Speed Control (CSC):** Under CSC, the power applied to the motor is varied to maintain constant speed regardless of varying load conditions. The throttle setting (using 128 speed steps specifies the locomotive's speed in 1 smph (scale miles per hour) increments. If your throttle is set at 35, the locomotive tries to maintain 35 smph on level track, uphill, and downhill. If locomotives in a consist differ even slightly in speed calibration, some of the locomotives do all the work while the other locomotives are dragged along.
- **Load Compensated BEMF Speed Control (BEMFSC):** Under BEMFSC, each speed step corresponds to a target BEMF value. The locomotive adjusts the power applied to the motor so that the locomotive's measured BEMF matches the target BEMF.
- **Regulated Throttle Control (RTC):** RTC combines the best of STC and Speed Control. It is the preferred method when multiple heading Quantum locomotives together because it automatically equalizes power between locomotives. Like Speed Control, RTC allows you to run your locomotive at very slow speeds without concern that it will abruptly stop from minor impediments such as misaligned track joints, tight curves, or rough switches. RTC operates your locomotive as though it has huge mass; your locomotive will resist changes in speed once it is moving and will resist starting up quickly if at rest.

For further explanation of these four modes, see CV 56.4: QSI Throttle Mode.

The default mode is RTC. You can change to STC using CV 56.4.

Quantum equipped locomotives will produce labored sounds under acceleration and lighter non-labored sounds under deceleration. The level of labored sounds is proportional to the value of CV 3 plus CV23, and of CV 4 plus CV24 and how much the throttle is increased or decreased. Diesel locomotives produce louder motor sounds under acceleration and softer motor sounds under deceleration. Steam locomotives produce louder chuffs under acceleration and softer chuffs under deceleration.

Important Legal Notice

BEMF Speed Control and Calibrated Speed Control under DCC operation are not included in your Q1 or Q2 equipped locomotive model. These functions have been declined by model railroad importers of Quantum equipped locomotives because of threats of litigation by Mike's Train House. QSI believes the claim by Mikes Train House is unfounded because these control features were developed by QSI and others and were in use long before Mike's Train House claims to have invented them. QSI does not believe that Quantum Sound System infringes any MTH patent.

1.5 Function Keys

Quantum decoders support the 0-12 Function Key standard as now accepted by the NMRA. The old 0-8 standard is not supported.

1.5.1 Common Feature Function Key Assignments

The following table lists features that have been pre-assigned to your DCC Function Keys for common operation across the different types of Quantum locomotives. Check the Operation Manual that comes with your locomotive to see which of these common features are offered or what additional custom features have been included.

These common features are described in detail in the following sections.

Notice that some keys operate different features in Forward/Reverse than in Neutral.

F-Key	FWD/REV	NFF/NFR
FL(f) ⁵	Headlight, Reverse Light, and Hazard Light Directional Lighting	Headlight, Reverse Light, and Hazard Light Directional Lighting
FL(r) ⁶	Headlight, Reverse Light, and Hazard Light Directional Lighting	Headlight, Reverse Light, and Hazard Light Directional Lighting
F1	Bell on/off (if assigned ⁷)	Bell on/off (if assigned)
F2	Horn/Whistle w/ Doppler Shift	Horn/Whistle
F3	Coupler Crash/Coupler Fire	Coupler Arm (Enable) or Coupler Fire
F4	Steam Blower Hiss/ Diesel Fans and Louvers/ Electric Cooling Fans	Steam Blower Hiss/ Diesel Fans and Louvers/ Electric Cooling Fans
F5	Dynamic Brakes	Dynamic Brakes
F6	Doppler Shift	Locomotive Start Up
F7	Squealing Brakes/Flanges and Air Brakes	Steam Cylinder Cocks Arm Diesel Long Air Let-off Electric Long Air Let-off Gas Turbine/Diesel Transition
F8	Audio Mute	Audio Mute
F9	Heavy Load ⁸	Shut Down ⁹ : Disconnect-Standby-Total Shut Down
F10	Status Report (SMPH)	Status Report (ID's, etc.)
F11	Alternate Horn Selection Number Board or Marker Lights on/off	Alternate Horn Selection/ Number Board or Marker Lights on/off
F12	Automatic Cab Lights	Automatic Cab Lights
F13	System Volume Decrease (Ver 8, 9 only)	System Volume Decrease (Ver 8, 9 only)
F14	System Volume Increase (Ver 8, 9 only)	System Volume Increase (Ver 8, 9 only)
F15	Grade Crossing (Ver 8, 9 only)	
F26		Fuel Loading Scenario (Ver 8, 9 only)
F27		Maintenance Scenario (Ver 8, 9 only)
F28	Water Scoop Scenario (Ver 8, 9 steam only)	Water Loading Scenario (Ver 8, 9 only)

⁵ The FL Key is labeled "F0", "Headlights" "Lights" or "Directional Lighting" on some DCC controllers.

⁶ FL(f) and FL(r) activate/deactivate the automatic behavior of the Headlight, Reverse Light, and Hazard Directional Lighting regardless of which direction the train is moving.

⁷ If the prototype did not have a bell, the bell feature is not assigned to F1 and no other feature is assigned in its place.

⁸ Early Q1 BLI and Lionel locomotives used F9 for Cruise Control, which was only available on locomotives equipped with Speed Control.

⁹ There are three stages to Shut Down. You double click the F9 key to advance to each stage.

1.6 Automatic Features

Automatic Quantum Features depend on the directional state of the locomotive. Automatic Control can be enabled or disabled by their indicated function keys. The state of each Automatic feature in each direction is shown in the table below for all locomotive types including steam, diesel and electric.

Feature	Function Key	Forward	Neutral from Forward	Reverse	Neutral from Reverse
Headlight	F0 or FL	Bright	Dim ¹⁰	Dim	Dim
Rear Tender Light	F0 or FL	Dim ¹¹	Dim	Bright	Dim
Mars Light	F0 or FL	Strobing	Steady On	Steady On	Steady On
Ditch Lights	F0 or FL	On	Off	Off	Off
Number Board Lights	F11	On	On	On	On
Marker Lights	F11	On	On	On	On
Cab Lights	F12	Off after 15 seconds	On after 10 seconds.	Off after 15 seconds	On after 10 seconds.
Steam Blowers	F4	Off after 10 seconds.	On after 10 seconds.	Off after 10 seconds.	On after 10 seconds.
Vents & Cooling Fans	F4	On after 20 seconds.	Off after 10 seconds.	On After 20 seconds.	Off after 10 seconds.
Cylinder Cocks ¹²	F7	If armed, plays Cylinder Cocks for 16 times or until speed exceeds 12 smph.	Cylinder Cocks armed after 25 seconds.	If armed, plays Cylinder Cocks for 16 times or until speed exceeds 12 smph.	Cylinder Cocks armed after 25 seconds.

When an indicated function key enables an “automatic” light feature, the associated lights operate according to the states shown in the table. For instance, enabling the Automatic Mars Light in Neutral will not cause the Mars Light to strobe since their automatic behavior would have them at a steady-on setting in that directional state; however, if you then entered Forward, the Mars Light would begin to strobe. When an indicated function key disables an “automatic” feature, all lights will be off. For instance, disabling the “Automatic Mars Light” will immediately shut off the Mars Light in any direction and they will not turn on again until the automatic feature is enabled.

Note: Use CV 55 to change the behavior of lights from what is shown in the above table and description.

Note: Not all automatic features may be included in your locomotive model.

Note: Lights and other features can be assigned to function keys and configured to different kinds of operation and initial conditions in CV 53 (Output Feature Assignment) and CV 55 (QSI Feature Configuration). See the Quantum DCC Reference Manual, version 4.

Note: Cylinder Cocks can also be armed in Neutral with the F7 key or the F6 Start Up key without having to wait for the 25 time out period.

Note: The start up state for directional lighting is “activated”. See CV 55 for further information.

Note: Most steam locomotives use a steam-powered generator, called a Dynamo, to supply electricity to the lights. When the lighting system is turned on, the brightness of the headlight increases slowly as the steam generator revs up to full power. Check your Operation Manual to see if your steam model has a Dynamo.

Note: If your FL key does not predictably affect the Headlight or Reverse Light, see the troubleshooting section in the appendices.

¹⁰ If your locomotive has the Mars Light, the Headlight will be off (instead of “Dim”) in all states except Forward where it will be Bright.

¹¹ On Q1 decoders Reverse Lights cannot be dimmed; they only have bright and off settings. In these cases, “Dim” is equivalent to “Off”.

¹² Cylinder Cocks arming after Start Up and/or after 25 seconds in Neutral can be set using CV 51.2. The settings in this CV apply to both Analog and DCC operation.

1.7 Horn/Whistle and Bell Buttons (F2 Key and F1 Key)

Some DCC controllers have separate horn/whistle and bell buttons, in addition to Function Keys assigned to horn/whistle and bell operation. The bell is usually assigned to F1, and the horn is usually assigned to F2.

The F2 key behaves differently than the Horn button.

- Pressing F2 and releasing it will cause the horn/whistle to come on and stay on until you press F2 again.
- Pressing the Horn button will blow the horn/whistle only as long as you hold the button down.

There is no difference in operation between the Bell button and its corresponding function key. Pressing F1 and releasing it will cause the bell to come on and stay on until you press F1 again.

Horns and whistles have start up and shut down effects and a short hoot record for short duration horn/whistle blasts. Some models have an additional fancy ending (playing the horn/whistle). On these models, you can activate the fancy ending by tapping the horn button at the end of the horn blast.

If your locomotive is equipped with Ditch Lights, they will automatically strobe when the horn is being blown, and will continue to strobe until five seconds after the horn signal has stopped¹³.

With Diesel, Electric, and Gas Turbine models, since the prototype horn uses compressed air, you will hear Air Pump sounds turn on after the Horn is operated.

Note: If your DCC controller has assigned the Bell to F3, you can reassign your Quantum decoder's F3 to the bell output (see CV 37). Remember to reassign the F1 Function to some other output besides 3 (see CV 35).

1.8 Coupler and Coupler Crash Sounds (F3 Key)

There are two ways to use the F3 key.

- 1) In Forward or Reverse, as your locomotive is moving to couple up to a string of cars, press F3 to trigger the crashing sound of a locomotive coupling. Press F3 again as the locomotive is moving out to produce the same sound as the slack is taken up in the cars.
- 2) Press F3 in Neutral to produce uncoupling sounds as you disconnect cars over uncoupler magnets. Press F3 once to produce the sound of the lift bar and coupling pin being raised. This first press also arms the uncoupling sound effect. Press F3 again while moving or in Neutral to produce the sound of the coupler knuckle opening and the air-lines parting.

If you armed the Coupler in Neutral and your locomotive is now in Forward or Reverse, pressing F3 produces the sound of the coupler opening. Thereafter, as the locomotive continues in Forward or Reverse, pressing F3 will produce coupler crash sounds.

¹³ The hold time for strobing Ditch Lights after the horn button is released can be set in CV 55.84.5.

1.9 Sound-of-Power™

If CV 3, or CV 23 and CV 4, or CV 24 has been set to non-zero positive values, your locomotive will produce additional labored engine sounds under acceleration and lighter engine sounds under deceleration. The level of labored sounds is proportional to the values for these four CV's, and how much the throttle is increased or decreased. Laboring is different for the three primary types of locomotives:

Diesel Motor RPM: Quantum has all eight diesel-motor throttle “notches” found on prototype locomotives. As you increase the throttle, you will hear the Rpm's increase for every increase in ten speed steps (at 128 speed step setting). Idle is considered Notch 0 and occurs for speed step 0. Notch 1 ranges from 1 to 10, Notch 2 from 11 to 20, Notch 3 from 21 to 30, etc. If your controller has an option to increment or decrement your throttle set setting by ten speed steps, it is very easy and predicable to set your notch value.¹⁴

Steam Exhaust: Under acceleration the steam exhaust is labored and loud and under decelerating, the steam exhaust is lighter. Also, when starting out after an extended period in Neutral (over 25 seconds), you will hear steam and water vented from the Cylinder Cocks when it starts out. The Cylinder Cocks will vent 16 times or until speed exceeds 12 smph.

Electric Traction Motors: Under acceleration, hear the traction motors rev up and strain as the Electric locomotive gains full speed. Under deceleration, the traction motors are not labored and rev down as the locomotive slows.

1.10 Dynamic Brakes (F5 Key)

Diesel Locomotives: The prototype Dynamic Brakes, found on most diesels, cause the train to slow down by using the traction motors in generator mode. This helps dissipate the energy of a moving train by applying electrical power from the traction motors to a large air-cooled resistor load in the locomotive. These resistor grids can get quite hot and require cooling by fans located on the roofs of the locomotives.

- Pressing F5 in Forward/Reverse will set the Diesel Motor sound to idle at the lowest Sound of Power setting and turn on the powerful Dynamic Brake Cooling Fans.
- Pressing F5 in Neutral does not turn the Dynamic Brake Fans on unless the locomotive is in Disconnect (see F9 “Disconnect” below).

Electric Locomotives: Early Electric locomotives did not have Dynamic Brakes. However, the Dynamic Brake function has been included to make Electric locomotives consistent with other Quantum equipped locomotives.

- Pressing F5 in Forward/Reverse will set the Electric Traction Motor Sound-of-Power to the lowest setting allowing these early Electric locomotives to behave consistently¹⁵ with other locomotives that do have Dynamic Brake sounds in multiple unit Consists.
- If an Electric locomotive does have Dynamic Brakes with resistor grids and cooling fans, the locomotive will behave in a similar manner to Diesels.

Steam Locomotives: Prototype Steam locomotives do not have Dynamic Brake sounds. However, the Dynamic Brake function has been included to make Steam locomotives consistent with other Quantum equipped locomotives.

- Pressing F5 in Forward/Reverse will set the Steam Exhaust Sound-of-Power to the lowest setting allowing the Steam locomotive to behave consistently¹⁶ with other locomotives that do have Dynamic Brake sounds in multiple unit Consists.

The Dynamic Brakes feature automatically turns off when entering or leaving Neutral, or the speed of the locomotive drops below 8 smph, or if the throttle is turned up. The Dynamic Brakes cannot be turned on in Forward or Reverse unless the locomotive is traveling over 9 smph.

¹⁴ Use CV55.21.0 to change the number of speed steps per notch.

¹⁵ It would be inconsistent for the Electric Locomotive to be working at full Sound-of-Power while brakes are being applied in other locomotives within the same consist.

¹⁶ It would be inconsistent for the Steam Locomotives to be working at full Sound-of-Power while brakes are being applied in other locomotives within the same consist.

1.11 Doppler Shift (F6 in Forward and Reverse)

There are two ways to initiate the Doppler Shift effect.

1.11.1 Horn Button Method¹⁷

- 1) If your controller has a horn button in addition to the F2 key, press the horn button to turn on the Horn/Whistle while the locomotive is moving towards you.
- 2) Wait at least one second while the Horn/Whistle is blowing
- 3) Release and re-press the horn button quickly so the Horn/Whistle does not shut off. You will hear the Horn/Whistle and other locomotive sounds increase in volume and shift in pitch as the locomotive passes by and then reduce in volume.
- 4) Release the horn button or continue blowing long and short blasts. Five to seven seconds after releasing the horn button, the sounds will gradually return to normal.

1.11.2 F6 Doppler Shift Operation Method

- 1) Start the Horn/Whistle by pressing and releasing the F2 key.
- 2) Press F6 as the locomotive is moving towards you. The Horn/Whistle and other locomotive sounds increase in volume and shift in pitch as the locomotive passes by and then reduce in volume.
- 3) Press F2 button again to shut off the Horn/Whistle or continue blowing long and short blasts by pressing and re-pressing F2. If you shut off the Horn/Whistle for more than five to seven seconds, the sounds will gradually return to normal.

If the bell was on during Doppler Shift, it will automatically turn off prior to the sounds returning to normal.

If Doppler Shift is initiated without the Horn/Whistle blowing, the sounds return to normal soon after the Doppler Shift is finished.

Doppler Shift is speed dependent. The greater the speed, the greater the amount of pitch change as the locomotive passes by. There is no Doppler Shift at speeds less than 15 scale miles per hour (smph); instead you will hear a short air let-off when F6 is pressed.

Try using the F6 key to affect chuffing sounds (sans Whistle or Bell) to create interesting environmental effects.

Note: Some base stations produce an intermittent and independent horn signal interruption that causes an unexpected Doppler Shift. If this happens frequently, you may want to disable the horn triggered Doppler Shift by setting CV 51.2 bit 0 to 0.

Note: With some Command Stations, using the horn button to activate the Horn/Whistle, and then while this button is held down, pressing F6 causes the Horn/Whistle to shut off instead of causing a Doppler Shift effect.

¹⁷ This is similar to the method used in Analog DC to trigger a Doppler Shift.

1.12 Squealing Brakes and Flanges (F7 in Forward or Reverse)

Quantum locomotives provide automatic Brake Squeal as a locomotive slows to a stop. To enable automatic Squealing Brakes operate the locomotive over 40 smph (64 skph). When the speed is reduced to less than 20 smph (32 skph), squealing Brake sounds will sound automatically.

When the locomotive is moving, you can also manually activate continuous or variable brake sounds when slowing or stopping the locomotive or to simulate the sounds of squealing flanges on curved track.

- 1) Press F7 to start Squealing Brake sounds.
- 2) The Squealing Brakes sounds end automatically, but you can press F7 while the brake squeal is occurring to re-trigger the squealing sounds. This allows you to continue the squealing brake sounds without any dead period for an indefinite period.

The squealing brake sounds will terminate abruptly when the locomotive stops and enters Neutral.

Note: If you lower the throttle to speed step 0, pressing F7 will apply Air Brakes instead of activating squealing brake sounds.

1.13 Air Brakes (F7 in Forward or Reverse)

If you have selected any non-zero deceleration inertia value in CV 4 and/or CV 24, the F7 key can be used to apply Air Brakes to stop the locomotive more quickly than it would normally stop from the inertia settings¹⁸. To use Air Brakes:

- Turn the throttle down to speed step 0 on a moving locomotive; this enables the F7 key to act as a brake.
- Press the F7 key. Hear a brief brake squeal sound and air being released from the brake lines continually. The longer the air is released the greater the braking action.
- Press the F7 key again to stop the air release. The train will continue to slow at the last braking value.
Note: F7 will apply brakes when set to 1 and stop the air release when set to 0. Depending on the initial setting for F7 when you turn your throttle down to speed step zero, you may need to press the F7 key twice to first apply brakes.
- If you want to apply more braking, press the F7 key again to release more air. When you reach the desired amount of braking, press F7 again to stop the air release.
- Turn up the throttle to any value above 0 to release the brakes; this action resets the locomotive's deceleration to a value determined by the sum of CV 4 and CV 24.
- If the locomotive is in Neutral when the F7 key is pressed, the Cylinder Cocks will arm.¹⁹

Note: If the throttle is set to any speed step except 0, Air Brakes are not enabled; instead the F7 key will now manually activate Squealing Brake/Flange sounds but will not affect the locomotive's deceleration.

Note: If the direction state is changed while moving, F7 is enabled to act as a brake without the need to reduce the throttle to speed step 0. After stopping and changing direction, the loco will accelerate back to its original speed. If CV 4 or CV 24 is non-zero, F7 can be used to apply Air Brakes to stop a moving locomotive more quickly than it would normally stop from the inertia settings²⁰.

¹⁸ CV 4 and CV 24 determine the deceleration rate. Applying the brakes increases the deceleration rate temporarily.

¹⁹ If the optional Cylinder Cocks feature is not include in your model, the F7 key will produce a long Air Let-off.

²⁰ CV 4 and CV 24 determine the deceleration rate. Applying the brakes temporarily increases the rate of deceleration.

1.14 Audio Mute (F8 Key)

You can temporarily reduce the System Volume to a lower level or increase it back to its original setting using the F8 key. This is useful when you need to reduce the sound to engage in a conversation or to answer the phone.

- 1) Set F8 to "1". All sounds, including the Whistle, Bells, Motors and Chuff will gradually go off.
- 2) Set F8 to "0". All sounds, including the Whistle, Bells, Motors and Chuff will gradually return to normal volume.

If you have many locomotives operating at once, you can reduce the volume on all those that are running in the back of the layout and increase the volume of the closest locomotive. The Mute feature changes the sound gradually over a couple of seconds, which allows the sound to increase or decrease realistically as the locomotive approaches or recedes from the observer.

The Mute state is not retained if track power is turned off. On power up the locomotive returns to full system volume.

Note: You can set the Mute volume in CV 51.1 if you want to be able to quickly quiet your locomotive without having the sounds turn completely off.

1.15 Heavy Load (F9 in Forward or Reverse)

Heavy Load is applied while the train is moving; it maintains the train at a nearly steady speed while allowing you to have control over the sound effects of a working locomotive. Heavy Load represents a train that would take over ten minutes to accelerate to full speed or to bring to a complete stop. It is independent of any inertia values set in CV3, 4, 23, or 24.

Under Heavy Load, changing the throttle will have little effect on the locomotive's speed. Instead you use the throttle to control Sound-of-Power effects. When you approach a grade under Heavy Load, increase the throttle and hear the locomotive produce heavy laboring sounds. When the locomotive goes down a grade, reduce the throttle to hear the locomotive drop to light laboring sounds. You control labored sounds by how much the throttle is increased or decreased from its initial position (where Heavy Load was turned on).

- 1) Press F9 and hear one short hoot when Heavy Load is turned on²¹. You can apply Heavy Load as soon as you start moving, or wait until you are up to speed.
- 2) Press F9 and hear two short hoots when Heavy Load is turned off. Before turning Heavy Load off, return the throttle to its initial setting (where Heavy Load was turned on) to avoid sudden acceleration or deceleration.

Heavy Load can only be turned on or off in Forward or Reverse²². If turned on, it will remain on in Neutral. If you want it off when you start out from Neutral, turn it off immediately after increasing the throttle.

Heavy Load is automatically turned off when track power is turned off.

Under RTC and Heavy Load, grades, tight curves or other real loading effects, will have little effect on the speed of the train. But under STC and Heavy Load, grades, curves, loading, etc. will affect the train speed.

²¹ This feedback can be disabled via CV51.2 bit 3.

²² You can turn Heavy Load on and off in Neutral if you set CV53.x.1 to 179, the Heavy Load feature ID.

1.16 Status Report (F10)

Quantum locomotives provide verbal information about a locomotive's current operating state when the locomotive is in Neutral or the locomotive's current speed when the locomotive is moving.

- Press F10 in Neutral; the locomotive will verbally report first its currently enabled long or short DCC address followed by its consist ID if it has one, followed by its Shut Down state (Disconnect, Standby or Shut Down).
- Press F10 in Forward or Reverse; the locomotive will verbally report the locomotive's speed in scale miles per hour (smph) or scale kilometers per hour (skph). (You can select between scale miles per hour (smph) or scale kilometers per hour (skph) in CV56.0.)

Note: When a Status Report or Verbal Speedometer Readout begins, the locomotive's sounds will reduce to one half their current volume settings. Locomotive sounds return to normal volume when the report has ended.

Note: The Status Report in Forward and Reverse can be configured to also report the Back EMF value and/or motor Pulse Width Modulation (PWM) value. See CV 55.178.0.

Note: In a consist, all locomotives will simultaneously report their status when the F10 key is pressed unless disabled in CV 22.

1.17 Alternate Horn Selection (F11)

Some prototype steam locomotives had both a steam whistle and an air horn. The whistles worked best in areas where it was necessary for the sound to carry a long way, while the horn was more useful in the city or foggy areas where it was easier to tell the location of the locomotive by its higher pitched sound. Some diesels and electric locomotives used two horns for similar reasons. The Alternate Horn Selection key allows you to choose between two Horn/Whistle sounds.

- Press the Alternate Horn Selection key, F11, to select between the alternate Horn and the primary Horn or the Whistle. Hear a short hoot to indicate which one has been selected.
- Operate the selected Horn or Whistle with the F2 key.

Note: The feedback hoots can be disabled/enabled in CV51.2.

Note: Setting F11 to "1" selects the primary Horn or the Whistle. Setting F11 to "0" selects the alternate Horn.

1.18 Three Stages of Shut Down: Disconnect, Standby and Total Shut Down (F9 in Neutral)

Locomotive Shut Down has three distinct stages, each entered by double-clicking or double-pressing the F9 Key²³.

Stage One: Disconnect

- 1) In Neutral, double-press F9 to enter Disconnect. You will hear a Long Air Let-off, which represents the pneumatic reverse lever on a Steam locomotive being placed in the Neutral position or the Diesel transition level being placed in the off or disconnect position. Your locomotive's motor drive is disconnected.
- 2) To leave Disconnect, either double-press the F6 Start Up key as described in the Start Up section or double-press F9 again to reach the next stage of Shut Down, Standby.

A locomotive in Disconnect continues to respond to all function keys.

For a Diesel locomotive in Disconnect, if the throttle is increased or decreased, the motor sounds will rev up and down but the locomotive will not move. If the Dynamic Brakes are activated, the motors sounds will be labored under Sound of Power control as the throttle is increased and decreased. Prototype Diesel Motor/Generator power output is often tested under Dynamic Brake load in disconnect.

For an Electric locomotive in Disconnect, there is no action or sound associated with moving the throttle up and down and no affect from having the Dynamic Brakes activated.

For a Steam locomotive in Disconnect, if the throttle is increased/decreased, the hissing sound of venting steam will get louder/softer but the locomotive will not move. Prototype Steam locomotives would sometimes vent steam in Neutral to clear rust debris from the super-heaters that can affect the throttle.

Stage Two: Standby

- 1) In Disconnect, double press F9 to enter Standby. You will hear a Long Air Let-off followed by the Directional Lighting turning off. The motor will remain disconnected, while the Air Pumps, automatic Steam Blower/Cooling Fan operation, Number Board Lights and Cab Lights will continue to operate.
- 2) To leave Standby, either double-press the F6 Start Up key described in the Start Up section or double-press F9 again to reach the final stage of Shut Down, Total Shut Down.

In Standby, the locomotive will not respond to the throttle or most function keys²⁴. The three exceptions are the F6 Start Up Function Key (described below), the F8 Mute Key (described above) and the F10 Status Key (described above).

Standby in Diesel locomotives, called Low Idle, has more utility than Standby in Steam and Electric locomotives. It allows a Diesel to be left on a siding inactive with only the motor running at its special "Low Idle" sounds. For Steam and Electric locomotives, the locomotive will appear to be completely inactive except for Cab and Number Board lights, occasional Air Pump sounds, and Blower or Fan sounds.

Stage Three: Total Shut Down

- 1) In Standby, double-press F9 to enter Total Shut Down. You will hear a Long Air Let-off followed by the sounds of a shut down procedure specific to your type of locomotive.

Diesel Locomotives: Low Idle Diesel Motors will return to normal idle sounds. Then the Air Pumps will turn off, as will the Number Board Lights, followed by the sounds of the Cooling Fans shutting off, the Louvers closing, the Diesel Motor(s) shutting down, Cab Lights shutting off, and finally the engineer's door opening and shutting.

Electric Locomotives: The Air Pumps will turn off, Cab Lights will turn off, followed by the sounds of the Louvers being closed and the engineer's door being opened and shut.

Steam Locomotives: The Air Pumps will turn off, followed by the sounds of Pop Off operating for about ten seconds, the Cab Lights shutting off, and finally the Blower Hiss will die out.

- 2) To leave Total Shut Down, double-press the F6 key.

²³ Double-clicking ensures that Shut Down stages are not entered or exited accidentally. Doubling-pressing is defined as two F9 presses within two seconds. Note that the F9 key may have to be pressed three times the first time you use it due to the command station and locomotive having different initial states for F9.

²⁴ Pressing a Function Key will only produce a Short Air Let-off.

In Total Shut Down, the locomotive will not respond to any function keys except the F6 Start Up Function Key (described below) and the F10 Status Key (described above).

Total Shut Down allows you to take a locomotive “off-line” (turn off sounds, lights, ignore throttle and function commands (except turn on)) independent of the operating session; that is, the locomotive will still be “off line” when power is reapplied for the next operating session.

If power is turned off at any stage of Shut Down (Disconnect, Standby or Total Shut Down) or during a Shut Down procedure, the locomotive will remember its last Shut Down stage, and will power up in that Shut Down stage.

If Start Up is initiated during any of the above Shut Down procedures, Shut Down is aborted and the locomotive returns to normal operation.

Note: The “Shut Down” feature (ID=143)²⁵ can be assigned to a function key as an alternative to the “Disconnect/Standby/Total Shutdown” feature (ID=145). The two features are similar, both requiring a double press. The “Shut Down” feature puts the locomotive directly into Total Shut Down, bypassing the Disconnect and Standby states.

²⁵ The “Shut Down” feature (ID=143) is currently available only with Q3 firmware.

1.19 Start Up (F6 in Neutral)

If your locomotive is in any of the Shut Down stages, you can return your locomotive to normal operation by double-pressing²⁶ the F6 Key. Start Up will be different for each stage of Shut Down, but always begins with a Long Air Let-off and ends by the locomotive entering normal operation²⁷.

Start Up from Disconnect

- Double press F6 in Disconnect, the locomotive will produce a Long Air Let-off and enter normal operation.

Start Up from Standby

- Double press F6 in Standby, the locomotive will produce a Long Air Let-off, the Directional Lighting will turn on and then the locomotive will enter normal operation.

Start Up from Total Shut Down

- Double press F6 in Total Shut Down; the locomotive will produce a Long Air Let-off, and begin a full start up procedure.

Diesel Locomotives: The Long Air Let-off is followed by the sound of the engineer's door opening and closing. Cab Lights turn on, Number Boards come on, and Directional Lighting turns on. Then the Vents open and Fans start up, the Diesel Motor or Motors start up, the Air Pumps turn on, and finally the locomotive enters normal operation.

Electric Locomotives: The Long Air Let-off is followed by the sound of the engineer's door opening and closing. Cab Lights turn on, Number Boards and Marker Lights turn on, and Directional Lighting turns on. Then the Vents open and Fans start up, the Air Pumps turn on, and finally the locomotive enters normal operation.

Steam Locomotives: After the Long Air Let-off, the Dynamo revs up and the Directional Lighting turns on. Then Cab Lights turn on, followed by the Air Pumps and the Steam Blower turning on, and finally the locomotive enters normal operation.

During the Start Up from Total Shut Down procedure, a Quantum locomotive will not respond to any function key. However, if the throttle is turned up, the Start Up procedure abruptly terminates and the locomotive immediately enters normal operation.

Note: Whenever a locomotive receives a Start Up command, regardless of whether the locomotive is in a Shut Down stage or operating normally, the locomotive will restore all automatic operations and return all feature function states to their initial states as specified in CV55.

Note: Whenever F6 Start Up key is double-pressed in Neutral for a steam locomotive, the Cylinder Cocks²⁸ will be armed. Cylinder Cocks sounds will play when the throttle is turned up to leave Neutral.

²⁶ Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two F6 presses within two seconds. Note that the F6 Key may have to be pressed three times the first time you use it due to the command station and locomotive having different initial states for F6.

²⁷ The locomotive enters Neutral with Long Air Let-off if speed step is zero. If speed step is non-zero, the locomotive will enter either forward or reverse.

²⁸ Not all steam models have Cylinder Cocks feature.

1.20 System Volume Decrease and Increase (F13 and F14 Keys)

You can decrease the System Volume by 2db by pressing the F13 key. You can increase the System Volume by 2db by pressing the F14 key.

Each time you press the F13 or F14 key you will hear a horn hoot at the new system volume. If the system volume is already at the maximum when you press the F14 key, the volume will not increase and the locomotive will speak the word "Max".

Both F13 and F14 are inactive when the locomotive is in shutdown.

Pressing F13/F14 decreases/increases the value of CV51.0 System Volume.

Note: These F13/F14 features are currently available only with Q3 decoders.

1.21 Grade Crossing (F15 Key in Forward or Reverse)

Prototype railroads use horn or whistle codes of long and short blasts for communication or warning signals. One of the most common is the code of two longs, a short and a long horn signal to warn of approaching a grade crossing.

Although you can perform these signals with the Horn button, we have made it even more convenient.

When the locomotive is in FWD/REV, press the F15 key once to trigger the grade crossing horn signal.

If you press the Horn key during the Grade Crossing scenario, you will terminate this feature and take control of the Horn.

You can use CV55.154.SI to change the number of horn blasts and length of each horn blast in the grade crossing signal.

Note: The Grade Crossing feature is currently assigned to F15 by default only with Q3 decoders.

1.22 Fuel Loading Scenario (F26 Key in Neutral)

Press the F26 key when the locomotive is in NFF/NFR to trigger a fuel loading scenario.

For diesel, electric, and gas turbine locomotives, you will hear sounds of diesel fuel being pumped into the locomotive's fuel tank.

For steam locomotives, there are two types of scenarios available: coal loading and oil loading. You can select the type of fuel using CV51.3.

For locomotives using coal, you will hear sounds of coal begin dumped into the tender.

For locomotives using oil, you will hear sounds of oil being pumped into the locomotive's oil tank.

Note: The Fuel Loading Scenario is available only with Q3 decoders.

1.23 Maintenance Scenario (F27 Key in Neutral)

Press the F27 key when the locomotive is in NFF/NFR to trigger a maintenance scenario.

For diesel and gas turbine locomotives, you will hear sounds of the diesel motor being rev'ed up and down.

For electric locomotives, you will hear electrical sparking sounds caused by a short, and the sound of a fire being extinguished.

For steam locomotives, you will hear lubrication sounds followed by blowdown sounds.

Note: The Maintenance Scenario is available only with Q3 decoders.

1.24 Water Loading Scenario (F28 Key in Neutral)

Press the F28 when the locomotive is in NFF/NFR to trigger a water loading scenario.

For all locomotives, you will hear sounds of water being run into the locomotive's water tank.

Note: The Water Loading Scenario is available only with Q3 decoders.

1.25 Water Scoop Scenario (F28 Key in Forward or Reverse)

Press the F28 when the steam locomotive is in FWD/REV to trigger a water scoop scenario.

You will hear sounds of the water scoop begin lowered, water scooped into the locomotive's tender, and the water scoop raised.

Note: The Water Scoop Scenario is available only with Q3 steam decoders.

1.26 Function Key Operation in Neutral

Some function keys used in Forward and Reverse will have different effects when used in Neutral:

- Pressing F6 results in Doppler shift for a moving locomotive but activates Start Up in Neutral.
- The F7 key produces Squealing Brake Sounds or applies brakes for a moving locomotive but produces a Long Air Let-off in Neutral in Diesels or enables Cylinder Cocks in Steam locomotives.
- Pressing F9 turns on/off the Heavy Load feature in a moving locomotive but activates Shut Down in Neutral.
- Pressing F15 triggers the grade crossing scenario, but only in Forward or Reverse.
- Pressing F26 triggers the fuel loading scenario, but only in Neutral.
- Pressing F27 triggers the maintenance scenario, but only in Neutral.
- Pressing F28 triggers the water loading scenario in Neutral, but the steam locomotive water scoop scenario in Forward or Reverse.

2 Programming Configuration Variables

2.1 Service Mode Programming²⁹

To perform Service Mode Programming, place your locomotive on an isolated track, called a Programming Track, electrically insulated from the main line and separately connected to a special output from your Command Station.

There are two advantages to programming in Service Mode.

1. On the Programming Track, no Locomotive Address is required to program your locomotive. This is important if you have forgotten your locomotive's ID numbers or have programmed them incorrectly. This is also why programming must be done on an isolated track section. Otherwise, CV's of all locomotives on your layout would be programmed with the same value.
2. On the Programming Track, the locomotive responds with Service Mode Acknowledgements to command station requests to verify the contents of a CV. In this way the command station is able to read back the current value of a CV. This is important if you want to change a CV by some amount but need to know its current value before you enter a new value.

Some Command Stations restrict the amount of power that can be delivered to the Programming Track to prevent damage to improperly installed aftermarket decoders. If the decoder were wired correctly, the Programming Track would provide enough power to allow it to be programmed. If the decoder were wired incorrectly and a short circuit occurred, the limited current from the command station would not be enough to damage the decoder, allowing the operator another chance to wire it correctly.

To accommodate command stations that restrict power during Service Mode programming, the Quantum System reduces its power consumption to a minimum by shutting off all lights, sound and other operations during Service Mode operation. Even so, a Quantum Sound Decoder still requires more current than most non-sound decoders. If your Quantum System will not program with your particular command station, you may need to program on the Main (Ops Mode Programming). You can also purchase from Tony's Train Exchange³⁰, a simple, inexpensive power booster (PowerPak™ by DCC Specialties) that will allow you to program on the program track with any DCC command station.

Note: Some Command Stations will not operate Quantum Systems in Service Mode due to insufficient power output or timing problems. (Check the appendices for a listing of recommended command stations). If you cannot operate in Service Mode, use Ops Mode programming.

²⁹ All four methods are supported: Address-Only Mode, Physical Register Addressing Mode, Paged CV Addressing Mode, and Direct CV Addressing Mode.

³⁰ Tony's Train Exchange; 1-800-978-3472; info@ttx-dcc.com .

2.2 Operations Mode Programming³¹

Operations Mode Programming is also called Ops Mode Programming or Programming on the Main

In this programming mode, you do not move your locomotive to an isolated programming track. You program it in place on the Main track as you are operating it.

The Quantum System will allow you to program all CV's, including address CV's (CV 1, CV 17 and CV 18), in Operations Mode.

There are advantages and disadvantages to using Operations Mode Programming.

- 1) One disadvantage is that, in Ops Mode, Quantum decoders do not support any advanced acknowledgement mechanism, as defined by the NMRA. If you are using a command station that provides readout for your CV's in Ops Mode, it can only indicate which CV you are addressing and the value you want to program. You will not be able to determine what value is already entered in that CV or that the new value has been accepted and is correct.

Note: In Ops Mode, Quantum locomotives do give verbal feedback during CV programming. If CV Verbal Acknowledgement is enabled (see CV 62), the CV number and its new value are announced over the locomotive's sound system when a CV is programmed.

Note: In Ops Mode, you can command a Quantum locomotive to speak out the current value of any CV (see CV 64).

- 2) Another disadvantage with Programming on the Main is that you need to address your locomotive with its ID number in order to change its CV values. This could be a problem if you have forgotten your locomotive's ID number. Or you might use the wrong address and program the wrong locomotive. It could happen that you find yourself unable to communicate with your locomotive. If this does happen, you can move your locomotive to a Programming Track and change your locomotive's ID using Service Mode Programming. Or you can do a hardware reset by pulling the reset jumper on the circuit board or by using the Magnetic Wand³², which will set the locomotive's ID to short address 3 (See your locomotive's operating manual for further information on performing a hardware reset.).

Note: Some command stations do not support programming address CV's on the main. See notes in trouble shooting and related CV's (1, 17, 18, 56.129) for possible solutions to this problem.

- 3) One advantage of programming on the main is that you often can observe an immediate change to your locomotive's behavior when you program a CV. For example, you can hear the System Volume or an individual feature sound volume change immediately after you program its new CV value. In Service Mode, you have to move the locomotive from the Service Mode Programming track to the Main track to see the effect of changing a CV.

³¹ Both the short form and the long form of the CV access instructions are supported.

³² A magnetically activated switch on the circuit board replaced the jumper on later Quantum equipped locomotives.

2.3 List of CV's supported by Quantum Locomotives

The following table lists all CV's. The third column, labeled "NMRA", indicates whether these CV's are mandatory (M), recommended (R), or optional (O). The fourth column indicates if this CV is supported by QSI and the fifth column indicates the common default value.

CV#	CV Name	NMRA	QSI Supported	Default Value Decimal	Comment
1	Primary Address	M	Y	3	
2	V-Start	R	Y	32	This number may change from locomotive to locomotive.
3	Acceleration Rate	R	Y	0	
4	Deceleration Rate	R	Y	0	
5	V-High	O	Y	1	Either 1 or 0 in this CV disables V-High
6	V-Mid	O	Y	0	Either 1 or 0 in this CV disables V-Mid
7	Manufacturer Version No.	M	Y	-	See CV 56.254 and CV 56.255 for additional information on Quantum Version numbers.
8	Manufacturer's ID	M	Y	113	
9	Total PWM Period ³³	O	N	-	Not needed with our motor control
10	EMF Feedback Cutout2	O	N	-	Not needed with our BEMF detection.
11	Packet Time-Out Value	R	Y	0	
12	Power Source Conversion	O	N	-	
13	Analog Mode Function Status	O	N	-	
14	Reserved by NMRA for future use	-	-	-	
15	Reserved by NMRA for future use	-	-	-	
16	Reserved by NMRA for future use	-	-	-	
17	Extended Address	O	Y	0	CV 17 and 18 form a paired CV. CV 17 must be written first followed by CV 18
18	Extended Address	O	Y	0	
19	Consist Address	O	Y	0	
20	Reserved by NMRA for future use	-	-	-	
21	Consist Address Active for F1-F8	O	Y	0	
22	Consist Address Active for FL and F9-F12	O	Y	0	
23	Acceleration Adjustment	O	Y	0	
24	Deceleration Adjustment	O	Y	0	
25	Speed Table Selection	O	Y	2	Linear
26	Reserved by NMRA for future use	-	-	-	
27	Reserved by NMRA for future use	-	-	-	
28	Reserved by NMRA for future use	-	-	-	
29	Configuration Data #1	M	Y	6	28 speed step mode. Power Source Conversion enabled.
30	Error Information	O	N	-	
31	Configuration Data #2	O	N	-	Reserved by NMRA for future use.
32	Configuration Data #3	O	N	-	Reserved by NMRA for future use.
33	Output Location for FL(f)	O	Y	1	By default set to directional lighting.
34	Output Location for FL(r)	O	Y	3	By default set to directional lighting.
35	Output Location for F1	O	Y	4	By default set to bell output.
36	Output Location for F2	O	Y	8	By default set to whistle output.
37	Output Location for F3	O	Y	16	By default set to coupler sounds output.
38	Output Location for F4	O	Y	4	By default set to Cooling Fans output.

³³ Changes are not allowed. The PWM is already optimized for Quantum equipped locomotives.

39	Output Location for F5	O	Y	8	By default set to Dynamic Brakes output.
40	Output Location for F6	O	Y	16	By default set to Doppler output.
41	Output Location for F7	O	Y	32	By default set to Air Brakes output.
42	Output Location for F8	O	Y	64	By default set to Mute output.
43	Output Location for F9	O	Y	16	By default set to Heavy Load output.
44	Output Location for F10	O	Y	32	By default set to Status Report output.
45	Output Location for F11	O	Y	64	By default set to Number Boards output.
46	Output Location for F12	O	Y	128	By default set to Cab Lights output.
47	Reserved by NMRA for future use	-	-		
48	Reserved by NMRA for future use	-	-		
49	QSI Primary Index	O	Y	0	"PI" for short.
50	QSI Secondary Index	O	Y	0	"SI" for short.
51	QSI System Sound Control	O	Y		1-dimensional table[PI]
52	QSI Individual Sound Volume Control	O	Y		1-dimensional table[PI]
53	QSI Function Output Feature Assignment	O	Y		2-dimensional table[PI,SI]
54	Reserved by QSI for future use	-	-		
55	QSI Feature Configuration	O	Y		2-dimensional table[PI,SI]
56	QSI Configuration	O	Y		2-dimensional table[PI,SI]
57	Reserved by QSI for future use	-	-		
58	Odometer	-	-		2-dimensional table[PI,SI]
59	Reserved by QSI for future use	-	-		
60	Reserved by QSI for future use	-	-		
61	Reserved by QSI for future use	-	-		
62	QSI Control	O	Y	1	Turn on/off programming verbal acknowledgement.
63	Reserved by QSI for future use	-	-		
64	Verbal CV Inquiry	O	Y		Decoder speaks out value of any CV.
65	Kick Start	O	N	-	
66	Forward Trim	O	Y	128	
67	Speed Step 1	O	Y	0	
68	Speed Step 2	O	Y	9	
69	Speed Step 3	O	Y	18	
70	Speed Step 4	O	Y	28	
71	Speed Step 5	O	Y	37	
72	Speed Step 6	O	Y	47	
73	Speed Step 7	O	Y	56	
74	Speed Step 8	O	Y	66	
75	Speed Step 9	O	Y	75	
76	Speed Step 10	O	Y	85	
77	Speed Step 11	O	Y	94	
78	Speed Step 12	O	Y	103	
79	Speed Step 13	O	Y	113	
80	Speed Step 14	O	Y	122	
81	Speed Step 15	O	Y	132	
82	Speed Step 16	O	Y	141	
83	Speed Step 17	O	Y	151	
84	Speed Step 18	O	Y	160	
85	Speed Step 19	O	Y	170	
86	Speed Step 20	O	Y	179	
87	Speed Step 21	O	Y	188	
88	Speed Step 22	O	Y	198	
89	Speed Step 23	O	Y	207	

90	Speed Step 24	O	Y	217	
91	Speed Step 25	O	Y	226	
92	Speed Step 26	O	Y	236	
93	Speed Step 27	O	Y	245	
94	Speed Step 28	O	Y	255	
95	Reverse Trim	O	Y	128	
96	Reserved by NMRA for future use	-	-		
97	Reserved by NMRA for future use	-	-		
98	Reserved by NMRA for future use	-	-		
99	Reserved by NMRA for future use	-	-		
100	Reserved by NMRA for future use	-	-		
101	Reserved by NMRA for future use	-	-		
102	Reserved by NMRA for future use	-	-		
103	Reserved by NMRA for future use	-	-		
104	Reserved by NMRA for future use	-	-		
105	User Identifier #1	O	N		
106	User Identifier #2	O	N		
107	Reserved by NMRA for future use	-	-		
:	:	-	-		
111	Reserved by NMRA for future use	-	-		
112	Reserved by QSI for future use	-	-		
113	Reserved by QSI for future use	-	-		
114	Reserved by QSI for future use	-	-		
115	Feature to Port Mapping	O	Y		2-dimensional table[PI,SI]
116	Individual Sound Balance	O	Y		1-dimensional table[PI]
117	Individual Sound Selection	O	Y		2-dimensional table[PI,SI]
118	Reserved by QSI for future use	-	-		
119	Reserved by QSI for future use	-	-		
120	Ready to Move Scenario	O	Y		2-dimensional table[PI,SI]

2.4 Overview of CV Descriptions

The following sections provide detailed descriptions of each CV supported by the Quantum System. Each description includes the default value, a pictorial of the CV data register and sometimes, operational hints or notes about special use and limitations.

The data for each bit shown in the pictorial data registers are classified as:

“**A**” for Address data

“**D**” for general data

“**F**” for Function Designation value

“**Sign**” for plus or minus sign.

“**N/A**” for Not Applicable meaning the user is not to enter data in these bits.

“**Output**” for assigning different Output locations for Function Inputs.

“**P**” for QSI Primary Index values

“**S**” for QSI Secondary Index values

“**V**” for audio volume data

In addition, QSI or NMRA pre-assigned data for individual bits in CV registers are shown as their binary value, “1” or “0”.

Examples:

CV 1: Primary Address Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	A6	A5	A4	A3	A2	A1	A0

Bits 0-6 are data bits, which specify the locomotive’s seven bit Primary Address. A zero means, “Do not attempt to write a 1 to this bit”.

CV 49: Primary Index Register

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
P7	P6	P5	P4	P3	P2	P1	P0

Bits 0-7 are data bits, which specify any of the possible eight bit Primary Index values.

CV 40: F6 Output Location for F6 Register (with Factory Default Features)

Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes – Air Brakes (Brake Set)	Doppler (Start Up)	Dynamic Brakes	Blower Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 11	Output 10	Output 9	Output 8	Output 7	Output 6	Output 5	Output 4

The “**Output 4**” means that bit 0 specifies whether Output 4 is controlled by Function Key 6.

Gray background for an Output bit means that it is the default setting.

3 CV's 1-29: NMRA Standard CV's

This section describes in detail NMRA standard CV's supported by Quantum locomotives.

3.1 CV 1 Primary Address Control

Programs the Short or Primary Address from 1 to 127 decimal.

Default Value:

CV 1: Primary Address Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	A6	A5	A4	A3	A2	A1	A0

- Any attempt to set this CV to any value outside the range of 1 to 127 will be ignored and the previous address in this register will remain.
- The Primary Address can be set either in Service Mode or Operations Mode. Remember to change bit 5 of CV 29 to "0" to enable the Primary Address.

Note: Some Command Stations will not operate Quantum Systems in Service Mode due to insufficient power output or timing problems. (Check the appendices for a listing of recommended command stations). If you cannot operate in Service Mode, use Ops Mode programming.

If your command station will not allow setting ID numbers in Ops Mode, use QSI CV 56.129.

3.2 CV 2 V-Start

V-Start defines the voltage drive level applied to the motor at the first throttle speed step. Use CV 2 to adjust the responsiveness of your locomotive at low throttle settings.

Default Value:

32

CV 2: V-Start Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- CV 2 sets a start voltage for the motor to any value between 0 and 255. A value of 0 provides no offset while a value of 255 provides maximum starting voltage with no throttle range left.

CV 2 specifies how much of the available track voltage will be applied to the motor at the start of the throttle range as defined by the following equation:

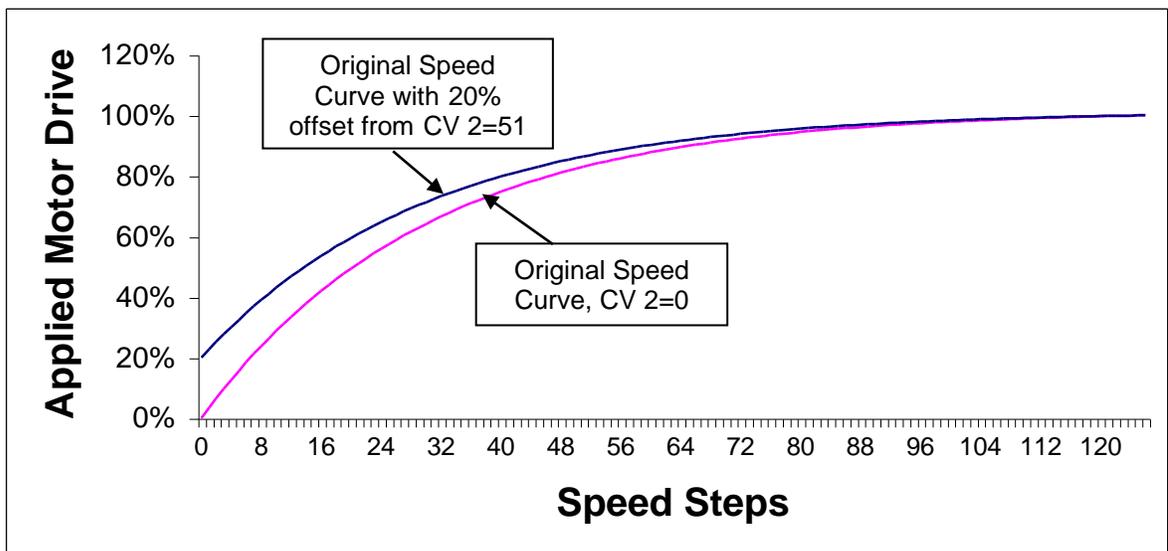
$$\text{Start Voltage} = (\text{Track Voltage}) \times (\text{CV2}/255)$$

- The value of motor drive (as a percentage of total track voltage) is computed according to the formula below:

$$\% \text{ Applied Motor Voltage} = (\text{CV 2} + ((\text{CV5}-\text{CV 2}) * \text{Speed Table Value for speed step}/255)) * (100/255)$$

If CV 5 is less than or equal to CV 2, or CV 5 is set to 0 or 1, then 255 is used for CV 5 in the above equation.

The graph below shows the original curve plus the effect of an offset of 20% (CV 2 = 51 and assuming CV 5, V-High, is set at its maximum value of 255). Note how CV 2 preserves the shape of the original speed curve but compresses it to fit between V-Start and V-High.



- DCC V Start is not related to V Start for Analog Operation.
- V-Start is not used when Throttle Mode = Calibrated Speed Control .
- See CV 5 for more information.

3.3 CV 3 Acceleration Rate³⁴

Sets the value of Inertia under Acceleration

Default Value:

CV 3: Acceleration Rate Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- CV 3 can contain any value between 0 and 255. A value of “0” provides no inertia and gives the fastest response to changes in throttle position.
- The larger the value of CV 3, the more gradually the locomotive increases speed as the throttle is increased. The inertia, in seconds/speed step, is calculated by the formula:

$$\text{Acceleration Inertia (seconds/speed step)} = \frac{(\text{CV 3}) * 0.896}{\text{Number of Speed Steps}}$$

This inertia is independent of which “Number of Speed Steps” is in use (14, 28, or 128). For the same value of CV 3, it will take the same amount of time to go from a dead stop to full speed for a throttle change from minimum to maximum regardless of the speed step choice. The time can vary from a quick response measured in seconds for CV 3=0 to as long as 3.8 minutes (228 seconds) for CV 3 = 255.

- The acceleration rate is the inverse of the inertia formula.

$$\text{Acceleration Rate (speed steps/second)} = \frac{\text{Number of speed steps}}{(\text{CV 3}) * 0.896}$$

- The acceleration and deceleration rate values in CV 3 and CV 4 will apply if you change the direction on a moving locomotive. The locomotive will slow to a stop at a rate set by CV 4 and then accelerate in the opposite direction at a rate set by CV 3.

³⁴ This NMRA CV is more aptly entitled “Inertia under Acceleration” since higher values for this CV result in higher inertia values but lower acceleration rates. Using the term “Momentum” to describe CV 3 is not correct since a non-moving train has no momentum even if CV 3 is set to the maximum value. Inertia is the property of an object that resists any change to its state of rest or motion.

3.4 CV 4 Deceleration Rate³⁵

Sets the Inertia under Deceleration.

Default Value:

CV 4: Deceleration Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- CV 4 can contain any value between 0 and 255. A value of “0” provides no inertia and gives the fastest response to changes in throttle position.
- The larger the value of CV 4, the more gradually the locomotive slows down as the throttle is decreased. The inertia, in seconds/speed step, is calculated by the formula:

$$\text{Deceleration Inertia (seconds/speed step)} = \frac{(\text{CV 4}) * 0.896}{\text{Number of Speed Steps}}$$

This inertia is independent of which “Number of Speed Steps” is in use (14, 28, or 128). For the same value of CV 4, it will take the same amount of time to go from full speed to a dead stop for a throttle change from maximum to minimum regardless of the speed step choice. The time can vary from a quick response measured in seconds for CV 4=0 to as long as 3.8 minutes (228 seconds) for CV 4 = 255.

- The deceleration rate is the inverse of the above formula.

$$\text{Deceleration Rate (speed steps/second)} = \frac{\text{Number of speed steps}}{(\text{CV 4}) * 0.896}$$

- The acceleration and deceleration rate values in CV 3 and CV 4 will apply if you change the direction of a moving locomotive. The locomotive will slow to a stop at a rate set by CV 4 and then accelerate in the opposite direction at a rate set by CV 3.

³⁵ This NMRA name is more aptly entitled “Inertia under Deceleration” since higher values for this CV result in higher inertia values but lower deceleration rates. Using the term “Momentum” to describe CV 3 is not correct since a non-moving train has no momentum even if CV 3 is set to the maximum value. Inertia is the property of an object that resists any change to its state of rest or motion.

3.5 CV 5 V-High

V-High defines the voltage drive level applied to the motor at maximum throttle. Use CV 5 to reduce the maximum speed of locomotives that operate too fast at maximum throttle.

Default Value:

CV 5: V-High Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- CV 5 sets a maximum voltage for the motor to any value between 2 and 255. A value of 0, 1, or 255 provides maximum motor voltage at maximum throttle.

The value of CV 5 determines the maximum motor drive as a fraction of the applied voltage as defined by the following equation:

$$\text{Maximum Motor Voltage} = (\text{Track Voltage}) \times (\text{CV5}/255)$$

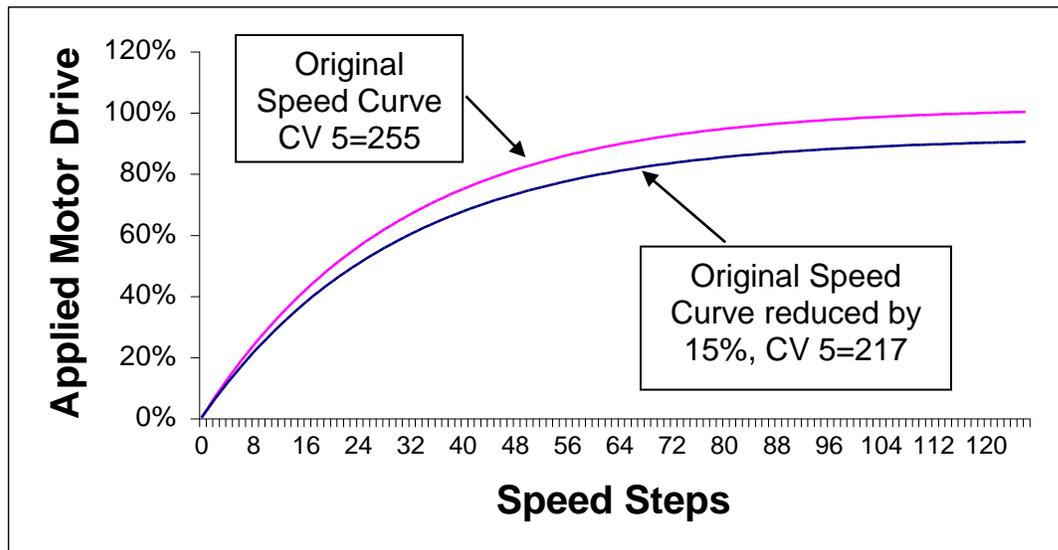
For instance, a value of “217” for CV 5 means that the maximum voltage will be 217/255 or 85% of the applied track voltage.

- The value of motor drive (as a percentage of total track voltage) is computed according to the formula below:

$$\% \text{ Applied Motor Voltage} = (\text{CV 2} + ((\text{CV5}-\text{CV 2}) * \text{Speed Table Value for speed step}/255)) * (100/255)$$

If CV 5 is less than or equal to CV 2, or CV 5 is set to 0 or 1, then 255 is used for CV 5 in the above equations.

The graph below shows the effect of only CV 5 (CV 2 =0) on the original curve. Here a value of CV 5 = 217 reduces the original speed curve by 15% over the entire speed step range. Note how CV 5 preserves the shape of the original speed curve but compresses it to fit between V-Start and V-High.

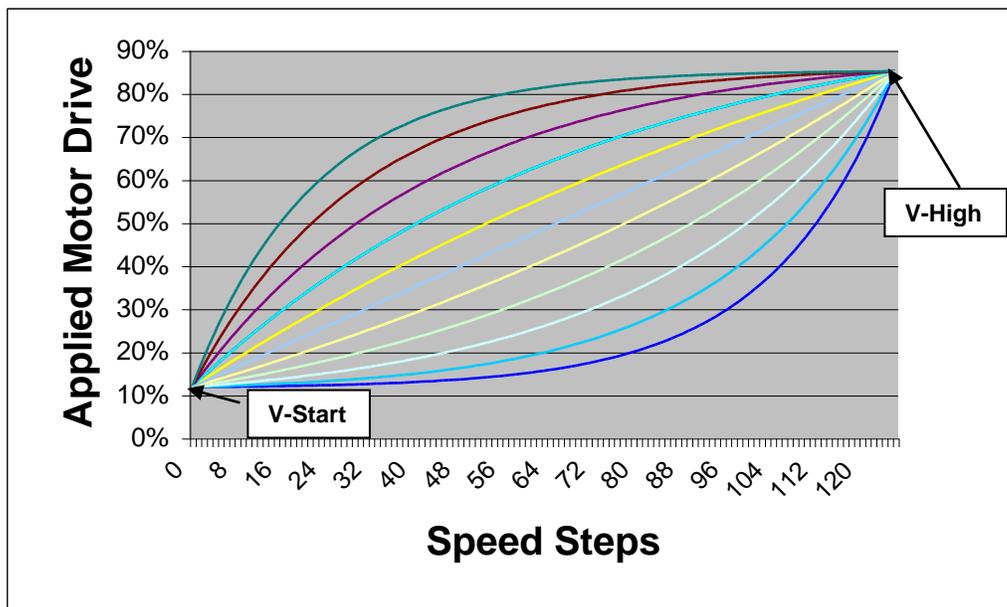


V-High is not related to V Max for Analog Operation.
V-High is not used when Throttle Mode = Calibrated Speed Control.

Recommendations for specifying speed curves, V-Start and V-High.

The following is a method we use at QSI to configure a locomotive to match the speed of other locomotives. We use Ops mode programming since it lets us change the locomotive's speed characteristics while the locomotive is operating.

1. Place your locomotive to be configured (call it locomotive A) on a fairly large loop of track. Place your standard locomotive³⁶ (call it locomotive B) that you use as your speed reference on the same loop of track but on the opposite side. Each locomotive should have a different ID.
2. For both locomotives set CV 56.4 to "0" (STC) or "1" (RTC).
3. For both locomotives set CV 29 bit 4 to "1" to enable speed curves.
4. Run both locomotives at speed step 1.
5. Change locomotive A's CV 2 value until it is moving at the same speed as locomotive B.
6. Run both locomotives at full throttle. You may have to restrain one of the locomotives if they get too close to each other.
7. Change locomotive A's CV 5 value until Locomotive A is moving at the same speed as Locomotive B.
8. Set both locomotives to speed step 64. For locomotive A, choose speed curves from the list of QSI speed curves from CV 25 until both locomotives are running at a similar speed. The speed curves are compressed to fit between V-High and V-Start as shown in the graph below.



Speed Curves with V-Start set to 30 (10% of applied voltage) and V-High set to 217 (85% of applied voltage).

9. If none of the speed curves are acceptable, set CV 25 to 1 and make your own custom speed curve using CV 67 through CV 94. Your custom speed curve will also be compressed to fit within the limits set by V-Start and V-High. Set both locomotives at 28 speed-step selection so your custom changes are at the speed step the locomotive is operating at. Start both locomotives at speed step 1; enter Ops mode programming for Locomotive A and set CV 67 to match Locomotive B speed. Leave Ops mode programming, and set both locomotives to operate at speed step 2, enter Ops mode programming for Locomotive B and set CV 68 to match Locomotive B speed. Repeat this procedure until you have entered speed curve values for all CV's between CV 67 and CV 94.

³⁶ You may have a number of standard locomotives for different speed classifications. For instance, you might have a standard locomotive for yard operations with a top speed of 35 smph, a standard freight locomotive with a top speed of 65 smph and a third standard locomotive for passenger service with a top speed of 100 smph.

3.6 CV6 V-Mid

V-Mid defines the voltage drive level applied to the motor halfway between minimum and maximum throttle. Use CV6 along with CV2 V-Start and CV5 V-High as a simple way to specify a speed table.

Default Value:

0

CV 6: V-Mid Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- CV6 sets the middle voltage for the motor to any value between 2 and 255. A value of 0 or 1 specifies that CV6 not be used in the calculation of the speed table.
- CV6 is not used in the calculation of the speed table if CV29 bit 4 is 1.
- If CV29 bit 4 is 0, then CV2, CV5, and CV6 are used to calculate a speed curve. If CV6 is 0 or 1, then the speed curve is a straight line segment between CV2 and CV5. If CV6 has a value between 2 and 255, then the speed curve consists of two straight line segments, the first between the CV2 and CV6 values, the second between the CV6 and CV5 values.

3.7 CV 7 Manufacturer's Version Number

This is a read only CV that returns the major version number of the decoder's firmware.

Default Value:

N/A

CV 7: Manufacturer's Version Number Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Production release versions start with 1. If your locomotive has a 1 in this register, your locomotive contains the first version of Quantum HO firmware. A "2" in this register corresponds to the second version of Quantum HO firmware.
- This DCC Reference Manual describes CV's supported by version 7 firmware. If your Quantum locomotive has a value of 1...6 in this CV, version 3.1 of the DCC Reference Manual more accurately describes your locomotive's firmware.

3.8 CV 8 Manufacturer's ID

This read-only CV identifies QSI as the manufacturer or developer of the software used in the Quantum System.

Default Value:

113

CV 8: Manufacturer's ID Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	1	1	1	0	0	0	1

- The value of this read only register is 113, which is the official NMRA designation for QSI as a manufacturer of DCC decoders.

3.9 CV 11 Packet Time-Out Value

The value in CV 11 is the maximum time the decoder will maintain its current speed without receiving a valid DCC packet.

Default Value:

0³⁷

CV 11: Packet Time-Out Value Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
N/A	N/A	N/A	D4	D3	D2	D1	D0

- If CV 11 has a non-zero value, and the locomotive receives no DCC packets addressed to the locomotive for that number of seconds then the locomotive will decelerate to a stop at a rate specified by CV 4 and CV 24 and will enter Neutral. The usual Neutral Sounds will then be heard.
- When DCC packets addressed to the locomotive are again received, the locomotive will respond to the DCC packet commands addressed to the locomotive. It will remain in Neutral until a new speed packet is received at which time it will accelerate at the rate set in CV 3 and CV 23.
- A value of zero will disable the time-out function and the locomotive will continue to run at its last speed setting when it stops receiving packets addressed to the locomotive.
- The factory default is "0".
- The maximum value for CV 11 is "255"³⁸, which is interpreted as 255 seconds.
- If both Power Source Conversion (CV 29, bit 2) and Packet time-out Value are enabled, Power Source Conversion takes precedence, since it will always have the shorter time-out period.

³⁷ Firmware built prior to 1-Nov-06 has a default of "1".

³⁸ For firmware built prior to 1-Nov-06, the maximum value is "20".

3.10 CV 17, 18 Extended Address

CV 17 and CV 18 together provide a larger (14 bit) range for locomotive ID numbers from 0 to 10,239.

CV 17 Default Value:	0 ³⁹
CV 18 Default Value	0

CV 17: Extended Address Most Significant Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	1	A13	A12	A11	A10	A9	A8

CV 18: Extended Address Least Significant Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
A7	A6	A5	A4	A3	A2	A1	A0

- Use CV 17 and CV 18 to assign your locomotive one of 10,240 addresses from 0 to 10,239, although most Command Stations will only allow entering ID's up to 9,999. You can assign your locomotive an address that is identical to the locomotive's cab number, which rarely exceed four digits.
- Your locomotive can have both a Primary Address (CV 1) and an Extended Address. There is overlap in the Primary Address and Extended Address range 1...127 so that a locomotive can have the same number for its Primary Address as it has for its Extended Address. For example, a locomotive can have Primary Address "53" and Extended Address "53". Although the same number, these two addresses are not the same and are treated differently by your locomotive and your Command Station. See your Command Station Instructions to learn how to tell the difference between the two addresses.
- The Extended Address can be set either in Service Mode or Operations Mode. Remember to change bit 5 of Configuration CV 29 to "1" to enable the Extended Address.

3.9.1 Entering Extended Address into CV 17 and CV 18 Directly:

Most modern Command Stations allow the operator to input an Extended Address from 0 to 9999 directly in decimal format without having to individually enter data into CV 17 and CV 18. However, if you have an older Command Station and need to program these CV's directly, the following information will be helpful.

- ◆ CV 17 and CV 18 form a paired CV and it makes a difference how data is entered. CV 17, the most significant byte, must be written first followed by CV 18, the least significant byte. If the order is reversed, the Quantum decoder will not accept the values entered.
- ◆ Bits A15 and A14 must both be assigned "1" which adds 192 to the value of the byte in CV 17. The remaining 6 bits of C17 and the 8 bits of C18 allow addresses to be assigned between 0 and 10,239 inclusive. Any attempt to program an extended ID above 10,239 will be ignored.

To enter CV 17 and CV 18 by direct programming, first divide the decimal address you intend to enter by 256, convert the quotient to binary, add the two leading 1's for bits A14 and A15, and write the result to CV 17. Convert the remainder to binary and write this number to CV 18.

³⁹ The default for CV 17 is actually "192" which is an artifact of how these ID numbers are specified by the NRMA where 192 is added to the MSB (Most Significant Byte) of the address you want to enter. If you have a modern Command Station that programs your ID numbers directly, you will enter your ID number equal to the Extended Address you intend to use; however, if you program the extended address CV directly, a zero address must be entered as 192. See example in this section on directly programming CV 17 and CV 18.

Example1 Decimal Entry: Program CV 17 and CV 18 to Extended Address 5343.

Divide 5343 by 256 to get 20 as quotient and 223 as remainder.

Note: If you use a calculator, you will get 20.8711. Note the integer value $n = 20$, which is the quotient.

Add 192 to this quotient to get 212 and store this value in CV 17:

$$CV\ 17 = n + 192$$

$$CV\ 17 = 20 + 192 = 212$$

Compute the remaining integer value by multiplying 20 by 256 and subtract from the locomotive value to get remainder and store in CV 18:

$$CV\ 18 = \text{Locomotive Number} - (n \times 256)$$

$$CV\ 18 = 5343 - (20 \times 256) = 223$$

Remember to change CV 29, bit 5 to "1" to allow the Extended Address operation (see CV 29).

Example2 Binary or Hex Entry: Program CV 17 and CV 18 to Extended Address 5343.

Convert 212 from previous example to binary 11010100 or hex 0xD4. Enter this number in CV 17.

Convert 223 from previous example to binary 11011111 or hex 0xDF and enter in CV 18.

Remember to change CV 29, bit 5 to "1" to allow the Extended Address operation (see CV 29).

To check: Compute $(CV\ 17 - 192) \times (256) + CV\ 18$ where 192 is the decimal equivalent of CV 17 with only the leading 1's (11000000)

Decimal: $(212 - 192) \times (256) + 223 = \mathbf{5343}$

Binary: $(11010100 - 11000000) \times (100000000) + 11011111 = 1010011011111 = \mathbf{5343}$ decimal.

Hex: $(0xD4 - 0xC0) \times 0x100 + 0xDF = 0x14DF = \mathbf{5343}$ decimal, where 0xC0 is the hex equivalent of 192.

The following table shows examples for some common Steam locomotive cab numbers. See if your calculations match the values in the table. After you have calculated your ID numbers, just follow the procedure below to enter your extended ID number.

1. Find out if your command station accepts Decimal, Binary or Hex inputs for CV entries.
2. First enter CV 17 (Most Significant Byte) from the table below as a Decimal, Binary or Hex number shown.
3. Next enter CV 18 (Least Significant Byte) from the table below as a Decimal, Binary or Hex number shown.
4. Change CV 29, bit 5 to "1" to allow operation with your new Extended Address.
5. Read your ID number back from your program track or verbally in Opts Mode to see if you entered the correct number.

Common Steam Locomotive Numbers

Loco Number	CV 17 (Dec)	CV 18 (Dec)	CV 17 (Hex)	CV 18 (Hex)	CV 17 (Binary)	CV 18 (Binary)
3985	207	145	CF	91	11001111	10010001
611	194	99	C2	63	11000010	01100011
8444	224	252	E0	FC	11100000	11111100
4449	209	97	D1	61	11010001	01100001
3751	206	167	CE	A7	11001110	10100111
261	193	5	C1	5	11000001	00000101
1218	196	194	C4	C2	11000100	11000010
1361	197	81	C5	51	11000101	01010001
700	194	188	C2	BC	11000010	10111100

Note: Some command stations will not operate Quantum Systems in Service Mode due to insufficient power output or timing problems. (Check the appendices for a listing of recommended command stations). If you cannot operate in Service Mode, use Ops mode programming.

If your command station will not allow setting ID numbers in Ops Mode, use QSI CV 56.129 to enter your ID numbers.

3.11 CV 19 Consist Address

Sets a locomotive's Consist⁴⁰ address in addition to setting the locomotive's direction within the Consist.

Default Value:

0

CV 19: Consist Address Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	A6	A5	A4	A3	A2	A1	A0

- Bits A0-A6 set the Consist address to any value from 0 to 127.
- Bit D7 sets the locomotive's direction. "0" in D7 sets the locomotive to a normal Forward and "1" sets locomotive to Reverse Direction within the Consist.
- If the address in bits 0-6 is 0, the locomotive is not in a Consist.
- If the seven bit address has a value 1...127, when decoder receives a command packet addressed to this address, the packet will be processed as any other packet except,
 - ◆ The direction bit in a speed/direction or advanced operation packet is inverted if D7=1.
 - ◆ Function Key commands are ignored unless enabled in CV's 21 and 22.
 - ◆ Long Form CV Access instructions will be ignored.
 - ◆ Only Short Form CV Access instructions for CV's 23 and 24 are allowed.
- If a locomotive has the same Consist Address as its Primary Address, it will respond to commands as though it were being addressed by its Primary Address without the restrictions set in CV 21 and CV 22.

⁴⁰ Consists are also know as Multiple Heading, Lashups or Multiple Unit Trains (MU's) .

3.12 CV 21 Consist Address Active for F1-F8⁴¹

Specifies the Function Keys that are enabled when a locomotive is addressed by its Consist ID.

Default Value:

0

CV 21: Consist Address Active for F1-F8 Register⁴²

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
F8	F7	F6	F5	F4	F3	F2	F1

- If a “0” is placed in any bit, that function key is disabled when the locomotive is addressed by its Consist ID.
- If a “1” is placed in any bit, that function key is enabled when the locomotive is addressed by its Consist ID.
- See also CV56.36.0 Consist Address Active for F13-F20 and CV56.36.1 Consist Address Active for F21-F28.
- This CV is useful for disabling certain features for helper locomotives within the Consist. For instance, only the Lead locomotive should have its Horn/ Whistle and Bell enabled. If the F2 key controls the Horn and the F3 key controls the Bell, then all slave locomotives should have "0" in Bit 1 and Bit 2, while the Lead locomotive should have “1” in these bits.
- The following recommended values are for locomotives that have factory default features assigned to Function Outputs (see CV 53). Features that are different in the Neutral State are shown with parentheses (i.e. Doppler (Start Up) means Doppler is only operable in Forward and Reverse and Start Up is operable only in Neutral). Features shown that do not indicate a special Neutral Option, will operate in all states (Forward, Neutral and Reverse).

Recommended value of CV 21 for a Lead Locomotive in a Consist.

(The QSI default features assignments are shown for Forward/Reverse operation in the top row and for Neutral in parenthesis).

Audio Mute	Brake Squeal and Air Brakes (Arm Cylinder Cocks or long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle	Bell
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	1	1	1	1	0	1	1

Recommended value of CV 21 for a Mid⁴³ Helper Locomotive in a Consist.

(The QSI default features assignments are shown for Forward/Reverse operation in the top row and for Neutral in parenthesis).

Audio Mute	Brake Squeal and Air Brakes (Arm Cylinder Cocks or long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower Hiss/Fans	Coupler Crash	Horn/Whistle	Bell
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	1	1	1	1	0	0	0

⁴¹ See also CV56.36.0 Consist Address Active for F13-F20 and CV56.36.1 Consist Address Active for F21-F28.

⁴² Write bit operation is supported for CV 21.

⁴³ A Mid Helper is any locomotive between the Lead and the last or End helper in a Consist.

Recommended value of CV 21 for an End⁴⁴ Helper Locomotive in a Consist.

(The QSI default features assignments are shown for Forward/Reverse operation in the top row and for Neutral in parenthesis).

Audio Mute	Brake Squeal and Air Brakes (Arm Cylinder Cocks or long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower Hiss/Fans	Coupler Crash	Horn/Whistle	Bell
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	1	1	1	1	1	0	0

⁴⁴ An End Helper is the last helper in a consist.

3.13 CV 22 Consist Address Active for FL and F9-F12

Sets whether the FL(r) or FL(f) keys and F9-F12 keys are enabled when a locomotive is addressed by its Consist ID.

Default Value:

CV 22: Consist Address Active for FL and F9-F12 Register⁴⁵

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	F12	F11	F10	F9	FL(r)	FL(f)

- If a "0" is placed in bits 0 through 5, that function key is disabled when the locomotive is addressed by its Consist ID.
- If a "1" is placed in bits 0 through 5, that function key is enabled when the locomotive is addressed by its Consist ID.
- Any "1" placed in bits 6 or 7 will be ignored.
- FL in the Forward Direction is controlled by bit 0, FL in the Reverse Direction is controlled by bit 1.
- This CV and CV 21 are useful for disabling certain features for Helper locomotives within the Consist.
 - ◆ Only the Lead Locomotive should have operational Directional Lighting. Helpers should have their Directional Lighting disabled.
 - ◆ F9, Heavy Load and Shut Down are recommended for all Helper types in a Consist since Heavy Load should apply to all locomotives or none at all; otherwise there would be fighting between locomotives that have Heavy Load enabled and those that do not. Similarly, the F9 Shut Down key should apply to all locomotives in Consist or none at all.
 - ◆ F10, Status Report should be disabled for all Helper types in a Consist since it would be difficult to hear the verbal announcement if more than one locomotive announced its status at the same time.
 - ◆ Features for Function keys 11 and 12 are usually reserved for Number Board Lights and Cab Lights. It is recommended that Cab Lights be disabled and Number Board Lights be enabled. At times F11 and F12 are reserved for custom appliance sounds or operations for the different locomotive types (Steam, Diesel or Electric) such as steam Blow Down, etc. It is recommended that these functions be disabled for all Helper types except the Lead Locomotive to avoid confusion. Check your individual models to determine which features are assigned to F11 and F12.
- The following recommended values are for locomotives that have factory default values assigned to FL Outputs (see CV 53). Features that are different in the Neutral State are shown with parentheses; i.e. Heavy Load (Shut Down) means Heavy Load is only operable in Forward and Reverse and Shut Down is operable only in Neutral.

Recommended value of CV 22 for a Lead Locomotive in a Consist:

N/A	N/A	Cab Lights	Number Board Lights	SMPH Report (Status Report)	Heavy Load (Disconnect-Standby-Total Shut Down)	Directional Lighting	Directional Lighting
N/A	N/A	F12	F11	F10	F9	FL(r)	FL(f)
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	1	1	1	1	1

Recommended value of CV 22 for a Mid Helper Locomotive in a Consist:

⁴⁵ Write bit operation is supported for CV 22.

N/A	N/A	Cab Lights	Number Board Lights	SMPH Report (Status Report)	Heavy Load (Disconnect-Standby-Total Shut Down)	Directional Lighting	Directional Lighting
N/A	N/A	F12	F11	F10	F9	FL(r)	FL(f)
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	1	0	1	0	0

Recommended value of CV 22 for an End Helper Locomotive in a Consist:

N/A	N/A	Cab Lights	Number Board Lights	SMPH Report (Status Report)	Heavy Load (Disconnect-Standby-Total Shut Down)	Directional Lighting	Directional Lighting
N/A	N/A	F12	F11	F10	F9	FL(r)	FL(f)
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	1	0	1	0	0

When making up a consist, remember to have the directional lighting turned off before you assign zeros for bits 0 and 1. Otherwise the directional lighting will be on with no way to turn them off with the FL(r) or FL(f) keys⁴⁶.

The above selections for directional lighting for locomotives in a consist are not ideal for the following reasons:

1. You may not want the Lead Locomotive to have an operating Directional Reverse Light since it would only illuminate the locomotive behind it and not the track. The simplest way to have the reverse light off in all motive states is to set CV55.73.1 to 0.
2. You may want the End Helper to have an operational reverse facing light (which may be either the End Helper's Reverse Light or Headlight depending on the locomotive's direction within the consist). If the End Helper is facing forward, set CV55.70.1 to 0, CV55.73.1 to 32, and set bit 0 and bit 1 in CV 22 to 1. If the End Helper is facing Backwards, set CV55.70.1 to 86, CV55.73.1 to 0, and set bit 0 and bit 1 in CV 22 to 1.

With the above changes, the directional lighting in your consist will operate like a single locomotive. That is, the FL key is on, the Lead Locomotive Directional Headlight will be on, all other Helper Headlights will be off, and all Reverse Lights will be off. If the consist is moving in Reverse, only the End Helper Reverse Light will be on and the Lead Locomotive Headlight will either be off or Dim (if the Dim feature is part of the Directional Headlight for your model).

⁴⁶ Since the default for directional lighting is off, any helpers that did have their directional lighting on will be set to off if the power is turned off and back on, or if the locomotive is shut down and started using the F9 and F6 keys.

3.14 CV 23 Acceleration Adjustment

Increases or decreases the Acceleration from the base Acceleration Rate in CV 3.

Default Value:

0

CV 23: Acceleration Adjustment Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- CV 23 can have any value from -127 to +127 where positive values will increase the acceleration time and negative values will decrease the acceleration time. A positive value is indicated by a 0 in bit 7 while a "1" indicates a negative value.
- A positive value of CV 23 adds directly to the value of CV 3 by the formula below:

$$\text{Seconds/speed step} = \frac{(\text{CV 3} + \text{CV 23}) * 0.896}{\text{Number of Speed Steps}}$$

- The purpose of CV 23 is to allow the operator to simulate differing train lengths/loads, most often when operating in Consists. It can, however, apply to single locomotives as well.

3.15 CV 24 Deceleration Adjustment

Increases or decreases the Deceleration from the base Deceleration Rate in CV 4.

Default Value:

0

CV 24: Deceleration Adjustment Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- CV 24 can have any value from -127 to +127 where positive values will increase the deceleration time and negative values will decrease the deceleration time. A positive value is indicated by a 0 in bit 7 while a "1" indicates a negative value.
- A positive value of CV 24 adds directly to the value of CV 4 by the formula below:

$$\text{Seconds/speed step} = \frac{(\text{CV 4} + \text{CV 24}) * 0.896}{\text{Number of Speed Steps}}$$

- The purpose of CV 24 is to allow the operator to simulate differing train lengths/loads, most often when operating in Consists. It can, however, apply to single locomotives as well.

3.16 CV 25 Quantum Speed Table Selection

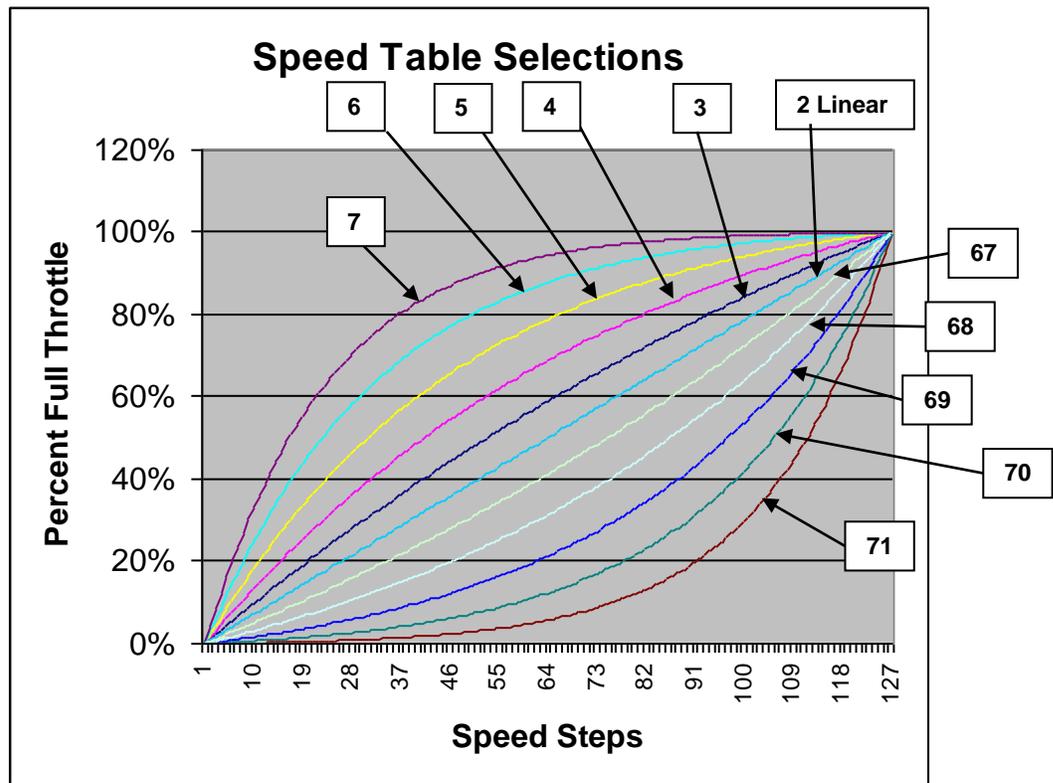
Use this CV to select of one of 11 predefined speed curves.

Default Value: 2

CV 25: Quantum Speed Table Selection Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	D6	N/A	N/A	N/A	D2	D1	D0

- You can select from 11 predefined speed curves that are shown in the graph below. The upper five convex curves are “fast start” curves while the lower five concave curves are “slow start” curves. The “fast start” curves will compensate for locomotives that are less responsive getting started while the “slow start” curves compensate for locomotives that tend to “rocket out” when the throttle is barely turned on.



- To select a predefined speed curve, set CV 25 to the value associated with the curve in the graph above. Set CV 25 to “0” or “1” to select a User Defined Curve (see CV 67 – 94). Set CV 25 to any other number to select a predefined Linear Curve.
- Bit 4 of CV 29 must be set to “1” to enable any of the above speed curves. If CV 29 bit 4 is set to “0”, then a linear straight-line response is enabled.

Additional Information for the Curious Regarding QSI Speed Curves:

- The assignment of bits to this register follows a logical sequence:
 - Bits 0-2:** Determines how much curvature. For low values the curves are closer to linear while higher values provide greater curvature. Bits 0-2 set to 000 or 001 indicates that speed table is not used regardless of the setting in bit 6. Bits 0-2 set to 010 indicate a linear speed table.

Bit 3-5: Reserved for future QSI expansion of speed curves. Any non-zero value entered for these bits will automatically result in a Linear Response regardless of what is entered in other bits.

Bit 6: Determines if it is convex “Fast Start” or concave “Slow Start” curve.
 0 = “Fast Start” Convex Curve
 1 = “Slow Start” Concave Curve

Bit 7: This bit specifies the mid-range Speed Step and is not supported by Quantum decoders. Set the value to 0. Either a “1” or a “0” is ignored.

The decimal value for each curve from the table below is shown on the above speed graph.

- Curve Tables in order of value for CV 25

Value of CV 25 (Decimal)	Value of CV 25 Bits 7-0 (Binary)	Resulting Speed Table
Convex “Fast Start” Curves		
0	0 0 0 0 0 0 0 0	Reverts to User Defined Speed Table (CV 67-94)
1	0 0 0 0 0 0 0 1	Reverts to User Defined Speed Table (CV 67-94)
2	0 0 0 0 0 0 1 0	Linear Curve
3	0 0 0 0 0 0 1 1	Fast Start 1 (close to linear)
4	0 0 0 0 0 1 0 0	Fast Start 2
5	0 0 0 0 0 1 0 1	Fast Start 3
6	0 0 0 0 0 1 1 0	Fast Start 4
7	0 0 0 0 0 1 1 1	Fast Start 5 (greatest curvature)
Concave “Slow Start” Curves		
64	0 1 0 0 0 0 0 0	Reverts to Linear Curve
65	0 1 0 0 0 0 0 1	Reverts to Linear Curve
66	0 1 0 0 0 0 1 0	Linear Curve
67	0 1 0 0 0 0 1 1	Slow Start 1 (close to linear)
68	0 1 0 0 0 1 0 0	Slow Start 2
69	0 1 0 0 0 1 0 1	Slow Start 3
70	0 1 0 0 0 1 1 0	Slow Start 4
71	0 1 0 0 0 1 1 1	Slow Start 5 (greatest curvature)

- If any of the “Reverts to User Defined Table” values are set in CV 25, then the user specified speed table programmed into CV’s 67-94 will be enabled.
- V-Start and V-High settings will apply to these and all curve tables as described in the sections for CV 2 and CV 5. When selecting a speed table, it is recommended that you first select your V-Start offset based on a linear curve and enter this value into CV 2, particularly for concave “slow start” curves where the V-Start point may not be obvious. Setting V-Start for a linear curve will be much more discernible; then select the type of curve you want.

3.17 CV 29 Configuration Data⁴⁷

Each bit in CV 29 controls some basic operational settings for DCC decoders.

Default Value: 00000110 = 6

CV 29: Configuration Data Register (with NMRA Assigned Features)

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Accessory Decoder	Reserved for Future Use	Extended Addressing	Speed Table Enable	Advanced Decoder Acknowledgement	Power Source Conversion	FL Location	Locomotive Direction

- Bit 0 = Locomotive Direction:
 “0” = normal Forward Direction
 “1” = Reversed Direction.

This bit controls the locomotive’s Forward and Reverse direction. With Bit 0 set to 1, the locomotive will move in the Reverse Direction even though the Command Station indicates a Forward Direction. Directional sensitive functions, such as FL(f) and FL(r) , will also be reversed to be consistent with the locomotive’s Reversed Direction.

- Bit 1 = Speed Steps and FL Location
 “0” = Bit 4 sets 14 Speed Step Mode.
 “1” = Bit 4 sets 28 and 128 Speed Step Mode.

In 14 Speed Step Operation, the speed and direction instruction is in one byte of transmitted data that tells the locomotive what direction to go, what speed to travel and whether FL should be “0” or “1”. For 28-speed step operation, the bit used for FL is instead used to double the number of speed steps, so that the light state must be transmitted in a Function Group 1 instruction. Similarly, when using 128 speed step mode, bit 1 of CV 29 must be set to “1”.

- Bit 2 = Power Source Conversion.
 “0” = Power Source Conversion disabled
 “1” = Power Source Conversion enabled.

If CV 29 bit 2 is “1”, and a period of approximately 200mSec⁴⁸ elapses in which no DCC packet is detected, then the locomotive will convert to Analog power.

If the polarity of the track would result in the locomotive moving in the same direction that it was last moving in DCC mode, then the locomotive will continue to move at the speed corresponding to the last received speed step packet. The usual FWD/REV locomotive sound will be heard.

If the polarity of the track would result in the locomotive moving the opposite direction than it was last moving in DCC mode, then the locomotive will decelerate to a stop at a rate determined by CV 4 and CV 24⁴⁹, and will enter Neutral. The usual Neutral sounds will be heard.

When in Analog mode, switching the polarity of the track will either start the locomotive moving or bring it to a stop.

If the locomotive is moving and the polarity is reversed, the locomotive will decelerate to a stop at a rate determined by CV 4 and CV 24 and will enter Neutral.

⁴⁷ Write bit operation is supported for CV 29.

⁴⁸ NMRA Spec RP-9.2.4 specifies that Power Source Conversion should take place when DCC packets are absent for more than 30 mSec. However Quantum requires approximately 200mSec to determine the Analog track polarity.

⁴⁹ Q3 firmware supports CV58.10.0-1 Power Conversion Stopping Distance to specify the distance the locomotive travels before it stops.

If the locomotive is stopped in Neutral and the polarity is reversed, the locomotive will accelerate at a rate determined by CV 3 and CV 23 to a speed corresponding to the last received speed step packet.

The actual locomotive speed under Analog power may differ from its speed under DCC power depending on the Analog track voltage and whether the locomotive is using Calibrated Speed Control, Regulated Throttle Control, or Standard Throttle Control (e.g. the locomotive may jerk upon switching to analog power).

NOTE: This bit must be set to 1 in order for the locomotive to operate on an Analog track. See trouble shooting section.

- Bit 3 = Advanced Decoder Acknowledgement (not used)
- Bit 4 = Speed Table set by configuration variables.
 - “0” Speed Table not used.
 - “1” Speed Table set by CV 25, Quantum Speed Table selection.

When bit 4 of CV 29 is set to “0” a linear Speed Table is used by default.

- Bit 5 = Extended Address Mode enable
 - “0” = The decoder responds to one byte Primary Address (see CV 1).
 - “1” = The decoder responds to a two byte Extended Address (see CV 17 and CV 18)
- Bit 6 = Reserved for NMRA future use.
- Bit 7 = Accessory Decoder
 - “0” = Multifunction locomotive decoder.
 - “1” = Accessory Decoder. .

Quantum decoders are Multifunction Decoders; this bit cannot be changed.

Some command stations make it easy for you to change CV 29 one bit one at a time. Other command stations require you to enter the value of CV 29 as a complete 8-bit byte. The table below shows all the possible combinations of the five programmable bits supported by Quantum locomotives. Where an “X” appears the feature is enabled and the corresponding CV 29 bit is a “1”. The Binary, Decimal, and Hex values are shown for each combination. Choose the features you want enabled and enter the corresponding number into CV 29 using the format recommended by your command station. The default for Quantum decoders is shown in bold type.

CV 29 Common Settings

Extended Addressing	Speed Tables	Power Conversion	28/ 128 speed step	Reversed Direction	Decimal Value	Binary Value	Hex Value
					0	00000000	0x0
				X	1	00000001	0x1
			X		2	00000010	0x2
			X	X	3	00000011	0x3
		X			4	00000100	0x4
		X		X	5	00000101	0x5
		X	X		6	00000110	0x6
		X	X	X	7	00000111	0x7
	X				16	00010000	0x10
	X			X	17	00010001	0x11
	X		X		18	00010010	0x12
	X		X	X	19	00010011	0x13
	X	X			20	00010100	0x14
	X	X		X	21	00010101	0x15
	X	X	X		22	00010110	0x16
	X	X	X	X	23	00010111	0x17
X					32	00100000	0x20
X				X	33	00100001	0x21
X			X		34	00100010	0x22
X			X	X	35	00100011	0x23
X		X			36	00100100	0x24
X		X		X	37	00100101	0x25
X		X	X		38	00100110	0x26
X		X	X	X	39	00100111	0x27
X	X				48	00110000	0x30
X	X			X	49	00110001	0x31
X	X		X		50	00110010	0x32
X	X		X	X	51	00110011	0x33
X	X	X			52	00110100	0x34
X	X	X		X	53	00110101	0x35
X	X	X	X		54	00110110	0x36
X	X	X	X	X	55	00110111	0x37

4 CV's 33-46: Output Locations⁵⁰

4.1 Overview

The NMRA standard currently provides for fourteen Function Inputs, which are transmitted to the locomotive decoder to control different Outputs. These fourteen Function Inputs are generally operated by thirteen⁵¹ Function Keys (FL, F1, F2, F3, F4, F5, F6, F7, F8, F9, F10, F11 and F12) on the command station or the hand held throttle. The FL⁵² Function Key can produce two different Function Inputs, called FL(r) and FL(f), depending on the direction of the locomotive.

The NMRA standard provides for fourteen Outputs, numbered from 1 to 14. CV's 33 through 46 specify which Function Input is connected to which Output.

Note: Q2 firmware built after 1-June-08 does not support CV's 33-46. The following fixed mapping is used:

- FL(f) -> Output 1
- FL(r) -> Output 2
- F1 -> Output 3
- ...
- F12 -> Output 14

The table below shows Output numbers across the top and Function Inputs along the side. The CV number associated with each Function Input is shown in the first column. Each of these CV's consists of an eight bit register with a "1" or "0" in each bit location, specifying which Outputs are controlled by that Function Input. The default value for each CV is shown.

CV #	Function Inputs	Output Numbers and Pre-assigned Features													
		Cab Lights	Alternate Horn Selection	Status Report	Heavy Load (Shut Down)	Mute	Squealing Brakes Air Brakes (Cylinder Cocks)	Doppler Shift	Dynamic Brakes	Blower Hiss/Fans	Coupler	Horn/Whistle	Bell	Directional Lighting	Directional Lighting
	Outputs	14	13	12	11	10	9	8	7	6	5	4	3	2	1
33	FL(f)							0	0	0	0	0	0	1	1
34	FL(r)							0	0	0	0	0	0	1	1
35	Function 1							0	0	0	0	0	1	0	0
36	Function 2							0	0	0	0	1	0	0	0
37	Function 3							0	0	0	1	0	0	0	0
38	Function 4				0	0	0	0	0	1	0	0			
39	Function 5				0	0	0	0	1	0	0	0			
40	Function 6				0	0	0	1	0	0	0	0			
41	Function 7				0	0	1	0	0	0	0	0			
42	Function 8				0	1	0	0	0	0	0	0			
43	Function 9	0	0	0	1	0	0	0	0						
44	Function 10	0	0	1	0	0	0	0	0						
45	Function 11	0	1	0	0	0	0	0	0						
46	Function 12	1	0	0	0	0	0	0	0						

⁵⁰ Q2 firmware built after 1-June-08 does not support CV's 33-46.

⁵¹ Some earlier command stations only support the original NMRA specification of 10 functions using 9 Function Keys.

⁵² For Command Stations that do not have an FL key, the F0 Function key usually controls this function.

A “1” with light gray background shows the Output default settings for Quantum decoders. For example, CV 36 has a “1” in the column for Output 4, indicating that Function 2 controls Output 4 which will operate the Whistle or Horn.

Each Input Function can control up to 8 Outputs. The white squares in the table show allowed possible assignments of Outputs for each Function. The dark gray areas indicate where Outputs cannot be assigned. For instance, the F4 key (Function Input 4) can control only Outputs 4-11. You can chose to have the F4 Key operate Output 10 or a combination of Outputs 11, 9, 7, and 6 all at once, but you cannot have it operate Output 12.

For many non-sound decoders, the Outputs are literally wires that are connected to different features such as Headlights and Reverse Lights, overhead blinking lights, smoke generators, and couplers. All the Outputs are “hardwired” to the features, meaning you cannot change which feature corresponds to an Output without rewiring the features.

For Sound Decoders like the first Quantum System, only some of the Outputs were “hardwired” to a particular feature. Many of the features require no external wires. Examples of these internal features are bells, whistles, air let-offs, blower hiss, and flange sounds.

On modern decoders, even those features that do require external wires, such as lights and smoke generators, are not necessarily “hardwired” to any particular Output. Outputs are now virtual and can be connected internally by firmware in the Quantum microprocessor to any physical driver, such as a power output for a lamp or a controller for a smoke generator. The connection between a virtual output and a physical feature is called a control port or simply “port”. For consistency with NMRA definitions, virtual outputs are called simply “outputs”.

A virtual output can be connected to more than one port. For example, the Multiple Automatic Lights #1 virtual output is by default connected to the Headlight, Reverse Light, and in some models a Mars Light.

Virtual outputs can be connected to different features depending on the directional state of the locomotive. For example, Output 8 is assigned to Doppler Shift in Forward and Reverse but is assigned to “Locomotive Start Up” in Neutral.

Both of these techniques increase the number of features that can be operated with a limited number of function keys.

The above table shows Common Default Quantum Features Assignments in the second row. Features assignments that operate only in Neutral are shown in parenthesis under the feature that operates in Forward and Reverse. If no Neutral feature is shown, the assigned feature shown will operate in all directional states.

Features are assigned to outputs in CV 53.

Advanced Sound Decoders like the Quantum Decoders allow great flexibility in choosing which function keys operate which features. However, this flexibility can get you into trouble if misused. For technical reasons too complicated to discuss here⁵³, we recommend you follow the two rules below to avoid having your decoder behave in a confusing manner.

1. In CV's 33-46, do not attempt to control the same Output with two or more function keys. This means, in the table above, only one row in each column should have a “1”. Yes, we violated this rule for Output 1 and Output 2, where we have both FL(f) and FL(r) operating the Directional Lighting System. This is an exception, which does work for Directional Lighting using FL(f) and FL(r). In general, it is not a good idea.
2. In CV 53, do not assign the same feature to two or more Outputs.

⁵³ See Appendix VI Interaction of Function Keys, Function Groups, Function Inputs and Outputs and Feature Assignments for additional technical explanation.

4.2 CV 33 Output Location for FL(f)⁵⁴

This CV specifies whether outputs 1 through 8 are controlled by FL(f).

A '1' in a bit location specifies the output is controlled by FL(f), while a '0' specifies the output is not controlled by FL(f).

Default Value: 00000011 = 3

CV 33: Output Location for FL(f) (with Factory Default Features)

Doppler (Start Up)	Dynamic Brakes	Blower-Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle	Bell	Directional Lighting ⁵⁵	Directional Lighting
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 8	Output 7	Output 6	Output 5	Output 4	Output 3	Output 2	Output 1

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Outputs 1 and 2 is the Directional Lighting System. Therefore, by default FL(f) controls the Directional Lighting System in Forward or Neutral from Forward.
- You can specify that FL(f) controls any of Outputs 2 through 8 in addition to or instead of Outputs 1 and 2.
- Assuming the default CV 53 settings (shown in the top row)⁵⁶, you can specify that FL(f) controls the following features.

Bit 0 Output 1: Directional Lighting

- "0" The Directional Lighting System is unaffected by FL(f).
- "1" The Directional Lighting System is affected by FL(f).

Bit 1 Output 2: Directional Lighting

- "0" The Directional Lighting System is unaffected by FL(f).
- "1" The Directional Lighting System is affected by FL(f).

Bit 2 Output 3; Bell

- "0" The Bell is unaffected by FL(f).
- "1" The Bell is affected by FL(f).

Bit 3 Output 4; Horn/Whistle

- "0" The Horn/Whistle is unaffected by FL(f).
- "1" Horn/Whistle is affected by FL(f).

⁵⁴ Write bit operation is supported for CV 33.

⁵⁵ The lights used in Directional Lighting are selected in Multiple Lights #1, which is the actual feature assigned to Outputs 1 and 2 (see CV55.136). Depending on your model, different lights may be selected for Multiple Lights #1.

⁵⁶ Features that are different in the Neutral state are shown in parentheses

Bit 4 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

“0” The Coupler Sounds are unaffected by FL(f).

“1” The Coupler Sounds are affected by FL(f).

Bit 5 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

“0” Blower-Hiss/Fans are unaffected by FL(f).

“1” Blower-Hiss/Fans are affected by FL(f).

Bit 6 Output 7: Dynamic Brakes

“0” Dynamic Brakes are unaffected by FL(f).

“1” Dynamic Brakes are affected by FL(f).

Bit 7 Output 8: Doppler, Start Up

“0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by FL(f).

“1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by FL(f).

4.3 CV 34 Output Location for FL(r)⁵⁷

This CV specifies whether outputs 1 through 8 are controlled by FL(r).

A '1' in a bit location specifies the output is controlled by FL(r), while a '0' specifies the output is not controlled by FL(r).

Default Value: 00000011 = 3

CV 34: Output Location for FL(r) (with Factory Default Features)

Doppler (Start Up)	Dynamic Brakes	Blower-Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle	Bell	Directional Lighting ⁵⁸	Directional Lighting
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 8	Output 7	Output 6	Output 5	Output 4	Output 3	Output 2	Output 1

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Outputs 1 and 2 is the Directional Lighting System. Therefore, by default FL(r) controls the Directional Lighting System in Reverse or Neutral from Reverse.
- You can specify that FL(r) control any of Outputs 3 through 8 in addition to or instead of Outputs 1 and 2.
- Assuming the default CV 53 settings (shown in the top row)⁵⁹, you can specify that FL(r) control the following features.

Bit 0 Output 1: Directional Lighting

- “0” The Directional Lighting System is unaffected by FL(r).
- “1” The Directional Lighting System is affected by FL(r).

Bit 1 Output 2: Directional Lighting

- “0” The Directional Lighting System is unaffected by FL(r).
- “1” The Directional Lighting System is affected by FL(r).

Bit 2 Output 3; Bell

- “0” The Bell is unaffected by FL(r).
- “1” The Bell is affected by FL(r).

Bit 3 Output 4; Horn/Whistle

- “0” The Horn/Whistle is unaffected by FL(r).
- “1” Horn/Whistle is affected by FL(r).

⁵⁷ Write bit operation is supported for CV 34.

⁵⁸ The lights used in Directional Lighting are selected in Multiple Lights #1, which is the actual feature assigned to Outputs 1 and 2 (see CV55.136). Depending on your model, different lights may be selected for Multiple Lights #1.

⁵⁹ Features that are different in the Neutral state are shown in parentheses

Bit 4 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

“0” The Coupler Sounds are unaffected by FL(r).

“1” The Coupler Sounds are affected by FL(r).

Bit 5 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

“0” Blower-Hiss/Fans are unaffected by FL(r).

“1” Blower-Hiss/Fans are affected by FL(r).

Bit 6 Output 7: Dynamic Brakes

“0” Dynamic Brakes are unaffected by FL(r).

“1” Dynamic Brakes are affected by FL(r).

Bit 7 Output 8: Doppler, Start Up

“0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by FL(r).

“1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by FL(r).

4.4 CV 35 Output Location for F1⁶⁰

This CV specifies whether outputs 1 through 8 are controlled by F1.

A '1' in a bit location specifies the output is controlled by F1, while a '0' specifies the output is not controlled by F1.

Default Value: 00000100 = 4

CV 35: Output for F1 (with Factory Default Features)

Doppler (Start Up)	Dynamic Brakes	Blower-Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle	Bell	Directional Lighting ⁶¹	Directional Lighting
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 8	Output 7	Output 6	Output 5	Output 4	Output 3	Output 2	Output 1

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 3 is the Bell. Therefore, by default F1 controls the Bell.
- You can specify that F1 control any of Outputs 1-2 and 4-8 in addition to or instead of Output 3.
- Assuming the default CV 53 settings (shown in the top row)⁶², you can specify that F1 control the following features.

Bit 0 Output 1: Directional Lighting

"0" The Directional Lighting System is unaffected by F1.
 "1" The Directional Lighting System is affected by F1.

Bit 1 Output 2: Directional Lighting

"0" The Directional Lighting System is unaffected by F1.
 "1" The Directional Lighting System is affected by F1.

Bit 2 Output 3; Bell

"0" The Bell is unaffected by F1.
 "1" The Bell is affected by F1.

Bit 3 Output 4; Horn/Whistle

"0" The Horn/Whistle is unaffected by F1.
 "1" Horn/Whistle is affected by F1.

⁶⁰ Write bit operation is supported for CV 35.

⁶¹ The lights used in Directional Lighting are selected in Multiple Lights #1, which is the actual feature assigned to Outputs 1 and 2 (see CV55.136). Depending on your model, different lights may be selected for Multiple Lights #1.

⁶² Features that are different in the Neutral state are shown in parentheses

- Bit 4** Output 5: Coupler Crash, Coupler Arm, Coupler Fire
“0” The Coupler Sounds are unaffected by F1.
“1” The Coupler Sounds are affected by F1.
- Bit 5** Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans
“0” Blower-Hiss/Fans are unaffected by F1.
“1” Blower-Hiss/Fans are affected by F1.
- Bit 6** Output 7: Dynamic Brakes
“0” Dynamic Brakes are unaffected by F1.
“1” Dynamic Brakes are affected by F1.
- Bit 7** Output 8: Doppler, Start Up
“0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F1.
“1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by F1.

4.5 CV 36 Output Location for F2⁶³

This CV specifies whether outputs 1 through 8 are controlled by F2.

A '1' in a bit location specifies the output is controlled by F2, while a '0' specifies the output is not controlled by F2.

Default Value: 00001000 = 8

CV 36: Output Location for F2 (with Factory Default Features)

Doppler (Start Up)	Dynamic Brakes	Blower-Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle	Bell	Directional Lighting ⁶⁴	Directional Lighting
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 8	Output 7	Output 6	Output 5	Output 4	Output 3	Output 2	Output 1

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 4 is the Whistle or Horn. Therefore, by default F2 controls the Whistle or Horn while locomotive is moving or stopped.
- You can specify that F1 control any of Outputs 1-3 and 5-8 in addition to or instead of Output 4.
- Assuming the default CV 53 settings (shown in the top row)⁶⁵, you can specify that F2 control the following features.

Bit 0 Output 1: Directional Lighting

- “0” The Directional Lighting System is unaffected by F2.
- “1” The Directional Lighting System is affected by F2.

Bit 1 Output 2: Directional Lighting

- “0” The Directional Lighting System is unaffected by F2.
- “1” The Directional Lighting System is affected by F2.

Bit 2 Output 3; Bell

- “0” The Bell is unaffected by F2.
- “1” The Bell is affected by F2.

Bit 3 Output 4; Horn/Whistle

- “0” The Horn/Whistle is unaffected by F2.
- “1” Horn/Whistle is affected by F2.

⁶³ Write bit operation is supported for CV 36.

⁶⁴ The lights used in Directional Lighting are selected in Multiple Lights #1, which is the actual feature assigned to Outputs 1 and 2 (see CV55.136). Depending on your model, different lights may be selected for Multiple Lights #1.

⁶⁵ Features that are different in the Neutral state are shown in parentheses

- Bit 4** Output 5: Coupler Crash, Coupler Arm, Coupler Fire
“0” The Coupler Sounds are unaffected by F2.
“1” The Coupler Sounds are affected by F2.
- Bit 5** Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans
“0” Blower-Hiss/Fans are unaffected by F2.
“1” Blower-Hiss/Fans are affected by F2.
- Bit 6** Output 7: Dynamic Brakes
“0” Dynamic Brakes are unaffected by F2.
“1” Dynamic Brakes are affected by F2.
- Bit 7** Output 8: Doppler, Start Up
“0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F2.
“1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by F2.

4.6 CV 37 Output Location for F3⁶⁶

This CV specifies whether outputs 1 through 8 are controlled by F3.

A '1' in a bit location specifies the output is controlled by F3, while a '0' specifies the output is not controlled by F3.

Default Value:

00010000 = 16

CV 37: Output Location for F3 (with Factory Default Features)

Doppler (Start Up)	Dynamic Brakes	Blower-Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle	Bell	Directional Lighting ⁶⁷	Directional Lighting
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 8	Output 7	Output 6	Output 5	Output 4	Output 3	Output 2	Output 1

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 5 is the Coupler Crash, Coupler Fire and Coupler Arm. Therefore, by default F3 controls the Coupler Sounds.
- You can specify that F3 control any of Outputs 1-4 and 6-8 in addition to or instead of Output 5.
- Assuming the default CV 53 settings (shown in the top row)⁶⁸, you can specify that F3 control the following features.

Bit 0 Output 1: Directional Lighting

- “0” The Directional Lighting System is unaffected by F3.
- “1” The Directional Lighting System is affected by F3.

Bit 1 Output 2: Directional Lighting

- “0” The Directional Lighting System is unaffected by F3.
- “1” The Directional Lighting System is affected by F3.

Bit 2 Output 3; Bell

- “0” The Bell is unaffected by F3.
- “1” The Bell is affected by F3.

Bit 3 Output 4; Horn/Whistle

- “0” The Horn/Whistle is unaffected by F3.
- “1” Horn/Whistle is affected by F3.

⁶⁶ Write bit operation is supported for CV 37.

⁶⁷ The lights used in Directional Lighting are selected in Multiple Lights #1, which is the actual feature assigned to Outputs 1 and 2 (see CV55.136). Depending on your model, different lights may be selected for Multiple Lights #1.

⁶⁸ Features that are different in the Neutral state are shown in parentheses

- Bit 4** Output 5: Coupler Crash, Coupler Arm, Coupler Fire
“0” The Coupler Sounds are unaffected by F3.
“1” The Coupler Sounds are affected by F3.
- Bit 5** Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans
“0” Blower-Hiss/Fans are unaffected by F3.
“1” Blower-Hiss/Fans are affected by F3.
- Bit 6** Output 7: Dynamic Brakes
“0” Dynamic Brakes are unaffected by F3.
“1” Dynamic Brakes are affected by F3.
- Bit 7** Output 8: Doppler, Start Up
“0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F3.
“1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by F3.

Example: Change F3 to Bell Operation (Output 3), and change F1 to Coupler Sounds (Output 5).
Output 3 is set to Bell by default. Output 5 is set to Coupler Sounds by default.
Set CV 37 (F3) to “4” (bit 2 = output 3 = Bell)
Set CV 35 (F1) to “16” (bit 4 = output 5 = Coupler Sounds)
After these changes, F3 will activate the bell, and F1 will activate Coupler Sounds.

4.7 CV 38 Output Location for F4⁶⁹

This CV specifies whether outputs 4 through 11 are controlled by F4.

A '1' in a bit location specifies the output is controlled by F4, while a '0' specifies the output is not controlled by F4.

Default Value:

0000100 = 4

CV 38: Output Location for F4 Register (with Factory Default Features)

Heavy Load (Disconnect- Standby-Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower- Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 11	Output 10	Output 9	Output 8	Output 7	Output 6	Output 5	Output 4

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 6 is Blower Hiss/Fans. Therefore, by default F4 controls the Blower Hiss/Fans Sound.
- You can specify that F4 control any of Outputs 4-5 and 7-11 in addition to or instead of Output 6.
- Assuming the default CV 53 settings (shown in the top row)⁷⁰, you can specify that F4 control the following features.

Bit 0 Output 4; Horn/Whistle

"0" The Horn/Whistle is unaffected by F4.
 "1" Horn/Whistle is affected by F4.

Bit 1 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

"0" The Coupler Sounds are unaffected by F4.
 "1" The Coupler Sounds are affected by F4.

Bit 2 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

"0" Blower-Hiss/Fans are unaffected by F4.
 "1" Blower-Hiss/Fans are affected by F4.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes are unaffected by F4.
 "1" Dynamic Brakes are affected by F4.

Bit 4 Output 8: Doppler, Start Up

"0" Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F4.
 "1" Doppler shift in Forward/Reverse and Start up in Neutral are affected by F4.

⁶⁹ Write bit operation is supported for CV 38.

⁷⁰ Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

- "0" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F4.
- "1" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F4.

Bit 6 Output 10: Audio Mute

- "0" Audio Mute is unaffected by F4.
- "1" Audio Mute is affected by F4.

Bit 7 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

- "0" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F4.
- "1" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F4.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

4.8 CV 39 Output Location for F5⁷¹

This CV specifies whether outputs 4 through 11 are controlled by F5.

A '1' in a bit location specifies the output is controlled by F5, while a '0' specifies the output is not controlled by F5.

Default Value:

00001000 = 8

CV 39: Output Location for F5 Register (with Factory Default Features)

Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower- Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 11	Output 10	Output 9	Output 8	Output 7	Output 6	Output 5	Output 4

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 7 is Dynamic Brakes. Therefore, by default F5 controls the Dynamic Brake Sounds.
- You can specify that F5 control any of Outputs 4-6 and 8-11 in addition to or instead of Output 7.
- Assuming the default CV 53 settings (shown in the top row)⁷², you can specify that F5 control the following features.

Bit 0 Output 4; Horn/Whistle

"0" The Horn/Whistle is unaffected by F5.
 "1" Horn/Whistle is affected by F5.

Bit 1 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

"0" The Coupler Sounds are unaffected by F5.
 "1" The Coupler Sounds are affected by F5.

Bit 2 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

"0" Blower-Hiss/Fans are unaffected by F5.
 "1" Blower-Hiss/Fans are affected by F5.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes are unaffected by F5.
 "1" Dynamic Brakes are affected by F5.

Bit 4 Output 8: Doppler, Start Up

"0" Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F5.
 "1" Doppler shift in Forward/Reverse and Start up in Neutral are affected by F5.

⁷¹ Write bit operation is supported for CV 39.

⁷² Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

- "0" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F5.
- "1" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F5.

Bit 6 Output 10: Audio Mute

- "0" Audio Mute is unaffected by F5.
- "1" Audio Mute is affected by F5.

Bit 7 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

- "0" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F5.
- "1" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F5.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

4.9 CV 40 Output Location for F6⁷³

This CV specifies whether outputs 4 through 11 are controlled by F6.

A '1' in a bit location specifies the output is controlled by F6, while a '0' specifies the output is not controlled by F6.

Default Value:

00010000 = 16

CV 40: F6 Output Location for F6 Register (with Factory Default Features)

Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower- Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 11	Output 10	Output 9	Output 8	Output 7	Output 6	Output 5	Output 4

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 8 are Doppler Shift for a moving locomotive and Locomotive Start Up in Neutral. Therefore, by default F6 controls Doppler Shift and Start Up.
- You can specify that F6 control any of Outputs 4-7 and 9-11 in addition to or instead of Output 8.
- Assuming the default CV 53 settings (shown in the top row)⁷⁴, you can specify that F6 control the following features.

Bit 0 Output 4; Horn/Whistle

"0" The Horn/Whistle is unaffected by F6.
 "1" Horn/Whistle is affected by F6.

Bit 1 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

"0" The Coupler Sounds are unaffected by F6.
 "1" The Coupler Sounds are affected by F6.

Bit 2 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

"0" Blower-Hiss/Fans are unaffected by F6.
 "1" Blower-Hiss/Fans are affected by F6.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes are unaffected by F6.
 "1" Dynamic Brakes are affected by F6.

Bit 4 Output 8: Doppler, Start Up

"0" Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F6.
 "1" Doppler shift in Forward/Reverse and Start up in Neutral are affected by F6.

⁷³ Write bit operation is supported for CV 40.

⁷⁴ Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off.

“0” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F6.

“1” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F6.

Bit 6 Output 10: Audio Mute

“0” Audio Mute is unaffected by F6.

“1” Audio Mute is affected by F6.

Bit 7 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

“0” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F6.

“1” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F6.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

4.10 CV 41 Output Location for F7⁷⁵

This CV specifies whether outputs 4 through 11 are controlled by F7.

A '1' in a bit location specifies the output is controlled by F7, while a '0' specifies the output is not controlled by F7.

Default Value:

00100000 = 32

CV 41: Output Location for F7 Register (with Factory Default Features)

Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower- Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 11	Output 10	Output 9	Output 8	Output 7	Output 6	Output 5	Output 4

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 9 are Squealing Brakes plus Air Brakes for a moving locomotive and Cylinder Cocks Arm or a Long Air Let-off for a Brake Set in Neutral. Therefore, by default F7 controls Squealing Brakes or Air Brakes for a moving locomotive and a Cylinder Cocks Arm or Brake Set Sound in Neutral.
- You can specify that F7 control any of Outputs 4-8 and 10-11 in addition to or instead of Output 9.
- Assuming the default CV 53 settings (shown in the top row)⁷⁶, you can specify that F7 control the following features.

Bit 0 Output 4; Horn/Whistle

"0" The Horn/Whistle is unaffected by F7.
 "1" Horn/Whistle is affected by F7.

Bit 1 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

"0" The Coupler Sounds are unaffected by F7.
 "1" The Coupler Sounds are affected by F7.

Bit 2 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

"0" Blower-Hiss/Fans are unaffected by F7.
 "1" Blower-Hiss/Fans are affected by F7.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes are unaffected by F7.
 "1" Dynamic Brakes are affected by F7.

Bit 4 Output 8: Doppler, Start Up

"0" Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F7.
 "1" Doppler shift in Forward/Reverse and Start up in Neutral are affected by F7.

⁷⁵ Write bit operation is supported for CV 41.

⁷⁶ Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

- "0" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F7.
- "1" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F7.

Bit 6 Output 10: Audio Mute or

- "0" Audio Mute is unaffected by F7.
- "1" Audio Mute is affected by F7.

Bit 7 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

- "0" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F7.
- "1" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F7.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

4.11 CV 42 Output Location for F8⁷⁷

This CV specifies whether outputs 4 through 11 are controlled by F8.

A '1' in a bit location specifies the output is controlled by F8, while a '0' specifies the output is not controlled by F8.

Default Value: 01000000 = 64

CV 42: Output Location for F8 Register (with Factory Default Features)

Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes	Blower- Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Horn/Whistle
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 11	Output 10	Output 9	Output 8	Output 7	Output 6	Output 5	Output 4

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 10 is Audio Mute. Therefore, by default F8 controls Audio Mute.
- You can specify that F8 control any of Outputs 4-9 and 11 in addition to or instead of Output 10.
- Assuming the default CV 53 settings (shown in the top row)⁷⁸, you can specify that F8 control the following features.

Bit 0 Output 4; Horn/Whistle

"0" The Horn/Whistle is unaffected by F8.
 "1" Horn/Whistle is affected by F8.

Bit 1 Output 5: Coupler Crash, Coupler Arm, Coupler Fire

"0" The Coupler Sounds are unaffected by F8.
 "1" The Coupler Sounds are affected by F8.

Bit 2 Output 6: Steam Locomotive Blower Hiss or Diesel or Electric Loco Vents and Fans

"0" Blower-Hiss/Fans are unaffected by F8.
 "1" Blower-Hiss/Fans are affected by F8.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes are unaffected by F8.
 "1" Dynamic Brakes are affected by F8.

Bit 4 Output 8: Doppler, Start Up

"0" Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F8.
 "1" Doppler shift in Forward/Reverse and Start up in Neutral are affected by F8.

⁷⁷ Write bit operation is supported for CV 42.

⁷⁸ Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

- "0" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F8.
- "1" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F8.

Bit 6 Output 10: Audio Mute

- "0" Audio Mute is unaffected by F8.
- "1" Audio Mute is affected by F8.

Bit 7 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

- "0" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F8.
- "1" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F8.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

4.12 CV 43 Output Location for F9⁷⁹

This CV specifies whether outputs 7 through 14 are controlled by F9.

A '1' in a bit location specifies the output is controlled by F9, while a '0' specifies the output is not controlled by F9.

Default Value:

00010000 = 16

CV 43: Output Location for F9 Register (with Factory Default Features)

Cab Lights ⁸⁰	Alternate Horn Selection ⁸¹ / Number Board Lights ⁸²	SMPH Report (Status Report)	Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 14	Output 13	Output 12	Output 11	Output 10	Output 9	Output 8	Output 7

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 11 are Heavy Load for a moving locomotive and Disconnect-Standby-Shut Down for a locomotive in Neutral. Therefore, by default F9 controls Heavy Load and Disconnect-Standby-Shut Down.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

- You can specify that F9 control any of Outputs 7-10 and 12-14 in addition to or instead of Output 11.
- Assuming the default CV 53 settings (shown in the top row)⁸³, you can specify that F9 control the following features.

Bit 0 Output 7: Dynamic Brakes

"0" Dynamic Brakes are unaffected by F9.
 "1" Dynamic Brakes are affected by F9.

Bit 1 Output 8: Doppler, Start Up

"0" Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F9.
 "1" Doppler shift in Forward/Reverse and Start up in Neutral are affected by F9.

Bit 2 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

"0" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F9.
 "1" Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F9.

⁷⁹ Write bit operation is supported for CV 43.

⁸⁰ Cab Lights are usually selected by default in Multiple Lights #3, which is the actual feature assigned to Output 14 (see CV 55.138). Depending on your model, different lights may be selected for Multiple Lights #3.

⁸¹ Alternate Horn is available only on selected models. Consult your Model's Operation Manual feature list.

⁸² Number Board Lights are usually selected by default in Multiple Lights #2, which is the actual feature assigned to Output 13 (see CV 55.137). Depending on your model, different lights may be selected for Multiple Lights #2.

⁸³ Features that are different in the Neutral state are shown in parentheses

Bit 3 Output 10: Audio Mute

“0” Audio Mute is unaffected by F9.

“1” Audio Mute is affected by F9.

Bit 4 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

“0” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F9.

“1” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F9.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

Bit 5 Output 12: Speed Report, Status Report

“0” Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F9.

“1” Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F9.

Bit 6 Output 13: Number Board Lights

“0” Alternate Horn Selection or Number Board Lights are unaffected by F9.

“1” Alternate Horn Selection or Number Board Lights are affected by F9.

Bit 7 Output 14: Cab Lights

“0” Cab Lights are unaffected by F9.

“1” Cab Lights are affected by F9.

4.13 CV 44 Output Location for F10⁸⁴

This CV specifies whether outputs 7 through 14 are controlled by F10.

A '1' in a bit location specifies the output is controlled by F10, while a '0' specifies the output is not controlled by F10.

Default Value:

00100000 = 32

CV 44: Output Location for F10 Register (with Factory Default Features)

Cab Lights ⁸⁵	Alternate Horn Selection ⁸⁶ / Number Board Lights ⁸⁷	Speed Report (Status Report)	Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes – Air Brakes (Brake Set)	Doppler (Start Up)	Dynamic Brakes
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 14	Output 13	Output 12	Output 11	Output 10	Output 9	Output 8	Output 7

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 12 is a Scale Miles Per Hour (smph) or Scale Kilometers Per Hour (skph)⁸⁸ Speed Report in Forward/Reverse or Status Report in Neutral. Therefore F10 controls SMPH and Status Report.
- You can specify that F10 control any of Outputs 7-11 and 13-14 in addition to or instead of Output 12.
- Assuming the default CV 53 settings (shown in the top row)⁸⁹, you can specify that F10 control the following features.

Bit 0 Output 7: Dynamic Brakes

- “0” Dynamic Brakes are unaffected by F10.
- “1” Dynamic Brakes are affected by F10.

Bit 1 Output 8: Doppler, Start Up

- “0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F10.
- “1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by F10.

⁸⁴ Write bit operation is supported for CV 44.

⁸⁵ Cab Lights are usually selected by default in Multiple Lights #3, which is the actual feature assigned to Output 14 (see CV 55.138). Depending on your model, different lights may be selected for Multiple Lights #3.

⁸⁶ Alternate Horn is available only on selected models. Consult your Model's Operation Manual feature list.

⁸⁷ Number Board Lights are usually selected by default in Multiple Lights #2, which is the actual feature assigned to Output 13 (see CV 55.137). Depending on your model, different lights may be selected for Multiple Lights #2.

⁸⁸ Scale Miles Per Hour or Scale Kilometers Per Hour can be selected in CV 56.0.

⁸⁹ Features that are different in the Neutral state are shown in parentheses

- Bit 2** Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off
- “0” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F10.
- “1” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F10.
- Bit 3** Output 10: Audio Mute
- “0” Audio Mute is unaffected by F10.
- “1” Audio Mute is affected by F10.
- Bit 4** Output 11: Heavy Load, Disconnect-Standby-Total Shut Down
- “0” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F10.
- “1” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F10.
- Note:** Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.
- Bit 5** Output 12: Speed Report, Status Report
- “0” Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F10.
- “1” Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F10.
- Bit 6** Output 13: Number Board Lights
- “0” Alternate Horn Selection or Number Board Lights are unaffected by F10.
- “1” Alternate Horn Selection or Number Board Lights are affected by F10.
- Bit 7** Output 14: Cab Lights
- “0” Cab Lights are unaffected by F10.
- “1” Cab Lights are affected by F10.

4.14 CV 45 Output Location for F11⁹⁰

This CV specifies whether outputs 7 through 14 are controlled by F11.

A '1' in a bit location specifies the output is controlled by F11, while a '0' specifies the output is not controlled by F11.

Default Value: 01000000 = 64

CV 45: Output Location for F11 Register (with Factory Default Features)

Cab Lights ⁹¹	Alternate Horn Selection ⁹² / Number Board Lights ⁹³	SMPH Report (Status Report)	Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes/Flanges /Air Brakes (Cylinder Cocks/ Long Air Let-Off)	Doppler (Start Up)	Dynamic Brakes
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 14	Output 13	Output 12	Output 11	Output 10	Output 9	Output 8	Output 7

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 13 is Number Board Lights. Therefore F11 controls Number Board Lights.
- You can specify that F11 control any of Outputs 7-12 and 14 in addition to or instead of Output 13.
- Assuming the default CV 53 settings (shown in the top row)⁹⁴, you can specify that F11 control the following features.

Bit 0 Output 7: Dynamic Brakes

- “0” Dynamic Brakes are unaffected by F11.
- “1” Dynamic Brakes are affected by F11.

Bit 1 Output 8: Doppler, Start Up

- “0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F11.
- “1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by F11.

Bit 2 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

- “0” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F11.
- “1” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F11.

⁹⁰ Write bit operation is supported for CV 45.

⁹¹ Cab Lights are usually selected by default in Multiple Lights #3, which is the actual feature assigned to Output 14 (see CV 55.138). Depending on your model, different lights may be selected for Multiple Lights #3.

⁹² Alternate Horn is available only on selected models. Consult your Model's Operation Manual feature list.

⁹³ Number Board Lights are usually selected by default in Multiple Lights #2, which is the actual feature assigned to Output 13 (see CV 55.137). Depending on your model, different lights may be selected for Multiple Lights #2.

⁹⁴ Features that are different in the Neutral state are shown in parentheses

Bit 3 Output 10: Audio Mute.

- "0" Audio Mute is unaffected by F11.
- "1" Audio Mute is affected by F11.

Bit 4 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

- "0" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F11.
- "1" Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F11.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

Bit 5 Output 12: Speed Report, Status Report

- "0" Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F11.
- "1" Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F11.

Bit 6 Output 13: Number Board Lights

- "0" Alternate Horn Selection or Number Board Lights are unaffected by F11.
- "1" Alternate Horn Selection or Number Board Lights are affected by F11.

Bit 7 Output 14: Cab Lights

- "0" Cab Lights are unaffected by F11.
- "1" Cab Lights are affected by F11.

4.15 CV 46 Output Location for F12⁹⁵

This CV specifies whether outputs 7 through 14 are controlled by F12.

A '1' in a bit location specifies the output is controlled by F12, while a '0' specifies the output is not controlled by F12.

Default Value:

10000000 = 128

CV 46: Output Location for F12 Register (with Factory Default Features)

Cab Lights ⁹⁶	Alternate Horn Selection ⁹⁷ / Number Board Lights ⁹⁸	SMPH Report (Status Report)	Heavy Load (Disconnect- Standby-Total Shut Down)	Mute	Squealing Brakes – Air Brakes (Brake Set)	Doppler (Start Up)	Dynamic Brakes
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Output 14	Output 13	Output 12	Output 11	Output 10	Output 9	Output 8	Output 7

- QSI has pre-assigned default features to each output but any feature can be assigned to any output in CV 53. In CV 53, the default setting for Output 14 is Cab Lights. Therefore F12 controls Cab Lights.
- You can specify that F12 control any of Outputs 7-13 in addition to or instead of Output 14.
- Assuming the default CV 53 settings (shown in the top row)⁹⁹, you can specify that F12 control the following features.

Bit 0 Output 7: Dynamic Brakes

- “0” Dynamic Brakes are unaffected by F12.
- “1” Dynamic Brakes are affected by F12.

Bit 1 Output 8: Doppler, Start Up

- “0” Doppler shift in Forward/Reverse and Start up in Neutral are unaffected by F12.
- “1” Doppler shift in Forward/Reverse and Start up in Neutral are affected by F12.

Bit 2 Output 9: Squealing Brakes and Air Brakes, Cylinder Cocks Arm or Long Air Let-off

- “0” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are unaffected by F12.
- “1” Squealing Brakes, Air Brakes in Forward/Reverse and Cylinder Cocks Arm, Long Air Let-off are affected by F12.

⁹⁵ Write bit operation is supported for CV 46.

⁹⁶ Cab Lights are usually selected by default in Multiple Lights #3, which is the actual feature assigned to Output 14 (see CV 55.138). Depending on your model, different lights may be selected for Multiple Lights #3.

⁹⁷ Alternate Horn is available only on selected models. Consult your Model's Operation Manual feature list.

⁹⁸ Number Board Lights are usually selected by default in Multiple Lights #2, which is the actual feature assigned to Output 13 (see CV 55.137). Depending on your model, different lights may be selected for Multiple Lights #2.

⁹⁹ Features that are different in the Neutral state are shown in parentheses

Bit 3 Output 10: Audio Mute

“0” Audio Mute is unaffected by F12.
“1” Audio Mute is affected by F12.

Bit 4 Output 11: Heavy Load, Disconnect-Standby-Total Shut Down

“0” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are unaffected by F12.
“1” Heavy Load in Forward/Reverse and Disconnect-Standby-Total Shut Down in Neutral are affected by F12.

Note: Heavy Load has replaced the Cruise Control feature that was available on Lionel HO and early BLI locomotives.

Bit 5 Output 12: Speed Report, Status Report

“0” Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F12.
“1” Speed Report in Forward/Reverse and Status Report in Neutral are unaffected by F12.

Bit 6 Output 13: Number Board Lights

“0” Horn Selection or Number Board Lights are unaffected by F12.
“1” Horn Selection or Number Board Lights are affected by F12.

Bit 7 Output 14: Cab Lights

“0” Cab Lights are unaffected by F12.
“1” Cab Lights are affected by F12.

5 CV's 49-64: QSI Unique CV's

5.1 Overview

Many of the available CV's have been reserved by the NMRA to provide standardized and compatible operation by all manufacturers with each other's products.

These standard CV's relate to operations that are common to all DCC products such as ID numbers, speed steps, and acceleration and deceleration rates.

Many model railroad products today, and a much larger number in the future, require manufacturer unique CV's to configure their product's special features. The command structure and protocols for changing and retrieving manufacturer unique CV values are standardized through the NMRA, but the individual manufacturers specify the meaning of the CV values.

The NMRA has provided a number of CV's for manufacturers to use in configuring their own products: CV's 49 through 64, and CV's 112-128.

Instead of filling up the available manufacturer unique CV's in a linear or chronological order, QSI uses an indexing system that organizes these CV's in a meaningful way.

Two of the available manufacturer unique CV's are used as indices to expand some of the remaining CV's into 256 register one-dimensional tables, or into 256x256 register two-dimensional tables.

CV 49 is the Primary Index (PI), and is used for accessing up to 256 registers of a one-dimensional table.

Primary Index CV 49	
0	CV X Register 0
1	CV X Register 1
2	CV X Register 2
3	CV X Register 3
:	CV X Register n
:	
255	CV X Register 255

CV 52 is an example of one of the CV's implemented as a one-dimensional table.

CV 50 is the Secondary Index (SI), and is used together with the Primary Index for accessing up to 256x256 registers of a two-dimensional table.

Primary Index CV 49	Secondary Index CV 50					
	0	1	2	3	255
0	CV X Register 0,0	CV X Register 0,1	CV X Register 0,2	CV X Register 0,3	CV X Register 0,m	CV X Register 0,255
1	CV X Register 1,0	CV X Register 1,1	CV X Register 1,2	CV X Register 1,3	CV X Register 1,m	CV X Register 1,255
2	CV X Register 2,0	CV X Register 2,1	CV X Register 2,2	CV X Register 2,3	CV X Register 2,m	CV X Register 2,255
3	CV X Register 3,0	CV X Register 3,1	CV X Register 3,2	CV X Register 3,3	CV X Register 3,m	CV X Register 3,255

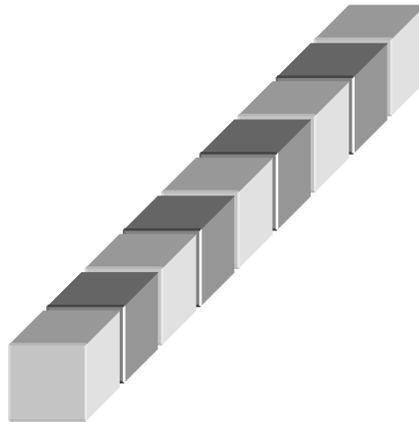
:	CV X Register n,0	CV X Register n,1	CV X Register n,2	CV X Register n,3	CV X Register n,m	CV X Register n,255
255	CV X Register 255,0	CV X Register 255,1	CV X Register 255,2	CV X Register 255,3	CV X Register 255,m	CV X Register 255,255

CV 53 is an example of one of the CV's implemented as a two-dimensional table.

5.1.1 Warehouse Analogy

Here is a way of looking at CV's, which may make the concept of indexed CV's easier to understand.

Imagine CV1 through CV106 as 106 storage boxes arranged one behind the other.

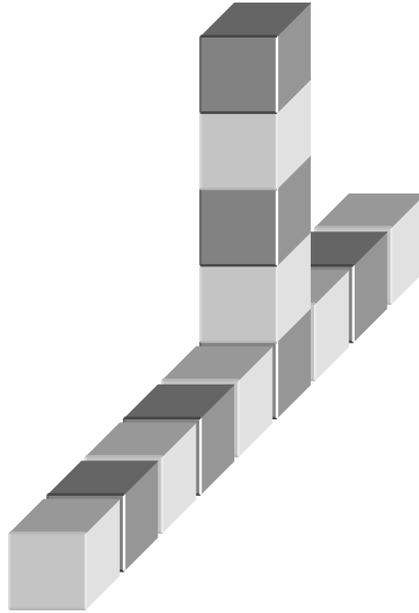


Most of these boxes contain a single number, which is the value of the corresponding CV. If you look inside the 1st box you will see the value of CV1, in the 2nd box the value of CV2, etc. If you walk back to the 29th box, inside you will see the value of CV29. Some of the boxes may be empty. That is because the use of that CV, such as CV47, has not yet been defined or because that CV is not supported.

In this analogy, the statement "Set CV 29 to 6" translates to "Walk back to box 29 and put the number '6' in that box".

The statement "Read CV 65" translates to "Walk back to box 65 and read the number in that box".

If you walk back to the 52nd box, corresponding to QSI's CV52, instead of a single box with a single number, you will see 256 boxes stacked in a column.

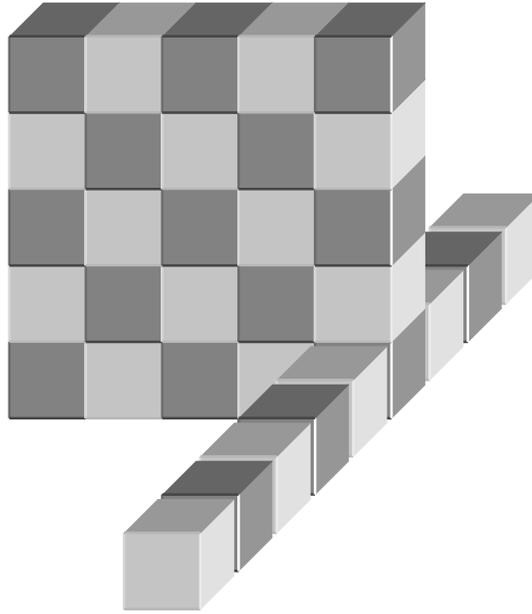


To keep track of these 256 boxes, each is assigned a row index. The 1st box has row index 0, the 2nd box row index 1, and the last box row index 255. We use the shorthand notation CV52.0 to refer to the first box, CV52.1 to refer to the 2nd box, and CV52.255 to refer to the last box. Each of these 256 boxes can contain a single number. If you look in the 1st box, you will see the value of CV52.0. If you look in the 2nd box, you will see the value of CV52.1. Some of these boxes may be empty. That is because the use of that CV has not yet been defined or the CV is not supported.

The statement "Set CV 52.5 to 12" translates to "Walk back to the column of boxes at box 52, climb up to row 6, and put the number '12' in that box".

The statement "Read CV 52.11" translates to "Walk back to the column of boxes at box 52, climb up to row 12, and read the number in that box".

If you walk back to the 53rd box, corresponding to QSI's CV53, you will see a wall of boxes arranged in columns and rows with 256 boxes in each row and 256 boxes in each column.



To keep track of these 256x256 boxes, each is assigned two indices, a row index and a column index. The box in the 1st row 1st column has row index 0 column index 0, the box in the 1st row 2nd column has row index 0 column index 1, etc. The box in the 6th row and 2nd column has row index 5 and column index 1. We use the shorthand notation CV53.0.0 to refer to the box in row 0 column 0, CV53.0.1 to refer to the box in row 0 column 1, etc. CV56.5.1 refers to the box in row 5 column 1. Each of these 256x256 boxes can contain a single number. If you look in the box in row 0 column 0, you will see the value of CV53.0.0. If you look in the box in row 5 column 1 you will see the value of CV53.5.1. Some of these boxes may be empty. That is because the use of that CV has not yet been defined or the CV is not supported.

The statement "Set CV 53.7.0 to 114" translates to "Walk back to the wall of boxes at box 53, climb up to the 8th row of boxes, and put the number '114' in the 1st column box".

The statement "Read CV 53.3.1" translates to "Walk back to the wall of boxes at box 53, climb up to the 4th row of boxes, move over to the 2nd column, and read the number in that box".

Now instead of us walking and climbing over the boxes, imagine we build a simple robot to carry out these tasks.

When we want the robot to execute the instruction "Set CV 29 to 6", we enter "29" into the robot's CV register, "6" into its Data register, and press its "Write" button. The robot then trundles down the boxes until it reaches the 29th box, and in that box deposits the number in its Data register.

When we want the robot to execute the instruction "Read CV 65", we enter "65" into the robot's CV register, and press its "Read" button. The robot moves down the boxes until it reaches the 65th box, and retrieves the number from that box into its Data register. The robot comes back to us, and we read the number showing in its Data register.

To have the robot execute the instruction "Set CV 52.5 to 12", we enter "52" into the robot's CV register, "5" into its Primary Index register, "12" into its Data register, and press the "Write" button. The robot moves to the column of boxes at CV52, rises to the 6th row, and there deposits the number in its Data register.

To have the robot execute the instruction "Read CV 53.3.1", we enter "53" into the robot's CV register, "3" into its Primary Index register, "1" into its Secondary Index register, and press the "Read" button. The robot moves to the wall of boxes at CV53, rises to the 4th row, moves over to the 2nd column, and retrieves the number from that box into its Data register. The robot comes back to us, and we read the number displayed in its Data register.

5.2 CV 49 QSI Primary Index

Use CV 49 to specify the Primary Index for a CV that is implemented as a one-dimensional or two-dimensional array.

Default Value:

0

CV 49: Primary Index Register (PI)

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
P7	P6	P5	P4	P3	P2	P1	P0

- CV 49 is used as an index into a table of up to 256 related values.

Primary Index	Table of Values
0	Value[0]
1	Value[1]
2	Value[2]
3	Value[3]
...	...

- For example, CV 49 is used as an index for CV 52, which contains the volume, levels for up to 256 Individual Sounds.

Primary Index	Table of Volume Levels
0	Volume Level for Sound[0]
1	Volume Level for Sound[1]
2	Volume Level for Sound[2]
3	Volume Level for Sound[3]
...	...

- In this document the terms CV 49 and Primary Index mean the same thing. PI is the abbreviation for Primary Index.
- We use a shorthand notation to simplify description of a CV that is composed of a one-dimensional table of values. The elements of the table are referred to as CV NN.PI, where NN is the CV number, and PI is the Primary Index. For example, Individual Sound Volume 5 is written CV 52.5. During verbal acknowledgement or during CV Numeric Verbal Readout (CV 64) from the locomotive, it is spoken out as “CV five two point five”.

5.3 CV 50 QSI Secondary Index

Use CV 50 to specify the Secondary Index for a CV that is implemented as a two-dimensional array.

Default Value: 0

CV 50: Secondary Index Register (SI)

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
S7	S6	S5	S4	S3	S2	S1	S0

- CV 50 is used along with CV 49 as an index into a two-dimensional table of up to 256x256 related values. CV 49 is the row index and CV 50 is the column index.

Primary Index	Secondary Index				...
	0	1	2	3	
0	Value[0,0]	Value[0,1]	Value[0,2]	Value[0,3]	...
1	Value[1,0]	Value[1,1]	Value[1,2]	Value[1,3]	...
2	Value[2,0]	Value[2,1]	Value[2,2]	Value[2,3]	...
3	Value[3,0]	Value[3,1]	Value[3,2]	Value[3,3]	...
...

- For example, CV 53 uses CV 49 as a row index (1...14) and CV 50 as a column index (0...1) to assign different QSI Features to each of fourteen outputs for two states: Forward/Reverse, and NFF/NFR.

Primary Index	Secondary Index	
	0	1
1	Feature Assigned to Output 1 in FWD/REV	Feature Assigned to Output 1 in NFF/NFR
2	Feature Assigned to Output 2 in FWD/REV	Feature Assigned to Output 2 in NFF/NFR
3	Feature Assigned to Output 3 in FWD/REV	Feature Assigned to Output 3 in NFF/NFR
...
14	Feature Assigned to Output 14 in FWD/REV	Feature Assigned to Output 14 in NFF/NFR

- In this document the terms CV 50 and Secondary Index mean the same thing. SI is the abbreviation for Secondary Index.
- We use a shorthand notation to simplify description of a CV that is composed of a two-dimensional table of values. The elements of the table are referred to as CV NN.PI.SI, where NN is the CV number, PI is the Primary Index, and SI is the Secondary Index. For example, the CV for output 4 in neutral is written CV 53.4.1. During verbal acknowledgement or during CV Numeric Verbal Readout (CV 64) from the locomotive, it is spoken out as “CV five three point four point one”.

5.4 CV 51.PI QSI System Sound Control

Use CV 51 to control your Quantum locomotive's System Volume, Mute Volume and Special Sound Effects CV51 is implemented as a one-dimensional array, with CV 49 used as an index to these CV 51 registers.

5.4.1 CV 51.0 Operations Mode System Volume (PI = 0)

Use CV 51.0 to change the System Volume.

Default Value:

127

CV 51.0: Ops Mode System Volume Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	V6	V5	V4	V3	V2	V1	V0

- Set CV 49 to "0" to specify the Primary Index for **Operations Mode System Volume**.
- The System Volume can be set to any value between 0 (no sound) and 127 (100%). The upper bit is reserved and should be 0. The default Operations Mode Volume is 127 (**100%**). A "0" in this CV will reduce all sound effects to zero volume.
- The Operations Mode System Volume is the overall sound volume when the locomotive is in normal operation on the main (Operations Mode). When you change the Operations Mode System Volume on the main, you will immediately hear the change in volume.
- All sound is turned off in Service Mode because of the limited power usually available for the programming track. You can program the System Volume in Service Mode, but you won't hear the change in volume until you enter Operations Mode.
- In addition to explicitly writing a value to CV51.0, the system volume can be adjusted manually using a magnetic wand or potentiometer (see Appendix IV), or by pressing a function key assigned to System Volume Increase or System Volume Decrease (see CV53).

Note: The system volume in this CV is the same system volume used during conventional Analog operation. Changing this CV changes the system volume in Analog DC, and changing the system volume in Analog DC changes the value of this CV.

Example: Set the Operations Mode System volume to 64 (50% of max).

1. Set CV 49 to 0.
2. Set CV 51 to 64.

5.4.2 CV 51.1 Operations Mode Mute Volume (PI = 1)

Use CV 51.0 to change the Mute Volume. Mute is one of the Quantum features that can be turned on and off by a Function Key. When Mute is “On”, the overall volume reduces to the volume set by CV 51.1.

Default Value:

0

CV 51.1: Ops Mode Mute Volume Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	V5	V4	V3	V2	V1	V0

- Set CV 49 to “1” to specify the Primary Index for **Operations Mode Mute Volume**.
- The Mute Volume can be set to any value between 0 (no sound) and 63 (50%). If the Mute Volume is set over 50% of the System Volume set in CV 51.0, the applied Mute Volume will be 50% of the System Volume setting. The upper bit is reserved and should be 0. A “0” in this CV will mute all sound effects to zero volume.
- The default Mute Volume is 0 (**0%**).
- The Mute Volume applies when the locomotive is in normal operation on the main (Operations Mode). When you change the Mute Volume on the main and “Mute” has been turned “On” by its assigned Function Key, you will immediately hear the change in volume.
- If you program the Mute Volume in Service Mode, you won’t hear the change in Mute volume until you enter Operations Mode and activate the Mute feature.

Example: Set the Operations Mode Mute Volume to 32 (25% of max).

- 1) Set CV 49 to 1.
- 2) Set CV 51 to 32.

5.4.3 CV 51.2 Special Sound Effects Enable¹⁰⁰ (PI = 2)

Use CV 51.2 to enable/disable special sound effects.

Default Value:

Depends on Locomotive

CV 51.2: Special Sound Effects Enable Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved for future use	Bell Actuator Sound	Cylinder Cocks Armed after 25 seconds in NFF/NFR	Cylinder Cocks Armed on Startup	Heavy Load On/Off Feedback	Alternate Horn Selection Feedback	Coded Horn for Gas Turbine Start Up	Horn Triggered Doppler + Horn Fancy Ending

- Write 2 to CV 49 to specify the Primary Index for **Special Sound Effects Enable**.
- Set data in Bit 0 as follows:

“0” = Horn triggered Doppler and Horn Fancy Ending effects are disabled¹⁰¹.

“1” = Horn triggered Doppler and Horn Fancy Ending effects are enabled. (Default)

If Horn Triggered Doppler is enabled, you can obtain a Doppler effect by first blowing the Horn for a least one second. Any time thereafter, briefly interrupt the horn signal by releasing the horn button and reapplying to produce the Doppler Effect.

Some models have an alternate fancy horn ending. You can play the fancy ending by tapping the horn button at the end of the horn blast.

- Set data in Bit 1 as follows:

“0” = Coded Horn triggered Gas Turbine Start Up is disabled.

“1” = Coded Horn triggered Gas Turbine Start Up is enabled. (Default)

If Coded Horn triggered Gas Turbine Start Up is enabled, then 4 short horn blasts in neutral will cause the Gas Turbine decoder to transition from Diesel to Turbine operation or from Turbine to Diesel operation.

- Set data in Bit 2 as follows:

“0” = Alternate Horn Selection Feedback is disabled.

“1” = Alternate Horn Selection Feedback is enabled. (Default)

If Alternate Horn Selection Feedback is enabled, then the newly selected Horn sounds a short hoot when it is selected. Only certain models have an Alternate Horn.

- Set data in Bit 3 as follows:

“0” = Heavy Load On/Off Feedback is disabled.

“1” = Heavy Load On/Off Feedback is enabled. (Default)

If Heavy Load On/Off Feedback is enabled, a single horn hoot is played when Heavy Load is turned on. When Heavy Load is turned off, two horn hoots are played.

- Set data in Bit 4 as follows:

“0” = Cylinder Cocks are not automatically armed as a result of a Startup (F6) operation.

“1” = Cylinder Cocks are automatically armed as a result of a Startup (F6) operation. (Default)

If this bit is “1” and a Startup (F6) operation occurs, Cylinder Cocks sounds play when the locomotive starts moving in FWD/REV. The Cylinder Cocks sounds automatically terminate after 16 repetitions or when the locomotive reaches a speed greater than 12 smph.

¹⁰⁰ Write bit operation is supported for Special Sound Effects Enable.

¹⁰¹ Setting bit 0 to “0” does not disable fancy endings specified in CV55.154.SI for the Grade Crossing Horn Signal.

- Set data in Bit 5 as follows:
 - “0” = Cylinder Cocks are not automatically armed after 25 seconds in NFF/NFR.
 - “1” = Cylinder Cocks are automatically armed after 25 seconds in NFF/NFR. (Default)

If this bit is “1” and the locomotive remains in neutral for at least 25 seconds, Cylinder Cocks sounds play when the locomotive starts moving in FWD/REV. The Cylinder Cocks sounds automatically terminate after 16 repetitions or when the locomotive reaches a speed greater than 12 smph.
- Set data in Bit 6 as follows:
 - “0” = The bell actuator sound does not play.
 - “1” = The bell actuator sound plays when the bell is turned on and the diesel locomotive is in NFF/NFR. (Default)
- All other bits are reserved. Any data entered in these bits is ignored.

Example: Set Special Sound Effects according to Feature Table below.
Set CV 49 to 2.
Set CV 51 to value indicated for the combination of features you want.

Cylinder Cocks Armed after 25 seconds in NFF/NFR	Cylinder Cocks Armed on Startup	Heavy Load On/Off Feedback	Std/Alt Horn Select Feedback	Coded Horn for Gas Turbine Start Up	Horn Triggered Doppler	Decimal Value	Binary Value	Hex Value
						0	00000000	00
					X	1	00000001	01
				X		2	00000010	02
				X	X	3	00000011	03
			X			4	00000100	04
			X		X	5	00000101	05
			X	X		6	00000110	06
			X	X	X	7	00000111	07
		X				8	00001000	08
		X			X	9	00001001	09
		X		X		10	00001010	0A
		X		X	X	11	00001011	0B
		X	X			12	00001100	0C
		X	X		X	13	00001101	0D
		X	X	X		14	00001110	0E
		X	X	X	X	15	00001111	0F
	X					16	00010000	10
	X				X	17	00010001	11
	X			X		18	00010010	12
	X			X	X	19	00010011	13
	X		X			20	00010100	14
	X		X		X	21	00010101	15
	X		X	X		22	00010110	16
	X		X	X	X	23	00010111	17
	X	X				24	00011000	18
	X	X			X	25	00011001	19
	X	X		X		26	00011010	1A
	X	X		X	X	27	00011011	1B
	X	X	X			28	00011100	1C
	X	X	X		X	29	00011101	1D
	X	X	X	X		30	00011110	1E
	X	X	X	X	X	31	00011111	1F
X						32	00100000	20
X					X	33	00100001	21
X				X		34	00100010	22
X				X	X	35	00100011	23
X			X			36	00100100	24
X			X		X	37	00100101	25
X			X	X		38	00100110	26
X			X	X	X	39	00100111	27
X		X				40	00101000	28
X		X			X	41	00101001	29
X		X		X		42	00101010	2A
X		X		X	X	43	00101011	2B
X		X	X			44	00101100	2C
X		X	X		X	45	00101101	2D
X		X	X	X		46	00101110	2E
X		X	X	X	X	47	00101111	2F
X	X					48	00110000	30
X	X				X	49	00110001	31
X	X			X		50	00110010	32
X	X			X	X	51	00110011	33
X	X		X			52	00110100	34
X	X		X		X	53	00110101	35
X	X		X	X		54	00110110	36
X	X		X	X	X	55	00110111	37
X	X	X				56	00111000	38
X	X	X			X	57	00111001	39
X	X	X		X		58	00111010	3A
X	X	X		X	X	59	00111011	3B
X	X	X	X			60	00111100	3C
X	X	X	X		X	61	00111101	3D
X	X	X	X	X		62	00111110	3E
X	X	X	X	X	X	63	00111111	3F

5.4.4 CV 51.3 Special Sound Effects Enable¹⁰² (PI = 3)

Use CV 51.3 to enable/disable special sound effects.

Default Value:

Depends on Locomotive

CV 51.3: Special Sound Effects Enable Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Long Air Letoff on Start Up	Reverser Type	Reverser Type	Fuel Type	Fuel Type

- Set data in Bits 1 and 0 as follows:

“00” = Coal shovel
“01” = Coal auger (Default)
“10” = Oil
“11” = Wood

This affects the steam automatic neutral fuel sounds, the steam Fuel Sounds feature (ID = 15), and the steam Fuel Loading Scenario feature (ID = 146).

When the steam automatic neutral fuel sounds play or the Fuel Sounds feature is triggered, the following sounds are played:

“00” = Coal shovel sounds
“01” = Coal auger sounds
“10” = no sound (oil sounds not available at this time)
“11” = no sound (wood sounds not available at this time)

When the steam Fuel Loading Scenario feature is triggered, the following sounds are played:

“00” = Coal loading sounds
“01” = Coal loading sounds
“10” = Oil loading sounds
“11” = no sound (wood loading sounds not available at this time)

- Set data in Bits 2 and 3 as follows:

“00” = Lever Reverser
“01” = Power Reverser
“10” = Screw Reverser
“11” = Reserved

- Set data in Bit 4 as follows:

“0” = A long air let-off sound does not play on start up.
“1” = A long air let-off sound plays on start up

If this bit is “1” and the locomotive first enters Ops Mode after power up or a Start up (F6) operation occurs, then a long air let-off sound plays. This is the standard behavior for Q1 and Q2 decoders.

- All other bits are reserved. Any data entered in these bits is ignored.

¹⁰² Write bit operation is supported for Special Sound Effects Enable.

5.4.5 CV 51.5 Automatic Mute Timeout Value (PI = 5)

Use this CV to specify the number of seconds of "idle time" after which the locomotive automatically mutes its sounds.

Default Value:

0

CV 51.5: Automatic Mute Timeout Value Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Each unit represents 10 seconds. The maximum value is 255, which represents 2550 seconds or 42 minutes and 30 seconds.
- If the number of specified seconds of idle time is exceeded, the locomotive's sounds are automatically reduced to the Mute Volume specified in CV51.1. If the locomotive's sounds are already muted via the Mute function, the locomotive's sounds will not change in volume.
- If the value of this CV is "0", this timeout is disabled. Sounds are not automatically muted.
- Idle time is defined as the period of time during which the locomotive is in neutral and receives only Speed packets with speed step "0".
- If the locomotive receives a Speed packet with speed step > 0, or any non-speed packet such as a Function packet or Configuration Variable Access packet, then the idle time is immediately reset and the sounds return to their previous volume.
- Idle time also includes the case where the locomotive receives no valid packets addressed specifically to its Primary, Extended, or Consist address. This overlaps with the condition, which triggers the CV11 Packet Timeout, but CV51.5 is independent of CV11 and vice versa. Either or both timeouts may be enabled and do not interfere with each other.

Example 1: Suppose CV11 = "10" and CV51.5 = "6". Suppose the locomotive enters neutral (speed step 0) and the locomotive receives no packets other than Speed "0" packets. After 60 seconds of this, the locomotive's sounds are reduced to the CV51.1 Mute Volume.

Example 2: Suppose CV11 = "10" and CV51.5 = "6". The locomotive's speed corresponds to the last received Speed packet specifying speed step "30". The locomotive does not receive any valid packets addressed to one of its addresses. After 10 seconds of this the CV11 Packet Timeout Value is exceeded and the locomotive automatically slows to a stop and enters neutral, but the locomotive's sounds do not change in volume. After the locomotive comes to a stop and after 60 additional seconds of receiving no valid packets addressed to one of its addresses, the locomotive's sounds are reduced to the CV51.1 Mute Volume.

Example: Set the Automatic Mute Timeout Value to 10 (100 seconds).

- | |
|--|
| <ol style="list-style-type: none">1) Set CV 49 to 5.2) Set CV 51 to 10. |
|--|

5.4.6 CV 51.10 Chuff Cutoff Minimum Inertia¹⁰³ (PI = 10)

Use this CV to specify the value of CV3+CV23 above which the steam locomotive switches from Throttle Mode to Cutoff Mode.

Default Value:

50

CV 51.10: Chuff Cutoff Minimum Inertia Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to control the amount of chuff “bark” you hear when the locomotive accelerates.
- If CV3+CV23 is less than or equal to CV51.10, the locomotive operates in Throttle Mode using minimum cutoff (about 15%). The chuff sounds have a softer and wetter sound, the released steam being reduced in pressure and temperature, since the steam is injected for only a small percentage of the piston stroke.
- If CV3+CV23 is greater than CV51.10, the locomotive operates in Cutoff Mode. The amount of cutoff is proportional to the difference CV3+CV23 - CV51.10. The greater the difference, the greater the amount of cutoff. When cutoff is at maximum (about 85%), steam is being injected into the cylinders during most of the piston stroke and is exhausted at full pressure and temperature. This provides the characteristic "bark" of an accelerating steam locomotive.
- See the document "Throttle Mode and Cutoff Mode" for further description of these two modes.

Example: Set the Chuff Cutoff Minimum Inertia to 96.

- 1) Set CV 49 to 10.
- 2) Set CV 51 to 96.

¹⁰³ This CV is supported only by Q2 firmware.

5.4.7 CV 51.12 Minimum Sound of Power Scale Factor¹⁰⁴ (PI = 12)

Use this CV to control the low end of Sound of Power volume.

Default Value:

40

CV 51.12: Minimum Sound of Power Scale Factor Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to control the chuff volume when the locomotive is not accelerating under load. If the chuff sounds are too quiet at low loads and low acceleration, increase the value of this CV.
- See the document "Throttle Mode and Cutoff Mode" for further description of steam Sound of Power.

Example: Set the Minimum Sound of Power Scale Factor to 80.

- 3) Set CV 49 to 12.
- 4) Set CV 51 to 80.

¹⁰⁴ This CV is supported only by Q2 firmware.

5.4.8 CV 51.13 Maximum Sound of Power Scale Factor¹⁰⁵ (PI = 13)

Use this CV to control the high end of Sound of Power volume.

Default Value:

65

CV 51.13: Maximum Sound of Power Scale Factor Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to control the chuff volume when the locomotive is accelerating under load. If the chuff sounds are too loud at high loads and high acceleration, decrease the value of this CV.
- See the document "Throttle Mode and Cutoff Mode" for further description of steam Sound of Power.

Example: Set the Maximum Sound of Power Scale Factor to 50.

- 5) Set CV 49 to 13.
- 6) Set CV 51 to 50.

¹⁰⁵ This CV is supported only by Q2 firmware.

5.4.9 CV 51.14 System Volume Balance (PI = 14)¹⁰⁶

For Quantum systems with two stereo speaker outputs, CV51.14 functions as the system volume balance control. .

Default Value:

0

CV 51.14: System Volume Balance Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- CV 51.14 can have any value from -127 to +127. A positive value is indicated by a 0 in bit 7 while a “1” indicates a negative value.
- To specify a negative balance, add 128 to the unsigned balance value. For example, to specify a balance of -60, add 128 to 60 to obtain 188.
- Negative values decrease the volume of speaker 1 and positive values decrease the volume of speaker 2. For example, a value of 63 decreases the volume of speaker 2 to $((127 - 63) * 100) / 127 = 50\%$, while leaving the speaker 1 volume at 100%.
- The default value of 0 results in both speaker 1 and speaker 2 having 100% of the system volume specified in CV51.0 System Volume.

Example: Set the system balance control so that speaker 1 has 100% of the system volume and speaker 2 has 75% of the system volume.

1. Set CV 49 to 14 to select the system volume balance register.
2. Set CV 51 to 31 to specify the balance.

Example: Set the system balance control so that speaker 2 has 100% of the system volume and speaker 1 has 75% of the system volume.

1. Set CV 49 to 14 to select the system volume balance register.
2. Set CV 51 to 159 to specify the balance.

¹⁰⁶ This CV is supported only by Q3 firmware.

5.4.10 CV 51.15 System Pitch Shift (PI = 15)¹⁰⁷

This CV shifts the system sound sample rate from the normal samples per second¹⁰⁸.

Default Value:

CV 51.15: System Pitch Shift Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- CV 51.15 can have any value from -127 to +127 where positive values will increase the pitch and negative values will decrease the pitch. A positive value is indicated by a 0 in bit 7 while a "1" indicates a negative value.
- To specify a negative pitch shift, add 128 to the unsigned pitch shift value. For example, to specify a pitch shift down of 60 samples per second, add 128 to 60 to obtain 188.
- Each unit represents a shift of 4 samples per second. For example, a value of 10 increases the pitch by 40 samples per second.
- Use CV 51.15 to change the pitch of similar locomotives in a consist so that each locomotive produces a distinct sound.

Example: Pitch shift the system sample rate down 60 samples per second.

1. Set CV 49 to 15 to select the system pitch shift register.
2. Set CV 51 to 188 to specify the pitch shift.

¹⁰⁷ This CV is supported only by Q3 firmware.

¹⁰⁸ The normal sample rate for version 8 firmware is 7633 samples per second. For version 9 firmware it is 15625 samples per second.

5.4.11 CV 51.16 Atmospherics Level (PI = 16)¹⁰⁹

Use this CV to select the audio system atmospherics level.

Default Value:

2

CV 51.16: Atmospherics Level Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	D2	D1	D0

Valid values for CV 51.16 are:

- 0 – None
- 1 – Low
- 2 - Medium (default)
- 3 – High
- 4 - Extreme

When CV51.16 is not 0, the Quantum decoder's overall sound is artificially enhanced to simulate natural variations in sound caused by weather conditions, by temperature and wind gradients, and by topographical features such as ground cover, hills, buildings, and other obstacles.

Example: Set the atmospherics level to Low.

1. Set CV 49 to 16 to select the atmospherics level register.
2. Set CV 51 to 1 to select the "Low" atmospherics level.

¹⁰⁹ This CV is supported only by Q3 firmware.

5.4.12 CV 51.20 Motive State Change Warning Signals (PI = 20)

Use CV 51.20 to enable/disable motive state change horn warning signals. .

Default Value:

0

CV 51.20: Motive State Change Warning Signals

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved for future use	Reserved for future use	Warning Signals Entering Neutral	Warning Signals Entering Neutral	Reserved for future use	Reserved for future use	Warning Signals Leaving Neutral	Warning Signals Leaving Neutral

- Bits 0 and 1 specify the Warning Signal behavior when leaving neutral.

Bit 0...Bit 1 Value	Warning Signals Leaving Neutral
0	None (default)
1	Automatic Horn Warning Signals
2	Bell Triggered Ready to Move Scenario
3	Reserved

If the bit 0...bit 1 value = 1, then when the locomotive leaves neutral and the horn is not already playing, two horn blasts are played if the direction is FWD. Three horn blasts are played if the direction is REV.

If the bit 0...bit 1 value = 2, then when the locomotive is in neutral and the bell is turned on in neutral and the horn is not already playing, the "Ready to Move" scenario plays.

Note that the bell turning on in neutral triggers the Ready to Move scenario. If the bell is on when the locomotive enters neutral, the Ready to Move scenario will not play unless the bell is turned off and then turned on again.

The default Ready to Move scenario for NFF->FWD is as follows:

After four seconds, the Front Headlight switches to its FWD state as specified in CV55.70.1.

Two seconds later, the Front Mars Light, Front Ditch Lights, and other warning lights switch to their FWD states.

Two seconds later, two horn blasts are played.

Three seconds after the horn blasts complete, a brake release sound is played. The brake release sound continues until the throttle is increased and the locomotive enters FWD.

The default scenario for NFR->REV is as follows:

After four seconds, the Rear Headlight switches to its REV state as specified in CV55.73.1.

Two seconds later, the Rear Mars Light, Rear Ditch Lights, and other warning lights switch to their REV states.

Two seconds later, three horn blasts are played.

Three seconds after the horn blasts complete, a brake release sound is played. The brake release sound continues until the throttle is increased and the locomotive enters REV.

Use CV120 to change the timing, duration and number of horn blasts in the Ready to Move scenario.

If the bell is turned off or the horn is turned on manually before the throttle is increased, the scenario is aborted and the lights return to their NFF/NFR states.

After the locomotive enters FWD/REV, the bell does not turn off automatically. If you want the bell to be off, you must turn it off manually. Firmware built after 17-July-2014 supports CV120.10.0 Bell Hold Time which allows the bell to be turned off automatically a specified number of seconds after leaving neutral.

- Bits 4 and 5 specify the Warning Signal behavior when entering neutral.

Bit 4...Bit 5 Value	Warning Signal Entering Neutral
0	None (default)
1	Automatic Horn Signal
2	Bell Armed Upon Stopping Scenario
3	Reserved

Normally, a long air letoff is played when the locomotive leaves FWD/REV and enters neutral.

If the bit 4...bit 5 value = 1, then when the locomotive leaves FWD/REV and enters neutral and the horn is not already playing, a single horn blast is played instead of the long air letoff.

If the bit 4...bit 5 value = 2, then if the bell is on when the locomotive leaves FWD/REV and enters neutral and the horn is not already playing, a scenario consisting of a single horn blast is played.¹¹⁰ The default Upon Stopping scenario is as follows:

Two seconds after entering neutral, a single horn blast is played.

Two seconds later, the Front Mars Light, Front Ditch Lights, and other warning lights switch to their NFF/NFR states.

One second later, the Headlight switches to its NFF/NFR state.

Two seconds after that, a long air letoff is played.

Use CV135 to change the duration of the horn blast and the timing of events in the Upon Stopping scenario. Use CV135.6.0 to specify whether the bell turns off automatically after the long air letoff.

¹¹⁰ For firmware built before 1-Aug-2014, if the bit 4...bit 5 value = 2, then if the bell is on when the locomotive leaves FWD/REV and enters neutral and the horn is not already playing, a single horn blast is played instead of the long air letoff. After the locomotive enters neutral, the bell does not turn off automatically. If you want the bell to be off, you must turn it off manually.

5.5 CV 52.PI QSI Individual Sound Volume Control

Use CV 52 to specify volume levels for individual Quantum sounds.

CV 52.PI: Individual Sound Volume Registers

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	V3	V2	V1	V0

- CV 52 is implemented as a one-dimensional table of up to 256 Individual Sound Volume registers, with CV 49 used as an index to these registers.

Primary Index	Table of Volume Levels
0	Volume Level for Sound[0]
1	Volume Level for Sound[1]
2	Volume Level for Sound[2]
3	Volume Level for Sound[3]
...	...

- To change the volume level of an individual sound, do the following:
 - Set CV 49 to the identifier for the individual sound (see table next page).
 - Set data in Bits 0-3 of CV 52 as follows:
 - “0” = No sound
 - “1 – 15” = Sets the volume level from the lowest level at “1” to the highest level at “15”
- 4 bits of volume level are used, providing 16 volume levels. The volume levels correspond to 2db increments.
- All other bits are reserved. Data in bits 4-7 are not used. Any data entered in these bits will be ignored.
- For most CV52.PI CV's the default value is 11.

Example: Set the bell volume to the 6th volume level and then set the Horn/Whistle volume to 10th level (i.e. set CV 52.8 to 6 followed by setting CV 52.0 to 11)

- Set CV 49 to 8 to select the Bell sound.
- Set CV 52 to 6 to select the 6th volume level for the Bell.
- Set CV 49 to 0 to select the Horn/Whistle sound.
- Set CV 52 to 10 to select the 10th volume level for the Horn/Whistle.

Example: For dual Air Pump Steam Locomotives, turn the volume off on one pump to create single pump action.

- Set CV 49 to 17 to select the second pump sound.
- CV 52 to zero to select no volume.

5.5.1 Individual Sound Identifiers

Primary Index	Sound	Used CV52	Used CV116	Used CV117	Used CV118
0	Horn/Whistle ¹¹¹	X	X	X	
8	Bell	X	X	X	
10	Prime Mover1/Diesel Motor Idle/Traction Motor ¹¹² / Chuff	X	X	X	X
11	Prime Mover2 ¹¹³ /Diesel Motor2 Idle/Chuff 2 ¹¹⁴	X	X		X
13	Valve Rod Clank/Gas Turbine Whoosh	X	X		
14	Turbo Idle Volume ¹¹⁵	X	X		
15	Cylinder Cocks/Gas Turbine Whine	X	X		
16	Air Pump 1	X	X	X	
17	Air Pump 2 (Steam Locomotives Only)	X	X		
19	Steam Blower Hiss/Cooling Fans ¹¹⁶	X	X		
20	Snifter Valve	X	X		
21	Long Air Let-off	X	X		
22	Short Air Let-off	X	X		
24	Squealing Brakes	X	X		
26	Steam Generator/Diesel Generator Idle ¹¹⁷	X	X	X ¹¹⁸	
28	Dynamic Brakes Fans	X	X	X	
29	Boiler Pop-off/Spitter Valve ¹¹⁹	X	X		
30	Blow down/Air Dryer ¹²⁰	X	X		
31	Injector	X	X		
32	Fuel Sounds (Coal Shovel, Coal Auger))	X	X		
34	Coupler Sounds	X	X		
37	Air Brakes	X	X		
40	Alternate Horn	X	X	X	
41	Reverser	X	X		
46	User Sound Effect	X	X		
47	User Sound Effect2	X	X		
50	Verbal Feedback ¹²¹	X	X		
52	Crew Talk	X	X		
53	Water Loading Scenario	X	X		
54	Water Scoop	X	X		
55	Fuel Loading Scenario	X	X		
56	Maintenance Scenario	X	X		

¹¹¹ Whistle in steam locomotives; Horn in diesel and electric locomotives.

¹¹² Chuff in steam Locomotives; Traction Motor in electric locomotives; Diesel Motor Idle in diesel locomotives; Prime Mover1 in diesel locomotives with version 9 firmware.

¹¹³ In version 9 diesel firmware built after 1-Jan-15, if CV52.11 = 0 at power-on, the prime mover2 sounds are disabled. If you then set CV52.11 to a non-zero value, the prime mover2 sounds remain disabled until the next power cycle. If CV52.11 != 0 at power-on the prime mover2 sounds are enabled. If you then set CV52.11 = 0, the prime mover2 sounds remain enabled until the next power cycle.

¹¹⁴ Chuff2 in articulated steam locomotives; Diesel Motor2 Idle in dual motor diesel locomotives

¹¹⁵ Replaced by CV127.10.SI in version 9 firmware.

¹¹⁶ Steam Blower in steam locomotives; Cooling Fans in diesel and electric Locomotives.

¹¹⁷ Replaced by CV127.10.SI in version 9 diesel firmware.

¹¹⁸ Steam Generator only.

¹¹⁹ Popoff in steam locomotives; Spitter Valve in diesel locomotives.

¹²⁰ Blow down in steam locomotives; Air Dryer in diesel locomotives.

¹²¹ Affects CV Readout, Programming Acknowledgement, Status Report, and Odometer Readout.

5.6 CV 53.PI.SI Output Feature Assignment

Use CV 53 to assign QSI features to the 30 decoder outputs.

CV 53.PI.SI: Output Feature Assignment Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- CV 53 is implemented as a two-dimensional table of 30x2 registers, with CV 49 used as a row index to these registers, and CV 50 used as a column index.

Primary Index (CV 49)	Secondary Index (CV 50)	
	0	1
1	Feature Assigned to Output 1 in FWD/REV	Feature Assigned to Output 1 in NFF/NFR
2	Feature Assigned to Output 2 in FWD/REV	Feature Assigned to Output 2 in NFF/NFR
3	Feature Assigned to Output 3 in FWD/REV	Feature Assigned to Output 3 in NFF/NFR
.	"	"
.	"	"
.	"	"
14	Feature Assigned to Output 14 in FWD/REV	Feature Assigned to Output 14 in NFF/NFR
15	Feature Assigned to Output 15 in FWD/REV	Feature Assigned to Output 15 in NFF/NFR ¹²²
.	"	"
.	"	"
.	"	"
30	Feature Assigned to Output 30 in FWD/REV	Feature Assigned to Output 30 in NFF/NFR ¹²³

- To change an output assignment, do the following:
 - Set CV 49 to the decoder Output Number (1...30).
 - Set CV 50 to the Locomotive State (0 for Forward/Reverse, 1 for Neutral (NFF/NFR)).
 - Set CV 53 to the QSI Feature Identification Number (see table next page)
- For outputs 1-14, some features can only be assigned to the FWD/REV state and some only to the NFF/NFR state.
- Never assign the same feature to two or more outputs; it is unclear what the effect will be since both outputs may have different states. For instance, if you assign the Blower Hiss to Output 5 and to Output 7, and Output 5 is off but Output 7 is on, would Blower Hiss be on or off?
- Older firmware, which does not support F13-F28, only supports outputs 1-14. When using this firmware, restrict PI to 1-14.
- Firmware that supports F13-F28 also supports outputs 15-30. Because of memory size issues, for Q1 and Q2 decoders SI is restricted to 0 for PI = 15-30 (i.e., for PI = 15-30, CV53.PI.0 is supported but CV53.PI.1 is not supported). This means the same feature assigned to an output for FWD/REV is also assigned to that output for NFF/NFR.

¹²² CV53.PI.1 is not supported on Q1 and Q2 decoders. Instead CV53.PI.0 specifies the feature for both FWD/REV and NFF/NFR.

¹²³ CV53.PI.1 is not supported on Q1 and Q2 decoders. Instead CV53.PI.0 specifies the feature for both FWD/REV and NFF/NFR.

Example: Set Long Air Let-Off to Output 5 to operate in Forward and Reverse and set Short Air Let-Off to Output 5 to operate in Neutral (i.e. set CV 53.5.0 to 9 and set CV 53.5.1 to 10).

- 1) Set Primary Index CV 49 to "5" to select output 5.
- 2) Set Secondary Index CV 50 to "0" to select Forward/Reverse.
- 3) Set CV 53 to "9" (00000101) which is Long Air Let-Off Feature Identification Number.
- 4) Set Secondary Index CV 50 to "1" to select Neutral. (CV 49 is already set to output 5.)
- 5) Set CV 53 to "10" (00001010) for Short Air Let-Off.

Now the Function key mapped to output 5 will produce a Short Air-Let-Off when the locomotive is in Neutral, and a Long Air Let-Off when the locomotive is moving in Forward and Reverse.

5.6.1 QSI Feature Identification Numbers used with CV 53

The following table lists the QSI Features that may be assigned to function key outputs.

The third column shows the directional states (All, Forward/Reverse, Neutral) for which the feature may be assigned to an output. Some features, like Blower Hiss or Mute, apply to all states; some features, like Doppler and Squealing Brakes, only apply to a moving locomotive; some features, like Pop-off or Blow-Down, only apply to Neutral. The Quantum System allows you to assign, say, Squealing Brakes to Output 7 in Neutral but when the F5 Key is pressed to activate this feature in Neutral, it will produce no effect.

Feature	Feature ID	Allowed Directional States	Comments
Air Brakes	176	FWD/REV	See section "1.13 Air Brakes (F7 in Forward or Reverse)".
Alternate Horn Selection	2	All	This selects between the primary warning device be it either Horn or Whistle and an alternate Horn. Each time you make a selection, you hear a short hoot that identifies the Horn or Whistle selected. To disable feedback, see CV 51.2.
Arm Cylinder Cocks	6	NFF/NFR	Explicitly arms Cylinder Cocks. If Cylinder Cocks are armed, Cylinder Cocks sounds play when the locomotive begins moving in FWD/REV. The Cylinder Cocks sounds automatically terminate after 16 repetitions or when the locomotive reaches a speed greater than 12 smph. See CV 51.2.
Automatic Ditch Lights	84	All	When Automatic Ditch Lights is activated, the Ditch Lights intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.84.x.
Automatic Front Cab Lights	116	All	When Automatic Front Cab Lights is activated, the Front Cab Lights intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.116.x.
Automatic Front Marker Lights	104	All	When Automatic Front Marker Lights are activated, the Front Marker Light intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.104.x.
Automatic Front Number Board Lights	100	All	When Automatic Front Number Board Lights is activated, Front Number Board Light intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.100.x.
Automatic Headlight	70	All	If Automatic Headlight is activated, the Headlight intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.70.x.
Automatic Mars Light	76	All	If Automatic Mars Light is activated, the Mars Light intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.76.x.
Automatic Overhead Beacon Light	92	All	If Automatic OHBL is activated, the OHBL intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.92.x.
Automatic Rear	118	All	When Automatic Rear Cab Lights is activated,

Cab Lights			Rear Cab Lights turn off in Forward/Reverse after 15 seconds and turn on in Neutral after 10 seconds. See CV 55.118.x.
Automatic Rear Ditch Lights	88	All	When Automatic Rear Ditch Lights is activated, the Rear Ditch Lights intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.88.x.
Automatic Rear Marker Lights	106	All	When Automatic Rear Marker Lights is activated, the Rear Marker Light intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.108.x.
Automatic Rear Mars Light	80	All	If Automatic Rear Mars Light is activated, the Rear Mars Light intensity changes automatically in response to changes to the locomotive's directional state. See CV 55.80.x.
Automatic Rear Number Board Lights	102	All	When Automatic Rear Number Board Lights is activated, the Rear Number Board Light intensity changes automatically in response to changes to locomotive's directional state. See CV 55.102.x.
Automatic Rear Overhead Beacon Light	97	All	When Automatic Rear OHBL is activated, the Rear OHBL intensity changes automatically in response to changes in the locomotive's directional state. See CV 55.96.x.
Automatic Reverse Light	73	All	When Automatic Reverse Light is activated, the Reverse Light intensity changes automatically in response to changes in the locomotive's directional state. See CV 55.73.x.
Bell	3	All	When on, the bell rings continuously. Some bells have both start up and shut down sounds. See section "1.7 Horn and Bell Buttons (F2 Key and F1 Key)". See also CV 55.3.x.
Blow down	13	NFF/NFR	Blow Down produces a sound sequence of venting water, steam and residue that collects at the bottom of the boiler. The length of the Blow Down sequence is random. Blow Down sounds are produced automatically in Neutral at random intervals so there is no need to assign this feature to a function key output unless you really want to.
Blower Hiss	8	All	See section "1.9 Steam Blower Hiss and Cooling Fans (F4 Key)".
Calibrate BEMF to SMPH	200	All	Used to calibrate CV56.7.0-1 SMPH/BEMF Ratio using the trip odometer.
Cooling Vents and Fans	8	All	See section "1.9 Steam Blower Hiss and Cooling Fans (F4 Key)".
Coupler	211	All	See section "1.8 Coupler and Coupler Crash Sounds (F3 Key)".
Gas Turbine<-> Diesel Transition	24	NFF/NFR	Selects between Diesel mode and Turbine mode for the UP Gas Turbine Locomotive.
Dim Ditch Lights	86	All	Explicitly switches the Ditch Lights from Bright to be Dim. See CV 55.84.x.
Dim Headlight	72	All	Explicitly switches the Headlight from Bright to Dim. See CV 55.70.x.
Dim Mars Light	78	All	Explicitly switches the Mars Light from Bright to Dim. See CV 55.76.x.
Dim Rear Ditch Lights	90	All	Explicitly switches the Rear Ditch Lights from Bright to be Dim. See CV 55.88.x.
Dim Rear Mars	82	All	Explicitly switches the Rear Mars Light from Bright

Light			to Dim. See CV 55.80.x.
Dim Reverse Light	75	All	Explicitly switches the Reverse light from Bright to Dim. See CV 55.73.x.
Disconnect/Stand by/Total Shut Down	145	NFF/NFR	See section "1.18 Three Stages of Shut Down: Disconnect, Standby and Total Shut Down (F9 in Neutral)".
Ditch Lights	85	All	Explicitly turns the Ditch Lights On or Off. See CV 55.84.x.
Doppler Shift	65	FWD/REV	See section "1.11 Doppler Shift (F6 in Forward and Reverse)".
Dynamic Brakes	5	FDW/REV and Disconnect	See section "1.10 Dynamic Brakes (F5 Key)".
Engine Room Lights	120	All	Explicitly turns the Engine Room Lights On or Off. See CV 55.120.x.
Engine Room2 Lights	121	All	Explicitly turns the Engine Room2 Lights On or Off. See CV 55.120.x.
Firebox	122	All	Turns the Firebox On or Off. See CV 55.122.x.
Flanges/Squealing Brakes	215	FWD/REV	See section "1.12 Squealing Brakes and Flanges (F7 in Forward or Reverse)".
Flanges/Squealing Brakes + Air Brakes	216	FWD/REV	This feature is a combination of Flanges/Squealing Brakes, 215, and Air Brakes, 176. If assigned to a function key and pressed when Air Brakes would not normally be functional (i.e. throttle at some non-zero setting), squealing brakes would still be heard.
Front Cab Lights	117	All	Explicitly turns Front Cab Lights On or Off. See CV 55.116.x.
Front Marker Lights	105	All	Explicitly turns Front Marker Lights On or Off. See CV 55.104.x.
Front Number Board Lights	101	All	Explicitly turns Front Number Board Lights On or Off. See CV 55.100.x.
Fuel Loading Scenario	146	NFF/NFR	Play fuel loading scenario.
Fuel Sounds (Coal Shovel, Coal Auger)	15	NFF/NFR	Play fuel sounds.
Grade Crossing	154	FWD/REV	Plays a grade crossing scenario consisting of four horn blasts: two long blasts, one short blast, and one long blast. See CV55.154.x.
Headlight	71	All	Explicitly turns the Headlight On or Off. See CV 55.70.x.
Heavy Load	179	All	See section "1.15 Heavy Load (F9 in Forward or Reverse)".
Head End Power	208	NFF/NFR	Turn Head End Power On/Off.
Horn	1	All	See section "1.7 Horn and Bell Buttons (F2 Key and F1 Key)".
Injector	14	NFF/NFR	When triggered, Injector produces a sound sequence of water being injected into the boiler. This can happen in any directional state but it is more obvious in Neutral. The length of the Injector sequence is random. Injector sounds are produced automatically in Neutral at random intervals so there is no need to assign this feature to a function key output unless you really want to.

Long Air Let-off	9	All	When triggered, Long Air Let-off produces an air release sound of about 1.5 seconds. Use a Long Air Let-off to simulate operating some steam appliances like power reverse or applying the brakes in Neutral on any locomotive.
Maintenance Scenario	148	NFF/NFR	Play maintenance scenario.
Mars Light	77	All	Explicitly turn the Mars Light On or Off. See CV 55.76.x.
Multiple Automatic Lights #1	136	All	The Multiple Automatic Lights #1 feature allows you to activate more than one automatic light feature with a single function key. See CV 55.136.x.
Multiple Automatic Lights #2	137	All	The Multiple Automatic Lights #2 feature allows you to activate more than one automatic light feature with a single function key. See CV 55.137.x
Multiple Automatic Lights #3	138	All	The Multiple Automatic Lights #3 feature allows you to activate more than one automatic light feature with a single function key. See CV 55.138.x.
Mute	64	All	See section "1.14 Audio Mute (F8 Key)".
None	0	All	If this feature is assigned to a function key output, pressing the function key does nothing.
Overhead Beacon Light	93	All	Explicitly turns the Overhead Beacon Light On or Off. See CV 55.92.x.
Pop-off	12	NFF/NFR	When triggered, Pop Off produces a sound sequence of steam being ejected from the boiler. This can happen in any directional state but it is more obvious in Neutral. The length of the Pop Off sequence is random. Pop Off sounds are produced automatically in Neutral at random intervals so there is no need to assign this feature to a function key output unless you really want to.
Rear Cab Lights	119	All	Explicitly turns Rear Cab Lights On or Off. See CV 55.118.x.
Rear Ditch Lights	89	All	Explicitly turns Rear Ditch Lights On or Off. See CV 55.88.x.
Rear Marker Lights	107	All	Explicitly turns Rear Marker Lights On or Off. See CV 55.106.x.
Rear Mars Light	81	All	Explicitly turn the Rear Mars Light On or Off. See CV 55.80.x.
Rear Number Board Lights	103	All	Explicitly turns the Rear Number Board Lights On or Off. See CV 55.102.x.
Rear Overhead Beacon Light	97	All	Explicitly turns the Rear Overhead Beacon Light On or Off. See CV 55.96.x.
Reverse Light	74	All	Explicitly turns the Reverse light On or Off. See CV 55.73.x.
Short Air Let-off	10	All	When triggered, Short Air Let-off produces an air release sound of about 1 second. Use a Short Air Let-off to simulate operating some locomotive appliances or as a place holder feature for unused function keys.
Shut Down	143	NFF/NFR	Similar to feature 145 Disconnect/Standby/Total Shut Down except goes direction to Total Shutdown bypassing Disconnect/Standby.

Start Up	144	NFF/NFR	See section "1.19 Start Up (F6 in Neutral)".
Status Report	178	All	See section "1.16 Status Report (F10)".
Steam Generator	218	All	Turns the Steam Generator On or Off. Lights are on only if the Steam Generator is On. Lights brighten gradually when the Steam Generator is turned on and darken gradually when the Steam Generator is turned off.
Step Lights	113	All	Explicitly turns the Step Lights On or Off.
Strobe Ditch Lights	87	All	Explicitly turns on or off Ditch Lights strobe. See CV 55.84.x.
Strobe Mars Light	79	All	Explicitly turns on or off Mars Light strobe. See CV 55.76.x.
Strobe Rear Ditch Lights	91	All	Explicitly turns on or off Rear Ditch Lights strobe. See CV 55.88.x.
Strobe Rear Mars Light	83	All	Explicitly turns on or off Rear Mars Light strobe. See CV 55.80.x.
System Volume Increase	62	All	Increase the system volume by 2db. See also CV51.0 Operations Mode System Volume.
System Volume Decrease	63	All	Decrease the system volume by 2db. See also CV51.0 Operations Mode System Volume.
Truck Lights	109	All	Explicitly turns the Truck Lights On or Off.
User Looped Sound Effect	26	All	Turn on/off a User Recorded Sound Effect. See Q2Upgrade User Manual for further information.
User Looped Sound Effect2	28	All	Turn on/off a 2 nd User Recorded Sound Effect. See Q2Upgrade User Manual for further information.
User Sound Effect	25	All	Trigger the single playing of a User Recorded Sound Effect. See Q2Upgrade User Manual for further information.
User Sound Effect2	27	All	Trigger the single playing of a 2 nd User Recorded Sound Effect. See Q2Upgrade User Manual for further information.
Water Scoop Scenario	150	FWD/REV	Play water scoop scenario.
Water Loading Scenario	147	NFF/NFR	Play water loading scenario.
Whistle	1	All	See section "1.7 Horn and Bell Buttons (F2 Key and F1 Key)".

Note: Do not confuse the above table with the Individual Sound Identifiers Table shown in CV 52. The above table lists ID's of Features while CV 52 table lists ID's of Individual Sounds.

5.6.2 CV 53 Factory Default Settings

Primary Index (PI) (CV 49 Value)	Output	Secondary Index (SI) (CV 50 Value)	
		0	1
		Forward/Reverse only	Neutral only
1	Output 1	Multiple Automatic Lights #1 (136)	Multiple Automatic Lights #1 (136)
2	Output 2	Multiple Automatic Lights #1 (136)	Multiple Automatic Lights #1 (136)
3	Output 3	Bell (3)	Bell (3)
4	Output 4	Horn/Whistle (1)	Horn/Whistle (1)
5	Output 5	Coupler (211)	Coupler (211)
6	Output 6	Blower Hiss/Fans (8)	Blower Hiss/Fans (8)
7	Output 7	Dynamic Brakes (5)	Dynamic Brakes (5)
8	Output 8	Doppler Shift (65)	Start Up (144)
9	Output 9	Squealing Brakes + Air Brakes (216)	Long Air Let-off (9) or Arm Cylinder Cocks (6)
10	Output 10	Mute (64)	Mute (64)
11	Output 11	Heavy Load (179)	Disconnect/Standby/ Shut Down (145)
12	Output 12	Status Report (178)	Status Report (178)
13	Output 13	Alternate Horn Selection (2) Multiple Automatic Lights #2 (137)	Alternate Horn Selection (2) Multiple Automatic Lights #2 (137)
14	Output 14	Multiple Automatic Lights #3 (138)	Multiple Automatic Lights #3 (138)
15	Output 15	System Volume Decrease (63)	System Volume Decrease (63)
16	Output 16	System Volume Increase (62)	System Volume Increase (62)
17	Output 17	Grade Crossing (154)	Short Air Let-off
18	Output 18	Short Air Let-off	Short Air Let-off
19	Output 19	Short Air Let-off	Short Air Let-off
20	Output 20	Short Air Let-off	Short Air Let-off
21	Output 21	Short Air Let-off	Short Air Let-off
22	Output 22	Short Air Let-off	Short Air Let-off
23	Output 23	Short Air Let-off	Short Air Let-off
24	Output 24	Short Air Let-off	Short Air Let-off
25	Output 25	Short Air Let-off	Short Air Let-off
26	Output 26	Short Air Let-off	Short Air Let-off
27	Output 27	Short Air Let-off	Short Air Let-off
28	Output 28	Short Air Let-off	Fuel Loading Scenario (146)
29	Output 29	Short Air Let-off	Maintenance Scenario (148)
30	Output 30	Water Scoop Scenario (150)	Water Loading Scenario (147)

5.7 CV 55.PI.SI QSI Feature Configuration

Use CV 55 to configure the behavior of Quantum features.

CV 55 is implemented as a two-dimensional array of registers with both CV 49 and CV 50 used to access these registers. The CV 49 Primary Index corresponds to QSI feature identification numbers.

5.7.1 CV 55.1.SI Horn

5.7.1.1 CV 55.1.1 Horn Type¹²⁴

Your Quantum Decoder may support more than one type of horn. Use CV 55.1.1 to choose from the available horn sounds.

Default Value:

Depends on Locomotive

CV 55.1.1: Horn Type

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The following choices are available:

CV55.1.1 Value	Type of Horn
1	Native Horn
2	User-defined Horn
10	Buell Single
11	Buell Single x2
12	Buell 3-Chime
13	Buell 5-Chime
20	Leslie S-2A
21	Leslie S-2B
22	Leslie S-2G
23	Leslie S-2H
24	Leslie S-2M
25	Leslie S-3B
26	Leslie S-3C
27	Leslie S-3E
28	Leslie S-3J
29	Leslie S-3K
30	Leslie S-3L
31	Leslie S-3P
32	Leslie S-4T
33	Leslie S-5A
34	Leslie S-5D
35	Leslie S-5T
36	Leslie A-125-200-3G
37	Leslie A-125-200-3H
38	Leslie A-125-200-5B
39	Leslie A-125-200-5C
40	Leslie A-125-3E
41	Leslie A-125-3F
42	Leslie A-125-4A
43	Leslie A-125-5A
44	Leslie A-75-262
45	Leslie A-75-262 x2
46	Leslie A-75-330
47	Leslie A-75-330 x2
48	Leslie A-75-440
49	Leslie A-125-200 Combo
50	Leslie A-125-206
51	Leslie A-125-206 x2

¹²⁴ CV55.1.1 is currently supported only by version 9 Diesel firmware.

52	Leslie A-125-247
53	Leslie A-125-247 x2
54	Leslie A-125-277
55	Leslie A-125-277 x2
56	Leslie A-125-311
57	Leslie A-125-311 x2
58	Leslie A-125-349
59	Leslie A-125-349 x2
60	Leslie A-125-440
61	Leslie A-125-440 x2
62	Leslie A-200-156
63	Leslie A-200-156 x2
64	Leslie A-200-233
65	Leslie A-200-233 x2
70	Nathan/AirChime H5-1
71	Nathan/AirChime H5-2
72	Nathan/AirChime H5-3
73	Nathan/AirChime H6
74	Nathan/AirChime K3
75	Nathan/AirChime K3H
76	Nathan/AirChime K3Ha
77	Nathan/AirChime K3L
78	Nathan/AirChime K3La
79	Nathan/AirChime K3LL
80	Nathan/AirChime K5
81	Nathan/AirChime K5H
82	Nathan/AirChime K5L
83	Nathan/AirChime K5La
84	Nathan/AirChime K5La Amtrak HP
85	Nathan/AirChime K5La Amtrak LP
86	Nathan/AirChime K5Lam
87	Nathan/AirChime K5LL
88	Nathan/AirChime K5LLa
89	Nathan/AirChime K5LLLa
90	Nathan/AirChime K6La
91	Nathan/AirChime M3
92	Nathan/AirChime M3-1
93	Nathan/AirChime M3-1 x2
94	Nathan/AirChime M3-12
95	Nathan/AirChime M3H
96	Nathan/AirChime M5
97	Nathan/AirChime M5 (Bumett)
98	Nathan/AirChime M5-124
99	Nathan/AirChime M5H
100	Nathan/AirChime MS1
101	Nathan/AirChime MS2
102	Nathan/AirChime MS3
103	Nathan/AirChime P3
104	Nathan/AirChime P5
105	Nathan/AirChime P5a
106	Nathan/AirChime P5s
110	Prime PM920 1st Gen
111	Prime PM920 2nd Gen
112	Prime PM920 3rd Gen
113	Prime PM990 1st Gen
114	Prime PM990 2nd Gen
120	Wabco A-1
121	Wabco A-1 x2
122	Wabco A-1 #2
123	Wabco A-1 #2 x2
124	Wabco A-2
125	Wabco A-2 x2
126	Wabco AA-1
127	Wabco AA-2
128	Wabco B-7-21
129	Wabco B-7-21 x2
130	Wabco B-7-25
131	Wabco B-7-25 x2
132	Wabco D-5 long
133	Wabco D-5 long x2

134	Wabco D-5 short
135	Wabco D-5 short x2
136	Wabco DD-5
137	Wabco E-2
138	Wabco E-2 x2
139	Wabco E-2B4
140	Wabco E-2B4 x2
141	Wabco E-2B-1
142	Wabco E-44"
143	Wabco E-44" x2

Selection "1: Native Horn" refers to the horn the model manufacturer considers to be prototypical for the locomotive.¹²⁵

If you select "2 User-defined Horn", use the following CV's to define pitch, volume, and stereo balance for up to 6 chimes:

- CV130.1-6.0 User-defined Horn Component Pitch
- CV127.0.1-6 User-defined Horn Component Volume Levels
- CV128.0.1-6 User-defined Horn Component Balance

Selections 10 thru 143 have pre-defined component pitch, component volume, and component balance settings. If you select one of the pre-defined horns, CV130, CV127, and CV128 have no effect.

Use CV52.0 Horn Volume and CV116.0 Horn Balance to adjust the overall volume and stereo balance of all the listed horns.

If you set CV 55.1.1 to a value other than the listed choices, the decoder will revert to "1: Native Horn".

¹²⁵ The native horn can be replaced using Q2Upgrade's Cut&Paste feature.

5.7.1.2 CV 55.1.2 Alternate Horn Type¹²⁶

Your Quantum Decoder may support more than one type of alternate horn. Use CV 55.1.2 to choose from the available alternate horn sounds.

Default Value:

Depends on Locomotive

CV 55.1.2: Alternate Horn Type

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The following choices are available:

CV55.1.2 Value	Type of Horn
1	Native Alternate Horn
2	User-defined Alternate Horn
10	Buell Single
...	...
143	Wabco E-44" x2

Choices 10 thru 143 are the same as those for CV55.1.1 Horn Type.

Selection “1: Native Alternate Horn” refers to the horn the model manufacturer considers to be prototypical for the locomotive.¹²⁷

If you select “2 User-defined Alternate Horn”, use the following CV’s to define pitch, volume, and stereo balance for up to 6 chimes:

- CV131.1-6.0 User-defined Alternate Horn Component Pitch
- CV127.40.1-6 User-defined Alternate Horn Component Volume Levels
- CV128.40.1-6 User-defined Alternate Horn Component Balance

Selections 10 thru 143 have pre-defined component pitch, component volume, and component balance settings. If you select one of the pre-defined horns, CV131, CV127, and CV128 have no effect.

Use CV52.40 Alternate Horn Volume and CV116.40 Alternate Horn Balance to adjust the overall volume and stereo balance of all the listed horns.

If you set CV 55.1.2 to a value other than the listed choices, the decoder will revert to “1: Native Alternate Horn”.

¹²⁶ CV55.1.2 is currently supported only by version 9 Diesel firmware.

¹²⁷ The native alternate horn can be replaced using Q2Upgrade’s Cut&Paste feature.

5.7.1.3 CV 55.1.10 Horn Reverb Amount

Use CV 55.1.10 to adjust the reverb amount for certain horns.

Default Value:

96

CV 55.1.10: Horn Reverb Amount Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV specifies the amount of reverb for all types of horns except “1: Native Horn” and for all types of alternate horns except “1: Native Alternate Horn”.

Valid values are 0...255.

A value of 0 specifies no reverb.

A value of 255 specifies the maximum amount of reverb.

5.7.1.4 CV 55.1.11 Horn Reverb Distance

Use CV 55.1.11 to adjust the reverb distance for certain horns.

Default Value:

2

CV 55.1.11: Horn Reverb Distance Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV specifies the reverb distance for all types of horns except “1: Native Horn” and for all types of alternate horns except “1: Native Alternate Horn”.

Valid values are 0...6.

A value of 0 specifies “near” reverb.

A value of 255 specifies “far” reverb.

5.7.2 CV 55.3.SI Bell

5.7.2.1 CV 55.3.0 Maximum Bell Index

This read-only CV contains the number of bell sounds available in your Quantum Decoder.

Value:

Depends on Locomotive

CV 55.3.0: Maximum Bell Index

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

In Service Mode, to determine the number of bells available:

- 1) Set CV 49 to 3.
- 2) Set CV 50 to 0.
- 3) Then read back CV 55.

In Ops Mode, to determine the number of bells available:

- 1) Set CV 49 to 3.
- 2) Set CV 50 to 0.
- 3) Then set CV 64 to 55 to hear a verbal response.

5.7.2.2 CV 55.3.1 Bell Type

Your Quantum Decoder may have more than one type of bell sound. Use CV 55.3.1 to choose from the available bell sounds.

Default Value:

1 ¹²⁸

CV 55.3.1: Bell Type

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

Q1a version 7, Q2 version 7, and Q2x version 8 firmware

Use CV 55.3.0 to determine “N”, the number of bell sounds available.

Set CV 55.3.1 to a number from “0” to “N”. Selection “1” is the native bell for this model; selection “0” is “Feedback Bell”¹²⁹.

If you set CV 55.3.1 to a value larger than “N”, the decoder will revert to “0”, the “Feedback Bell”.

If you set CV 55.3.1 to 1...N in Ops Mode, and the locomotive’s bell is ringing, the newly selected bell will begin ringing immediately.

Q3 version 9 firmware

The following choices are available:

CV55.3.1 Value	Type of Bell
0	Feedback Bell
1	Native Bell
2	User-defined Pneumatic Bell
10	Bronze Bell, High Tone, Slow
11	Bronze Bell, High Tone, Medium
12	Bronze Bell, High Tone, Fast
13	Bronze Bell, Mid Tone, Slow
14	Bronze Bell, Mid Tone, Medium
15	Bronze Bell, Mid Tone, Fast
16	Bronze Bell, Low Tone, Slow
17	Bronze Bell, Low Tone, Medium
18	Bronze Bell, Low Tone, Fast
19	Mixed Metal Bell, High Tone, Slow
20	Mixed Metal Bell, High Tone, Medium
21	Mixed Metal Bell, High Tone, Fast
22	Mixed Metal Bell, Mid Tone, Slow
23	Mixed Metal Bell, Mid Tone, Medium
24	Mixed Metal Bell, Mid Tone, Fast
25	Mixed Metal Bell, Low Tone, Slow
26	Mixed Metal Bell, Low Tone, Medium
27	Mixed Metal Bell, Low Tone, Fast
28	Steel Bell, High Tone, Slow
29	Steel Bell, High Tone, Medium
30	Steel Bell, High Tone, Fast
31	Steel Bell, Mid Tone, Slow
32	Steel Bell, Mid Tone, Medium
33	Steel Bell, Mid Tone, Fast
34	Steel Bell, Low Tone, Slow
35	Steel Bell, Low Tone, Medium
36	Steel Bell, Low Tone, Fast

Type “1: Native Bell” has a fixed ring rate, metallurgy, and pitch.

¹²⁸ The default for some European models is 0, because their prototype did not have a bell.

¹²⁹ Feedback Bells produce a single light “ding” when turning the bell on and a double “ding” when shutting the bell off. This bell type is suitable for locomotives that are not intended to have bells but need a bell sound to indicate that the bell state is on or off.

Type “2: User-defined Pneumatic Bell” has a ring rate that can be changed using CV55.3.6, metallurgy that can be changed using CV55.3.7, and pitch that can be changed using CV118.8.0-1.

The pre-defined types 10 thru 36 have fixed ring rates, metallurgy, and pitch.

If you set CV 55.3.1 to a value other than those listed, the decoder will revert to “1: Native Bell”.

If you change CV55.3.1 in Ops Mode, and the locomotive’s bell is ringing, the bell sound will not change to the new type until the bell is stopped and restarted. If the locomotive’s bell is not ringing, the locomotive will play a short demo of the newly selected bell.

5.7.2.3 CV 55.3.5 Automatic Bell

Use CV 55.3.5 if you want the bell to turn on automatically when you blow the horn.

Default Value:

5

CV 55.3.5: Automatic Bell

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Enable Automatic Bell	Hold Time						

- If bit 7 = "1", the bell will turn on automatically when you blow the horn. The bell will also turn on automatically when you trigger the Grade Crossing feature (feature 154).
- Bits 0...6 specify the automatic bell hold time, or the number of seconds the bell will remain on after the horn blast ends. For example, if the hold time is "5", then the bell will turn off automatically 5 seconds after the horn blast ends.
- Prototypically, in locomotives where the bell turns on automatically when the horn is blown, the bell remains on indefinitely and must be turned off manually. To obtain this behavior, set the hold time to "0" (i.e., set CV55.3.5 to 128). Then the bell does not automatically turn off when the horn blast ends. You must manually turn the bell off by pressing the Bell button (F3) twice. The first Bell button press sets F3 to "1", or bell on. The second Bell button press sets F3 to "0", or bell off.
- If the hold time is not "0", the maximum hold time is 127 seconds.
- If the bell is already on (F3 = "1") when you blow the horn, the bell remains on indefinitely after the horn blast ends.
- The automatic bell and CV55.3.5 are not supported by steam and articulated steam firmware.

5.7.2.4 CV 55.3.6 User-defined Bell Ring Period

Use CV 55.3.6 to adjust the bell ring period for user-defined bells.

Default Value:

100

CV 55.3.6: User-defined Bell Ring Period Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV specifies the time between the start of each bell record for the when CV55.3.1 = “2: User-defined Pneumatic Bell”.

Each unit represents 0.01 second¹³⁰. A value of 100 gives a ring period of 1.0 second. The maximum period is 2.55 seconds.

Ring rate is the inverse of ring period. The longer the ring period, the slower the ring rate. The shorter the ring period, the faster the ring rate.

Valid values are 10...255. If the value is less than 10, a ring period of 10 is used.

¹³⁰ For 1123-0v9-2-0 and 1127-0v9-2-0 firmware, each unit represents 0.1 second. A value of 10 gives a ring period of 1.0 second. Valid values are 1...255.

5.7.2.5 CV 55.3.7 User-defined Bell Metallurgy

Use CV 55.3.6 to adjust the bell ring period for certain bells.

Default Value:

128

CV 55.3.7: User-defined Bell Metallurgy Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV specifies the relative amounts of bronze vs steel when CV55.3.1 = "2: User-defined Pneumatic Bell".

Valid values are 0...255.

A value of 255 represents 100% bronze and 0% steel.

A value of 0 represents 0% bronze and 100% steel.

A value of 128 represents 50% bronze and 50% steel.

5.7.3 CV 55.5.SI Dynamic Brakes Fans

5.7.3.1 CV 55.5.12 Dynamic Brakes Fans Max Power¹³¹

This CV specifies the power applied to the dynamic brakes fans port (see CV115.5.0) when the dynamic brakes are turned on.

Default Value:

255

CV 55.5.12: Dynamic Brakes Fans Max Power

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 giving the least power (off) and 255 giving most power.
- In Ops mode, with the Dynamic Brakes “On”, you can observe the fans speed change as you change the value of CV 55.5.12.

¹³¹ This CV is supported only by version 9 Q3 firmware.

5.7.3.2 CV 55.5.17 Dynamic Brakes Fans Ramp Up Time¹³²

This CV specifies the time for the dynamic brakes fans to go from “Off” to “Max Power”.

Default Value:

Depends on Locomotive

CV 55.5.17: Dynamic Brakes Fans Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the power applied to the fans to change from 0 to its maximum.
- Each unit represents 0.1 second. For example, a value of 25 represents 2.5 second.
- Valid values are 1...255, 1 being the least and 255 being the most amount of time.
- If the Ramp Up Time is 60, it takes 6.0 seconds for the light to go from off to bright.
- The default value corresponds to the length of the fan start record.

¹³² This CV is supported only by version 9 Q3 firmware.

5.7.3.3 CV 55.5.18 Dynamic Brakes Fans Ramp Down Time¹³³

This CV specifies the time for the dynamic brakes fans to go from “Max Power” to “Off”.

Default Value:

Depends on Locomotive

CV 55.5.18: Dynamic Brakes Fans Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the power applied to the fans to change from its maximum to 0.
- Each unit represents 0.1 second. For example, a value of 25 represents 2.5 second.
- Valid values are 1...255, 1 being the least and 255 being the most amount of time.
- If the Ramp Down Time is 80, it takes 8.0 seconds for the light to go from bright to off.
- The default value corresponds to the length of the fan stop record.

¹³³ This CV is supported only by version 9 Q3 firmware.

5.7.4 CV 55.8.SI Cooling Fans

5.7.4.1 CV 55.8.12 Cooling Fans Max Power¹³⁴

This CV specifies the power applied to the cooling fans port (see CV115.8.0) when the cooling fan is turned on.

Default Value:

Depends on Locomotive

CV 55.8.12: Cooling Fan Max Power

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 giving the least power (off) and 255 giving most power.
- In Ops mode, with the cooling fans “On”, you can observe the fans speed change as you change the value of CV 55.8.12.

¹³⁴ This CV is supported only by version 9 Q3 firmware.

5.7.4.2 CV 55.8.17 Cooling Fans Ramp Up Time¹³⁵

This CV specifies the time for the cooling fans to go from “Off” to “Max Power”.

Default Value:

Depends on Locomotive

CV 55.8.17: Cooling Fans Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the power applied to the fans to change from 0 to its maximum.
- Each unit represents 0.1 second. For example, a value of 25 represents 2.5 second.
- Valid values are 1...255, 1 being the least and 255 being the most amount of time.
- If the Ramp Up Time is 60, it takes 6.0 seconds for the light to go from off to bright.
- The default value corresponds to the length of the fan start record.

¹³⁵ This CV is supported only by version 9 Q3 firmware.

5.7.4.3 CV 55.8.18 Cooling Fans Ramp Down Time¹³⁶

This CV specifies the time for the cooling fans to go from “Max Power” to “Off”.

Default Value:

Depends on Locomotive

CV 55.8.18: Cooling Fans Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the power applied to the fans to change from its maximum to 0.
- Each unit represents 0.1 second. For example, a value of 25 represents 2.5 second.
- Valid values are 1...255, 1 being the least and 255 being the most amount of time.
- If the Ramp Down Time is 80, it takes 8.0 seconds for the light to go from bright to off.
- The default value corresponds to the length of the fan stop record.

¹³⁶ This CV is supported only by version 9 Q3 firmware.

5.7.5 CV 55.12.SI Spitter Valve

5.7.5.1 CV 55.12.1 Spitter Valve Minimum Interval

Use this CV to specify the minimum time interval for the diesel spitter valve sound to play.

Default Value:

5

CV 55.12.1: Spitter Valve Minimum Interval

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the minimum time interval in seconds between spitter valve sounds.
- The spitter valve sound plays at intervals randomly chosen between the CV55.12.1 and CV55.12.2 values. For example, if CV55.12.1 = 5 and CV55.12.2 = 10, the spitter valve sound will play at 5 to 10 second intervals.
- If CV55.12.2 is less than or equal to CV55.12.1, CV55.12.2 is not used and the spitter valve sound plays at a fixed interval specified by CV55.12.1.
- If CV55.12.1 = 0, the spitter valve sound will not play.

5.7.5.2 CV 55.12.2 Spitter Valve Maximum Interval

Use this CV to specify the maximum time interval for the diesel spitter valve sound to play.

Default Value:

10

CV 55.12.1: Spitter Valve Maximum Interval

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the maximum time interval in seconds between spitter valve sounds.
- The spitter valve sound plays at intervals randomly chosen between the CV55.12.1 and CV55.12.2 values. For example, if CV55.12.1 = 5 and CV55.12.2 = 10, the spitter valve sound will play at 5 to 10 second intervals.
- If CV55.12.2 is less than or equal to CV55.12.1, CV55.12.2 is not used and the spitter valve sound plays at a fixed interval specified by CV55.12.1.
- If CV55.12.1 = 0, the spitter valve sound will not play.

5.7.6 CV 55.13.SI Air Dryer

5.7.6.1 CV 55.13.1 Air Dryer Minimum Interval

Use this CV to specify the minimum time interval for the air dryer valve sound to play.

Default Value:

20

CV 55.12.1: Air Dryer Minimum Interval

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the minimum time interval in seconds between air dryer sounds.
- The air dryer sound plays at intervals randomly chosen between the CV55.13.1 and CV55.13.2 values. For example, if CV55.13.1 = 20 and CV55.13.2 = 25, the air dryer sound will play at 20 to 25 second intervals.
- If CV55.13.2 is less than or equal to CV55.13.1, CV55.13.2 is not used and the air dryer sound plays at a fixed interval specified by CV55.13.1.
- If CV55.13.1 = 0, the air dryer sound will not play.

5.7.6.2 CV 55.13.2 Air Dryer Maximum Interval

Use this CV to specify the maximum time interval for the air dryer sound to play.

Default Value:

25

CV 55.13.1: Air Dryer Maximum Interval

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the maximum time interval in seconds between air dryer sounds.
- The air dryer sound plays at intervals randomly chosen between the CV55.13.1 and CV55.13.2 values. For example, if CV55.13.1 = 20 and CV55.13.2 = 25, the air dryer sound will play at 20 to 25 second intervals.
- If CV55.13.2 is less than or equal to CV55.13.1, CV55.13.2 is not used and the air dryer sound plays at a fixed interval specified by CV55.13.1.
- If CV55.13.1 = 0, the air dryer sound will not play.

5.7.7 CV 55.21.SI Diesel Motor Parameters

5.7.7.1 CV 55.21.0 Speed Steps Per Notch¹³⁷

Use this CV to specify the number of speed steps between notches for your diesel locomotive.

Default Value:

10

CV 55.21.0: Speed Steps Per Notch Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies how DCC speed steps in 128 speed step mode map to notch levels for automatic diesel motor notching. In 14 or 28 speed step mode, the speed step is converted to 128 speed step format before this CV is applied.
- Valid values are 1...255. A value of 0 effectively disables automatic notching.
- The formula used to map the speed steps to notches is:

```

if ( CV55.21.0 != 0 ) {
    if ( Speed_Step == 0 ) {
        Notch_Level = 0;
    } else {
        Notch_Level = ((Speed_Step - 1) / CV55.21.0) + 1;
    }
}

```

- The default value of 10 maps speed steps to notch levels as follows:

Speed Step	Notch Level
0	0
1...10	1
11...20	2
21...30	3
31...40	4
41...50	5
51...60	6
61...70	7
71...126	8

- A value of 8 maps speed steps to notch levels as follows:

Speed Step	Notch Level
0	0
1...8	1
9...16	2
17...24	3
25...32	4
33...40	5
41...48	6
49...56	7
57...126	8

- A value of 15 maps speed steps to notch levels as follows:

Speed Step	Notch Level
0	0
1...15	1
16-30	2
31-45	3
44...60	4

¹³⁷ CV55.21.0 is replaced by CV129.1.0 in version 9 firmware.

61...75	5
76...90	6
91-105	7
106-126	8

5.7.7.2 CV 55.21.1 Low Idle Timeout¹³⁸

Use this CV to specify the time after entering neutral when a diesel motor automatically drops to low idle.

Default Value:

Depends on Locomotive

CV 55.21.1: Low Idle Timeout Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies the time that a diesel motor automatically drops to low idle after entering neutral (speed step 0 and locomotive stopped).
- Each unit represents 1 second. For example, if the CV has value 8, then the motor will drop to low idle 8 seconds after entering neutral.
- If the value of this CV is 0, the motor does not automatically drop to low idle.
- All function keys and the throttle remain enabled after the motor drops to low idle. By contrast, in the Standby stage of shutdown, where the diesel motor is also in low idle, most function keys and the throttle are disabled.
- The motor remains in low idle until one of the following events occurs:
 - The throttle is increased to speed step > 0.
 - F6 is double pressed, assuming the Startup (144) feature is assigned to F6.
- If you double press F6 after the locomotive enters neutral and before the countdown reaches 0, the motor will not drop to low idle.
- If the locomotive is in Disconnect (F9 double press) when the countdown reaches 0, the motor will drop to low idle. If the locomotive is then put into Standby, the motor remains in low idle.
- This CV is supported only by Q3 firmware running on FX decoders.

¹³⁸ CV55.21.1 is replaced by CV129.2.0 in version 9 firmware.

5.7.8 CV 55.70.SI Headlight

Three features can be assigned to function keys to control headlight operation:

Feature ID	Feature Name	Use
70	Automatic Headlight Activate	Activate/Deactivate Automatic Control of the Headlight
71	Headlight On	Explicitly turn the Headlight On/Off
72	Headlight Dim	Explicitly specify the Headlight be Dim/Bright

The headlight intensity (Off, Dim*, Bright) can be controlled automatically or explicitly.

Automatic Control

When the Feature 70 function state is 1, automatic control is activated. The headlight intensity changes automatically in response to changes to the locomotive's motive state.

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Bright	Dim*	Dim*	Dim*

The automatic behavior can be configured in CV 55.70.1.

Feature 70 has precedence over Features 71 and 72. When the Feature 70 function state is 1, the Feature 71 and 72 function states are ignored.

Explicit Control

When the Feature 70 function state is 0, automatic control is deactivated. The headlight intensity reverts to the Feature 71 and 72 function states.

Feature 72 Function State	Feature 71 Function State	Intensity
X	0	Off
0	1	Bright
1	1	Dim*

Feature 70 has precedence over Features 71 and 72. If the Feature 70 function state changes to 1, because of a Feature 70 function key press or a start up operation, automatic control is re-activated.

Feature 71 has precedence over Feature 72. If the Feature 71 function state is 0, the Feature 72 function state is ignored.

* If the headlight cannot be dimmed, then Dim = Off.

5.7.8.1 CV 55.70.0 Headlight Initial State

Use this CV to specify the startup state function states for the Headlight features.

Default Value:

1

CV 55.70.0: Headlight Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Gas Turbine Transition Light Behavior	Reserved	Reserved	Reserved	Reserved	Feature 72 Function State	Feature 71 Function State	Feature 70 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Headlight Activate (Feature 70) function.
- Bit 1 is the initial state of the Headlight On (Feature 71) function.
- Bit 2 is the initial state of the Headlight Dim (Feature 72) function.
- A write to this CV in operations mode causes the Feature 70, 71 and 72 function states to be immediately set to the new values.
- A start up operation causes the Feature 70, 71 and 72 function states to be set to the values in this CV.
- Bit 7 is used only with Gas Turbine firmware. If the value of bit 7 is 0, then the Headlight is turned off at the beginning of the Diesel to Turbine and Turbine to Diesel transition scenarios and turned back on when the scenarios end. If the value of bit 7 is 1, the Headlight remains in its current state during these scenarios. This bit also controls whether the Reverse Light, Mars Light, Rear Mars Light, Ditch Lights, and Rear Ditch Lights are turned off and back on during these scenarios.

5.7.8.2 CV 55.70.1 Automatic Headlight Configuration

Use this CV to configure the Automatic Headlight behavior¹³⁹.

Default Value:

86

CV 55.70.1: Automatic Headlight Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
NFR Intensity	NFR Intensity	REV Intensity	REV Intensity	NFF Intensity	NFF Intensity	FWD Intensity	FWD Intensity

- Default value = 01010110 binary = 56 hex = 86 decimal.
- Bits 0,1 specify the headlight intensity in FWD, bits 2,3 the intensity in NFF, bits 4,5 the intensity in REV, and bits 6,7 the intensity in NFR.

Bit 1 Bit 3 Bit 5 Bit 7	Bit 0 Bit 2 Bit 4 Bit 6	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Reserved

- The default settings specify the following behavior:

FWD	NFF	REV	NFR
Bright	Dim*	Dim*	Dim*

* If the headlight cannot be dimmed, then Dim = Off.

¹³⁹ CV55.70.1 does not affect headlight behavior in Analog DC.

5.7.8.3 CV 55.70.10 Headlight Dim Intensity

For models with a dimmable Headlight, this CV controls its dim intensity.

Default Value:

Depends on Locomotive

CV 55.70.10: Headlight Dim Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The default value is dependent on the model.
- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Headlight dimmed, you can observe the Headlight intensity change as you change the value of CV 55.70.10.

5.7.8.4 CV 55.70.12 Headlight Max Intensity

For models with a 256 intensity level Headlight, this CV controls its intensity when its state is “bright”.

Default Value:

255

CV 55.70.12: Headlight Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Headlight state “bright”, you can observe the Headlight intensity change as you change the value of CV 55.70.12.

5.7.8.5 CV 55.70.15 Headlight Ramp Up Rate¹⁴⁰

For models with a 256 intensity level Headlight, this CV controls the rate at which its intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

25

CV 55.70.15: Headlight Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 being the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Headlight to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Up Rate is 25, it takes 0.013 second for the Headlight to go from off to dim, and 0.089 second to go from dim to bright.

¹⁴⁰ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.8.6 CV 55.70.16 Headlight Ramp Down Rate¹⁴¹

For models with a 256 intensity level Headlight, this CV controls the rate at which its intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

25

CV 55.70.16: Headlight Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Headlight to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Down Rate is 25, it takes 0.089 second for the Headlight to go from bright to dim, and 0.013 second to go from dim to off.

¹⁴¹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.8.7 CV 55.70.17 Headlight Ramp Up Time¹⁴²

For models with a 256 intensity level Headlight, this CV controls the rate at which its intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

10

CV 55.70.17: Headlight Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Up Time is 120, it takes 0.3 second for the light to go from off to dim, and 0.9 second to go from dim to bright.

¹⁴² This CV replaces CV55.70.15 Headlight Ramp Up Rate.

5.7.8.8 CV 55.70.18 Headlight Ramp Down Time¹⁴³

For models with a 256 intensity level Headlight, this CV controls the rate at which its intensity decreases when it's state changes from bright to off, bright to dim, or dim to off.

Default Value:

10

CV 55.70.18: Headlight Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Down Time is 120, it takes 0.9 second for the light to go from bright to dim, and 0.3 second to go from dim to off.

¹⁴³ This CV replaces CV55.70.16 Headlight Ramp Down Rate.

5.7.8.9 CV 55.70.SI Headlight Examples

Example 1: I want the automatic headlight to be bright in all four motive states, NFF, REV and NFR as well as FWD.

Solution: Set CV 55.70.1 to 10101010 binary = AA hex = 170 decimal.

Example 2: How will the headlight behave if I set CV 55.70.0 to 00000111 binary = 07 hex = 7 decimal?

Answer: The automatic headlight is initially activated and the headlight intensity is controlled by the CV 55.70.1 settings. If the automatic headlight is deactivated, for example, by pressing FL so that the FL function state is 0, then the Feature 71 function state turns the headlight on, and the Feature 72 function state makes the headlight dim.

Example 3: I want explicit headlight on/off control at all times. At startup I want the headlight off until I turn it on with a function key. When the headlight is on, it should be bright.

Solution: First set CV 55.70.0 to 0. Next remove the automatic headlight feature from multiple automatic lights #1 by setting CV 55.136.0 bit 0 to 0. Finally in CV 53 assign feature 71 to a function output .

Example 4: Same as example 3, but I want to explicitly dim the headlight as well. When I first turn the headlight on, it should be dim.

Solution: First set CV 55.70.0 to 00000100 binary = 04 hex = 4 decimal. Next remove the automatic headlight feature from multiple automatic lights #1 by setting CV 55.136.0 bit 0 to 0. Finally in CV 53 assign feature 71 to a function output and feature 72 to a second function output.

Example 5: I want explicit control over whether the headlight is bright or dim, but the headlight will always be on. On startup the headlight should be dim.

Solution: First set CV 55.70.0 to 00000110 binary = 05 hex = 5 decimal. Next remove the Automatic Headlight feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 0 to 0. Finally in CV 53 assign feature 72 to a function output. You do not need to assign feature 71 to a function output.

5.7.9 CV 55.73.SI Reverse Light

Three features can be assigned to function keys to control reverse light operation:

Feature ID	Feature Name	Use
73	Automatic Reverse Light Activate	Activate/Deactivate Automatic Control of the Reverse Light
74	Reverse Light On	Explicitly turn the Reverse Light On/Off
75	Reverse Light Dim	Explicitly specify the Reverse Light be Dim/Bright

The reverse light intensity (Off, Dim*, Bright) can be controlled automatically or explicitly.

Automatic Control

When the Feature 73 function state is 1, automatic control is activated. The reverse light intensity changes automatically in response to changes to the locomotive's motive state.

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Dim*	Dim*	Bright	Dim*

The automatic behavior can be configured in CV 55.73.1.

Feature 73 has precedence over Features 74 and 75. When the Feature 73 function state is 1, the Feature 74 and 75 function states are ignored.

Explicit Control

When the Feature 73 function state is 0, automatic control is deactivated. The reverse light intensity changes in response to Feature 74 and 75 function key presses.

Feature 75 Function State	Feature 74 Function State	Intensity
X	0	Off
0	1	Bright
1	1	Dim*

If the Feature 73 function state changes to 1, because of a Feature 73 function key press or a start up operation, automatic control is re-activated.

Feature 74 has precedence over Feature 75. If the Feature 74 function state is 0, the Feature 75 function state is ignored.

* If the reverse light cannot be dimmed, then Dim = Off.

5.7.9.1 CV 55.73.0 Reverse Light Initial State

Use this CV to specify the startup state function states for the Reverse Light features.

Default Value:

1

CV 55.73.0: Reverse Light Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Feature 75 Function State	Feature 74 Function State	Feature 73 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Reverse Light Activate (Feature 73) function.
- Bit 1 is the initial state of the Reverse Light On (Feature 74) function.
- Bit 2 is the initial state of the Reverse Light Dim (Feature 75) function.
- A write to this CV in operations mode causes the Feature 73, 74 and 75 function states to be immediately set to the new values.
- A start up operation causes the Feature 73, 74 and 75 function states to be set to the values in this CV.

5.7.9.2 CV 55.73.1 Automatic Reverse Light Configuration

Use this CV to configure the Automatic Reverse Light behavior¹⁴⁴.

Default Value:

101

CV 55.73.1: Automatic Reverse Light Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
NFR Intensity	NFR Intensity	REV Intensity	REV Intensity	NFF Intensity	NFF Intensity	FWD Intensity	FWD Intensity

- Default value = 01100101 binary = 65 hex = 101 decimal.
- Bits 0,1 specify the reverse light intensity in FWD, bits 2,3 the intensity in NFF, bits 4,5 the intensity in REV, and bits 6,7 the intensity in NFR.

Bit 1 Bit 3 Bit 5 Bit 7	Bit 0 Bit 2 Bit 4 Bit 6	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Reserved

- The default settings specify the behavior:

FWD	NFF	REV	NFR
Dim*	Dim*	Bright	Dim*

* If the reverse light cannot be dimmed, then Dim = Off.

¹⁴⁴ CV55.73.1 does not affect reverse light behavior in Analog DC.

5.7.9.3 CV 55.73.10 Reverse Light Dim Intensity

For models with a dimmable Reverse Light, this CV controls its dim intensity.

Default Value:

Depends on Locomotive

CV 55.73.10: Reverse Light Dim Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The default value is dependent on the model.
- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Reverse Light dimmed, you can observe the Reverse Light intensity change as you change the value of CV 55.73.10.

5.7.9.4 CV 55.73.12 Reverse Light Max Intensity¹⁴⁵

For models with a 256 intensity level Reverse Light, this CV controls its intensity when its state is “bright”.

Default Value:

255

CV 55.73.12: Reverse Light Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Reverse Light state “bright”, you can observe the Reverse Light intensity change as you change the value of CV 55.73.12.

¹⁴⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.9.5 CV 55.73.15 Reverse Light Ramp Up Rate¹⁴⁶

For models with a 256 intensity level Reverse Light, this CV controls the rate at which its intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

25

CV 55.73.15: Reverse Light Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Reverse Light to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Up Rate is 25, it takes 0.013 second for the Reverse Light to go from off to dim, and 0.089 second to go from dim to bright.

¹⁴⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.9.6 CV 55.73.16 Reverse Light Ramp Down Rate¹⁴⁷

For models with a 256 intensity level Reverse Light, this CV controls the rate at which its intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

25

CV 55.73.16: Reverse Light Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Reverse Light to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Down Rate is 25, it takes 0.089 second for the Reverse Light to go from bright to dim, and 0.013 second to go from dim to off.

¹⁴⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.9.7 CV 55.73.17 Reverse Light Ramp Up Time¹⁴⁸

For models with a 256 intensity level reverse light, this CV controls the rate at which its intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

10

CV 55.73.17: Reverse Light Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Up Time is 120, it takes 0.3 second for the light to go from off to dim, and 0.9 second to go from dim to bright.

¹⁴⁸ This CV replaces CV55.73.15 Reverse Light Ramp Up Rate.

5.7.9.8 CV 55.73.18 Reverse Light Ramp Down Time¹⁴⁹

For models with a 256 intensity level reverse light, this CV controls the rate at which its intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

10

CV 55.73.18: Reverse Light Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Down Time is 120, it takes 0.9 second for the light to go from bright to dim, and 0.3 second to go from dim to off.

¹⁴⁹ This CV replaces CV55.73.16 Reverse Light Ramp Down Rate.

5.7.9.9 CV 55.73.SI Reverse Light Examples

Example 1: I want the automatic reverse light to be bright in all four motive states, NFF, REV and NFR as well as FWD.

Solution: Set CV 55.73.1 to 10101010 binary = AA hex = 170 decimal.

Example 2: How will the reverse light behave if I set CV 55.73.0 to 00000111 binary = 07 hex = 7 decimal?

Answer: The automatic reverse light is initially activated and the reverse light intensity is controlled by the CV 55.73.1 settings. If the automatic reverse light is deactivated, for example, by pressing FL so that the FL function state is 0, then the Feature 74 function state turns the reverse light on, and the Feature 75 function state makes the reverse light dim.

Example 3: I want explicit reverse light on/off control at all times. At startup I want the reverse light off until I turn it on with a function key. When the reverse light is on, it should be bright.

Solution: First set CV 55.73.0 to 0. Next remove the automatic reverse light feature from multiple automatic lights #1 by setting CV 55.136.0 bit 1 to 0. Finally in CV 53 assign Feature 74 to a function output.

Example 4: Same as example 3, but I want to explicitly dim the reverse light as well. When I first turn the reverse light on, it should be dim.

Solution: First set CV 55.73.0 to 00000100 binary = 04 hex = 4 decimal. Next remove the automatic reverse light feature from multiple automatic lights #1 by setting CV 55.136.0 bit 1 to 0. Finally in CV 53 assign Feature 74 to a function output and Feature 75 to a second function output.

5.7.10 CV 55.76.SI Mars Light

Four features can be assigned to function keys to control mars light operation:

Feature ID	Feature Name	Use
76	Automatic Mars Light Activate	Activate/Deactivate Automatic Control of the Mars Light
77	Mars Light On	Explicitly turn the Mars Light On/Off
78	Mars Light Dim	Explicitly specify the Mars Light be Dim/Bright
79	Mars Light Strobe	Explicitly turn on/off Mars Light strobe

The mars light intensity (Off, Dim, Bright, Strobe) can be controlled automatically or explicitly.

Automatic Control

When the Feature 76 function state is 1, automatic control is activated. The mars light intensity changes automatically in response to changes to the locomotive's motive state.

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Strobe	Dim	Dim	Dim

The automatic behavior can be configured in CV 55.76.1, CV 55.76.2, CV 55.76.3, and CV 55.76.4.

Feature 76 has precedence over Features 77, 78 and 79. When the Feature 76 function state is 1, the Feature 77, 78 and 79 function states are ignored.

Explicit Control

When the Feature 76 function state is 0, automatic control is deactivated. The Mars Light intensity changes in response to Feature 77, 78 and 79 function key presses.

Feature 79 Function State	Feature 78 Function State	Feature 77 Function State	Intensity
x	X	0	Off
0	0	1	Bright
0	1	1	Dim
1	X	1	Strobe

Feature 76 has precedence over Features 77, 78 and 79. If the Feature 76 function state changes to 1, because of a Feature 76 function key press or a start up operation, automatic control is re-activated.

Feature 77 has precedence over Features 78 and 79. If the Feature 77 function state is 0, the Feature 78 and 79 function states are ignored.

Feature 79 has precedence over Feature 78. If the Feature 79 function state is 1, the Feature 78 function state is ignored.

5.7.10.1 CV 55.76.0 Mars Light Initial State

Use this CV to specify the startup state function states for the Mars Light features.

Default Value:

1

CV 55.76.0: Mars Light Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Strobe with Horn	Feature 79 Function State	Feature 78 Function State	Feature 77 Function State	Feature 76 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Mars Light Activate (Feature 76) function.
- Bit 1 is the initial state of the Mars Light On (Feature 77) function.
- Bit 2 is the initial state of the Mars Light Dim (Feature 78) function.
- Bit 3 is the initial state of the Mars Light Strobe (Feature 79) function.
- If bit 4 = 1, under explicit control the mars light strobes when the horn blows. Note that if the mars light is already strobing, no change in mars light behavior will be observed when the horn blows. Bit 4 is applied even if the Feature 77 function state is 0, but is ignored if the Feature 76 function state is 1.
- A write to this CV in operations mode causes the Feature 76, 77, 78 and 79 function states to be immediately set to the new values.
- A start up operation causes the Feature 76, 77, 78 and 79 function states to be set to the values in this CV.

5.7.10.2 CV 55.76.1 Automatic Mars Light FWD Configuration

Use this CV to configure how the Automatic Mars Light behaves when the locomotive is in forward¹⁵⁰.

Default Value:

3

CV 55.76.1: Automatic Mars Light FWD Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000011 binary = 03 hex = 3 decimal (strobe).
- Bits 0 and 1 specify the mars light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in mars light behavior will be observed when the horn blows.

¹⁵⁰ CV55.76.1 does not affect mars light behavior in Analog DC.

5.7.10.3 CV 55.76.2 Automatic Mars Light NFF Configuration

Use this CV to configure how the Automatic Mars Light behaves when the locomotive is in neutral from forward¹⁵¹.

Default Value:

1

CV 55.76.2: Automatic Mars Light NFF Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000001 binary = 01 hex = 1 decimal (dim).
- Bits 0 and 1 specify the mars light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in mars light behavior will be observed when the horn blows.

¹⁵¹ CV55.76.2 does not affect mars light behavior in Analog DC.

5.7.10.4 CV 55.76.3 Automatic Mars Light REV Configuration

Use this CV to configure how the Automatic Mars Light behaves when the locomotive is in reverse¹⁵².

Default Value:

1

CV 55.76.3: Automatic Mars Light REV Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000001 binary = 01 hex = 1 decimal (dim).
- Bits 0 and 1 specify the mars light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in mars light behavior will be observed when the horn blows.

¹⁵² CV55.76.3 does not affect mars light behavior in Analog DC.

5.7.10.5 CV 55.76.4 Automatic Mars Light NFR Configuration

Use this CV to configure how the Automatic Mars Light behaves when the locomotive is in neutral from reverse¹⁵³.

Default Value:

1

CV 55.76.4: Automatic Mars Light NFR Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000001 binary = 01 hex = 1 decimal (dim).
- Bits 0 and 1 specify the mars light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in mars light behavior will be observed when the horn blows.

¹⁵³ CV55.76.4 does not affect mars light behavior in Analog DC.

5.7.10.6 CV 55.76.5 Mars Light Strobe Hold Time

Use this CV to specify the number of seconds the mars light continues to strobe after a horn blast ends.

Default Value:

5

CV 55.76.5: Mars Light Strobe Hold Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Hold Time				

- If Strobe with Horn is specified, this CV is applied at the end of a horn blast.
- Default value = 00000101 binary = 05 hex = 5 decimal.
- Valid values are 0...31 seconds.

5.7.10.7 CV 55.76.6 Mars Light Strobe Period

For models with a Mars Light, this CV controls its strobe rate.

Default Value:

100

CV 55.76.6: Mars Light Strobe Period

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 2...255. Each unit represents 0.01 second. A value of 100 represents 1.00 second. If the value of this CV is 0 or 1, a period of 0.02 second is used.
- The CV value is the time for one complete strobe cycle to complete.
- In Ops mode, with the Mars Light strobing, you can observe the Mars Light strobe rate change as you change the value of CV 55.76.6.

5.7.10.8 CV 55.76.10 Mars Light Dim Intensity

For models with a Mars Light, this CV controls its dim intensity.

Default Value:

Depends on Locomotive

CV 55.76.10: Mars Light Dim Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The default value is dependent on the model.
- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Mars Light dimmed, you can observe the Mars Light intensity change as you change the value of CV 55.76.10.

5.7.10.9 CV 55.76.11 Mars Light Min Intensity

For models with a Mars Light, this CV controls its minimum brightness when its state is “strobing”.

Default Value:

4

CV 55.76.11: Mars Light Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.76.11 to a value less than the value of CV55.76.13.
- In Ops mode, with the Mars Light strobing, you can observe the intensity change as you change the value of CV 55.76.11.

5.7.10.10 CV 55.76.12 Mars Light Max Intensity

For models with a Mars Light, this CV controls its intensity when its state is “bright” or “strobing”.

Default Value:

255

CV 55.76.12: Mars Light Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.76.12 to a value greater than the value of CV55.76.13.
- In Ops mode, with the Mars Light bright or strobing, you can observe the Mars Light intensity change as you change the value of CV 55.76.12.

5.7.10.11 CV 55.76.13 Mars Light Mid Intensity

For models with a Mars Light, this CV controls the brightness of the secondary strobe pulse.

Default Value:

32

CV 55.76.13: Mars Light Mid Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.76.13 to a value greater than the value of CV55.76.11 and less than the value of CV55.76.12.
- In Ops mode, with the Mars Light strobing, you can observe the intensity of the secondary strobe pulse change as you change the value of CV 55.76.13.

5.7.10.12 CV 55.76.15 Mars Light Ramp Up Rate¹⁵⁴

For models with a Mars Light, this CV controls the rate at which its intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

25

CV 55.76.15: Mars Light Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Mars Light to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Up Rate is 25, it takes 0.013 second for the Mars Light to go from off to dim, and 0.089 second to go from dim to bright.
- This CV does not affect the rate at which the Mars Light intensity changes while it is strobing.

¹⁵⁴ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.10.13 CV 55.76.16 Mars Light Ramp Down Rate¹⁵⁵

For models with a Mars Light, this CV controls the rate at which its intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

25

CV 55.76.16: Mars Light Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Mars Light to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Down Rate is 25, it takes 0.089 second for the Mars Light to go from bright to dim, and 0.013 second to go from dim to off.
- This CV does not affect the rate at which the Mars Light intensity changes while it is strobing.

¹⁵⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.10.14 CV 55.76.17 Mars Light Ramp Up Time¹⁵⁶

This CV controls the rate at which the Mars Light intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

10

CV 55.76.17: Mars Light Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Up Time is 120, it takes 0.3 second for the light to go from off to dim, and 0.9 second to go from dim to bright.
- This CV does not affect the rate at which the Mars Light intensity changes while it is strobing.

¹⁵⁶ This CV replaces CV55.76.15 Mars Light Ramp Up Rate.

5.7.10.15 CV 55.76.18 Mars Light Ramp Down Time¹⁵⁷

This CV controls the rate at which the Mars Light intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

10

CV 55.76.18: Mars Light Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Down Time is 120, it takes 0.9 second for the light to go from bright to dim, and 0.3 second to go from dim to off.
- This CV does not affect the rate at which the Mars Light intensity changes while it is strobing.

¹⁵⁷ This CV replaces CV55.76.16 Mars Light Ramp Down Rate.

5.7.10.16 CV 55.76.SI Mars Light Examples

Example 1: I want the automatic mars light to be bright (not strobing) in all four motive states, NFF, REV and NFR as well as FWD.

Solution: Set CV 55.76.1...4 to 00000010 binary = 02 hex = 2 decimal.

Example 2: How will the mars light behave if I set CV 55.76.0 to 00001111 binary = 0F hex = 15 decimal?

Answer: The automatic mars light is initially activated and the mars light intensity is controlled by the CV 55.76.1...4 settings. If the automatic mars light is deactivated, for example, by pressing FL so that the FL function state is 0, then the Feature 77 function state turns the mars light on, and the Feature 79 function state makes the mars light strobe.

Example 3: I want explicit mars light on/off control at all times. At startup I want the mars light off until I turn it on with a function key. When the mars light is on, it should strobe.

Solution: First set CV 55.76.0 to 00001000 binary = 08 hex = 8 decimal. Next remove the automatic mars light feature from multiple automatic lights #1 by setting CV 55.136.0 bit 2 to 0. Finally in CV 53 assign Feature 77 to a function output.

Example 4: Same as example 3, but I want to explicitly dim and strobe the mars light as well. When I first turn the mars light on, it should be dim.

Solution: First set CV 55.76.0 to 00000100 binary = 04 hex = 4 decimal. Next remove the automatic mars light feature from multiple automatic lights #1 by setting CV 55.136.0 bit 2 to 0. Finally in CV 53 assign Feature 77 to a function output, Feature 78 to a second function output, and Feature 79 to a third function output.

Example 5: I want to explicitly dim and strobe the mars light, but the mars light should be always on. On startup, the mars light should be dim.

Solution: First set CV 55.76.0 to 00000110 binary = 05 hex = 5 decimal. Next remove the Automatic Mars Light feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 2 to 0. Finally in CV 53 assign Feature 78 to a function output and Feature 79 to a second function output. You do not need to assign Feature 77 to a function output.

5.7.11 CV 55.80.SI Rear Mars Light

Four features can be assigned to function keys to control Rear Mars Light operation:

Feature ID	Feature Name	Use
80	Automatic Rear Mars Light Activate	Activate/Deactivate Automatic Control of the Rear Mars Light
81	Rear Mars Light On	Explicitly turn the Rear Mars Light On/Off
82	Rear Mars Light Dim	Explicitly specify the Rear Mars Light be Dim/Bright
83	Rear Mars Light Strobe	Explicitly turn on/off Rear Mars Light strobe

The rear mars light intensity (Off, Dim, Bright, and Strobe) can be controlled automatically or explicitly.

Automatic Control

When the Feature 80 function state is 1, automatic control is activated. The rear mars light intensity changes automatically in response to changes to the locomotive's motive state.

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Strobe	Dim	Dim	Dim

The automatic behavior can be configured in CV 55.80.1, CV 55.80.2, CV 55.80.3, and CV 55.80.4.

Feature 80 has precedence over Features 81, 82 and 83. When the Feature 80 function state is 1, the Feature 81, 82 and 83 function states are ignored.

Explicit Control

When the Feature 80 function state is 0, automatic control is deactivated. The Rear Mars Light intensity changes in response to Feature 81, 82 and 83 function key presses.

Feature 83 Function State	Feature 82 Function State	Feature 81 Function State	Intensity
x	X	0	Off
0	0	1	Bright
0	1	1	Dim
1	X	1	Strobe

Feature 80 has precedence over Features 81, 82 and 83. If the Feature 80 function state changes to 1, because of a Feature 80 function key press or a start up operation, automatic control is re-activated.

Feature 81 has precedence over Features 82 and 83. If the Feature 81 function state is 0, the Feature 82 and 83 function states are ignored.

Feature 83 has precedence over Feature 82. If the Feature 83 function state is 1, the Feature 82 function state is ignored.

5.7.11.1 CV 55.80.0 Rear Mars Light Initial State

Use this CV to specify the startup state function states for the Rear Mars Light features.

Default Value:

1

CV 55.80.0: Rear Mars Light Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Strobe with Horn	Feature 83 Function State	Feature 82 Function State	Feature 81 Function State	Feature 80 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Rear Mars Light Activate (Feature 80) function.
- Bit 1 is the initial state of the Rear Mars Light On (Feature 81) function.
- Bit 2 is the initial state of the Rear Mars Light Dim (Feature 82) function.
- Bit 3 is the initial state of the Rear Mars Light Strobe (Feature 83) function.
- If bit 4 = 1, under explicit control the rear mars light strobes when the horn blows. Note that if the rear mars light is already strobing, no change in rear mars light behavior will be observed when the horn blows. Bit 4 is applied even if the Feature 81 function state is 0, but is ignored if the Feature 80 function state is 1.
- A write to this CV in operations mode causes the Feature 80, 81, 82 and 83 function states to be immediately set to the new values.
- A start up operation causes the Feature 80, 81, 82 and 83 function states to be set to the values in this CV.

5.7.11.2 CV 55.80.1 Automatic Rear Mars Light FWD Configuration

Use this CV to configure how the Automatic Rear Mars Light behaves when the locomotive is in forward¹⁵⁸.

Default Value:

1

CV 55.80.1: Automatic Rear Mars Light FWD Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000001 binary = 01 hex = 1 decimal (dim).
- Bits 0 and 1 specify the Rear Mars Light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the rear mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in rear mars light behavior will be observed when the horn blows.

¹⁵⁸ CV55.80.1 does not affect rear mars light behavior in Analog DC.

5.7.11.3 CV 55.80.2 Automatic Rear Mars Light NFF Configuration

Use this CV to configure how the Automatic Rear Mars Light behaves when the locomotive is in neutral from forward¹⁵⁹.

Default Value:

1

CV 55.80.2: Automatic Rear Mars Light NFF Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000001 binary = 01 hex = 1 decimal (dim).
- Bits 0 and 1 specify the Rear Mars Light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the rear mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in rear mars light behavior will be observed when the horn blows.

¹⁵⁹ CV55.80.2 does not affect rear mars light behavior in Analog DC.

5.7.11.4 CV 55.80.3 Automatic Rear Mars Light REV Configuration

Use this CV to configure how the Automatic Rear Mars Light behaves when the locomotive is in reverse¹⁶⁰

Default Value:

3

CV 55.80.3: Automatic Rear Mars Light REV Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000011 binary = 03 hex = 3 decimal (strobe).
- Bits 0 and 1 specify the Rear Mars Light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the rear mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in rear mars light behavior will be observed when the horn blows.

¹⁶⁰ CV55.80.3 does not affect rear mars light behavior in Analog DC.

5.7.11.5 CV 55.80.4 Automatic Rear Mars Light NFR Configuration

Use this CV to configure how the Automatic Rear Mars Light behaves when the locomotive is in neutral from reverse¹⁶¹.

Default Value:

1

CV 55.80.4: Automatic Rear Mars Light NFR Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Strobe with Horn	Intensity	Intensity

- Default value = 00000001 binary = 01 hex = 1 decimal (dim).
- Bits 0 and 1 specify the Rear Mars Light intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the rear mars light strobos when the horn blows. Note that if the Intensity = Strobe, no change in rear mars light behavior will be observed when the horn blows.

¹⁶¹ CV55.80.4 does not affect rear mars light behavior in Analog DC.

5.7.11.6 CV 55.80.5 Rear Mars Light Strobe Hold Time

Use this CV to specify the number of seconds the rear mars light continues to strobe after a horn blast ends.

Default Value:

5

CV 55.80.5: Rear Mars Light Strobe Hold Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Hold Time				

- If Strobe with Horn is specified, this CV is applied at the end of a horn blast.
- Default value = 00000101 binary = 05 hex = 5 decimal.
- Valid values are 0...31 seconds.

5.7.11.7 CV 55.80.6 Rear Mars Light Strobe Period¹⁶²

For models with a Rear Mars Light, this CV controls its strobe rate.

Default Value:

100

CV 55.80.6: Rear Mars Light Strobe Period

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 2...255. Each unit represents 0.01 second. A value of 100 represents 1.00 second. If the value of this CV is 0 or 1, a period of 0.02 second is used.
- The CV value is the time for one complete strobe cycle to complete.
- In Ops mode, with the Rear Mars Light strobing, you can observe the Rear Mars Light strobe rate change as you change the value of CV 55.80.6.

¹⁶² This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.11.8 CV 55.80.10 Rear Mars Light Dim Intensity

For models with a Rear Mars Light, this CV controls its dim intensity.

Default Value:

Depends on Locomotive

CV 55.80.10: Rear Mars Light Dim Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The default value is dependent on the model.
- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Rear Mars Light dimmed, you can observe the Rear Mars Light intensity change as you change the value of CV 55.80.10.

5.7.11.9 CV 55.80.11 Rear Mars Light Min Intensity¹⁶³

For models with a Rear Mars Light, this CV controls its minimum brightness when its state is “strobing”.

Default Value:

4

CV 55.80.11: Rear Mars Light Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.80.11 to a value less than the value of CV55.80.13.
- In Ops mode, with the Rear Mars Light strobing, you can observe the intensity change as you change the value of CV 55.80.11.

¹⁶³ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.11.10 CV 55.80.12 Rear Mars Light Max Intensity¹⁶⁴

For models with a Rear Mars Light, this CV controls its intensity when its state is “bright” or “strobing”.

Default Value:

255

CV 55.80.12: Rear Mars Light Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.80.12 to a value greater than the value of CV55.80.13.
- In Ops mode, with the Rear Mars Light bright or strobing, you can observe the Rear Mars Light intensity change as you change the value of CV 55.80.12.

¹⁶⁴ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.11.11 CV 55.80.13 Rear Mars Light Mid Intensity¹⁶⁵

For models with a Rear Mars Light, this CV controls the brightness of the secondary strobe pulse.

Default Value:

32

CV 55.80.13: Rear Mars Light Mid Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.80.13 to a value greater than the value of CV55.80.11 and less than the value of CV55.80.12.
- In Ops mode, with the Rear Mars Light strobing, you can observe the intensity of the secondary strobe pulse change as you change the value of CV 55.80.13.

¹⁶⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.11.12 CV 55.80.15 Rear Mars Light Ramp Up Rate¹⁶⁶

For models with a Rear Mars Light, this CV controls the rate at which its intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

25

CV 55.80.15: Rear Mars Light Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Rear Mars Light to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Up Rate is 25, it takes 0.013 second for the Rear Mars Light to go from off to dim, and 0.089 second to go from dim to bright.
- This CV does not affect the rate at which the Rear Mars Light intensity changes while it is strobing.

¹⁶⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.11.13 CV 55.80.16 Rear Mars Light Ramp Down Rate¹⁶⁷

For models with a Rear Mars Light, this CV controls the rate at which its intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

25

CV 55.80.16: Rear Mars Light Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Rear Mars Light to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Down Rate is 25, it takes 0.089 second for the Rear Mars Light to go from bright to dim, and 0.013 second to go from dim to off.
- This CV does not affect the rate at which the Rear Mars Light intensity changes while it is strobing.

¹⁶⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.11.14 CV 55.80.17 Rear Mars Light Ramp Up Time¹⁶⁸

This CV controls the rate at which the Rear Mars Light intensity increases when its state changes from off to bright, off to dim, or dim to bright.

Default Value:

10

CV 55.80.17: Rear Mars Light Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Up Time is 120, it takes 0.3 second for the light to go from off to dim, and 0.9 second to go from dim to bright.
- This CV does not affect the rate at which the Rear Mars Light intensity changes while it is strobing.

¹⁶⁸ This CV replaces CV55.80.15 Rear Mars Light Ramp Up Rate.

5.7.11.15 CV 55.80.18 Rear Mars Light Ramp Down Time¹⁶⁹

This CV controls the rate at which the Rear Mars Light intensity decreases when its state changes from bright to off, bright to dim, or dim to off.

Default Value:

25

CV 55.80.18: Rear Mars Light Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Down Time is 120, it takes 0.9 second for the light to go from bright to dim, and 0.3 second to go from dim to off.
- This CV does not affect the rate at which the Rear Mars Light intensity changes while it is strobing.

¹⁶⁹ This CV replaces CV55.80.16 Rear Mars Light Ramp Down Rate.

5.7.11.16 CV 55.80.SI Rear Mars Light Examples

Example 1: I want the automatic rear mars light to be bright (not strobing) in all four motive states, NFF, REV and NFR as well as FWD.

Solution: Set CV 55.80.1...4 to 00000010 binary = 02 hex = 2 decimal.

Example 2: How will the rear mars light behave if I set CV 55.80.0 to 00001111 binary = 0F hex = 15 decimal?

Answer: The automatic rear mars light is initially activated and the rear mars light intensity is controlled by the CV 55.80.1...4 settings. If the automatic rear mars light is deactivated, for example, by pressing FL so that the FL function state is 0, then the Feature 81 function state turns the rear mars light on, and the Feature 83 function state makes the rear mars light strobe.

Example 3: I want explicit rear mars light on/off control at all times. At startup I want the rear mars light off until I turn it on with a function key. When the rear mars light is on, it should strobe.

Solution: First set CV 55.80.0 to 00001000 binary = 08 hex = 8 decimal. Next remove the automatic rear mars light feature from multiple automatic lights #1 by setting CV 55.136.0 bit 3 to 0. Finally in CV 53 assign Feature 81 to a function output.

Example 4: Same as example 3, but I want to explicitly dim and strobe the rear mars light as well. When I first turn the rear mars light on, it should be dim.

Solution: First set CV 55.80.0 to 00000100 binary = 04 hex = 4 decimal. Next remove the automatic rear mars light feature from multiple automatic lights #1 by setting CV 55.136.0 bit 3 to 0. Finally in CV 53 assign Feature 81 to a function output, Feature 82 to a second function output, and Feature 83 to a third function output.

Example 5: I want to explicitly dim and strobe the rear mars light, but the rear mars light should be always on. On startup, the rear mars light should be dim.

Solution: First set CV 55.80.0 to 00000110 binary = 05 hex = 5 decimal. Next remove the Automatic Rear Mars Light feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 3 to 0. Finally in CV 53 assign Feature 82 to a function output and Feature 83 to a second function output. You do not need to assign Feature 81 to a function output.

5.7.12 CV 55.84.SI Ditch Lights

Four features can be assigned to function keys to control ditch lights operation:

Feature ID	Feature Name	Use
84	Automatic Ditch Lights Activate	Activate/Deactivate Automatic Control of the Ditch Lights
85	Ditch Lights On	Explicitly turn the Ditch Lights On/Off
86	Ditch Lights Dim	Explicitly specify the Ditch Lights be Dim/Bright
87	Ditch Lights Strobe	Explicitly turn on/off Ditch Lights strobe

The ditch lights intensity (Off, Dim, Bright, Strobe) can be controlled automatically or explicitly.

Automatic Control

When the Feature 84 function state is 1, automatic control is activated. The ditch lights intensity changes automatically in response to changes to the locomotive's motive state.

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Bright	Off	Off	Off

The automatic behavior can be configured in CV 55.84.1, CV 55.84.2, CV 55.84.3, and CV 55.84.4.

Feature 84 has precedence over Features 85, 86 and 87. When the Feature 84 function state is 1, the Feature 85, 86 and 87 function states are ignored.

Explicit Control

When the Feature 84 function state is 0, automatic control is deactivated. The ditch lights intensity changes in response to Feature 85, 86 and 87 function key presses.

Feature 87 Function State	Feature 86 Function State	Feature 85 Function State	Intensity
X	X	0	Off
0	0	1	Bright
0	1	1	Dim*
1	X	1	Strobe

Feature 84 has precedence over Features 85, 86 and 87. If the Feature 84 function state changes to 1, because of a Feature 84 function key press or a start up operation, automatic control is re-activated.

Feature 85 has precedence over Features 86 and 87. If the Feature 85 function state is 0, the Feature 86 and 87 function states are ignored.

Feature 87 has precedence over Feature 86. If the Feature 87 function state is 1, the Feature 86 function state is ignored.

* If the ditch lights cannot be dimmed, then Dim = Off.

5.7.12.1 CV 55.84.0 Ditch Lights Initial State

Use this CV to specify the startup state function states for the Ditch Lights features.

Default Value:

1

CV 55.84.0: Ditch Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Off if Front Headlight Dim/Off	Reserved	Strobe with Bell	Strobe with Horn	Feature 87 Function State	Feature 86 Function State	Feature 85 Function State	Feature 84 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Ditch Lights Activate (Feature 84) function.
- Bit 1 is the initial state of the Ditch Lights On (Feature 85) function.
- Bit 2 is the initial state of the Ditch Lights Dim (Feature 86) function.
- Bit 3 is the initial state of the Ditch Lights Strobe (Feature 87) function.
- If bit 4 = 1, under explicit control the ditch lights strobe when the horn blows. Note that if the ditch lights are already strobing, no change in Ditch Lights behavior will be observed when the horn blows. Bit 4 is applied even if the Feature 85 function state is 0, but is ignored if the Feature 84 function state is 1.
- If bit 5 = 1, under explicit control the ditch lights strobe when the bell is on. Note that if the ditch lights are already strobing, no change in Ditch Lights behavior will be observed when the bell turns on. Bit 5 is applied even if the Feature 85 function state is 0, but is ignored if the Feature 84 function state is 1.
- If bit 7 = 1, the Ditch Lights automatically turn off if the Front Headlight turns dim or off. This applies to both automatic and explicit ditch lights control.
- A write to this CV in operations mode causes the Feature 84, 85, 86 and 87 function states to be immediately set to the new values.
- A start up operation causes the Feature 84, 85, 86 and 87 function states to be set to the values in this CV.

5.7.12.2 CV 55.84.1 Automatic Ditch Lights FWD Configuration

Use this CV to configure how the Automatic Ditch Lights behave when the locomotive is in forward¹⁷⁰.

Default Value:

6

CV 55.84.1: Automatic Ditch Lights FWD Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000110 binary = 06 hex = 6 decimal (bright, strobe with horn).
- Bits 0 and 1 specify the ditch lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the ditch lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the ditch lights cannot be dimmed, then Dim = Off.

¹⁷⁰ CV55.84.1 does not affect ditch light behavior in Analog DC.

5.7.12.3 CV 55.84.2 Automatic Ditch Lights NFF Configuration

Use this CV to configure how the Automatic Ditch Lights behave when the locomotive is in neutral from forward¹⁷¹.

Default Value:

0

CV 55.84.2: Automatic Ditch Lights NFF Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000000 binary = 00 hex = 0 decimal (off).
- Bits 0 and 1 specify the ditch lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the ditch lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the ditch lights cannot be dimmed, then Dim = Off.

¹⁷¹ CV55.84.2 does not affect ditch light behavior in Analog DC.

5.7.12.4 CV 55.84.3 Automatic Ditch Lights REV Configuration

Use this CV to configure how the Automatic Ditch Lights behave when the locomotive is in reverse¹⁷²

Default Value:

0

CV 55.84.3: Automatic Ditch Lights REV Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000000 binary = 00 hex = 0 decimal (off).
- Bits 0 and 1 specify the ditch lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the ditch lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the ditch lights cannot be dimmed, then Dim = Off.

¹⁷² CV55.84.3 does not affect ditch light behavior in Analog DC.

5.7.12.5 CV 55.84.4 Automatic Ditch Lights NFR Configuration

Use this CV to configure how the Automatic Ditch Lights behave when the locomotive is in neutral from reverse¹⁷³.

Default Value:

0

CV 55.84.4: Automatic Ditch Lights NFR Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000000 binary = 00 hex = 0 decimal (off).
- Bits 0 and 1 specify the ditch lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the ditch lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the ditch lights cannot be dimmed, then Dim = Off.

¹⁷³ CV55.84.4 does not affect ditch light behavior in Analog DC.

5.7.12.6 CV 55.84.5 Ditch Lights Strobe Hold Time

Use this CV to specify the number of seconds the ditch lights continue to strobe after a horn blast ends or the bell stops.

Default Value:

5

CV 55.84.5: Ditch Lights Strobe Hold Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Hold Time				

- If Strobe with Horn or Strobe with Bell is specified, this CV is applied at the end of a horn blast or when the bell stops.
- Default value = 00000101 binary = 05 hex = 5 decimal.
- Valid values are 0...31 seconds.

5.7.12.7 CV 55.84.6 Ditch Lights Strobe Period¹⁷⁴

For models with Ditch Lights, this CV controls their strobe rate.

Default Value:

100

CV 55.84.6: Ditch Lights Strobe Period

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 2...255. Each unit represents 0.01 second. A value of 100 represents 1.00 second. If the value of this CV is 0 or 1, a period of 0.02 second is used.
- The CV value is the time for one complete strobe cycle of both ditch lights to complete.
- In Ops mode, with the Ditch Lights strobing, you can observe the strobe rate change as you change the value of CV 55.84.6.

¹⁷⁴ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.12.8 CV 55.84.10 Ditch Lights Dim Intensity

For models with dimmable Ditch Lights, this CV controls the dim intensity.

Default Value:

Depends on Locomotive

CV 55.84.10: Ditch Lights Dim Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The default value is dependent on the model.
- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Ditch Lights dimmed, you can observe the Ditch Lights intensity change as you change the value of CV 55.84.10.

5.7.12.9 CV 55.84.11 Ditch Lights Min Intensity¹⁷⁵

For models with Ditch Lights, this CV controls its minimum brightness when its state is “strobing”.

Default Value:

0

CV 55.84.11: Ditch Lights Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.84.11 to a value less than the value of CV55.84.12.
- In Ops mode, with the Ditch Lights strobing, you can observe the minimum intensity change as you change the value of CV 55.84.11.

¹⁷⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.12.10 CV 55.84.12 Ditch Lights Max Intensity¹⁷⁶

For models with 256 intensity level Ditch Lights, this CV controls its intensity when its state is “bright” or “strobing”.

Default Value:

255

CV 55.84.12: Ditch Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Ditch Lights state “bright” or “strobing”, you can observe the Ditch Lights intensity change as you change the value of CV 55.84.12.

¹⁷⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.12.11 CV 55.84.15 Ditch Lights Ramp Up Rate¹⁷⁷

For models with 256 intensity level Ditch Lights, this CV controls the rate at which the intensity increases when the state changes from off to bright, off to dim, or dim to bright, or when strobing.

Default Value:

25

CV 55.84.15: Ditch Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Ditch Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Up Rate is 25, it takes 0.013 second for the Ditch Lights to go from off to dim, and 0.089 second to go from dim to bright.
- This CV does affect the rate at which the Ditch Lights intensity changes when they are strobing.

¹⁷⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.12.12 CV 55.84.16 Ditch Lights Ramp Down Rate¹⁷⁸

For models with a 256 intensity level Ditch Lights, this CV controls the rate at which the intensity decreases when the state changes from bright to off, bright to dim, or dim to off, or when strobing.

Default Value:

25

CV 55.84.16: Ditch Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Ditch Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Down Rate is 25, it takes 0.089 second for the Ditch Lights to go from bright to dim, and 0.013 second to go from dim to off.
- This CV does affect the rate at which the Ditch Lights intensity changes when they are strobing.

¹⁷⁸ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.12.13 CV 55.84.17 Ditch Lights Ramp Up Time¹⁷⁹

For models with 256 intensity level Ditch Lights, this CV controls the rate at which the intensity increases when the state changes from off to bright, off to dim, or dim to bright, or when strobing.

Default Value:

10

CV 55.84.17: Ditch Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Up Time is 120, it takes 0.3 second for the light to go from off to dim, and 0.9 second to go from dim to bright.
- This CV does affect the rate at which the Ditch Lights intensity changes when they are strobing.

¹⁷⁹ This CV replaces CV55.84.15 Ditch Lights Ramp Up Rate.

5.7.12.14 CV 55.84.18 Ditch Lights Ramp Down Time¹⁸⁰

For models with 256 intensity level Ditch Lights, this CV controls the rate at which the intensity decreases when the state changes from bright to off, bright to dim, or dim to off, or when strobing.

Default Value:

10

CV 55.84.18: Ditch Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Down Time is 120, it takes 0.9 second for the light to go from bright to dim, and 0.3 second to go from dim to off.
- This CV does affect the rate at which the Ditch Lights intensity changes when they are strobing.

¹⁸⁰ This CV replaces CV55.84.16 Ditch Lights Ramp Down Rate.

5.7.12.15 CV 55.84.SI Ditch Lights Examples

Example 1: I want the automatic ditch lights to be bright (not strobing) in all four motive states, NFF, REV and NFR as well as FWD. I want the ditch lights to strobe when the horn blows in both FWD and REV.

Solution: Set CV 55.84.1 and CV 55.84.3 to 00000110 binary = 06 hex = 6 decimal. Set CV 55.84.2 and CV 55.84.4 to 00000010 binary = 02 hex = 2 decimal.

Example2: I want the automatic ditch lights to be off in all four motive states. But I want the ditch lights to strobe when the horn blows in both FWD and REV.

Solution: Set CV 55.84.1 and CV 55.84.3 to 00000100 binary = 04 hex = 4 decimal. Set CV 55.84.2 and CV 55.84.4 to 0.

Example 3: How will the ditch lights behave if I set CV 55.84.0 to 00011111 binary = 1F hex = 31 decimal?

Answer: The automatic ditch lights are initially activated and the ditch lights intensity is controlled by the CV 55.84.1...4 settings. If the automatic ditch lights are deactivated, for example, by pressing FL so that the FL function state is 0, then the Feature 85 function state turns the ditch lights on, and the Feature 87 function state makes the ditch lights strobe.

Example 4: I want explicit ditch lights on/off control at all times. At startup I want the ditch lights off until I turn them on with a function key. When the ditch lights are on, they should be bright (not strobing).

Solution: First set CV 55.84.0 to 0. Next remove the automatic ditch lights feature from multiple automatic lights #1 by setting CV 55.136.0 bit 4 to 0. Finally in CV 53 assign Feature 85 to a function output.

Example 5: Same as example 4, but I want to explicitly dim and strobe the ditch lights as well. When I first turn the ditch lights on, they should be bright.

Solution: First set CV 55.84.0 to 0. Next remove the automatic ditch lights feature from multiple automatic lights #1 by setting CV 55.136.0 bit 4 to 0. Finally in CV 53 assign Feature 85 to a function output, Feature 86 to a second function output, and Feature 87 to a third function output.

Example 6: I want to explicitly strobe the ditch lights, but when not strobing the ditch lights should be always bright.

Solution: First set CV 55.84.0 to 00000010 binary = 02 hex = 2 decimal. Next remove the Automatic Ditch Lights feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 4 to 0. Finally in CV 53 assign Feature 87 to a function output. You do not need to assign Feature 85 to a function output.

Example7: Similar to example 2, I want the automatic ditch lights to be off in all four motive states. But I want the ditch lights to strobe when the horn blows in FWD only. Further, I want this behavior even if FL is 0.

Solution: First set CV 55.84.0 to 1. Then set CV 55.84.1 to 00000100 binary = 04 hex = 4 decimal. Set CV 55.84.2, CV 55.84.3 and CV 55.84.4 to 0. Finally remove the Automatic Ditch Lights feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 4 to 0.

5.7.13 CV 55.88.SI Rear Ditch Lights

Four features can be assigned to function keys to control Rear Ditch Lights operation:

Feature ID	Feature Name	Use
88	Automatic Rear Ditch Lights Activate	Activate/Deactivate Automatic Control of the Rear Ditch Lights
89	Rear Ditch Lights On	Explicitly turn the Rear Ditch Lights On/Off
90	Rear Ditch Lights Dim	Explicitly specify the Rear Ditch Lights be Dim/Bright
91	Rear Ditch Lights Strobe	Explicitly turn on/off Rear Ditch Lights strobe

The Rear Ditch Lights intensity (Off, Dim, Bright, Strobe) can be controlled automatically or explicitly.

Automatic Control

When the Feature 88 function state is 1, automatic control is activated. The Rear Ditch Lights intensity changes automatically in response to changes to the locomotive's motive state.

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Bright	Off	Off	Off

The automatic behavior can be configured in CV 55.88.1, CV 55.88.2, CV 55.88.3, and CV 55.88.4.

Feature 88 has precedence over Features 89, 90 and 91. When the Feature 88 function state is 1, the Feature 89, 90 and 91 function states are ignored.

Explicit Control

When the Feature 88 function state is 0, automatic control is deactivated. The Rear Ditch Lights intensity changes in response to Feature 89, 90 and 91 function key presses.

Feature 91 Function State	Feature 90 Function State	Feature 89 Function State	Intensity
X	X	0	Off
0	0	1	Bright
0	1	1	Dim*
1	X	1	Strobe

Feature 88 has precedence over Features 89, 90 and 91. If the Feature 88 function state changes to 1, because of a Feature 88 function key press or a start up operation, automatic control is re-activated.

Feature 89 has precedence over Features 90 and 91. If the Feature 89 function state is 0, the Feature 90 and 91 function states are ignored.

Feature 91 has precedence over Feature 90. If the Feature 91 function state is 1, the Feature 90 function state is ignored.

* If the Rear Ditch Lights cannot be dimmed, then Dim = Off.

5.7.13.1 CV 55.88.0 Rear Ditch Lights Initial State

Use this CV to specify the startup state function states for the Rear Ditch Lights features.

Default Value:

1

CV 55.88.0: Rear Ditch Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Off if Rear Headlight Dim/Off	Reserved	Strobe with Bell	Strobe with Horn	Feature 91 Function State	Feature 90 Function State	Feature 89 Function State	Feature 88 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Rear Ditch Lights Activate (Feature 88) function.
- Bit 1 is the initial state of the Rear Ditch Lights On (Feature 89) function.
- Bit 2 is the initial state of the Rear Ditch Lights Dim (Feature 90) function.
- Bit 3 is the initial state of the Rear Ditch Lights Strobe (Feature 91) function.
- If bit 4 = 1, under explicit control the Rear Ditch Lights strobe when the horn blows. Note that if the Rear Ditch Lights are already strobing, no change in Rear Ditch Lights behavior will be observed when the horn blows. Bit 4 is applied even if the Feature 89 function state is 0, but is ignored if the Feature 88 function state is 1.
- If bit 5 = 1, under explicit control the Rear Ditch Lights strobe when the bell is on. Note that if the Rear Ditch Lights are already strobing, no change in Rear Ditch Lights behavior will be observed when the bell turns on. Bit 5 is applied even if the Feature 89 function state is 0, but is ignored if the Feature 88 function state is 1.
- If bit 7 = 1, the Rear Ditch Lights automatically turn off if the Rear Headlight turns dim or off. This applies to both automatic and explicit rear ditch lights control.
- A write to this CV in operations mode causes the Feature 88, 89, 90 and 91 function states to be immediately set to the new values.
- A start up operation causes the Feature 88, 89, 90 and 91 function states to be set to the values in this CV.

5.7.13.2 CV 55.88.1 Automatic Rear Ditch Lights FWD Configuration

Use this CV to configure how the Automatic Rear Ditch Lights behave when the locomotive is in forward¹⁸¹.

Default Value:

0

CV 55.88.1: Automatic Rear Ditch Lights FWD Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000000 binary = 00 hex = 0 decimal (off).
- Bits 0 and 1 specify the Rear Ditch Lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the Rear Ditch Lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in Rear Ditch Lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the Rear Ditch Lights cannot be dimmed, then Dim = Off.

¹⁸¹ CV55.88.1 does not affect rear ditch light behavior in Analog DC.

5.7.13.3 CV 55.88.2 Automatic Rear Ditch Lights NFF Configuration

Use this CV to configure how the Automatic Rear Ditch Lights behave when the locomotive is in neutral from forward¹⁸².

Default Value:

0

CV 55.88.2: Automatic Rear Ditch Lights NFF Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000000 binary = 00 hex = 0 decimal (off).
- Bits 0 and 1 specify the Rear Ditch Lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the Rear Ditch Lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in Rear Ditch Lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the Rear Ditch Lights cannot be dimmed, then Dim = Off.

¹⁸² CV55.88.2 does not affect rear ditch light behavior in Analog DC.

5.7.13.4 CV 55.88.3 Automatic Rear Ditch Lights REV Configuration

Use this CV to configure how the Automatic Rear Ditch Lights behave when the locomotive is in reverse¹⁸³.

Default Value:

6

CV 55.88.3: Automatic Rear Ditch Lights REV Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000110 binary = 06 hex = 6 decimal (bright, strobe with horn).
- Bits 0 and 1 specify the Rear Ditch Lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the Rear Ditch Lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in Rear Ditch Lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the Rear Ditch Lights cannot be dimmed, then Dim = Off.

¹⁸³ CV55.88.3 does not affect rear ditch light behavior in Analog DC.

5.7.13.5 CV 55.88.4 Automatic Rear Ditch Lights NFR Configuration

Use this CV to configure how the Automatic Rear Ditch Lights behave when the locomotive is in neutral from reverse¹⁸⁴.

Default Value:

0

CV 55.88.4: Automatic Rear Ditch Lights NFR Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Strobe with Bell	Strobe with Horn	Intensity	Intensity

- Default value = 00000000 binary = 00 hex = 0 decimal (off).
- Bits 0 and 1 specify the Rear Ditch Lights intensity.

Bit 1	Bit 0	Intensity
0	0	Off
0	1	Dim*
1	0	Bright
1	1	Strobe

- If bit 2 = 1, the Rear Ditch Lights strobe when the horn blows. Note that if the Intensity = Strobe, no change in Rear Ditch Lights behavior will be observed when the horn blows.
- If bit 3 = 1, the ditch lights strobe when the bell is on. Note that if the Intensity = Strobe, no change in ditch lights behavior will be observed when the bell turns on.

* If the Rear Ditch Lights cannot be dimmed, then Dim = Off.

¹⁸⁴ CV55.88.4 does not affect rear ditch light behavior in Analog DC.

5.7.13.6 CV 55.88.5 Rear Ditch Lights Strobe Hold Time

Use this CV to specify the number of seconds the Rear Ditch Lights continue to strobe after a horn blast ends or the bell stops.

Default Value:

5

CV 55.88.5: Rear Ditch Lights Strobe Hold Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Hold Time				

- If Strobe with Horn or Strobe with Bell is specified, this CV is applied at the end of a horn blast or when the bell stops.
- Default value = 00000101 binary = 05 hex = 5 decimal.
- Valid values are 0...31 seconds.

5.7.13.7 CV 55.88.6 Rear Ditch Lights Strobe Period¹⁸⁵

For models with Rear Ditch Lights, this CV controls their strobe rate.

Default Value:

100

CV 55.88.6: Rear Ditch Lights Strobe Period

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 2...255. Each unit represents 0.01 second. A value of 100 represents 1.00 second. If the value of this CV is 0 or 1, a period of 0.02 second is used.
- The CV value is the time for one complete strobe cycle of both rear ditch lights to complete.
- In Ops mode, with the Rear Ditch Lights strobing, you can observe the strobe rate change as you change the value of CV 55.88.6.

¹⁸⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.13.8 CV 55.88.10 Rear Ditch Lights Dim Intensity

For models with dimmable Rear Ditch Lights, this CV controls the dim intensity.

Default Value:

Depends on Locomotive

CV 55.88.10: Rear Ditch Lights Dim Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The default value is dependent on the model.
- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Rear Ditch Lights dimmed, you can observe the Rear Ditch Lights intensity change as you change the value of CV 55.88.10.

5.7.13.9 CV 55.88.11 Rear Ditch Lights Min Intensity¹⁸⁶

For models with Rear Ditch Lights, this CV controls its minimum brightness when its state is “strobing”.

Default Value:

0

CV 55.88.11: Rear Ditch Lights Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.88.11 to a value less than the value of CV55.88.12.
- In Ops mode, with the Rear Ditch Lights strobing, you can observe the minimum intensity change as you change the value of CV 55.88.11.

¹⁸⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.13.10 CV 55.88.12 Rear Ditch Lights Max Intensity¹⁸⁷

For models with 256 intensity level Rear Ditch Lights, this CV controls its intensity when its state is “bright” or “strobing”.

Default Value:

255

CV 55.88.12: Rear Ditch Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, with the Rear Ditch Lights state “bright” or “strobing”, you can observe the Rear Ditch Lights intensity change as you change the value of CV 55.88.12.

¹⁸⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.13.11 CV 55.88.15 Rear Ditch Lights Ramp Up Rate¹⁸⁸

For models with 256 intensity level Rear Ditch Lights, this CV controls the rate at which the intensity increases when the state changes from off to bright, off to dim, or dim to bright, or when strobing.

Default Value:

25

CV 55.88.15: Rear Ditch Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Rear Ditch Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Up Rate is 25, it takes 0.013 second for the Rear Ditch Lights to go from off to dim, and 0.089 second to go from dim to bright.
- This CV does affect the rate the Rear Ditch Lights intensity changes while they are strobing.

¹⁸⁸ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.13.12 CV 55.88.16 Rear Ditch Lights Ramp Down Rate¹⁸⁹

For models with a 256 intensity level Rear Ditch Lights, this CV controls the rate at which the intensity decreases when the state changes from bright to off, bright to dim, or dim to off, or when strobing.

Default Value:

25

CV 55.88.16: Rear Ditch Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Rear Ditch Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- If the Dim Intensity is 32 and the Max Intensity is 255, and the Ramp Down Rate is 25, it takes 0.089 second for the Rear Ditch Lights to go from bright to dim, and 0.013 second to go from dim to off.
- This CV does affect the rate at which the Rear Ditch Lights intensity changes when they are strobing.

¹⁸⁹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.13.13 CV 55.88.17 Rear Ditch Lights Ramp Up Time¹⁹⁰

For models with 256 intensity level Rear Ditch Lights, this CV controls the rate at which the Rear Ditch Lights intensity increases when the state changes from off to bright, off to dim, or dim to bright, or when strobing.

Default Value:

10

CV 55.88.17: Rear Ditch Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Up Time is 120, it takes 0.3 second for the light to go from off to dim, and 0.9 second to go from dim to bright.
- This CV does affect the rate at which the Rear Ditch Lights intensity changes when they are strobing.

¹⁹⁰ This CV replaces CV55.88.15 Rear Ditch Lights Ramp Up Rate.

5.7.13.14 CV 55.88.18 Rear Ditch Lights Ramp Down Time¹⁹¹

For models with 256 intensity level Rear Ditch Lights, this CV controls the rate at which the Rear Ditch Lights intensity decreases when the state changes from bright to off, bright to dim, or dim to off, or when strobing.

Default Value:

10

CV 55.88.18: Rear Ditch Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- If the Dim Intensity is 64 and the Max Intensity is 255, and the Ramp Down Time is 120, it takes 0.9 second for the light to go from bright to dim, and 0.3 second to go from dim to off.
- This CV does affect the rate at which the Ditch Lights intensity changes when they are strobing.

¹⁹¹ This CV replaces CV55.88.16 Rear Ditch Lights Ramp Down Rate.

5.7.13.15 CV 55.88.SI Rear Ditch Lights Examples

Example 1: I want the automatic rear ditch lights to be bright (not strobing) in all four motive states, NFF, REV and NFR as well as FWD. I want the ditch lights to strobe when the horn blows in both FWD and REV.

Solution: Set CV 55.88.1 and CV 55.88.3 to 00000110 binary = 06 hex = 6 decimal. Set CV 55.88.2 and CV 55.88.4 to 00000010 binary = 02 hex = 2 decimal.

Example2: I want the automatic rear ditch lights to be off in all four motive states. But I want the rear ditch lights to strobe when the horn blows in both FWD and REV.

Solution: Set CV 55.88.1 and CV 55.88.3 to 00000100 binary = 04 hex = 4 decimal. Set CV 55.88.2 and CV 55.88.4 to 0.

Example 3: How will the rear ditch lights behave if I set CV 55.88.0 to 00011111 binary = 1F hex = 31 decimal?

Answer: The automatic rear ditch lights are initially activated and the rear ditch lights intensity is controlled by the CV 55.88.1...4 settings. If the automatic rear ditch lights are deactivated, for example, by pressing FL so that the FL function state is 0, then the Feature 89 function state turns the rear ditch lights on, and the Feature 91 function state makes the rear ditch lights strobe.

Example 4: I want explicit rear ditch lights on/off control at all times. At startup I want the rear ditch lights off until I turn them on with a function key. When the rear ditch lights are on, they should be bright (not strobing).

Solution: First set CV 55.88.0 to 0. Next remove the automatic rear ditch lights feature from multiple automatic lights #1 by setting CV 55.136.0 bit 5 to 0. Finally in CV 53 assign Feature 89 to a function output.

Example 5: Same as example 4, but I want to explicitly dim and strobe the rear ditch lights as well. When I first turn the rear ditch lights on, they should be bright.

Solution: First set CV 55.88.0 to 0. Next remove the automatic rear ditch lights feature from multiple automatic lights #1 by setting CV 55.136.0 bit 5 to 0. Finally in CV 53 assign Feature 89 to a function output, Feature 90 to a second function output, and Feature 91 to a third function output.

Example 6: I want to explicitly strobe the rear ditch lights, but when not strobing the rear ditch lights should be always bright.

Solution: First set CV 55.88.0 to 00000010 binary = 02 hex = 2 decimal. Next remove the Automatic Rear Ditch Lights feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 5 to 0. Finally in CV 53 assign Feature 91 to a function output. You do not need to assign Feature 89 to a function output.

Example7: Similar to example 2, I want the automatic rear ditch lights to be off in all four motive states. But I want the rear ditch lights to strobe when the horn blows in FWD only. Further, I want this behavior even if FL is 0.

Solution: First set CV 55.88.0 to 1. Then set CV 55.88.1 to 00000100 binary = 04 hex = 4 decimal. Set CV 55.88.2, CV 55.88.3 and CV 55.88.4 to 0. Finally remove the Automatic Rear Ditch Lights feature from Multiple Automatic Lights #1 by setting CV 55.136.0 bit 5 to 0.

5.7.14 CV 55.92.SI Overhead Beacon Light

Two features can be assigned to function keys to control overhead beacon light operation:

Feature ID	Feature Name	Use
92	Automatic OHBL Activate	Activate/Deactivate Automatic Control of the OHBL
93	OHBL On	Explicitly turn the OHBL On/Off

Automatic Control

When the Feature 92 function state is 1, automatic control is activated. The OHBL intensity changes automatically in response to changes to the locomotive's motive state.

The automatic behavior can be configured in CV 55.92.1.

Feature 92 has precedence over Feature 93. When the Feature 92 function state is 1, the Feature 93 function state is ignored.

Explicit Control

When the Feature 92 function state is 0, automatic control is deactivated. The OHBL intensity changes in response to Feature 93 function key presses.

Feature 93 Function State	Intensity
0	Off
1	On

Effects

Six different OHBL lighting effects can be selected using CV55.92.1¹⁹².

Blinking Light: the intensity increases to max intensity (CV55.92.12) and decreases to min intensity (CV55.92.11) using CV55.92.16 Ramp Up Time (or CV55.92.15), and CV55.92.18 Ramp Down Time (or CV55.92.16).

Rotary Light: the intensity uses CV55.92.12, CV55.92.11, and a pre-defined ramp profile to simulate a rotating light.

Strobe Light (Single Pulse): the intensity goes from 0 to max intensity (CV55.92.12) instantly, stays at max intensity for a specified time (CV55.92.11), and then instantly decreases to 0.

Prime Beacon: the intensity uses CV55.92.12, CV55.92.11, and a pre-defined ramp profile to simulate a beacon consisting of 4 lights spaced 90 degrees apart which turn on sequentially.

Prime Beacon X4: four lights are turned off and on sequentially using CV55.92.12, CV55.92.11, CV55.92.16, and CV55.92.18.¹⁹³

Strobe Light (Double Pulse): for the 1st pulse, the intensity goes from 0 to max intensity (CV55.92.12) instantly, stays at max intensity for a specified time (CV55.92.11), instantly decreases to 0, and stays at 0 for a specified time (CV55.92.17). For the 2nd pulse, the intensity goes from 0 to max intensity (CV55.92.19) instantly, stays at max intensity for a specified time (CV55.92.18), instantly decreases to 0, and stays at 0 for the remainder of the cycle.¹⁹⁴

¹⁹² For Q1 decoders running Q1a firmware only the Strobe Light (Single Pulse) effect is available. You can obtain a Blinking Light effect by increasing the value of CV55.92.11.

¹⁹³ The Prime Beacon X4 effect requires 4 light outputs connected to 4 light bulbs and is available with Q3 decoders only.

¹⁹⁴ The Strobe Light (Double Pulse) effect is available with Q3 decoders only.

5.7.14.1 CV 55.92.0 OHBL Initial State

Use this CV to specify the startup state function states for the OHBL features.

Default Value:

31

CV 55.92.0: OHBL Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Effect	Effect	Effect	Reserved	On with Bell	Feature 93 Function State	Feature 92 Function State

- Default value = 00100001 binary = 21 hex = 31 decimal (Strobe Light Effect and Automatic Control Activated).
- Bit 0 is the initial state of the Automatic OHBL Activate (Feature 92) function.
- Bit 1 is the initial state of the OHBL On (Feature 93) function.
- If bit 2 is "1", under explicit control the OHBL turns on when the bell turns on and turns off when the bell turns off. If the Feature 93 state is "1", the OHBL is already on and this bit is ignored.
- Bits 4, 5, and 6 specify the OBHL effect. Six effects are supported¹⁹⁵:

Bit 6	Bit 5	Bit 4	Effect
0	0	0	Blinking Light
0	0	1	Rotary Light
0	1	0	Strobe Light (Single Pulse)
0	1	1	Prime Beacon
1	0	0	Prime Beacon X4 ¹⁹⁶
1	0	1	Strobe Light (Double Pulse) ¹⁹⁷

- A write to this CV in operations mode causes the Feature 92 and 93 function states to be immediately set to the new values.
- A start up operation causes the Feature 92 and 93 function states to be set to the values in this CV.

¹⁹⁵ For Q1 decoders running Q1a firmware Bits 4, 5, and 6 are reserved and should be "0". The firmware only provides the Strobe Light effect. You can obtain a Blinking Light effect by increasing the value of CV55.92.11.

¹⁹⁶ The Prime Beacon X4 effect is available only with Q3 decoders.

¹⁹⁷ The Strobe Light (Double Pulse) effect is available only with Q3 decoders.

5.7.14.2 CV 55.92.1 Automatic OHBL Configuration

Use this CV to configure the Automatic OHBL behavior¹⁹⁸.

Default Value:

85

CV 55.92.1: Automatic OHBL Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
NFR Intensity	NFR Intensity	REV Intensity	REV Intensity	NFF Intensity	NFF Intensity	FWD Intensity	FWD Intensity

- Default value = 01010101 binary = 55 hex = 85 decimal.
- Bits 0,1 specify the OHBL intensity in FWD, bits 2,3 the intensity in NFF, bits 4,5 the intensity in REV, and bits 6,7 the intensity in NFR.

Bit 1 Bit 3 Bit 5 Bit 7	Bit 0 Bit 2 Bit 4 Bit 6	Intensity
0	0	Off
0	1	On
1	0	On with Bell
1	1	Reserved

- The default settings specify the following behavior:

FWD	NFF	REV	NFR
On	On	On	On

- “On with Bell” means the OHBL turns on automatically when the bell turns on and turns off automatically when the bell turns off.

¹⁹⁸ CV55.92.1 does not affect OHBL behavior in Analog DC.

5.7.14.3 CV 55.92.6 OHBL Period

For models with an OHBL, this CV controls its blink, revolve, or strobe rate.

Default Value:

100

CV 55.92.6: OHBL Period

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 2...255. Each unit represents 0.01 second. A value of 100 represents 1.00 second. If the value of this CV is 0 or 1, a period of 0.02 second is used.
- The CV value is the time for one complete blink, revolve, or strobe cycle of the OHBL to complete.
- In Ops mode, you can observe the blink, revolve, or strobe rate change as you change the value of CV 55.92.6.

5.7.14.4 CV 55.92.11 OHBL Min Intensity¹⁹⁹

For models with an OHBL, this CV controls the minimum brightness of the Blinking Light and Rotary Light effects, the bright time of the Strobe Light and Prime Beacon X4 effects, or the Mid Intensity of the Prime Beacon effect.

Default Value:

4

CV 55.92.11: OHBL Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.92.11 to a value less than the value of CV55.92.12.
- In Ops mode you can observe the intensity change as you change the value of CV 55.92.11.
- For firmware built prior to 24-Aug-09, when the Blinking Light effect is selected, this CV is not used.
- When the Strobe Light (Single Pulse) or Prime Beacon X4 effect is selected, this CV represents the time the light is in its brightest state. Each unit represents 0.01 second. A value of 4 represents 0.04 second. If the value of this CV is 0 or 1, a bright time of 0.02 second is used. If the value of this CV is greater than the value of CV56.92.6, a bright time $\frac{1}{2}$ the value of CV56.92.6 is used.
- When the Prime Beacon effect is selected, this CV represents the Mid Intensity, the brightness of the two secondary pulses.
- When the Strobe Light (Double Pulse) effect is selected, this CV represents the time of brightness of the 1st pulse. Each unit represents 0.01 second.

¹⁹⁹ In Q1a firmware, this CV controls only the bright time of the Strobe Light effect. You can obtain a blinking light effect by increasing the value of this CV.

5.7.14.5 CV 55.92.12 OHBL Max Intensity²⁰⁰

For models with a 256 intensity level OHBL, this CV controls its brightest intensity.

Default Value:

255

CV 55.92.12: OHBL Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.92.12 to a value greater than the value of CV55.92.11.
- In Ops mode, you can observe the OHBL intensity change as you change the value of CV 55.92.12.
- For the Strobe Light (Double Pulse) effect, this CV specifies the brightness of the 1st pulse.

²⁰⁰ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.14.6 CV 55.92.15 OHBL Ramp Up Rate²⁰¹

For models with a 256 intensity level Overhead Beacon Light, this CV controls the rate at which the intensity increases when the Blinking Light effect is selected.

Default Value:

25

CV 55.92.15: OHBL Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Min Intensity is 0, the Max Intensity is 255, and the Ramp Up Rate is 1, it takes 2.55 seconds for the OHBL to go from min to max intensity. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- This CV does not affect the rate the OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.

²⁰¹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.14.7 CV 55.92.16 OHBL Ramp Down Rate²⁰²

For models with a 256 intensity level OHBL, this CV controls the rate at which the intensity decreases when the Blinking Light effect is selected.

Default Value:

25

CV 55.92.16: OHBL Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Min Intensity is 0, the Max Intensity is 255, and the Ramp Down Rate is 1, it takes 2.55 seconds for the OHBL to go from max to min intensity. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- This CV does not affect the rate the OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.

²⁰² This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.14.8 CV 55.92.17 OHBL Ramp Up Time²⁰³

For models with a 256 intensity level Overhead Beacon Light, this CV controls the rate at which the intensity increases when the Blinking Light effect or the Prime Beacon X4 effect is selected. For the Strobe Light (Double Pulse) effect it specifies the time between the two pulses.

Default Value:

10

CV 55.92.17: OHBL Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- This CV does not affect the rate the OHBL intensity changes when the Revolving Light, Strobe Light (Single Pulse), or Prime Beacon effects are selected.
- For the Strobe Light (Double Pulse) effect, this CV specifies the time the light is off between the end of the 1st pulse and the start of the 2nd pulse.

²⁰³ This CV replaces CV55.92.15 OHBL Ramp Up Rate.

5.7.14.9 CV 55.92.18 OHBL Ramp Down Time²⁰⁴

For models with a 256 intensity level OHBL, this CV controls the rate at which the intensity decreases when the Blinking Light effect or the Prime Beacon X4 effect is selected. For the Strobe Light (Double Pulse) effect it specifies the time of brightness of the 2nd pulse.

Default Value:

10

CV 55.92.18: OHBL Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- This CV does not affect the rate the OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.
- When the Strobe Light (Double Pulse) effect is selected, this CV represents the time of brightness for the 2nd pulse.

²⁰⁴ This CV replaces CV55.92.16 OHBL Ramp Down Rate.

5.7.14.10 CV 55.92.19 OHBL Pulse 2 Max Intensity²⁰⁵

For models with a 256 intensity level OHBL, this CV controls its brightest intensity of the 2nd pulse of the Strobe Light (Double Pulse) effect.

Default Value:

255

CV 55.92.19: OHBL Pulse 2 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, you can observe the OHBL intensity change as you change the value of CV 55.92.19.

²⁰⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.15 CV 55.96.SI Rear Overhead Beacon Light

Two features can be assigned to function keys to control rear overhead beacon light operation:

Feature ID	Feature Name	Use
96	Automatic Rear OHBL Activate	Activate/Deactivate Automatic Control of the Rear OHBL
97	Rear OHBL On	Explicitly turn the Rear OHBL On/Off

Automatic Control

When the Feature 96 function state is 1, automatic control is activated. The Rear OHBL intensity changes automatically in response to changes to the locomotive's motive state.

The automatic behavior can be configured in CV 55.96.1.

Feature 96 has precedence over Feature 97. When the Feature 96 function state is 1, the Feature 97 function state is ignored.

Explicit Control

When the Feature 96 function state is 0, automatic control is deactivated. The Rear OHBL intensity changes in response to Feature 97 function key presses.

Feature 97 Function State	Intensity
0	Off
1	On

Effects

Six different rear OHBL lighting effects can be selected using CV55.96.1²⁰⁶.

Blinking Light: the intensity increases to max intensity (CV55.96.12) and decreases to min intensity (CV55.96.11) using CV55.96.16 Ramp Up Time (or CV55.96.15), and CV55.96.18 Ramp Down Time (or CV55.96.16).

Rotary Light: the intensity uses CV55.96.12, CV55.96.11, and a pre-defined ramp profile to simulate a rotating light.

Strobe Light (Single Pulse): the intensity goes from 0 to max intensity (CV55.96.12) instantly, stays at max intensity for a specified time (CV55.96.11), and then instantly decreases to 0.

Prime Beacon: the intensity uses CV55.96.12, CV55.96.11, and a pre-defined ramp profile to simulate a beacon consisting of 4 lights spaced 90 degrees apart which turn on sequentially.

Prime Beacon X4: four lights are turned off and on sequentially using CV55.96.12, CV55.96.11, CV55.96.16, and CV55.96.18.²⁰⁷

Strobe Light (Double Pulse): for the 1st pulse, the intensity goes from 0 to max intensity (CV55.96.12) instantly, stays at max intensity for a specified time (CV55.96.11), instantly decreases to 0, and stays at 0 for a specified time (CV55.96.17). For the 2nd pulse, the intensity goes from 0 to max intensity (CV55.96.19) instantly, stays at max intensity for a specified time (CV55.96.18), instantly decreases to 0, and stays at 0 for the remainder of the cycle²⁰⁸.

²⁰⁶ For Q1 decoders running Q1a firmware only the Strobe Light (Single Pulse) effect is available. You can obtain a Blinking Light effect by increasing the value of CV55.96.11.

²⁰⁷ The Prime Beacon X4 effect requires 4 light outputs connected to 4 light bulbs and is available with Q3 decoders only.

²⁰⁸ The Strobe Light (Double Pulse) effect is available with Q3 decoders only.

5.7.15.1 CV 55.96.0 Rear OHBL Initial State

Use this CV to specify the startup state function states for the Rear OHBL features.

Default Value:

31

CV 55.96.0: Rear OHBL Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Effect	Effect	Effect	Reserved	On with Bell	Feature 97 Function State	Feature 96 Function State

- Default value = 00100001 binary = 21 hex = 31 decimal (Strobe Light Effect and Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Rear OHBL Activate (Feature 96) function.
- Bit 1 is the initial state of the Rear OHBL On (Feature 97) function.
- If bit 2 is “1”, under explicit control the Rear OHBL turns on when the bell turns on and turns off when the bell turns off. If the Feature 97 state is “1”, the OHBL is already on and this bit is ignored.
- Bits 4, 5, and 6 specify the Rear OBHL effect. Six effects are supported²⁰⁹:

Bit 6	Bit 5	Bit 4	Effect
0	0	0	Blinking Light
0	0	1	Rotary Light
0	1	0	Strobe Light (Single Pulse)
0	1	1	Prime Beacon
1	0	0	Prime Beacon X4 ²¹⁰
1	0	1	Strobe Light (Double Pulse) ²¹¹

- A write to this CV in operations mode causes the Feature 96 and 97 function states to be immediately set to the new values.
- A start up operation causes the Feature 96 and 97 function states to be set to the values in this CV.

²⁰⁹ In Q1a firmware Bits 4 and 5 are reserved and should be “0”. The firmware only provides the Strobe Light effect. You can obtain a Blinking Light effect by increasing *the value of CV55.96.11.

²¹⁰ The Prime Beacon X4 effect is available only with Q3 decoders.

²¹¹ The Strobe Light (Double Pulse) effect is available only with Q3 decoders.

5.7.15.2 CV 55.96.1 Automatic Rear OHBL Configuration

Use this CV to configure the Automatic Rear OHBL behavior²¹².

Default Value:

85

CV 55.96.1: Automatic Rear OHBL Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
NFR Intensity	NFR Intensity	REV Intensity	REV Intensity	NFF Intensity	NFF Intensity	FWD Intensity	FWD Intensity

- Default value = 01010101 binary = 55 hex = 85 decimal.
- Bits 0,1 specify the Rear OHBL intensity in FWD, bits 2,3 the intensity in NFF, bits 4,5 the intensity in REV, and bits 6,7 the intensity in NFR.

Bit 1 Bit 3 Bit 5 Bit 7	Bit 0 Bit 2 Bit 4 Bit 6	Intensity
0	0	Off
0	1	On
1	0	On with Bell
1	1	Reserved

- The default settings specify the following behavior:

FWD	NFF	REV	NFR
On	On	On	On

- “On with Bell” means the Rear OHBL turns on automatically when the bell turns on and turns off automatically when the bell turns off.

²¹² CV55.96.1 does not affect rear OHBL behavior in Analog DC.

5.7.15.3 CV 55.96.6 Rear OHBL Period

For models with a Rear OHBL, this CV controls its blink, revolve, or strobe rate.

Default Value:

100

CV 55.96.6: Rear OHBL Period

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 2...255. Each unit represents 0.01 second. A value of 100 represents 1.00 second. If the value of this CV is 0 or 1, a period of 0.02 second is used.
- The CV value is the time for one complete blink, revolve, or strobe cycle of the Rear OHBL to complete.
- In Ops mode, you can observe the blink, revolve, or strobe rate change as you change the value of CV 55.96.6.

5.7.15.4 CV 55.96.11 Rear OHBL Min Intensity²¹³

For models with a Rear OHBL, this CV controls the minimum brightness of the Blinking Light and Rotary Light effects, the bright time of the Strobe Light or Prime Beacon X4 effects, or the Mid Intensity of the Prime Beacon effect.

Default Value:

4

CV 55.96.11: Rear OHBL Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.96.11 to a value less than the value of CV55.96.12.
- In Ops mode you can observe the intensity change as you change the value of CV 55.96.11.
- For firmware built prior to 24-Aug-09, when the Blinking Light effect is selected, this CV is not used.
- When the Strobe Light or Prime Beacon X4 effect is selected, this CV represents the time the light is in its brightest state. Each unit represents 0.01 second. A value of 4 represents 0.04 second. If the value of this CV is 0 or 1, a bright time of 0.02 second is used. If the value of this CV is greater than the value of CV56.96.6, a bright time $\frac{1}{2}$ the value of CV56.96.6 is used.
- When the Prime Beacon effect is selected, this CV represents the Mid Intensity, the brightness of the two secondary pulses.
- When the Strobe Light (Double Pulse) effect is selected, this CV represents the time of brightness of the 1st pulse. Each unit represents 0.01 second.

²¹³ In Q1a firmware, this CV controls only the bright time of the Strobe Light effect. You can obtain a Blinking Light effect by increasing the value of this CV.

5.7.15.5 CV 55.96.12 Rear OHBL Max Intensity²¹⁴

For models with a 256 intensity level Rear OHBL, this CV controls its brightest intensity.

Default Value:

255

CV 55.96.12: Rear OHBL Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright). For best results, set CV55.96.12 to a value greater than the value of CV55.96.11.
- In Ops mode, you can observe the Rear OHBL intensity change as you change the value of CV 55.96.12.
- For the Strobe Light (Double Pulse) effect, this CV specifies the brightness of the 1st pulse.

²¹⁴ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.15.6 CV 55.96.15 Rear OHBL Ramp Up Rate²¹⁵

For models with a 256 intensity level Rear Overhead Beacon Light, this CV controls the rate at which the intensity increases when the Blinking Light effect is selected.

Default Value:

25

CV 55.96.15: Rear OHBL Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Min Intensity is 0, the Max Intensity is 255, and the Ramp Up Rate is 1, it takes 2.55 seconds for the Rear OHBL to go from min to max intensity. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- This CV does not affect the rate the Rear OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.

²¹⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.15.7 CV 55.96.16 Rear OHBL Ramp Down Rate²¹⁶

For models with a 256 intensity level Rear OHBL, this CV controls the rate at which the intensity decreases when the Blinking Light effect is selected.

Default Value:

25

CV 55.96.16: Rear OHBL Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Min Intensity is 0, the Max Intensity is 255, and the Ramp Down Rate is 1, it takes 2.55 seconds for the Rear OHBL to go from max to min intensity. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.
- This CV does not affect the rate the Rear OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.

²¹⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.15.8 CV 55.96.17 Rear OHBL Ramp Up Time²¹⁷

For models with a 256 intensity level Rear Overhead Beacon Light, this CV controls the rate at which the intensity increases when the Blinking Light effect or the Prime Beacon X4 effect is selected. For the Strobe Light (Double Pulse) effect it specifies the time between the two pulses.

Default Value:

10

CV 55.96.17: Rear OHBL Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.
- This CV does not affect the rate the OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.
- For the Strobe Light (Double Pulse) effect, this CV specifies the time the light is off between the end of the 1st pulse and the start of the 2nd pulse.

²¹⁷ This CV replaces CV55.96.15 Rear OHBL Ramp Up Rate.

5.7.15.9 CV 55.96.18 Rear OHBL Ramp Down Time²¹⁸

For models with a 256 intensity level Rear OHBL, this CV controls the rate at which the intensity decreases when the Blinking Light effect or the Prime Beacon X4 effect is selected. For the Strobe Light (Double Pulse) effect it specifies the time of brightness of the 2nd pulse.

Default Value:

10

CV 55.96.18: Rear OHBL Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.
- This CV does not affect the rate the OHBL intensity changes when the Revolving Light, Strobe Light, or Prime Beacon effects are selected.
- When the Strobe Light (Double Pulse) effect is selected, this CV represents the time of brightness for the 2nd pulse.

²¹⁸ This CV replaces CV55.96.16 Rear OHBL Ramp Down Rate.

5.7.15.10 CV 55.96.19 Rear OHBL Pulse 2 Max Intensity²¹⁹

For models with a 256 intensity level OHBL, this CV controls its brightest intensity of the 2nd pulse of the Strobe Light (Double Pulse) effect.

Default Value:

255

CV 55.96.19: Rear OHBL Pulse 2 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense (bright).
- In Ops mode, you can observe the OHBL intensity change as you change the value of CV 55.96.19.

²¹⁹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.16 CV 55.100.SI Front Number Board Lights

Two features can be assigned to function keys to control front number board lights operation:

Feature ID	Feature Name	Use
100	Automatic Front Number Board Lights Activate	Activate/Deactivate Automatic Control of the Front Number Board Lights
101	Front Number Board Lights On	Explicitly turn the Front Number Board Lights On/Off

The front number board lights intensity (Off, On) can be controlled automatically or explicitly.

Automatic Control

When the Feature 100 function state is 1, automatic control is activated. The front number board lights intensity changes automatically in response to changes to the locomotive's motive state.

The default rules for automatic control are simple: the front number board lights are on regardless of the locomotive's motive state.

The automatic control can be configured in CV 55.100.1.

Feature 100 has precedence over Feature 101. When the Feature 100 function state is 1, the Feature 101 function state is ignored.

Explicit Control

When the Feature 100 function state is 0, automatic control is deactivated. The front number board lights intensity changes in response to Feature 101 function key presses.

Feature 101 Function State	Intensity
0	Off
1	On

Feature 100 has precedence over Feature 101. If the Feature 100 function state changes to 1, because of a Feature 100 function key press or a start up operation, automatic control is re-activated.

5.7.16.1 CV 55.100.0 Front Number Board Lights Initial State

Use this CV to specify the startup state function states for the Front Number Board Lights features.

Default Value:

1

CV 55.100.0: Front Number Board Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Feature 101 Function State	Feature 100 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Front Number Board Lights Activate (Feature 100) function.
- Bit 1 is the initial state of the Front Number Board Lights On (Feature 101) function.
- A write to this CV in operations mode causes the Feature 100 and 101 function states to be immediately set to the new values.
- A start up operation causes the Feature 100 and 101 function states to be set to the values in this CV.

5.7.16.2 CV 55.100.1 Automatic Front Number Board Lights Configuration

Use this CV to configure the Automatic Front Number Board Lights behavior²²⁰.

Default Value:

85

CV 55.100.1: Automatic Front Number Board Lights Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	NFR Intensity	Reserved	REV Intensity	Reserved	NFF Intensity	Reserved	FWD Intensity

- Default value = 01010101 binary = 55 hex = 85 decimal.
- If bit 0 = 1, the front number board lights are on in FWD.
- If bit 2 = 1, the front number board lights are on in NFF.
- If bit 4 = 1, the front number board lights are on in REV.
- If bit 6 = 1, the front number board lights are on in NFR.

²²⁰ CV55.100.1 does not affect front number board light behavior in Analog DC.

5.7.16.3 CV 55.100.12 Front Number Board Lights Max Intensity²²¹

For models with 256 intensity level Front Number Board Lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.100.12: Front Number Board Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Front Number Board Lights state “On”, you can observe the Front Number Board Lights intensity change as you change the value of CV 55.100.12.

²²¹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.16.4 CV 55.100.15 Front Number Board Lights Ramp Up Rate²²²

For models with 256 intensity level Front Number Board Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

25

CV 55.100.15: Front Number Board Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Front Number Board Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²²² This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.16.5 CV 55.100.16 Front Number Board Lights Ramp Down Rate²²³

For models with 256 intensity level Front Number Board Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

25

CV 55.100.16: Front Number Board Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Front Number Board Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²²³ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.16.6 CV 55.100.17 Front Number Board Lights Ramp Up Time²²⁴

For models with 256 intensity level Front Number Board Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

10

CV 55.100.17: Front Number Board Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²²⁴ This CV replaces CV55.100.15 Front Number Board Lights Ramp Up Rate.

5.7.16.7 CV 55.100.18 Front Number Board Lights Ramp Down Time²²⁵

For models with 256 intensity level Front Number Board Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

10

CV 55.100.18: Front Number Board Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²²⁵ This CV replaces CV55.100.16 Front Number Board Lights Ramp Down Rate.

5.7.16.6 CV 55.100.SI Front Number Board Lights Examples

Example 1: I want the automatic front number board lights to be on in FWD and REV, but off in NFF and NFR.

Solution: Set CV 55.100.1 to 00010001 binary = 11 hex = 17 decimal.

Example 2: How will the front number board lights behave if I set CV 55.100.0 to 00000011 binary = 03 hex = 3 decimal?

Answer: The automatic front number board lights are initially activated and the front number board lights intensity is controlled by the CV 55.100.1 settings. If the automatic front number board lights are deactivated, for example, by pressing F11 so that the F11 function state is 0, then the Feature 101 function state turns the front number board lights on.

Example 3: I want explicit front number board lights on/off control at all times. At startup I want the front number board lights off until I turn them on with a function key.

Solution: First set CV 55.100.0 to 0. Next remove the automatic front number board lights feature from multiple automatic lights #2 by setting CV 55.137.0 bit 0 to 0. Finally in CV 53 assign Feature 101 to a function output.

Example 4: I want the front number board lights to be on at all times. But I don't want them to be affected by function key presses.

Solution: First set CV 55.100.0 to 00000010 binary = 02 hex = 2 decimal. Then remove the automatic front number board lights feature from multiple automatic lights #2 by setting CV 55.137.0 bit 0 to 0.

Example 5: I want the front number board lights to be on automatically in FWD and NFF and off automatically in REV and NFR. But I don't want them to be affected by function key presses.

Solution: First set CV 55.100.0 to 00000001 binary = 01 hex = 1 decimal. Then set CV55.100.1 to 00000101 binary = 05 hex = 5 decimal. Finally remove the automatic front number board lights feature from multiple automatic lights #2 by setting CV 55.137.0 bit 0 to 0.

5.7.17 CV 55.102.SI Rear Number Board Lights

Two features can be assigned to function keys to control rear number board lights operation:

Feature ID	Feature Name	Use
102	Automatic Rear Number Board Lights Activate	Activate/Deactivate Automatic Control of the Rear Number Board Lights
103	Rear Number Board Lights On	Explicitly turn the Rear Number Board Lights On/Off

The rear number board lights intensity (Off, On) can be controlled automatically or explicitly.

Automatic Control

When the Feature 102 function state is 1, automatic control is activated. The rear number board lights intensity changes automatically in response to changes to the locomotive's motive state.

The default rules for automatic control are simple: the rear number board lights are on regardless of the locomotive's motive state.

The automatic control can be configured in CV55.102.1.

Feature 102 has precedence over Feature 103. When the Feature 102 function state is 1, the Feature 103 function state is ignored.

Explicit Control

When the Feature 102 function state is 0, automatic control is deactivated. The rear number board lights intensity changes in response to Feature 103 function key presses.

Feature 103 Function State	Intensity
0	Off
1	On

Feature 102 has precedence over Feature 103. If the Feature 102 function state changes to 1, because of a Feature 103 function key press or a start up operation, automatic control is re-activated.

5.7.17.1 CV 55.102.0 Rear Number Board Lights Initial State

Use this CV to specify the startup state function states for the Rear Number Board Lights features.

Default Value:

1

CV 55.102.0: Rear Number Board Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Feature 103 Function State	Feature 102 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Rear Number Board Lights Activate (Feature 102) function.
- Bit 1 is the initial state of the Rear Number Board Lights On (Feature 103) function.
- A write to this CV in operations mode causes the Feature 102 and 103 function states to be immediately set to the new values.
- A start up operation causes the Feature 102 and 103 function states to be set to the values in this CV.

5.7.17.2 CV 55.102.1 Automatic Rear Number Board Lights Configuration

Use this CV to configure the Automatic Rear Number Board Lights behavior²²⁶.

Default Value:

85

CV 55.102.1: Automatic Rear Number Board Lights Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	NFR Intensity	Reserved	REV Intensity	Reserved	NFF Intensity	Reserved	FWD Intensity

- Default value = 01010101 binary = 55 hex = 85 decimal (On in all motive states).
- If bit 0 = 1, the rear number board lights are on in FWD.
- If bit 2 = 1, the rear number board lights are on in NFF.
- If bit 4 = 1, the rear number board lights are on in REV.
- If bit 6 = 1, the rear number board lights are on in NFR.

²²⁶ CV55.102.1 does not affect rear number board light behavior in Analog DC.

5.7.17.3 CV 55.102.12 Rear Number Board Lights Max Intensity²²⁷

For models with 256 intensity level Rear Number Board Lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.102.12: Rear Number Board Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Rear Number Board Lights state “On”, you can observe the Rear Number Board Lights intensity change as you change the value of CV 55.102.12.

²²⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.17.4 CV 55.102.15 Rear Number Board Lights Ramp Up Rate²²⁸

For models with 256 intensity level Rear Number Board Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

25

CV 55.102.15: Rear Number Board Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Rear Number Board Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²²⁸ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.17.5 CV 55.102.16 Rear Number Board Lights Ramp Down Rate²²⁹

For models with 256 intensity level Rear Number Board Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

25

CV 55.102.16: Rear Number Board Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Rear Number Board Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²²⁹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.17.6 CV 55.100.17 Rear Number Board Lights Ramp Up Time²³⁰

For models with 256 intensity level Rear Number Board Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

10

CV 55.102.17: Rear Number Board Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²³⁰ This CV replaces CV55.102.15 Rear Number Board Lights Ramp Up Rate.

5.7.17.7 CV 55.102.18 Rear Number Board Lights Ramp Down Time²³¹

For models with 256 intensity level Rear Number Board Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

10

CV 55.102.18: Rear Number Board Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²³¹ This CV replaces CV55.102.16 Rear Number Board Lights Ramp Down Rate.

5.7.17.6 CV 55.102.SI Rear Number Board Lights Examples

Example 1: I want the automatic rear number board lights to be on in FWD and REV, but off in NFF and NFR.

Solution: Set CV 55.102.1 to 00010001 binary = 11 hex = 17 decimal.

Example 2: How will the rear number board lights behave if I set CV 55.102.0 to 00000011 binary = 03 hex = 3 decimal?

Answer: The automatic rear number board lights are initially activated and the rear number board lights intensity is controlled by the CV 55.102.1 settings. If the automatic rear number board lights are deactivated, for example, by pressing F11 so that the F11 function state is 0, then the Feature 103 function state turns the front number board lights on.

Example 3: I want explicit rear number board lights on/off control at all times. At startup I want the rear number board lights off until I turn them on with a function key.

Solution: First set CV 55.102.0 to 0. Next remove the automatic rear number board lights feature from multiple automatic lights #2 by setting CV 55.137.1 bit 0 to 0. Finally in CV 53 assign Feature 103 to a function output.

5.7.18 CV 55.104.SI Front Marker Lights

Two features can be assigned to function keys to control front marker lights operation:

Feature ID	Feature Name	Use
104	Automatic Front Marker Lights Activate	Activate/Deactivate Automatic Control of the Front Marker Lights
105	Front Marker Lights On	Explicitly turn the Front Marker Lights On/Off

The front marker lights intensity (Off, On) can be controlled automatically or explicitly.

Up to 3 front marker lights ports are supported.

Automatic Control

When the feature 104 function state is 1, automatic control is activated. The front marker lights intensity changes automatically in response to changes to the locomotive's motive state.

The automatic control can be configured in CV 55.104.1, CV 55.104.2, and CV 55.104.3.

Feature 104 takes precedence over feature 105. When the feature 104 function state is 1, the feature 105 function state is ignored.

Explicit Control

When the feature 104 function state is 0, automatic control is deactivated, the front marker lights intensity changes in response to feature 105 function key presses.

If a single Front Marker Light Port is in use, each function key press toggles the marker lights on/off.

State	Marker Lights1
0	Off
1	On

If two Front Marker Light Ports are in use, each function key press cycles the marker lights to the next of 3 states.

State	Marker Lights1	Marker Lights2
0	Off	Off
1	On	Off
2	Off	On

If three Front Marker Light Ports are in use, each function key press cycles the marker lights to the next of 4 states.

State	Marker Lights1	Marker Lights2	Marker Lights3
0	Off	Off	Off
1	On	Off	Off
2	Off	On	Off
3	Off	Off	On

Feature 104 takes precedence over features 105. If the feature 104 function state changes to 1, because of a feature 104 function key press or a start up operation, automatic control is re-activated.

5.7.18.1 CV 55.104.0 Front Marker Lights Initial State

Use this CV to specify the startup state function states for the Front Marker Lights features.

Default Value:

1

CV 55.104.0: Front Marker Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Lights3 Initial State	Lights2 Initial State	Lights1 Initial State	Feature 104 Function State

- Default value = 1 (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Front Marker Lights Activate (Feature 104) function.
- Bit 1 is the initial state of Front Marker Lights1 for feature 105.
- Bit 2 is the initial state of Front Marker Lights2 for feature 105.
- Bit 3 is the initial state of Front Marker Lights3 for feature 105.
- A write to this CV in operations mode causes the feature 104 and 105 function states to be immediately set to the new values.
- A start up operation causes the feature 104 and 105 function states to be set to the values in this CV.

5.7.18.2 CV 55.104.1 Automatic Front Marker Lights1 Configuration

Use this CV to configure the Automatic Front Marker Lights1 behavior.

Default Value:

85

CV 55.104.1: Automatic Front Marker Lights1 Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	NFR Intensity	Reserved	REV Intensity	Reserved	NFF Intensity	Reserved	FWD Intensity

- Default value = 01010101 binary = 55 hex = 85 decimal (On in all motive states).
- If bit 0 = 1, the front marker lights1 are on in FWD.
- If bit 2 = 1, the front marker lights1 are on in NFF.
- If bit 4 = 1, the front marker lights1 are on in REV.
- If bit 6 = 1, the front marker lights1 are on in NFR.

5.7.18.3 CV 55.104.2 Automatic Front Marker Lights2 Configuration

Use this CV to configure the Automatic Front Marker Lights2 behavior.

Default Value:

Depends on Locomotive

CV 55.104.2: Automatic Front Marker Lights2 Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	NFR Intensity	Reserved	REV Intensity	Reserved	NFF Intensity	Reserved	FWD Intensity

- If bit 0 = 1, the front marker lights2 are on in FWD.
- If bit 2 = 1, the front marker lights2 are on in NFF.
- If bit 4 = 1, the front marker lights2 are on in REV.
- If bit 6 = 1, the front marker lights2 are on in NFR.

5.7.18.4 CV 55.104.3 Automatic Front Marker Lights3 Configuration

Use this CV to configure the Automatic Front Marker Lights3 behavior.

Default Value:

Depends on Locomotive

CV 55.104.3: Automatic Front Marker Lights3 Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	NFR Intensity	Reserved	REV Intensity	Reserved	NFF Intensity	Reserved	FWD Intensity

- If bit 0 = 1, the front marker lights3 are on in FWD.
- If bit 2 = 1, the front marker lights3 are on in NFF.
- If bit 4 = 1, the front marker lights3 are on in REV.
- If bit 6 = 1, the front marker lights3 are on in NFR.

5.7.18.5 CV 55.104.12 Front Marker Lights1 Max Intensity

Use this CV to specify the Front Marker Lights1 intensity when their state is “On”.

Default Value:

255

CV 55.104.12: Front Marker Lights1 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Front Marker Lights1 state “On”, you can observe the intensity change when you change the value of CV 55.104.12.

5.7.18.6 CV 55.104.13 Front Marker Lights2 Max Intensity

Use this CV to specify the Front Marker Lights2 intensity when their state is “On”.

Default Value:

255

CV 55.104.13: Front Marker Lights2 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Front Marker Lights2 state “On”, you can observe the intensity change when you change the value of CV 55.104.13.

5.7.18.7 CV 55.104.14 Front Marker Lights3 Max Intensity

Use this CV to specify the Front Marker Lights3 intensity when their state is “On”.

Default Value:

255

CV 55.104.14: Front Marker Lights3 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Front Marker Lights3 state “On”, you can observe the intensity change as you change the value of CV 55.104.14.

5.7.18.8 CV 55.104.15 Front Marker Lights Ramp Up Rate²³²

For models with 256 intensity level Front Marker Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

25

CV 55.104.15: Front Marker Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Front Marker Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²³² This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.18.9 CV 55.104.16 Front Marker Lights Ramp Down Rate²³³

For models with 256 intensity level Front Marker Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

25

CV 55.104.16: Front Marker Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Front Marker Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²³³ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.18.10 CV 55.104.17 Front Marker Lights Ramp Up Time²³⁴

For models with 256 intensity level Front Marker Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

10

CV 55.104.17: Front Marker Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²³⁴ This CV replaces CV55.104.15 Front Marker Lights Ramp Up Rate.

5.7.18.11 CV 55.104.18 Front Marker Lights Ramp Down Time²³⁵

For models with 256 intensity level Front Marker Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

10

CV 55.104.18: Front Marker Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²³⁵ This CV replaces CV55.104.16 Front Marker Lights Ramp Down Rate.

5.7.18.12 CV 55.104.SI Front Marker Lights Examples

Example 1: I want the automatic front marker lights to be on in FWD and REV, but off in NFF and NFR.

Solution: Set CV 55.104.1 to 00010001 binary = 11 hex = 17 decimal.

Example 2: How will the front marker lights behave if I set CV 55.104.0 to 00000011 binary = 03 hex = 3 decimal?

Answer: The automatic front marker lights are initially activated and the front marker lights intensity is controlled by the CV 55.104.1 settings. If the automatic front marker lights are deactivated, for example, by pressing F11 so that the F11 function state is 0, then the Feature 105 function state turns the front marker lights on .

Example 3: I want explicit front marker lights on/off control at all times. At startup I want the front marker lights off until I turn them on with a function key.

Solution: First set CV 55.104.0 to 0. Next remove the automatic front marker lights feature from multiple automatic lights #2 by setting CV 55.137.2 bit 0 to 0. Finally in CV 53 assign Feature 105 to a function output.

5.7.19 CV 55.106.SI Rear Marker Lights

Four features can be assigned to function keys to control rear marker lights operation:

Feature ID	Feature Name	Use
106	Automatic Rear Marker Lights Activate	Activate/Deactivate Automatic Control of the Rear Marker Lights
107	Rear Marker Lights On	Explicitly turn the Rear Marker Lights On/Off

The rear marker lights intensity (Off, On) can be controlled automatically or explicitly.

Up to 3 sets of rear marker lights are supported.

Automatic Control

When the feature 106 function state is 1, automatic control is activated. The rear marker lights intensity changes automatically in response to changes to the locomotive's motive state.

The automatic control can be configured in CV 55.106.1, CV 55.106.2, and CV 55.106.3.

Feature 106 takes precedence over feature 107. When the feature 106 function state is 1, the feature 107 function state is ignored.

Explicit Control

When the feature 106 function state is 0, automatic control is deactivated. The front number board lights intensity changes in response to feature 107 function key presses.

If a single Rear Marker Light Port is in use, each function key press toggles the marker lights on/off.

State	Intensity
0	Off
1	On

If two Rear Marker Light Ports are in use, each function key press cycles the marker lights to the next of 3 states.

State	Marker Lights1	Marker Lights2
0	Off	Off
1	On	Off
2	Off	On

If three Rear Marker Light Ports are in use, each function key press cycles the marker lights to the next of 4 states.

State	Marker Lights1	Marker Lights2	Marker Lights3
0	Off	Off	Off
1	On	Off	Off
2	Off	On	Off
3	Off	Off	On

Feature 106 has precedence over feature 107. If the feature 106 function state changes to 1, because of a feature 106 function key press or a start up operation, automatic control is re-activated.

5.7.19.1 CV 55.106.0 Rear Marker Lights Initial State

Use this CV to specify the startup state function states for the Rear Marker Lights features.

Default Value:

1

CV 55.106.0: Rear Marker Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Lights3 Initial State	Lights2 Initial State	Lights1 Initial State	Feature 106 Function State

- Default value = 1 (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Rear Marker Lights Activate (Feature 106) function.
- Bit 1 is the initial state of Rear Marker Lights1 for feature 107.
- Bit 2 is the initial state of Rear Marker Lights2 for feature 107.
- Bit 3 is the initial state of Rear Marker Lights3 for feature 107.
- A write to this CV in operations mode causes the Feature 106, 107, 128, and 129 function states to be immediately set to the new values.
- A start up operation causes the Feature 106 and 107 function states to be set to the values in this CV.

5.7.19.2 CV 55.106.1 Automatic Rear Marker Lights1 Configuration

Use this CV to configure the Automatic Rear Marker Lights1 behavior.

Default Value:

85

CV 55.106.1: Automatic Rear Marker Lights1 Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	1 = On						

- Default value = 01010101 binary = 55 hex = 85 decimal (“On” in all motive states).
- If bit 0 = 1, the rear marker lights1 are on in FWD.
- If bit 2 = 1, the rear marker lights1 are on in NFF.
- If bit 4 = 1, the rear marker lights1 are on in REV.
- If bit 6 = 1, the rear marker lights1 are on in NFR.

5.7.19.3 CV 55.106.2 Automatic Rear Marker Lights2 Configuration

Use this CV to configure the Automatic Rear Marker Lights2 behavior.

Default Value:

85

CV 55.106.2: Automatic Rear Marker Lights2 Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	1 = On						

- Default value = 01010101 binary = 55 hex = 85 decimal (“On” in all motive states).
- If bit 0 = 1, the rear marker lights2 are on in FWD.
- If bit 2 = 1, the rear marker lights2 are on in NFF.
- If bit 4 = 1, the rear marker lights2 are on in REV.
- If bit 6 = 1, the rear marker lights2 are on in NFR.

5.7.19.4 CV 55.106.3 Automatic Rear Marker Lights3 Configuration

Use this CV to configure the Automatic Rear Marker Lights3 behavior.

Default Value:

85

CV 55.106.3: Automatic Rear Marker Lights3 Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	1 = On						

- Default value = 01010101 binary = 55 hex = 85 decimal (“On” in all motive states).
- If bit 0 = 1, the rear marker lights3 are on in FWD.
- If bit 2 = 1, the rear marker lights3 are on in NFF.
- If bit 4 = 1, the rear marker lights3 are on in REV.
- If bit 6 = 1, the rear marker lights3 are on in NFR.

5.7.19.5 CV 55.106.12 Rear Marker Lights1 Max Intensity

Use this CV to specify the Rear Marker Lights1 intensity when their state is “On”.

Default Value:

255

CV 55.106.12: Rear Marker Lights1 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Rear Marker Lights1 state “On”, you can observe the intensity change when you change the value of CV 55.106.12.

5.7.19.6 CV 55.106.13 Rear Marker Lights2 Max Intensity

Use this CV to specify the Rear Marker Lights2 intensity when their state is “On”.

Default Value:

255

CV 55.106.13: Rear Marker Lights2 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Rear Marker Lights2 state “On”, you can observe the intensity change when you change the value of CV 55.106.12.

5.7.19.7 CV 55.106.14 Rear Marker Lights3 Max Intensity

Use this CV to specify the Rear Marker Lights3 intensity when their state is “On”.

Default Value:

255

CV 55.106.14: Rear Marker Lights3 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Rear Marker Lights3 state “On”, you can observe the intensity change when you change the value of CV 55.106.14.

5.7.19.8 CV 55.106.15 Rear Marker Lights Ramp Up Rate²³⁶

For models with 256 intensity level Rear Marker Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

25

CV 55.106.15: Rear Marker Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Rear Marker Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²³⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.19.9 CV 55.106.16 Rear Marker Lights Ramp Down Rate²³⁷

For models with 256 intensity level Rear Marker Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

25

CV 55.106.16: Rear Marker Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Rear Marker Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²³⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.19.10 CV 55.106.17 Rear Marker Lights Ramp Up Time²³⁸

For models with 256 intensity level Rear Marker Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

10

CV 55.106.17: Rear Marker Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²³⁸ This CV replaces CV55.106.15 Rear Marker Lights Ramp Up Rate.

5.7.19.11 CV 55.106.18 Rear Marker Lights Ramp Down Time²³⁹

For models with 256 intensity level Rear Marker Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

10

CV 55.106.18: Rear Marker Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²³⁹ This CV replaces CV55.106.16 Rear Marker Lights Ramp Down Rate.

5.7.19.12 CV 55.106.SI Rear Marker Lights Examples

Example 1: I want the automatic rear marker lights to be on in FWD and REV, but off in NFF and NFR.

Solution: Set CV 55.106.1 to 00010001 binary = 11 hex = 17 decimal.

Example 2: How will the rear marker lights behave if I set CV 55.106.0 to 00000011 binary = 03 hex = 3 decimal?

Answer: The automatic rear marker lights are initially activated and the rear marker lights intensity is controlled by the CV 55.106.1 settings. If the automatic rear marker lights are deactivated, for example, by pressing F11 so that the F11 function state is 0, then the Feature 107 function state turns the rear marker lights on.

Example 3: I want explicit rear marker lights on/off control at all times. At startup I want the rear marker lights off until I turn them on with a function key.

Solution: First set CV 55.106.0 to 0. Next remove the automatic rear marker lights feature from multiple automatic lights #2 by setting CV 55.137.2 bit 1 to 0. Finally in CV 53 assign Feature 107 to a function output.

5.7.20 CV 55.109.SI Truck Lights

One feature can be assigned to function keys to control truck lights operation:

Feature ID	Feature Name	Use
109	Truck Lights On	Explicitly turn the Truck Lights On/Off

The truck lights intensity (Off, On) can be controlled explicitly.

The truck lights intensity changes in response to Feature 109 function key presses.

Feature 109 Function State	Intensity
0	Off
1	On

The feature 109 initial state can be specified using CV55.134.0 Exterior Lights Initial State.

Truck lights can also be assigned to one of the Multiple Lights features allowing many lights to be turned on/off with a single function key.

5.7.20.1 CV 55.109.12 Truck Lights Max Intensity²⁴⁰

For models with 256 intensity level Truck Lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.109.12: Truck Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Truck Lights state “On”, you can observe the Truck Lights intensity change as you change the value of CV 55.109.12.

²⁴⁰ This CV is currently supported only by Q3 firmware.

5.7.20.2 CV 55.109.17 Truck Lights Ramp Time²⁴¹

For models with 256 intensity level Truck Lights, this CV controls the rate at which their intensity increases and decreases going from “Off” to “On” and going from “On” to “Off”.

Default Value:

10

CV 55.109.17: Truck Lights Ramp Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity and the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Time is 120, it takes 1.2 seconds for the light to go from off to bright or bright to off. With the default time of 10, it takes 0.1 second.

²⁴¹ This CV is currently supported only by Q3 firmware.

5.7.21 CV 55.113.SI Step Lights

One feature can be assigned to function keys to control step lights operation:

Feature ID	Feature Name	Use
113	Step Lights On	Explicitly turn the Step Lights On/Off

The step lights intensity (Off, On) can be controlled explicitly.

The step lights intensity changes in response to Feature 113 function key presses.

Feature 113 Function State	Intensity
0	Off
1	On

The feature 113 initial state can be specified using CV55.134.0 Exterior Lights Initial State.

Step lights can also be assigned to one of the Multiple Lights features allowing many lights to be turned on/off with a single function key.

5.7.21.1 CV 55.113.12 Step Lights Max Intensity²⁴²

For models with 256 intensity level Step Lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.113.12: Step Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Step Lights state “On”, you can observe the Step Lights intensity change as you change the value of CV 55.113.12.

²⁴² This CV is currently supported only by Q3 firmware.

5.7.21.2 CV 55.109.17 Step Lights Ramp Time²⁴³

For models with 256 intensity level Step Lights, this CV controls the rate at which their intensity increases and decreases going from “Off” to “On” and going from “On” to “Off”.

Default Value:

10

CV 55.113.17: Step Lights Ramp Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity and the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Time is 120, it takes 1.2 seconds for the light to go from off to bright or bright to off. With the default time of 10, it takes 0.1 second.

²⁴³ This CV is currently supported only by Q3 firmware.

5.7.22 CV 55.116.SI Front Cab Lights

Two features can be assigned to function keys to control front cab lights operation:

Feature ID	Feature Name	Use
116	Automatic Front Cab Lights Activate	Activate/Deactivate Automatic Control of the Front Cab Lights
117	Front Cab Lights On	Explicitly turn the Front Cab Lights On/Off

The front cab lights intensity (Off, On) can be controlled automatically or explicitly.

Automatic Control

When the Feature 116 function state is 1, automatic control is activated. The front cab lights intensity changes automatically in response to changes to the locomotive's motive state.

The default rules for front cab light automatic control are:

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Off after 15 seconds	On after 10 seconds	Off after 15 seconds	On after 10 seconds

The automatic control can be configured in CV 55.116.1.

Feature 116 has precedence over Feature 117. When the Feature 116 function state is 1, the Feature 117 function state is ignored.

Explicit Control

When the Feature 116 function state is 0, automatic control is deactivated. The front cab lights intensity changes in response to Feature 117 function key presses.

Feature 117 Function State	Intensity
0	Off
1	On

Feature 116 has precedence over Feature 117. If the Feature 116 function state changes to 1, because of a Feature 116 function key press or a start up operation, automatic control is re-activated.

5.7.22.1 CV 55.116.0 Front Cab Lights Initial State

Use this CV to specify the startup state function states for the Front Cab Lights features.

Default Value:

1

CV 55.116.0: Front Cab Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Feature 117 Function State	Feature 116 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Front Cab Lights Activate (Feature 116) function.
- Bit 1 is the initial state of the Front Cab Lights On (Feature 117) function.
- A write to this CV in operations mode causes the Feature 116 and 117 function states to be immediately set to the new values.
- A start up operation causes the Feature 116 and 117 function states to be set to the values in this CV.

5.7.22.2 CV 55.116.1 Automatic Front Cab Lights Configuration

Use this CV to configure the Automatic Front Cab Lights behavior²⁴⁴.

Default Value:

68

CV 55.116.1: Automatic Front Cab Lights Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	1 = On						

- Default value = 01000100 binary = 44 hex = 68 decimal. (On in NFF and NFR.)
- If bit 0 = 1, the front cab lights are on in FWD.
- If bit 2 = 1, the front cab lights are on in NFF. If the front cab lights were already on in FWD, they remain on in NFF. If they were off in FWD, they come on after 10 seconds.
- If bit 4 = 1, the front cab lights are on in REV.
- If bit 6 = 1, the front cab lights are on in NFR. If the front cab lights were already on in REV, they remain on in NFR. If they were off in REV, they come on after 10 seconds.

²⁴⁴ CV55.116.1 does not affect front cab light behavior in Analog DC.

5.7.22.3 CV 55.116.12 Front Cab Lights Max Intensity²⁴⁵

For models with 256 intensity level Front Cab Lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.116.12: Front Cab Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Front Cab Lights state “On”, you can observe the Front Cab Lights intensity change as you change the value of CV 55.116.12.

²⁴⁵ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.22.4 CV 55.116.15 Front Cab Lights Ramp Up Rate²⁴⁶

For models with 256 intensity level Front Cab Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

25

CV 55.116.15: Front Cab Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Front Cab Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²⁴⁶ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.22.5 CV 55.116.16 Front Cab Lights Ramp Down Rate²⁴⁷

For models with 256 intensity level Front Cab Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

25

CV 55.116.16: Front Cab Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Front Cab Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²⁴⁷ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.22.6 CV 55.116.17 Front Cab Lights Ramp Up Time²⁴⁸

For models with 256 intensity level Front Cab Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

10

CV 55.116.17: Front Cab Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²⁴⁸ This CV replaces CV55.116.15 Front Cab Lights Ramp Up Rate.

5.7.22.7 CV 55.116.18 Front Cab Lights Ramp Down Time²⁴⁹

For models with 256 intensity level Front Cab Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

10

CV 55.116.18: Front Cab Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²⁴⁹ This CV replaces CV55.116.16 Front Cab Lights Ramp Down Rate.

5.7.22.8 CV 55.116.SI Front Cab Lights Examples

Example 1: I want the automatic front cab lights to be on in all motive states FWD, NFF, REV and NFR.

Solution: Set CV 55.116.1 to 01010101 binary = 55 hex = 85 decimal.

Example 2: How will the front cab lights behave if I set CV 55.116.0 to 00000011 binary = 03 hex = 3 decimal?

Answer: The automatic front cab lights are initially activated and the front cab lights intensity is controlled by the CV 55.116.1 settings. If the automatic front cab lights are deactivated, for example, by pressing F12 so that the F12 function state is 0, then the Feature 117 function state turns the front cab lights on.

Example 3: I want explicit front cab lights on/off control at all times. At startup I want the front cab lights off until I turn them on with a function key.

Solution: First set CV 55.116.0 to 0. Next remove the automatic front cab lights feature from multiple automatic lights #3 by setting CV 55.138.3 bit 0 to 0. Finally in CV 53 assign Feature 117 to a function output.

5.7.23 CV 55.118.SI Rear Cab Lights

Two features can be assigned to function keys to control rear cab lights operation:

Feature ID	Feature Name	Use
118	Automatic Rear Cab Lights Activate	Activate/Deactivate Automatic Control of the Rear Cab Lights
119	Rear Cab Lights On	Explicitly turn the Rear Cab Lights On/Off

The rear cab lights intensity (Off, On) can be controlled automatically or explicitly.

Automatic Control

When the Feature 118 function state is 1, automatic control is activated. The rear cab lights intensity changes automatically in response to changes to the locomotive's motive state.

The default rules for rear cab light automatic control are:

Forward	Neutral from Forward	Reverse	Neutral from Reverse
Off after 15 seconds	On after 10 seconds	Off after 15 seconds	On after 10 seconds

The automatic control can be configured in CV 55.118.1.

Feature 118 has precedence over Feature 119. When the Feature 118 function state is 1, the Feature 119 function state is ignored.

Explicit Control

When the Feature 118 function state is 0, automatic control is deactivated. The rear cab lights intensity changes in response to Feature 119 function key presses.

Feature 119 Function State	Intensity
0	Off
1	On

Feature 118 has precedence over Feature 119. If the Feature 118 function state changes to 1, because of a Feature 118 function key press or a start up operation, automatic control is re-activated.

5.7.23.1 CV 55.118.0 Rear Cab Lights Initial State

Use this CV to specify the startup state function states for the Rear Cab Lights features.

Default Value:

1

CV 55.118.0: Rear Cab Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Feature 119 Function State	Feature 118 Function State

- Default value = 00000001 binary = 01 hex = 1 decimal (Automatic Control Activated).
- Bit 0 is the initial state of the Automatic Rear Cab Lights Activate (Feature 118) function.
- Bit 1 is the initial state of the Rear Cab Lights On (Feature 119) function.
- A write to this CV in operations mode causes the Feature 118 and 119 function states to be immediately set to the new values.
- A start up operation causes the Feature 118 and 119 function states to be set to the values in this CV.

5.7.23.2 CV 55.118.1 Automatic Rear Cab Lights Configuration

Use this CV to configure the Automatic Rear Cab Lights behavior²⁵⁰.

Default Value:

68

CV 55.118.1: Automatic Rear Cab Lights Configuration

NFR		REV		NFF		FWD	
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	1 = On						

- Default value = 01000100 binary = 44 hex = 68 decimal. (On in NFF and NFR.)
- If bit 0 = 1, the rear cab lights are on in FWD.
- If bit 2 = 1, the rear cab lights are on in NFF. If the rear cab lights were already on in FWD, they remain on in NFF. If they were off in FWD, they come on after 10 seconds.
- If bit 4 = 1, the rear cab lights are on in REV.
- If bit 6 = 1, the rear cab lights are on in NFR. If the rear cab lights were already on in REV, they remain on in NFR. If they were off in REV, they come on after 10 seconds.

²⁵⁰ CV55.118.1 does not affect rear cab light behavior in Analog DC.

5.7.23.3 CV 55.118.12 Rear Cab Lights Max Intensity²⁵¹

For models with 256 intensity level Rear Cab Lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.118.12: Rear Cab Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Rear Cab Lights state “On”, you can observe the Rear Cab Lights intensity change as you change the value of CV 55.118.12.

²⁵¹ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.23.4 CV 55.118.15 Rear Cab Lights Ramp Up Rate²⁵²

For models with 256 intensity level Rear Cab Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

25

CV 55.118.15: Rear Cab Lights Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Up Rate is 1, it takes 2.55 seconds for the Rear Cab Lights to go from off to bright. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²⁵² This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.23.5 CV 55.118.16 Rear Cab Lights Ramp Down Rate²⁵³

For models with 256 intensity level Rear Cab Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

25

CV 55.118.16: Rear Cab Lights Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Max Intensity is 255 and the Ramp Down Rate is 1, it takes 2.55 seconds for the Rear Cab Lights to go from bright to off. If the rate is 255, it takes 0.01 second. With the default rate of 25, it takes 0.102 second.

²⁵³ This CV is currently supported only by Q2 firmware for the Quantum Revolution.

5.7.23.6 CV 55.118.17 Rear Cab Lights Ramp Up Time²⁵⁴

For models with 256 intensity level Rear Cab Lights, this CV controls the rate at which their intensity increases when their state changes from “Off” to “On”.

Default Value:

10

CV 55.118.17: Rear Cab Lights Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²⁵⁴ This CV replaces CV55.118.15 Rear Cab Lights Ramp Up Rate.

5.7.23.7 CV 55.118.18 Rear Cab Lights Ramp Down Time²⁵⁵

For models with 256 intensity level Rear Cab Lights, this CV controls the rate at which their intensity decreases when their state changes from “On” to “Off”.

Default Value:

10

CV 55.118.18: Rear Cab Lights Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²⁵⁵ This CV replaces CV55.118.16 Rear Cab Lights Ramp Down Rate.

5.7.23.8 CV 55.118.SI Rear Cab Lights Examples

Example 1: I want the automatic rear cab lights to be on in all motive states FWD, NFF, REV and NFR.

Solution: Set CV 55.118.1 to 01010101 binary = 55 hex = 85 decimal.

Example 2: How will the rear cab lights behave if I set CV 55.118.0 to 00000011 binary = 03 hex = 3 decimal?

Answer: The automatic rear cab lights are initially activated and the rear cab lights intensity is controlled by the CV 55.118.1 settings. If the automatic rear cab lights are deactivated, for example, by pressing F12 so that the F12 function state is 0, then the Feature 119 function state turns the rear cab lights on.

Example 3: I want explicit rear cab lights on/off control at all times. At startup I want the rear cab lights off until I turn them on with a function key.

Solution: First set CV 55.118.0 to 0. Next remove the automatic rear cab lights feature from multiple automatic lights #3 by setting CV 55.138.3 bit 1 to 0. Finally in CV 53 assign Feature 119 to a function output.

5.7.24 CV 55.120.SI Engine Room Lights

Two features can be assigned to function keys to control engine room lights operation:

Feature ID	Feature Name	Use
120	Engine Room Lights On	Explicitly turn the Engine Room Lights On/Off
121	Engine Room2 Lights On	Explicitly turn the Engine Room2 Lights On/Off

The engine room lights intensity (Off, On) can be controlled explicitly.

The engine room lights intensity changes in response to Feature 120/121 function key presses.

Feature 120/121 Function State	Intensity
0	Off
1	On

The feature 120/121 initial state can be specified using CV55.135.0 Interior Lights Initial State.

Engine room lights can also be assigned to one of the Multiple Lights features allowing many lights to be turned on/off with a single function key.

5.7.24.1 CV 55.120.12 Engine Room Lights Max Intensity²⁵⁶

For models with 256 intensity level engine room lights, this CV controls their intensity when their state is “On”.

Default Value:

255

CV 55.120.12: Engine Room Lights Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Engine Room Lights state “On”, you can observe the Engine Room Lights intensity change as you change the value of CV 55.120.12.

²⁵⁶ This CV is currently supported only by Q3 firmware.

5.7.24.2 CV 55.120.17 Engine Room Lights Ramp Time²⁵⁷

For models with 256 intensity level engine room lights, this CV controls the rate at which their intensity increases and decreases going from “Off” to “On” and going from “On” to “Off”.

Default Value:

10

CV 55.120.17: Engine Room Lights Ramp Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity and the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Time is 120, it takes 1.2 seconds for the light to go from off to bright or bright to off. With the default time of 10, it takes 0.1 second.

²⁵⁷ This CV is currently supported only by Q3 firmware.

5.7.25 CV 55.122.SI Firebox

One feature can be assigned to a function key to control firebox operation:

Feature ID	Feature Name	Use
122	Firebox On	Turn the Firebox On/Off

When the Feature 122 function state is 1, the Firebox is “On”. The Firebox intensity changes automatically in response to changes to the locomotive’s state.

When the locomotive is not moving, the firebox flickers. When the locomotive is moving, and a chuff occurs, the firebox flares briefly and then returns to flickering. At high speeds the firebox flares continuously.

If CV55.135.0 Interior Lights Initial State bit 4 = “1”, which is the default, the Firebox is “On” at power up and after a Start Up operation. This means the Firebox will automatically be “On” during normal operation. You need not assign feature 122 to a function key unless you want to turn the Firebox “Off”.

Firebox flicker can use one port, but two ports give a better effect. When two ports are in use, CV55.122.21-28 control the intensity, ramp up time, and ramp down time of the second firebox.

5.7.25.1 CV 55.122.11 Firebox Min Intensity

This CV controls the firebox min intensity when the firebox flickers.

Default Value:

4

CV 55.122.11: Firebox Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- When the Firebox is flickering, the intensity randomly changes between the CV55.122.11 value and the CV55.122.13 value.
- In Ops mode, with the Firebox “On”, you can observe the Firebox flicker intensity change as you change the value of CV 55.122.11.

5.7.25.2 CV 55.122.12 Firebox Max Intensity

This CV controls the firebox intensity when the firebox flares during a chuff.

Default Value:

255

CV 55.122.12: Firebox Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Firebox “On”, you can observe the Firebox flare intensity change as you change the value of CV 55.122.12.

5.7.25.3 CV 55.122.13 Firebox Mid Intensity

This CV controls the maximum firebox intensity when the firebox flickers.

Default Value:

64

CV 55.122.13: Firebox Mid Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- When the Firebox is flickering, the intensity randomly changes between the CV55.122.11 value and the CV55.122.13 value.
- In Ops mode, with the Firebox "On", you can observe the Firebox flicker intensity change as you change the value of CV 55.122.13.

5.7.25.4 CV 55.122.15 Firebox Ramp Up Rate²⁵⁸

This CV controls the rate at which the Firebox intensity increases.

Default Value:

4

CV 55.122.15: Firebox Ramp Up Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Ramp Up Rate is 1, it takes 2.55 seconds for the Firebox to go from 0 to 255. If the rate is 255, it takes 0.01 second. With the default rate of 4, it takes 0.64 second.

²⁵⁸ This CV is supported only by Q2 firmware for the Quantum Revolution.

5.7.25.5 CV 55.122.16 Firebox Ramp Down Rate²⁵⁹

This CV controls the rate at which the Firebox intensity decreases.

Default Value:

4

CV 55.122.16: Firebox Ramp Down Rate

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the number of intensity levels the intensity changes every 10ms.
- Valid values are 1...255, 1 being the slowest rate and 255 the fastest.
- If the Ramp Down Rate is 1, it takes 2.55 seconds for the Firebox to go from 0 to 255. If the rate is 255, it takes 0.01 second. With the default rate of 4, it takes 0.64 second.

²⁵⁹ This CV is supported only by Q2 firmware for the Quantum Revolution.

5.7.25.6 CV 55.122.17 Firebox Ramp Up Time²⁶⁰

This CV controls the rate at which the Firebox intensity increases.

Default Value:

10

CV 55.122.17: Firebox Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

²⁶⁰ This CV replaces CV55.122.15 Firebox Ramp Up Rate.

5.7.25.7 CV 55.122.18 Firebox Ramp Down Time²⁶¹

This CV controls the rate at which the Firebox intensity decreases.

Default Value:

10

CV 55.122.18: Firebox Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

²⁶¹ This CV replaces CV55.122.16 Firebox Ramp Down Rate.

5.7.25.8 CV 55.122.21 Firebox2 Min Intensity

This CV controls the firebox min intensity of the firebox2 when the firebox flickers.

Default Value:

4

CV 55.122.21: Firebox2 Min Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- When the Firebox2 is flickering, the intensity randomly changes between the CV55.122.21 value and the CV55.122.23 value.
- In Ops mode, with the Firebox "On", you can observe the Firebox2 flicker intensity change as you change the value of CV 55.122.21.

5.7.25.9 CV 55.122.22 Firebox2 Max Intensity

This CV controls the firebox intensity of the firebox2 when the firebox flares during a chuff.

Default Value:

255

CV 55.122.22: Firebox2 Max Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- In Ops mode, with the Firebox "On", you can observe the Firebox2 flare intensity change as you change the value of CV 55.122.22.

5.7.25.10 CV 55.122.23 Firebox2 Mid Intensity

This CV controls the maximum firebox2 intensity when the firebox flickers.

Default Value:

64

CV 55.122.23: Firebox2 Mid Intensity

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...255, 0 being least intense (off) and 255 being most intense.
- When the Firebox2 is flickering, the intensity randomly changes between the CV55.122.21 value and the CV55.122.13 value.
- In Ops mode, with the Firebox "On", you can observe the Firebox2 flicker intensity change as you change the value of CV 55.122.23.

5.7.25.11 CV 55.122.27 Firebox2 Ramp Up Time

This CV controls the rate at which the Firebox2 intensity increases.

Default Value:

10

CV 55.122.27: Firebox2 Ramp Up Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from 0 to its maximum intensity.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 being the slowest.
- If the Ramp Up Time is 120, it takes 1.2 seconds for the light to go from off to bright. With the default time of 10, it takes 0.1 second.

5.7.25.12 CV 55.122.28 Firebox2 Ramp Down Time

This CV controls the rate at which the Firebox2 intensity decreases.

Default Value:

10

CV 55.122.28: Firebox2 Ramp Down Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The value of this CV specifies the time for the light to change from its maximum intensity to 0.
- Each unit represents 0.01 second. For example, a value of 25 represents 0.25 second.
- Valid values are 1...255, 1 being the fastest time and 255 the slowest.
- If the Ramp Down Time is 120, it takes 1.2 seconds for the light to go from bright to off. With the default time of 10, it takes 0.1 second.

5.7.26 CV 55.134.0 Exterior Lights Initial State

This CV specifies the initial state of miscellaneous exterior lights.

CV 55.134.0 Exterior Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Step Lights (113)	Reserved	Truck Lights (109)

- Default value = 11111111 binary = FF hex = 255 decimal.

5.7.27 CV 55.135.0 Interior Lights Initial State

This CV specifies the initial state of miscellaneous interior lights.

CV 55.135.0 Interior Lights Initial State

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Firebox (122)	Reserved	Reserved	Engine Room2 Lights (120)	Engine Room Lights (121)

- Default value = 11111111 binary = FF hex = 255 decimal.
- If bit 4 of this CV is “1”, the Firebox feature state is “On” upon power up and start up operations.
- A write to this CV in operations mode causes the Feature 122 function state to be immediately set to the new value.
- A start up operation causes the Feature 122 function states to be set to the value in this CV.

5.7.28 CV 55.136.SI Multiple Automatic Lights #1

The Multiple Automatic Lights #1 feature allows you to activate more than one automatic light feature with a single function key. Select which lights you want to activate in CV 55.136.0 ... CV 55.136.2, and assign Feature 136 to a function output in CV 53.

By default, Feature 136 is assigned to outputs 1 and 2 (FL(f) and FL(r)) in CV 53.

By default, Multiple Automatic Lights #1 controls the automatic Headlight, Reverse Light, Front and Rear Mars Lights, Front and Rear Ditch Lights, and Front and Rear Overhead Blinking Lights.

CV 55.136.0 Multiple Automatic Lights #1 Configuration Byte 0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Rear OHBL (96)	OHBL (92)	Rear Ditch Lights (88)	Ditch Lights (84)	Rear Mars Light (80)	Mars Light (76)	Reverse Light (73)	Headlight (70)

- Default value = 11111111 binary = FF hex = 255 decimal.

CV 55.136.1 Multiple Automatic Lights #1 Configuration Byte 1

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Step Lights (113)	Reserved	Truck Lights (109)	Rear Marker Lights (106)	Front Marker Lights (104)	Rear Number Board Lights (102)	Front Number Board Lights (100)

- Default value = 00000000 binary = 00 hex = 0 decimal.

CV 55.136.2 Multiple Automatic Lights #1 Configuration Byte 2

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Engine Room2 Light	Engine Room Light	Firebox (122)	Reserved	Reserved	Rear Cab Lights (118)	Front Cab Lights (116)

- Default value = 00000000 binary = 00 hex = 0 decimal.

Example: My DCC controller has limited number of function keys and I want to be able to turn all the lights on and off with a single function key, F0. What can I do to accomplish this?

Solution: Set CV 55.136.1 to 255 and set CV 55.136.2 to 255. Since the Multiple Automatic Lights #1 feature is assigned to F0 by default, F0 will now activate or deactivate all the automatic lights. You can also set CV 55.137.1 to 0 and CV 55.138.2 to 0 if you wish, but unless you have F9...F12 on your controller, this should not be necessary.

5.7.29 CV 55.137.SI Multiple Automatic Lights #2

The Multiple Automatic Lights #2 feature allows you to activate more than one automatic light feature with a single function key. Select which lights you want to activate in CV 55.137.0 ... CV 55.137.2, and assign Feature 137 to a function output in CV 53.

By default, Feature 137 is assigned to output 13 (F11) in CV 53.

By default, the Multiple Automatic Lights #2 feature controls the automatic Front and Rear Number Board Lights, Front and Rear Marker Lights, Truck Lights, and Step Lights.

CV 55.137.0 Multiple Automatic Lights #2 Configuration Byte 0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Rear OHBL (96)	OHBL (92)	Rear Ditch Lights (88)	Ditch Lights (84)	Rear Mars Light (80)	Mars Light (76)	Reverse Light (73)	Headlight (70)

- Default value = 00000000 binary = 00 hex = 0 decimal.

CV 55.137.1 Multiple Automatic Lights #2 Configuration Byte 1

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Step Lights (113)	Reserved	Truck Lights (109)	Rear Marker Lights (106)	Front Marker Lights (104)	Rear Number Board Lights (102)	Front Number Board Lights (100)

- Default value = 11111111 binary = FF hex = 255 decimal.

CV 55.137.2 Multiple Automatic Lights #2 Configuration Byte 2

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Engine Room2 Light	Engine Room Light	Firebox (122)	Reserved	Reserved	Rear Cab Lights (118)	Front Cab Lights (116)

- Default value = 00000000 binary = 00 hex = 0 decimal.

5.7.30 CV 55.138.SI Multiple Automatic Lights #3

The Multiple Automatic Lights #3 feature allows you to activate more than one automatic light feature with a single function key. Select which lights you want to activate in CV 55.138.0 ... CV 55.138.2, and assign Feature 138 to a function output in CV 53.

By default, Feature 138 is assigned to output 14 (F12) in CV 53.

By default, Multiple Automatic Lights #3 controls the automatic Front and Rear Cab Lights.

CV 55.138.0 Multiple Automatic Lights #3 Configuration Byte 0

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Rear OHBL (96)	OHBL (92)	Rear Ditch Lights (88)	Ditch Lights (84)	Rear Mars Light (80)	Mars Light (76)	Reverse Light (73)	Headlight (70)

- Default value = 00000000 binary = 00 hex = 0 decimal.

CV 55.138.1 Multiple Automatic Lights #3 Configuration Byte 1

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Step Lights (113)	Reserved	Truck Lights (109)	Rear Marker Lights (106)	Front Marker Lights (104)	Rear Number Board Lights (102)	Front Number Board Lights (100)

- Default value = 00000000 binary = 00 hex = 0 decimal.

CV 55.138.2 Multiple Automatic Lights #3 Configuration Byte 2

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Engine Room2 Light	Engine Room Light	Firebox (122)	Reserved	Reserved	Rear Cab Lights (118)	Front Cab Lights (116)

- Default value = 11111111 binary = FF hex = 255 decimal.

5.7.31 CV 55.154.SI Grade Crossing Horn Signal

The Grade Crossing Horn Signal consists of up to 4 horn blasts interspersed with 3 silent periods.

You can specify the duration of each horn blast and the duration of each silent period to the nearest 0.1 second.

For each horn blast you can also specify whether a normal horn blast is played, or whether a hoot is played instead of a short horn blast or a fancy ending is played at the end of a long horn blast.

The default values for CV55.154.0-6 gives a grade crossing signal consisting of:

- An initial horn blast of 3.0 seconds.

- A silent period of 1.5 seconds.

- A horn blast of 3.0 seconds.

- A silent period of 1.5 seconds.

- A horn blast of 1.0 second.

- A silent period of 1.5 seconds.

- A final horn blast of 3.0 seconds.

To play the grade crossing horn signal use CV53 to assign feature 154 to a function key. Then press the function key whenever you want the grade crossing horn signal to play.

CV 55.154.0 Horn Blast 1 Duration

Use this CV to specify the duration of the first horn blast.

Default Value:

30

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D6 specify the duration. Valid values for the duration are 0 to 127. If the duration is 0, the horn blast will not be played.
- The default value of “30” represents 3.0 seconds.
- If D7 is “1”, and D0...D6 has a value less than or equal to 9 (0.9 second) but greater than 0, then a hoot record is played²⁶².
- If D7 is “1”, and D0...D6 has a value greater than or equal to 10 (1.0 second), then a fancy ending is played at the end of the long horn blast²⁶³.
- Setting D7 to “1” is equivalent to adding “128” to the value of the CV.
- The duration specified is the time from the start of the horn blast to the start of the next silent period. Because the length of horn records vary, the actual duration of the horn blast may be longer (or shorter if a hoot is played) than this time.

CV 55.154.1 Silent Period 1 Duration

Use this CV to specify the duration of the first silent period.

Default Value:

15

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D7 specify the duration. Valid values are 0 to 255.
- The default value of “15” represents 1.5 seconds.

²⁶² Firmware built prior to 9-Sept-10 does not support the use of D7 to specify a hoot or fancy ending.

²⁶³ A few horns/whistles do not have a fancy ending record. In those cases, the normal ending for a long horn blast is played.

CV 55.154.2 Horn Blast 2 Duration

Use this CV to specify the duration of the second horn blast.

Default Value:

30

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D6 specify the duration. Valid values for the duration are 0 to 127. If the duration is 0, the horn blast will not be played.
- The default value of "30" represents 3.0 seconds.
- If D7 is "1", and D0...D6 has a value less than or equal to 9 (0.9 second) but greater than 0, then a hoot record is played²⁶⁴.
- If D7 is "1", and D0...D6 has a value greater than or equal to 10 (1.0 second), then a fancy ending is played at the end of the long horn blast²⁶⁵.
- Setting D7 to "1" is equivalent to adding "128" to the value of the CV.
- The duration specified is the time from the start of the horn blast to the start of the next silent period. Because the length of horn records vary, the actual duration of the horn blast may be longer (or shorter if a hoot is played) than this time.

CV 55.154.3 Silent Period 2 Duration

Use this CV to specify the duration of the second silent period.

Default Value:

15

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D7 specify the duration. Valid values are 0 to 255.
- The default value of "15" represents 1.5 seconds.

²⁶⁴ Firmware built prior to 9-Sept-10 does not support the use of D7 to specify a hoot or fancy ending.

²⁶⁵ A few horns/whistles do not have a fancy ending record. In those cases, the normal ending for a long horn blast is played.

CV 55.154.4 Horn Blast 3 Duration

Use this CV to specify the duration of the third horn blast.

Default Value:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D6 specify the duration. Valid values for the duration are 0 to 127. If the duration is 0, the horn blast will not be played.
- The default value of “10” represents 1.0 seconds.
- If D7 is “1”, and D0...D6 has a value less than or equal to 9 (0.9 second) but greater than 0, then a hoot record is played²⁶⁶.
- If D7 is “1”, and D0...D6 has a value greater than or equal to 10 (1.0 second), then a fancy ending is played at the end of the long horn blast²⁶⁷.
- Setting D7 to “1” is equivalent to adding “128” to the value of the CV.
- The duration specified is the time from the start of the horn blast to the start of the next silent period. Because the length of horn records vary, the actual duration of the horn blast may be longer (or shorter if a hoot is played) than this time.

CV 55.154.5 Silent Period 3 Duration

Use this CV to specify the duration of the third silent period.

Default Value:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D7 specify the duration. Valid values are 0 to 255.
- The default value of “15” represents 1.5 seconds.

²⁶⁶ Firmware built prior to 9-Sept-10 does not support the use of D7 to specify a hoot or fancy ending.

²⁶⁷ A few horns/whistles do not have a fancy ending record. In those cases, the normal ending for a long horn blast is played.

CV 55.154.6 Horn Blast 4 Duration

Use this CV to specify the duration of the fourth horn blast.

Default Value:

30

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D6 specify the duration. Valid values for the duration are 0 to 127. If the duration is 0, the horn blast will not be played.
- The default value of "30" represents 3.0 seconds.
- If D7 is "1", and D0...D6 has a value less than or equal to 9 (0.9 second) but greater than 0, then a hoot record is played²⁶⁸.
- If D7 is "1", and D0...D6 has a value greater than or equal to 10 (1.0 second), then a fancy ending is played at the end of the long horn blast²⁶⁹.
- Setting D7 to "1" is equivalent to adding "128" to the value of the CV.
- Because the length of horn records vary, the actual duration of the horn blast may be longer (or shorter if a hoot is played) than the duration specified.

Example 1: To specify a grade crossing signal consisting of two 3.5 second long horn blasts with a 2.0 second silent period in between, set

CV55.154.0 to "35"
CV55.154.1 to "20"
CV55.154.2 to "35"
CV55.154.3 to "0"
CV55.154.4 to "0"
CV55.154.5 to "0"
CV55.154.6 to "0".

Example 2: To specify a grade crossing signal consisting of
3.0 second long horn blast
1.5 second silent period
3.0 second long horn blast
1.5 second silent period
0.5 second hoot
1.5 second silent period
3.0 second long horn blast with fancy ending

set

CV55.154.0 to "30"
CV55.154.1 to "15"
CV55.154.2 to "30"
CV55.154.3 to "15"
CV55.154.4 to "133"
CV55.154.5 to "15"
CV55.154.6 to "158".

²⁶⁸ Firmware built prior to 9-Sept-10 does not support the use of D7 to specify a hoot or fancy ending.

²⁶⁹ A few horns/whistles do not have a fancy ending record. In those cases, the normal ending for a long horn blast is played.

5.7.32 CV 55.178.SI Status Report

By default, Feature 178 is assigned to output 12 (F10) in CV 53.

By default, the Status Report announces the speed in scale MPH or scale KPH in forward and reverse.

5.7.32.1 CV 55.178.0 Status Report Configuration

Use this CV to select the type of information announced in the status report.

Default Value:

1

CV 55.178.0: Status Report Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Trip Odometer Scale Feet	Analog DC Voltage	Odometer Scale Miles	Internal Temp	PWM	BEMF	Scale MPH

- Default value = 00000001 binary = 01 hex = 1 decimal.
- If bit 0 = 1, the Scale MPH or Scale KPH is announced in FWD/REV. You can select between SMPH and SKPH in CV56.0.
- If bit 1 = 1, the BEMF is announced in FWD/REV. The spoken BEMF value is preceded by a spoken "BEMF"²⁷⁰.
- If bit 2 = 1, the PWM is announced in FWD/REV. The spoken PWM value is preceded by a spoken "PWM"²⁷¹.
- If bit 3 = 1, the Internal Temperature²⁷² is announced in degrees Celsius. The spoken temperature value is followed by the spoken phrase "degrees C". See CV56.32.0 for temperature calibration information.
- If bit 4 = 1, the Odometer²⁷³ distance traveled is announced in scale miles followed by the word "miles". If you want the distance reported in kilometers, set CV56.0 bit 1 to "1". See CV58.PI.SI for more information on the odometer feature.
- If bit 5 = 1, the Analog DC Voltage is announced followed by the word "volts". The voltage is announced only during Analog DC operation, not during DCC operation.
- If bit 6 = 1, the Trip Odometer²⁷⁴ distance traveled is announced in scale feet followed by the word "feet". If you want the distance reported in meters, set CV56.0 bit 1 to "1". See CV58.PI.SI for more information on the trip odometer feature.

²⁷⁰ Q1, Q2, and Q3 firmware built before Jan 2013 will precede the BEMF value with a spoken a 'B'.

²⁷¹ Q1, Q2, and Q3 firmware built before Jan 2013 will precede the PWM value with a spoken a 'D'.

²⁷² The Internal Temperature feature is currently only available with Q2 O-Scale and G-Scale firmware and with Q2 Quantum Revolution firmware.

²⁷³ The Odometer feature is available with Q3 firmware, Q2 firmware, and with Q1a firmware built after 23-Jul-09.

²⁷⁴ The Odometer feature is available with Q3 firmware, Q2 firmware, and with Q1a firmware built after 23-Jul-09.

5.8 CV 56.PI.SI QSI Configuration

Use CV 56 to access Quantum Configuration settings.

CV 56 is implemented as a two-dimensional table of registers. Some rows of this table have only one register and require the use of CV 49 only. Other rows require both CV 49 and CV 50 to select the configuration registers.

5.8.1 CV 56.0: QSI System Configuration 0 (PI = 0)

Use this CV to configure the Quantum system.

Default
Value:

0²⁷⁵

CV 56.0: QSI System Configuration 0 Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reed Switch Disable	Auxiliary Capacitor Enable	CAM Odometer	CAM Synchronized Chuffs	BEMF Synchronized Chuff Calibration	Antialiased BEMF Measurements	Metric Units	Sounds On Power Up

Bit 0 Sounds on Power Up

- “0” On power up, the locomotive’s sound system will turn on only when a valid DCC Ops Mode packet addressed to the locomotive is received.
- “1” On power up, the locomotive’s sound system will turn on when any valid DCC Ops Mode packet is received.

Bit 1 Selects between Imperial and Metric Units.

- “0” Selects “Imperial Units”. The locomotive’s speed is reported in scale miles per hour (smph). Under Calibrated Speed Control (see CV 56.4), each speed step increment is equal to 1 smph. “Imperial Units” is the default for models of US prototypes.
- “1” Selects “Metric Units”. The locomotive’s speed is reported in scale kilometers per hour (skph). Under Calibrated Speed Control, each speed step increment is equal to 1 skph. “Metric Units” is the default for models of non-US prototypes.

Bit 2 Enables Antialiased BEMF Measurements.

- “0” Antialiased BEMF Measurements are disabled.
- “1” Antialiased BEMF Measurements are enabled.

Bit 3 Selects BEMF synchronized chuff calibration mode²⁷⁶.

- “0” BEMF synchronized chuffs calibration mode “Off” (default).
- “1” BEMF synchronized chuffs calibration mode “On”. In this mode the locomotive maintains a constant speed at each speed step and, in place of normal chuffing sounds, produces a single short beep or single short air release sound once per wheel revolution. Cylinder Cocks sounds are turned off to make it easier to hear the beep/air release sound. It is now easy to adjust CV56.7.SI SMPH/BEMF Ratio (Q3) or CV56.13 Chuff Interval Trim (Q1 and Q2) to obtain exactly one air release per wheel revolution.

²⁷⁵ The default for models of non-US prototypes is 2, selecting for Metric Units.

²⁷⁶ The BEMF synchronized chuff calibration is available in Q3 firmware, Q2 firmware, and Q1a firmware built after 23-Jul-09.

Bit 4 Selects between BEMF synchronized and CAM²⁷⁷ synchronized chuffs on Steam locomotives.

“0” Synchronize chuffs using BEMF (default).

“1” Synchronize chuffs using a Chuff CAM.

Bit 5 Odometer²⁷⁸ Mode

“0” BEMF mode (default).

“1” CAM mode.

Bit 6 Auxiliary Capacitor Enable²⁷⁹

“0” Auxiliary capacitor disabled (default).

“1” Auxiliary capacitor enabled.

Bit 7 Reed Switch Disable

“0” Normal Reed Switch operation is in effect (default).

“1” The Reed Switch is ignored for all operations except the power up reset to factory defaults.

Bit 2 is ignored.

²⁷⁷ Chuff CAMs are currently supported only in Q3 firmware and Q2 firmware.

²⁷⁸ The Odometer feature is available with Q3 firmware, Q2 firmware, and Q1a firmware built after 23-Jul-09.

²⁷⁹ The auxiliary capacitor is available on Q3 FX-U models only.

5.8.2 CV 56.1: QSI System Configuration 1 (PI = 1)

Use this CV to configure the Quantum system²⁸⁰.

Default
Value:

0

CV 56.1: QSI System Configuration 1 Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reversed Motor Polarity	Reserved	CAM Synchronized Chuff2	Reserved	Reserved	Reserved	Enable AirWire

Bit 0 Enable AirWire

“0” AirWire operation is disabled.
“1” AirWire operation is enabled.

Bit 4 Selects CAM synchronized chuffs for chuff2 on Articulated Steam locomotives.

“0” Synchronize chuff2 without using a 2nd CAM (default).
“1” Synchronize chuff2 using a 2nd Chuff CAM.

Bit 6 Reversed Motor Polarity

“0” Normal Motor Polarity.
“1” Reversed Motor Polarity.

Bits 1,2,3,5 and 7 are ignored.

²⁸⁰ This CV is currently supported only by firmware for Q3 Titan-G decoders.

5.8.3 CV 56.4: QSI Throttle Mode (PI = 4)

Use this CV to specify how your Quantum Locomotive interprets throttle position²⁸¹.

Default Value:

1

CV 56.4: QSI Throttle Mode Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	0	D1	D0

- Set data in bits 0 and 1 as follows:
 - “0” = Standard Throttle Control (STC).
 - “1” = Regulated Throttle Control (RTC)²⁸²
 - “2” = Load Compensated BEMF Speed Control (BEMFSC)²⁸³.
 - “3” = Calibrated Speed Control (CSC)
- All other bits are reserved and should be set to 0.
- Default is “1”, Regulated Throttle Control.

Standard Throttle Control (STC) is the common way to control the power delivered to a locomotive’s motor. Under STC, the throttle setting (speed step) explicitly determines the percentage of full power applied to the motor as specified in a speed table. Because the power applied to the motor is constant for a given throttle setting, the speed of the locomotive will change under load, such as climbing grades, pulling a heavy train, binding wheels or gears, and poor track conditions. In addition, the speed of the locomotive will vary as a result of changes in track voltage caused by power pack resistance, track resistance, inconsistent or intermittent pickups, and changes in motor load current.

Calibrated Speed Control (CSC) uses internal motor control electronics to vary the power applied to the motor in an attempt to maintain the same speed regardless of varying load or track voltage conditions. In 128 speed step mode, the locomotive’s speed in scale miles per hour (smph) is equal to the throttle setting²⁸⁴. Default resolution is in 1-smph increments. If your throttle is set at 35, the locomotive will go 35 smph. In 14 or 28 speed step mode, you need to multiply your throttle settings by 9 and 4.5 respectively to determine the locomotive’s speed.

If CV 56.0 bit 1 is set to 1, the locomotive’s speed in scale kilometers per hour (skph) is equal to the throttle setting.

Although some prototype locomotives can achieve 128 miles per hour, most were not designed for these speeds. Increasing the speed step above the fastest speed obtainable by your model locomotive will not produce additional speed increase. Your model’s top speed is also limited by the track voltage. If your command station cannot supply sufficient voltage, at high speed steps the locomotive will run slower than the throttle indicates.

CSC is a big improvement over STC, but may not work well when locomotives are in Consists or are used as mid train helpers or pushers and the locomotives are slightly mismatched in speed calibration. A locomotive that tends to go slightly faster than 35 smph tries to pull the locomotive that tends to go slightly slower than 35 smph up to speed and applies more power to do so. The locomotive that tends to go slightly slower than 35 smph tries to slow the locomotive that tends to go slightly faster than 35 smph and reduces power to do so. The result is that the slightly faster locomotive does all the pulling work while the slightly slower locomotive is dragged along.

Under CSC, the following CV’s have no meaning and are not used: CV 2 (V-Start), CV 5 (V-High), CV 25 (Speed Table Selection), CV 66 (Forward Trim), CV 95 (Reverse Trim), and CV 67 – CV 94 (User Defined Speed Tables).

²⁸¹ CV56.4 does not affect Analog DC operation. Analog DC throttle mode is set using Programming Option #10.

²⁸² On early Quantum 1 factory equipped locomotives, CV56.4 = 1 was the setting for Speed Control, and CV 56.4 = 2 was the setting for RTC.

²⁸³ Both CSC and BEMFSC are not available in Q3, Q2, or Q1a firmware due to threatened litigation from Mike’s Train House (MTH) @.

²⁸⁴ Because of the way the NMRA has set up speed steps, the actual scale speed is 1 smph less than the speed step (i.e. Speed Step 2 = 1 smph, Speed Step 3 = 2 smph, etc.). Most Command Stations display the throttle setting as 1 less than the speed step (i.e. Speed Step 2 = Throttle Setting 1, Speed Step 3 = Throttle Setting 2, etc.) For those command stations, the throttle setting is equal to scale miles per hour.

Load Compensated BEMF Speed Control (BEMFSC): This is a non-calibrated speed control technique where each speed step corresponds to a specific BEMF target value. The speed control circuitry adjusts the power applied to the motor in order to minimize the difference between the measured BEMF and the target BEMF.

BEMFSC has the same problem with locomotives in a consist as does CSC.

The following CV's are used to determine the BEMF target value: CV2 (V-Start), CV5 (V-High), CV6 (V-Mid), CV25 (Speed Table Selection), CV66 (Forward Trim), CV95 (Reverse Trim), and CV67 – CV94 (User Defined Speed Tables).

Regulated Throttle Control (RTC) combines the best of both Standard Throttle Control and Speed Control. The locomotive still uses speed control circuitry to maintain the locomotive's speed but the speed is allowed to increase or decrease slowly in response to loading. When the locomotive encounters an uphill grade, it decreases speed slowly in response to the extra loading. If a locomotive encounters a tight curve or if it has to climb a bad track joint at low speed, it passes through or over these obstacles with little change in speed, just like the prototype. In RTC as in STC, the speed step is a requested power setting, but in RTC the locomotive acts like it weighs thousands of pounds in response to changing loads or layout conditions.

This "intrinsic mass" is not the same as the inertia settings specified in CV 3, CV 4, CV 23, and CV 24, where the locomotive responds to throttle increases and decreases slowly over time. Even with these CV's set to large values, in STC the locomotive would still stop suddenly if it encountered a minor obstacle at slow speeds since there is no Inertial Control circuitry to maintain its motion.

RTC provides an advantage when operating Consists. If the locomotives in a consist are slightly mismatched in speed and experience unequal loading, the RTC firmware in each locomotive responds to automatically equalize the loading.

RTC applies a little more power to the locomotive that tends to run slightly slower, and applies a little less power to the locomotive that tends to run slightly faster. As a result, all the locomotives in the consist tend to work together rather than fight each other.

RTC uses all the standard CV's pertaining to the throttle, including CV 2 (V-Start), CV 5 (V-High), CV 25 (Speed Table Selection), CV 66 (Forward Trim), CV 95 (Reverse Trim), and CV 67 – CV 94 (User Defined Speed Tables).

Example: Select Regulated Throttle Control

1. Set CV 49 to 4.
2. Set CV 56 to 1.

5.8.4 CV 56.5: Regulated Throttle Control (RTC) Minimum Back EMF (PI = 5)

Use this CV to specify the minimum speed under Regulated Throttle Control.

Default Value:

Depends on Locomotive

CV 56.5: Regulated Throttle Control Minimum BEMF Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	D4	D3	D2	D1	D0

- For models 100...999, the data range is from 0 to 7. Bits 3...7 are ignored. For models 1000...9999, the data range is 0 to 31. Bits 5...7 are ignored.
- The locomotive will operate at a speed corresponding to this minimum Back EMF until the speed table value corresponding to the throttle position exceeds V-Start at which time the locomotive will gain speed.
- If the value of this CV is 0, the locomotive does not maintain a minimum speed. The locomotive may not move at very low speed steps.
- If your locomotive runs very smoothly under RTC at speed step one, you may consider lowering the RTC Minimum BEMF value. If your locomotive exhibits non-smooth, jerky behavior at speed step one, you may want to increase the RTC Minimum BEMF value until operation is smooth.
- Before setting the minimum Back EMF, make sure that V-Start, CV2, is not affecting the minimum speed at speed step 1. At QSI, we set V-Start to provide minimum speed between speed step 1 and speed step 8²⁸⁵ in the following way.

Setting CV 2 for Best RTC Minimum Speed Performance at Lower Speed Steps

1. Place locomotive on a level section of track at least a few feet in length.
2. Set V-Start, CV 2, to 0.
3. Set locomotive Throttle Mode to STC in CV 56.4.
4. Set throttle to speed step 8. Unless your track voltage is very high, your locomotive should be stopped.
5. Increase CV2 in increments until the locomotive starts to move.
6. Decrease CV2 until the locomotive stops. Use this value for your CV2 setting.
7. Return to RTC in CV 56.4.

With this CV 2 setting, notice that your locomotive's minimum speed is maintained between speed step 0 and speed step 8. If the locomotive does not increase at speed step 9, you may want to increase CV 2 slightly. See Appendix VI for additional information on operating your locomotive at minimum speed under RTC.

²⁸⁵ Speed step 8 is an arbitrary choice. It maintains a reasonable speed step range that ensures that variations in track voltage settings, locomotive wear-in and others factors do not prevent the locomotive from obtaining a minimum speed at lower speed steps.

5.8.5 CV 56.6: Speed Step 1 Delay (PI = 6)

Use this CV to specify the amount of time the locomotive waits at speed step 1 before moving.

Default Value:

0

CV 56.6: Speed Step 1 Delay Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- The CV56.6 value is the time the locomotive waits at speed step 1 before moving. Each unit represents 0.1 second. For example, a value of 30 represents 3.0 seconds.
- This delay allows diesel motor sounds to rev up to notch 1 sounds before the locomotive moves.
- If the CV56.6 value is 0, there is no delay. The locomotive begins moving immediately when the throttle is increased from speed step 0 to speed step 1.
- If the CV56.6 value is > 0, the locomotive waits the CV56.6 value / 10 seconds of time before moving when the throttle is increased from speed step 0 to speed step 1. For example, if CV56.6 = 43, the locomotive waits 4.3 seconds before moving.
- If the throttle is increased to a speed step greater than 1, the locomotive begins moving immediately.
- This CV does not affect the locomotive's operation when the throttle is decreased from a speed step greater than 1 to speed step 1.

5.8.6 CV 56.7.SI: SMPH/BEMF Ratio (PI = 7, SI = 0,1)²⁸⁶

Use this CV to specify the relationship between scale MPH and BEMF.

Default Value:

Depends on Locomotive

The SMPH/BEMF Ratio requires 2 bytes. CV56.7.0 is the least significant byte, and CV56.7.1 is the most significant byte.

CV 56.7.0: SMPH/BEMF Ratio Low Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 56.7.1: SMPH/BEMF Ratio High Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The CV56.7.0-1 two byte value specifies the amount the SMPH changes for a change of 1.0 BEMF unit.

A value of 10000 represents 1.0, meaning that a change of 1.0 BEMF unit corresponds to a change of 1.0 SMPH. A value of 1000 represents 0.1, meaning that a change of 1.0 BEMF unit corresponds to a change of 0.1 SMPH.

The two byte CV value = (high byte * 256) + low byte. For example for a value of 1000, you would set CV56.7.0 to 232 and CV56.7.1 to 3 according to the calculations

$$\begin{aligned}\text{Low byte} &= 1000 \text{ modulo } 256 = 232 \\ \text{High byte} &= 1000 / 256 = 3\end{aligned}$$

You can hear the locomotive announce the BEMF value in Forward or Reverse in a verbal status report. You trigger the status report by pressing F10. To have the BEMF announced in the status report set CV55.178.0 to 2.

The SMPH can be determined using a commercial speedometer, or using a stopwatch to measure the time it takes the locomotive to travel a fixed distance.

If Programming Verbal Acknowledgement is enabled (see CV62), program CV56.7.1 first, then CV56.7.0. The locomotive reads out the two byte value when the low byte is programmed.

Example: Set CV56.7.0-1 to 0.0913.

Multiply 0.0913 by 10000 to get 913.

Divide 913 / 256 to get 3. This is the value of the high byte CV56.7.1.

Multiply 256 * 3 to get 768. Subtract this from 913 to get 913 – 768 = 145. This is the value of the low byte CV56.7.0.

Set CV49 to 7.

Set CV50 to 1.

Set CV56 to 3. (This sets CV56.7.1 to 3.)

Set CV50 to 0.

Set CV56 to 145. (This sets CV56.7.0 to 145.)

²⁸⁶ CV56.7.SI is supported only by Q3 decoders.

5.8.6.1 Calibrating BEMF to SMPH (Q3)

This section describes several calibration methods for Q3 decoders. For Q1 and Q2 decoders, see the methods described under CV56.9 BEMF to Scale MPH Trim.

(1) Calibrate BEMF Synchronized Chuff Rate

If you are calibrating a steam locomotive, you can calibrate BEMF to SMPH and BEMF Synchronized Chuff Rate at the same time. If you enter the correct scale wheel diameter for your locomotive, obtaining a synchronized chuff guarantees a correct BEMF to SMPH calibration. See the next section on calibrating chuff rate for further information.

(2) Use the Trip Odometer Calibration Procedure

- (a) Assign feature 200 “Calibrate BEMF to SMPH” to a function key using CV53.PI.1. For example, if you want to use FKey 12 for this purpose, set CV53.14.1 = 200.
- (b) Measure a distance on your track equivalent to the value of CV58.20.0-1 BEMF to SMPH Calibration Distance. For example, if the value of CV58.20.0-1 = 696, either measure 696 feet using a scale tape measure or convert 696 to actual feet and inches and measure the distance using a standard tape measure.
- (c) Mark a start point and a stop point at the two ends of this distance.
- (d) [Optional] Have the locomotive read out the value of CV56.7.0-1. Write this number on paper for future reference.
- (e) Move your locomotive to the start point.
- (f) Press the function key you assigned to feature 200. The locomotive will announce “Calibration Started” and the bell will start ringing.
- (g) Using the DCC controller throttle, move the locomotive to the stop point. Use any speed that allows you to comfortably control the locomotive and bring it to a stop as closely as possible to the stop point.
- (h) When the locomotive has completely stopped and entered neutral, press the function key you assigned to feature 200. The bell will automatically stop ringing, and the locomotive will announce “Calibration Finished” followed by the number of scale feet traveled as measured by the trip odometer.
- (i) [Optional] Have the locomotive read out the value of CV56.7.0-1.
- (j) If you make a mistake such as prematurely pressing the function key the second time, you can recover by manually entering the previous value of CV56.7.0-1 from step (d) and going back to step (e). You can also recover by resetting all CV's to their factory default values, but then you need to go back to step (a).
- (k) Repeat steps (e) thru (i) to make sure you get fairly consistent results.
- (l) When done calibrating, reassign the function key to a feature other than feature 200 using CV53.PI.1.

(3) Use a Commercial Speedometer

Measure your locomotive's SMPH using a device similar to one available from http://www.tonystains.com/products/tdp-assoc_speed.htm

Run your locomotive at a medium speed. Press F10 to have the locomotive announce its SMPH. If the locomotive's announced SMPH is less than the measured SMPH, increase the value of CV56.7.0-1. If the locomotive's announced SMPH is greater than the measured SMPH, decrease the value of CV56.7.0-1.

(Optional) Then run your locomotive at one mile per hour. Press F10 to have the locomotive announce its SMPH. If the announced SMPH is less than the measured SMPH, increase the value of CV56.8 BEMF Offset. If the announced SMPH is greater than the measured SMPH, decrease the value of CV56.8 BEMF Offset.

(4) Use a Stopwatch and Tape Measure

Use a tape measure to measure a distance on your layout. Mark a start point and a stop point.

For best results get your locomotive up to a medium speed and put the locomotive into “Heavy Load” by pressing F9. Under Heavy Load the locomotive acts as if it has enormous inertia and will speed up or slow down very little under varying track conditions.

Have the locomotive announce its speed from time to time. You may want to write these numbers down and compute an average.

When the locomotive passes the start point, start the stopwatch. When the locomotive passes the stop point, stop the stopwatch. Calculate the locomotive’s speed as:

$$\text{Distance_Traveled} / \text{Time}$$

Remember to convert your “Distance_Traveled” to miles and the “Time” to hours and multiply by the appropriate scale factor for your model (e.g., “87” for HO Scale).

For example, if the Distance_Traveled is 40 feet 6 inches and the Time is 1 minute 30 seconds, then the SMPH for 1:87 Scale is:

$$\begin{aligned} & \text{Distance_Traveled} / \text{Time} \\ & (40.5 \text{ feet} * 87 * (1 \text{ mile} / 5280 \text{ feet})) / (90 \text{ seconds} * (1 \text{ minute} / 60 \text{ seconds}) * (1 \text{ hour} / 60 \text{ minutes})) \\ & (40.5 * 87) / 5280 / (90 / 3600) \\ & (40.5 * 87 * 3600) / (90 * 5280) \\ & 26.693 \text{ SMPH} \end{aligned}$$

The longer your calibration course, the more accurate your calculated speed will be. If you have a small layout, measure the distance for one trip around the layout and run your locomotive 10 times around the layout, starting the stopwatch at the start of the first trip and stopping the stopwatch at the end of the tenth trip.

If the locomotive’s announced SMPH is less than the measured SMPH, increase the value of CV56.7.0-1. If the locomotive’s announced SMPH is greater than the measured SMPH, decrease the value of CV56.7.0-1.

(Optional) Then repeat by running the locomotive at 1 SMPH over a short distance.

For example, if the Distance_Traveled is 12 inches and the Time is 53 seconds, then the SMPH for 1:87 Scale is:

$$\begin{aligned} & \text{Distance_Traveled} / \text{Time} \\ & (1.0 \text{ feet} * 87 * (1 \text{ mile} / 5280 \text{ feet})) / (53 \text{ seconds} * (1 \text{ minute} / 60 \text{ seconds}) * (1 \text{ hour} / 60 \text{ minutes})) \\ & (1.0 * 87) / 5280 / (53 / 3600) \\ & (1.0 * 87 * 3600) / (53 * 5280) \\ & 1,119 \text{ SMPH} \end{aligned}$$

If the announced SMPH is less than the measured SMPH, increase the value of CV56.8 BEMF Offset. If the announced SMPH is greater than the measured SMPH, decrease the value of CV56.8 BEMF Offset.

(5) Graph SMPH vs BEMF

Use either a commercial speedometer or stopwatch and tape measure to determine the locomotive’s SMPH. Run the locomotive at several different speeds. Have the locomotive announce its BEMF at each speed. Graph SMPH on the y axis and BEMF on the x axis. Draw a straight line through the graphed points.

The slope of the line is the SMPH/BEMF ratio (CV56.7.0-1).

The x intercept of the line is the negative of the BEMF Offset (CV56.8).

5.8.6.2 Calibrating BEMF Synchronized Chuff Rate (Q3)

Follow these steps to calibrate your Q3 decoder's BEMF synchronized chuff rate. If you enter the correct Scale Wheel Diameter in step 1, this procedure also results in a correct BEMF to SMPH mapping.

- 1) Set CV56.26.0-1 Scale Wheel Diameter to your locomotive's wheel diameter.
- 2) Set CV56.0 bit 3 to "1" to turn on BEMF synchronized chuff calibration mode so that the locomotive will produce a single short beep or single short air release²⁸⁷ every wheel revolution. Setting this bit also causes the locomotive to maintain a constant speed at each speed step. The speed may be slower than under normal operation for a given speed step.
- 3) Run your locomotive at a moderate speed, for example speed step 100, which is approximately 20 SMPH when CV56.0 bit 3 = 1.

If the beep/air release does not occur at the same point on the wheel every revolution, giving exactly one air let-off per revolution, adjust the CV56.7.0-1 SMPH/BEMF Ratio.

If the beep/air release occurs earlier and earlier every revolution, the chuff rate is too fast. Decrease the value of CV56.7.0-1 to slow the chuff rate. (Note: increasing the value of CV56.26.0-1 also slows the chuff rate.)

If the beep/air release occurs later and later every revolution, the chuff rate is too slow. Increase the value of CV56.7.0-1 to speed up the chuff rate. (Note: decreasing the value of CV56.26.0-1 also speeds up the chuff rate.)

- 4) Then run your locomotive at a slow speed, for example speed step 5, which is approximately 1 SMPH when CV56.0 bit 3 = 1.

If the beep/air release does not occur at the same point on the wheel every revolution, giving exactly one air let-off per revolution, adjust the CV56.8 BEMF Offset.

If the beep/air release occurs earlier and earlier every revolution, the chuff rate is too fast. Decrease the value of CV56.8 to slow the chuff rate.

If the beep/air release occurs later and later every revolution, the chuff rate is too slow. Increase the value of CV56.8 to speed up the chuff rate.

- 5) Repeat step (3) at a different moderate speed and adjust CV56.7.0-1 if necessary.
- 6) Repeat step (4) and adjust CV56.8 if necessary.
- 7) Set CV56.0 bit 3 to "0" to turn off BEMF synchronized chuff calibration mode.

²⁸⁷ Firmware built after 29-May-13 plays a single short beep.

5.8.7 CV 56.8: BEMF Offset (PI = 8)

Use this CV to add an offset to each BEMF reading.

Default Value:

Depends on Locomotive

CV 56.8: BEMF Offset Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- CV 56.8 can have any value from -127 to $+127$. A positive value is indicated by a 0 in bit 7 while a "1" indicates a negative value.
- To specify a negative offset, add 128 to the unsigned offset value. For example, to specify an offset of -60 , add 128 to 60 to obtain 188.
- Each unit represents an offset of $1/16$ BEMF unit. For example, a value of 10 adds $10/16 = 0.625$ to each BEMF reading.
- Use CV 56.8 as a final adjustment to the BEMF to SMPH mapping in all locomotives and chuff rate in steam locomotives.

Example: Add 1.2 ($1.2 * 16 = 19$) to each BEMF reading.

1. Set CV 49 to 8 to select the BEMF offset register.
2. Set CV 56 to 19 to specify the offset.

5.8.8 CV 56.9: BEMF to SMPH Trim²⁸⁸ (PI = 9)

Use this CV to change the mapping of BEMF to scale MPH.

Default Value:

128

CV 56.9: BEMF to SMPH Trim Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV determines the relationship between the measured BEMF of the motor and the speed of the locomotive in smph. The content of this CV is interpreted as “X / 128”, which means a CV value of 128 is equivalent to a Trim Factor of 1.0.

The locomotive announces the speed of the locomotive in Forward or Reverse in a verbal status report. You can trigger the status report by pressing F10. The locomotive’s speed can be announced in either scale miles per hour or scale kilometers per hour. To have scale kilometers per hour announced, set CV56.0 bit 1 to “1”.

The factory default value for CV56.9 is “128” which represents “1.0”. If your locomotive is reporting speeds that are too slow or too fast, you can correct this by increasing or decreasing the value of this CV.

For example, suppose that your locomotive reports that it is moving 30 smph, but that you measure its speed by some other means to be 35 smph. To correct this, set CV56.9 to “149”. The “149” is arrived at by the following calculation:

$$\begin{aligned} &(\text{Measured_Speed} / \text{Reported_Speed}) * \text{Current_CV56.9} \\ &(35 / 30) * 128 \\ &1.167 * 128 \\ &149 \end{aligned}$$

Suppose that now the locomotive reports that it is going 36 smph when it is actually going 35 smph. You can further adjust the mapping by setting CV56.9 to “145” according to the calculation:

$$\begin{aligned} &(\text{Measured_Speed} / \text{Reported_Speed}) * \text{Current_CV56.9} \\ &(35 / 36) * 149 \\ &0.972 * 149 \\ &145 \end{aligned}$$

5.8.8.1 Calibrating BEMF to SMPH (Q1 and Q2)

This section describes calibration methods for Q1 and Q2 decoders. For Q3 decoders, see the methods described under CV56.7.SI SMPH/BEMF Ratio.

Here are three ways you can calibrate your locomotive’s BEMF to SMPH mapping. Two methods involve measuring your locomotive’s actual speed and comparing with the locomotive’s reported speed. One method involves comparing the actual distance the locomotive travels with the distance it reports it travels.

(1) Using a Commercial Speedometer

Measure your locomotive’s speed using a device similar to one available from http://www.tonystains.com/products/tdp-assoc_speed.htm

For best results get your locomotive up to the desired speed and put the locomotive into “Heavy Load” by pressing F9. Under Heavy Load the locomotive acts as if it has enormous inertia and will speed up or slow down very little under varying track conditions.

²⁸⁸ This CV is not available in Q1a firmware released prior to 23-Jul-09. This CV is not supported by Q3 decoders; instead use CV56.7.SI SMPH/BEMF Ratio.

Have the locomotive report its speed from time to time. You may want to write these numbers down and compute an average.

Adjust CV56.9 as discussed above until the measured speed matches the locomotive's reported speed.

(2) Using a Stopwatch and Tape Measure

Use a tape measure to measure a distance on your layout. Mark a start point and a stop point.

For best results get your locomotive up to the desired speed and put the locomotive into "Heavy Load" by pressing F9. Under Heavy Load the locomotive acts as if it has enormous inertia and will speed up or slow down very little under varying track conditions.

Have the locomotive report its speed from time to time. You may want to write these numbers down and compute an average.

When the locomotive passes the start point, start the stopwatch. When the locomotive passes the stop point, stop the stopwatch. Calculate the locomotive's speed as:

$$\text{Distance_Traveled} / \text{Time}$$

Remember to convert your "Distance_Traveled" to miles and the "Time" to hours and multiply by the appropriate scale factor for your model (e.g., "29" for Aristocraft G-Scale).

For example, if the Distance_Traveled is 40 feet 6 inches and the Time is 1 minute 30 seconds, then the SMPH for 1:29 Scale is:

$$\begin{aligned} & \text{Distance_Traveled} / \text{Time} \\ & (40.5 \text{ feet} * 29 * (1 \text{ mile} / 5280 \text{ feet})) / (90 \text{ seconds} * (1 \text{ minute} / 60 \text{ seconds}) * (1 \text{ hour} / 60 \text{ minutes})) \\ & (40.5 * 29) / 5280 / (90 / 3600) \\ & (40.5 * 29 * 3600) / (90 * 5280) \\ & 8.897 \text{ SMPH} \end{aligned}$$

The longer your calibration course, the more accurate your calculated speed will be. If you have a small layout, measure the distance for one trip around the layout and run your locomotive 10 times around the layout, starting the stopwatch at the start of the first trip and stopping the stopwatch at the end of the tenth trip.

Adjust CV56.9 as discussed above until your measured speed matches the locomotive's reported speed.

(3) Using the Locomotive's Odometer

Using this method you compare the measured distance traveled against the locomotive's reported distance traveled. When using this method, the Odometer mode must be "BEMF" (CV56.0 bit 5 = '0').

(1) Mark a start point and a stop point on your layout.

(2) Use a tape measure to measure the distance to be traveled through the calibration course. The longer the calibration course, the more accurate the calibration will be. If you have a small layout, measure the distance for one trip around the layout and run your locomotive 10 times around the layout.

(3) Convert the measured length to scale miles and save as "Measured_Scale_Distance". For example, for a G-Scale locomotive (scale 1:29), suppose the measured length around your layout is 60 feet 3¼ inches and the calibration course is 10 times around the layout. Then

$$\begin{aligned} \text{Measured_Scale_Distance} &= (60.27 \text{ feet} * 10) * (1 \text{ mile} / 5280 \text{ feet}) * 29.0 \\ \text{Measured_Scale_Distance} &= 3.31 \text{ scale miles} \end{aligned}$$

(4) Move the locomotive to the start point.

(5) Reset the odometer to "0" by writing "0" to CV58.1.0 (see note 3).

- (6) Start the locomotive and run it through the calibration course. Stop the locomotive at the stop point.
- (7) Have the locomotive report the distance traveled (see notes 1, 2 and 3). Save this value as "Reported_Distance".
- (8) Read out the current trim factor in CV56.9. Save this as "Old_Trim".
- (9) Calculate the new trim factor as shown:

$$\text{New_Trim} = (\text{Measured_Scale_Distance} / \text{Reported_Distance}) * \text{Old_Trim}$$

- (10) Set CV56.9 to the value of "New_Trim".
- (11) Repeat steps 4 through 10 if desired.

Note 1: To have the locomotive speak out the odometer value in scale miles or scale kilometers, set CV55.178.0 bit 4 to "1". Then press the F10 key. If you want the odometer value in scale kilometers, set CV56.0 bit 1 to "1".

Note 2: You can also have the locomotive speak out the odometer value by writing 58 to CV64.1.0. (CV64 is the CV Numeric Verbal Readout).

Set CV49 to "1"
Set CV50 to "0"
Set CV64 to "58"

Note 3: Version 1.1.0.1 and later versions of QuantumCVManager make this easy to do. Just select the Decoder menu item "Odometer..." to display the Odometer dialog box. There is one button for odometer read out and a second button for resetting the odometer.

5.8.9 CV 56.10: Speed Step to SMPH Scale Factor (PI = 10)

Use this CV to change the mapping of speed step to scale MPH under Calibrated Speed Control (CSC).

Default Value:

64

CV 56.10: Speed Step to SMPH Scale Factor Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV determines the relationship between speed steps and smph for CSC. The content of this CV is interpreted as "X / 64", which means a CV value of 64 is equivalent to a Scale Factor of 1.0. Some examples are:

CV 56.10	Scale Factor	Slowest possible speed at Speed Step 2	Fastest possible speed at Speed Step 127.
32 (0x20)	0.5	0.5 smph	63 smph
64 (0x40)	1.0	1 smph	126 smph
128 (0x80)	2.0	2 smph	252 smph

- Change the Scale Factor if you want a more active throttle range for a locomotive under CSC.
- A Scale Factor less than 1.0 makes sense when the top speed of the locomotive is much less than 126 smph. For example, suppose a locomotive has a top speed of 60 smph. With a Scale Factor of 1.0, all speed steps from 61 through 127 will result in a speed of 60 smph. If the Scale Factor is set to 0.5, then the top speed of 60 smph will correspond to speed steps 121 and above.
- A Scale Factor greater than 1.0 make sense when the top speed of the locomotive is much greater than 126 smph. For example, suppose a locomotive has a top speed of 200 smph. With a Scale Factor of 1.0 the locomotive would only go up to 126 smph. If the Scale Factor were set to 2.0, then the top speed of 200 smph would be obtained at speed steps 101 and above.
- The advantage of a Scale Factor of "1.0" is that you easily know the locomotive's speed if you have a command station that displays the current speed step.
- The Scale Factor can also be used to increase the accuracy of locomotive's speed. For example, if your locomotive runs at 34 smph when it should run at 35 smph, you could increase the scale factor slightly to $(35/34) * 64 = 66$.
- Adjusting the Scale Factor when trying to match locomotives in Consists when all are operating under CSC is another possibility.
- This CV has no effect under Standard Throttle Control, Regulated Throttle Control, or Load Compensated BEMF Speed Control.

5.8.10 CV 56.12: Chuff Interval Scale Factor²⁸⁹ (PI = 12)

Use this CV to adjust the time between BEMF synchronized chuffs.

Default Value:

32

CV 56.12: Chuff Interval Scale Factor Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This byte specifies a scale factor used to determine the amount of time between BEMF synchronized chuffs. This is inversely related to the chuff rate or the number of chuffs per wheel revolution; the larger the scale factor (more time between chuffs), the slower the chuff rate (fewer chuffs per wheel revolution). The content of this CV is interpreted as “X / 32”, which means a CV value of 32 is equivalent to a scale factor of 1.0.
- Some examples of different scale factors are:

CV 56.12	Scale Factor	Chuffs Per Wheel Revolution
32 (0x20)	1.0	4
43 (0x2B)	1.3	3
64 (0x40)	2.0	2
128 (0x80)	4.0	1

- To calculate the scale factor for a desired number of chuffs per wheel revolution, use the formula Scale Factor = (4 / N) * 32, where N is the number of chuffs per revolution.
- Use this scale factor to fine-tune the chuff rate. For example, if your locomotive chuffs a little slower than four per revolution, you can decrease the scale factor to 31 (0.97) to slightly increase the number of chuffs per revolution. Or if your locomotive chuffs a little faster than four per revolution, you can increase the scale factor to 33 (1.03) to slightly decrease the number of chuffs per revolution. If your locomotive supports CV56.13, use CV56.13 instead of this CV for fine-tuning the chuff rate.

Note: We recommend that you set the chuff rate at some speed value greater than 2 smph.

²⁸⁹ All QSI equipped steam locomotives since 1-July-04 support CV 56.12 Chuff Interval Scale Factor and it is available on all version 6 software which includes all Life Like and the BLI PRR K4, C&O Texas and all following models.

5.8.11 CV 56.13: Chuff Interval Trim²⁹⁰ (PI = 13)

Use this CV to adjust the time between BEMF synchronized chuffs.

Default Value:

128

CV 56.13: Chuff Interval Trim Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This byte specifies a scale factor used to determine the amount of time between BEMF synchronized chuffs. This is inversely related to the chuff rate or the number of chuffs per wheel revolution; the larger the scale factor (more time between chuffs), the slower the chuff rate (fewer chuffs per wheel revolution). The content of this CV is interpreted as “X / 128”, which means a CV value of 128 is equivalent to a scale factor of 1.0.
- Use this scale factor to fine-tune the chuff rate. For example, if your locomotive chuffs a little slower than four per revolution, you can decrease the scale factor to 127 (0.992) to slightly increase the number of chuffs per revolution. Or if your locomotive chuffs a little faster than four per revolution, you can increase the scale factor to 129 (1.008) to slightly decrease the number of chuffs per revolution.
- Set CV56.0 bit 3 to “1” to turn on BEMF synchronized chuff calibration mode to make it easier to adjust the chuff rate.
- If you find that one value of CV56.13 gives good synchronized chuff at one speed, but at another speed a different value of CV56.13 is required, see the Q2Upgrade User Manual for a procedure for calibrating the chuff rate for multiple values of CV56.13.
- This CV is similar to CV56.12 Chuff Interval Scale Factor. The resolution is greater in CV56.13 but the range is less. CV56.12 is a coarse adjustment while CV56.13 is a fine adjustment. In locomotives that support both CV56.12 and CV56.13, both CV’s are applied. For example, if CV56.12 is “40” and CV56.13 is “144”, then the resulting scale factor applied to the chuff interval is:

$$\begin{aligned} &40/32 * 144/128 \\ &1.25 * 1.125 \\ &1.40625 \end{aligned}$$

Note: We recommend that you trim the chuff rate at some speed value greater than 2 smph.

²⁹⁰ CV56.13 is not available in Q1a firmware built prior to 23-Jul-09.

5.8.12 CV 56.14: Chuffs Per Wheel Revolution (PI = 14)

Use this CV to specify the number of chuffs per wheel revolution.

Default Value:

4

CV 56.14: Chuffs Per Wheel Revolution Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This byte specifies the number of chuffs per wheel revolution for BEMF synchronized chuffs.
- Valid values for this CV are 1...255.
- If the value of this CV = 0, then a value of 1 is used.
- This CV is not used if CV56.0 bit 3 is "1" enabling BEMF Synchronized Chuff Calibration mode.
- This CV together with CV56.7.SI SMPH/BEMF ratio and CV56.8 BEMF Offset replace CV56.12 Chuff Interval Scale Factor and CV56.13 Chuff Interval Trim for Q3 decoders.
- Do not use this CV to calibrate your locomotive's chuff rate. Use the procedure described in the CV56.7.SI SMPH/BEMF Ratio section to calibrate the chuff rate.

5.8.13 CV 56.18-21.SI: Quantum PID Parameters

“PID” is an acronym standing for “Proportional, Integral, Differential”.

PID parameters are used to control the amount of power applied to the motor of QSI locomotives when operating under Regulated Throttle Control, Calibrated Speed Control, or Load Compensated BEMF Speed Control.

The PID control loop strives to match the locomotive’s measured BEMF to a target BEMF value. Basically, if the measured BEMF is less than the target BEMF, the PID control loop increases the power supplied to the motor to make the locomotive go faster. If the measured BEMF is greater than the target BEMF, the PID control loop decreases the power supplied to the motor to make the locomotive go slower.

A relatively easy-to-read on-line summary of PID control can be found at the following site:

http://en.wikipedia.org/wiki/PID_controller

For Q1 decoders running Q1a firmware and Q2 decoders running firmware built before 1-Oct-08, there are two PID parameters that you can set for each BEMF range. Q1a firmware and early Q2 firmware do not allow changing the Integral Gain. For Q2 decoders running firmware built after 1-Oct-08 and for Q3 decoders, you can also set the Integral Gain.

Because model locomotives behave differently at different speeds, we use four different sets of PID parameters within four different speed ranges. Since BEMF is directly proportional to speed, we classify these speed ranges in terms of BEMF ranges. The actual BEMF values for each range depend on the type of decoder and the type of firmware. Use the following table to determine the BEMF value for each range for a particular decoder and firmware.

Decoder/Firmware Type	VLS_MAX	LS_MAX	MS_MAX
Q1 decoder/Q1a firmware	7	54	108
Q1 decoder/Q2 firmware	CV56.5 + 5	54	108
Q2 decoder	CV56.5 + 5	54	108
Q3 FX-U decoder	CV56.5 + 5	293	586
Q3 FX-SD decoder	CV56.5 + 5	293	586
Q3 FX-AO decoder	CV56.5 + 5	479	958
Q3 FX-DO decoder	CV56.5 + 5	479	958

5.8.13.1 CV 56.18.SI PID Parameters for Very Slow Speed (PI=18, SI = 0,1,2)

Default Values:

Depends on Locomotive

CV 56.18.0: Proportional Gain for BEMF ≤ VLS_MAX

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Proportional Gain for very slow speeds: $0 < \text{BEMF} \leq 7$. For Q2 and Q3 firmware, this range is $0 < \text{BEMF} \leq \text{CV56.5} + 5$.
- Valid values are 0 to 255.

CV 56.18.1: Integral Gain for BEMF ≤ VLS_MAX

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Integral Gain for very slow speeds: $0 < \text{BEMF} \leq 7$. For Q2 and Q3 firmware, this range is $0 < \text{BEMF} \leq \text{CV56.5} + 5$.
- Valid values are 0 to 2. The decoder firmware may allow you to set any value 0 to 255, but during operation, if the value is greater than 2, a value of 2 is used.

CV 56.18.2: Differential Gain for BEMF ≤ VLS_MAX

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV byte to specify the Differential Gain for very slow speeds for: $0 < \text{BEMF} \leq 7$. For Q2 and Q3 firmware, this range is $0 < \text{BEMF} \leq \text{CV56.5} + 5$.
- Valid values are 0 to 255.

5.8.13.2 CV 56.19.SI PID Parameters for Slow Speed (PI=19, SI = 0,1,2)

Default Values:

Depends on Locomotive

CV 56.19.0: Proportional Gain for: $VLS_MAX < BEMF \leq LS_MAX$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Proportional Gain for slow speeds: $7 < BEMF \leq 54$. For Q2 firmware, this range is $CV56.5 + 5 < BEMF \leq 54$. For Q3 firmware, refer to the table above to determine the appropriate VLS_MAX and LS_MAX .
- Valid values are 0 to 255.

CV 56.19.1: Integral Gain for $VLS_MAX < BEMF \leq LS_MAX$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Integral Gain for slow speeds: $7 < BEMF \leq 54$. For Q2 firmware, this range is $CV56.5 + 5 < BEMF \leq 54$. For Q3 firmware, refer to the table above to determine the appropriate VLS_MAX and LS_MAX .
- Valid values are 0 to 2. The decoder firmware may allow you to set any value 0 to 255, but during operation, if the value is greater than 2, a value of 2 is used.

CV 56.19.2: Differential Gain for: $VLS_MAX < BEMF \leq LS_MAX$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Differential Gain for slow speeds for: $7 < BEMF \leq 54$. For Q2 firmware, this range is $CV56.5 + 5 < BEMF \leq 54$. For Q3 firmware, refer to the table above to determine the appropriate VLS_MAX and LS_MAX .
- Valid values are 0 to 255.

5.8.13.3 CV 56.20.SI PID Parameters for Medium Speed (PI=20, SI = 0,1,2)

Default Values:

Depends on Locomotive

CV 56.20.0: Proportional Gain for: $LS_MAX < BEMF \leq MS_MAX$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Proportional Gain for medium speeds: $54 < BEMF \leq 108$. For Q3 firmware, refer to the table above to determine the appropriate LS_MAX and MS_MAX .
- Valid values are 0 to 255.

CV 56.20.1: Integral Gain for $LS_MAX < BEMF \leq MS_MAX$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Integral Gain for medium speeds: $54 < BEMF \leq 108$. For Q3 firmware, refer to the table above to determine the appropriate LS_MAX and MS_MAX .
- Valid values are 0 to 2. The decoder firmware may allow you to set any value 0 to 255, but during operation, if the value is greater than 2, a value of 2 is used.

CV 56.20.2: Differential Gain for: $LS_MAX < BEMF \leq MS_MAX$

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Differential Gain for medium speeds for: $54 < BEMF \leq 108$. For Q3 firmware, refer to the table above to determine the appropriate LS_MAX and MS_MAX .
- Valid values are 0 to 255.

5.8.13.4 CV 56.21.SI PID Parameters for High Speed (PI=21, SI = 0,1,2)

Default Values:

Depends on Locomotive

CV 56.21.0: Proportional Gain for: MS_MAX < BEMF

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Proportional Gain for high speeds: 108 < BEMF. For Q3 firmware, refer to the table above to determine the appropriate MS_MAX.
- Valid values are 0 to 255.

CV 56.21.1: Integral Gain for MS_MAX < BEMF

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Integral Gain for high speeds: BEMF < 108. For Q3 firmware, refer to the table above to determine the appropriate MS_MAX.
- Valid values are 0 to 2. The decoder firmware may allow you to set any value 0 to 255, but during operation, if the value is greater than 2, a value of 2 is used.

CV 56.21.2: Differential Gain for: MS_MAX < BEMF

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this CV to specify the Differential Gain for high speeds: 108 < BEMF. For Q3 firmware, refer to the table above to determine the appropriate MS_MAX.
- Valid values are 0 to 255.

5.8.13.5 Setting PID Parameters for Quantum Equipped Model Locomotives:

- Make sure your locomotive is in the best possible mechanical condition. RTC can improve the operation of a well-tuned locomotive but it cannot compensate for locomotives that have serious mechanical problems. Set CV 56.4 to “0” to select Standard Throttle Control and operate your model at slow speed over a level piece of straight track at the minimum sustainable speed. Note any gear bind or “catching”. If the locomotive always slows down at the same wheel position, you may need to make mechanical adjustments. With a steam locomotive, look for any mechanical problems with the valve gear. Lubricate all moving joints with appropriate non-corrosive oil and lube the gearbox. Check your electrical pickups and clean the wheels to ensure consistent power to the motor.
- Make sure your test conditions are consistent.
- If you are using a test track or a different layout to set PID parameters, set the DCC track voltage to match the layout you intend to use for normal operation. When we calibrate motor control and throttle CV’s at QSI, we set our track at 16 volts with only the test locomotive on the track and in Neutral.
- Use a flat oval of track that is consistently powered in all sections (i.e. Track voltage should be the same at all locations). Make sure track does not have misaligned track joints or turnouts that can slow the locomotive.
- Reset All CV’s.
- Set Status Report (F10) to both smph and BEMF (set CV 55.178.0 to 3). Speed will be announced first followed by the BEMF value. The BEMF report will be preceded by “B” to distinguish it from the speed report.
- Set minimum BEMF to 3 (set CV 56.5 to 3). This CV specifies the slowest speed the locomotive will travel in RTC.
- Set CV 56.4 to “0” to select STC.
- While in STC, with the throttle set to speed step = 8 (126 speed step range), increase CV 2 until locomotive moves, and then decrease CV 2 until locomotive stops. This will ensure that the low-end speed on your model is not being affected by CV 2 during the PID setting procedure. This will likely be the value of CV 2 you will retain in your model after you have set all your PID parameters.
- Set CV 56.4 to 1 to select RTC and adjust PID parameters:
 - 1) **Very Slow Speed PID’s:** Set your locomotive to Speed Step 1. Change CV 56.18.0 and CV 56.18.2 to achieve optimal performance.
 - 2) **Slow Speed PID’s:** Increase your throttle until the Status Report (F10 key) announces a BEMF value between 20 and 56. Change CV 56.19.0 and CV 56.19.2 to achieve optimal performance.
 - 3) **Medium Speed PID’s:** Increase your throttle until the Status Report (F10 key) announces a BEMF between 56 and 125. Change CV 56.20.0 and CV 56.20.2 to achieve optimal performance.
 - 4) **High Speed PID’s:** Increase your throttle until the Status Report (F10 key) announces a BEMF greater than 125. Change CV 56.21.0 and CV 56.21.2 to achieve optimal performance
- If your locomotive surges at medium and high speeds and this behavior remains after changing the Proportional and Differential Gain parameters, then setting the Integral Gain parameters CV56.20.1 and CV56.21.1 to “1” or “0” may correct the problem.
- Transient Response Test: Does the locomotive stop smoothly in DCC when the throttle is changed from full throttle to zero throttle quickly? If it overshoots (i.e. slows, speeds up, and then slows again when you lower the throttle quickly and the locomotive slows to its new speed), then PID parameters need to be re-adjusted (see Hints below).
- It is also a good idea to test your PID settings under Analog operation to see if there is any overshoot or surging when the throttle is changed from full to just below V-Start quickly. RTC problems under DC operation almost always appear in DCC, although they can have different characteristics.
- Set New Minimum BEMF: Adjust CV 56.5 for the best possible low speed performance in RTC. If your locomotive runs very smoothly and has good Very Slow Speed PID parameters, the minimum BEMF can be reduced to 1 to achieve the ultimate low-end speed.

5.8.13.6 General Hints for Setting PID Parameters:

Choosing the correct PID parameters is more an art form than a science. Here are some general rules based on our experience that will get you close to the best performance.

1. We usually set the Proportional Gain (P) between 4 and 16. High values can cause overshooting, or surging when the throttle is changed quickly and low terms can result in poor response time. Higher values of P are generally used at the "Very Slow Speed" and "Slow Speed" BEMF ranges. We have seldom set P above 20 for the "High Speed" range.
2. The Integral Gain (I) is normally left as the default value, which for most locomotives is "2". If your locomotive surges at medium and high speeds, this may be corrected by lowering I to "1" or "0". Be wary of setting CV 56.18.1 Integral Gain for BEMF ≤ 7 to "0". If you do this, the locomotive may not come to a complete stop and enter neutral when you lower the throttle.
3. The Differential Gain (D) is usually set between 1 and 100 with some notable exceptions as high as 150. The very high values for D are best at the "Very Slow Speed" range, while moderate D values are better at the higher BEMF ranges (10 to 60). High values of D help at slow speeds since this term compensates for rapid changes in speed that can occur from gear binding or minor obstacles such as misaligned track joints. At higher speed, high values of D are less significant since the flywheel momentum will often keep the locomotive moving despite minor gear issues. Too high a value of D will result in surging. This effect is sometimes very subtle. Carefully watch your train for any slight changes in steady-state speed as it moves around that track oval. Too high a Proportional term can also cause steady-state surging.
4. If your locomotive fails the "Transient Response" test, try lowering the Proportional terms and increase the Differential terms for the Slow Speed, Medium Speed and High Speed ranges. Adjustments of the Differential term for Very Low Speed will probably have no effect on transient performance. Try to bring the differential terms closer to the same value for the three top ranges. Do the same for the Proportional term. You will probably have the best luck with the Differential term in adjusting transient performance. The larger the Differential term, the less overshoot or surging the locomotive will do as it slows to its lower speed or stops. However, a large Differential term can result in steady state surging at some speeds. Always go back and check your steady state speed performance after optimizing your transient behavior.

In some cases it is best to ignore all the above. We have seen locomotives that do not fit neatly into the above set of rules. You may want to experiment using your own intuition, knowledge, and methodology. If you do obtain a good set of PID parameters, please let us know or publish for the rest of the railroad community.

5.8.14 CV 56.24.SI: Wheel Diameter²⁹¹ (PI = 24, SI = 0,1)

Use this CV to specify the locomotive's wheel diameter to 0.001 of an inch.

Default Value:

NA

The wheel diameter requires 2 bytes. CV56.24.0 is the least significant byte, and CV56.24.1 is the most significant byte.

CV 56.24.0: Wheel Diameter Low Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 56.24.1: Wheel Diameter High Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The wheel diameter = low byte + (high byte * 256). This 16 bit number represents the wheel diameter in units of 0.001 inch.

For example, a value of 930 represents a diameter of 0.930 inches. You would set CV56.24.0 to "162" and CV56.24.1 to "3", according to the calculations

Low byte = 930 modulo 256 = 162

High byte = 930 / 256 = 3

This CV is the actual (non-scaled) diameter of the locomotive's wheel as measured using a caliper or ruler.

This CV is used with CV56.25 Locomotive Scale when calculating the distance the locomotive has traveled when the odometer mode = "CAM".

This CV is not supported by Q3 decoders. Use CV56.26.SI Scale Wheel Diameter instead.

If Programming Verbal Acknowledgement is enabled (see CV62), program CV56.24.1 first, then CV56.24.0. The locomotive reads out the two byte value when the low byte is programmed.

²⁹¹ The CAM Odometer feature and this CV is currently only available with Q2 firmware.

5.8.15 CV 56.25.SI: Locomotive Scale²⁹² (PI = 25, SI = 0,1)

Use this CV to specify the locomotive's scale.

Default Value:

NA

The locomotive scale requires 2 bytes. CV56.25.0 is the least significant byte, and CV56.25.1 is the most significant byte.

CV 56.25.0: Locomotive Scale Low Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 56.25.1: Locomotive Scale High Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The locomotive scale = low byte + (high byte * 256). This 16 bit number represents the locomotive scale in units of 0.01.

For example, a value of 2900 represents a scale of 29.00. You would set CV56.25.0 to "84" and CV56.25.1 to "11", according to the calculation

Low byte = 2900 modulo 256 = 84

High byte = 2900 / 256 = 11

This CV is used with CV56.24 Wheel Diameter when calculating the distance the locomotive has traveled when the odometer mode = "CAM".

This CV is not supported by Q3 decoders. Use CV56.26.SI Scale Wheel Diameter instead.

If Programming Verbal Acknowledgement is enabled (see CV62), program CV56.25.1 first, then CV56.25.0. The locomotive reads out the two byte value when the low byte is programmed.

²⁹² The CAM Odometer feature and this CV is currently only available with Q2 firmware.

5.8.16 CV 56.26.SI: Scale Wheel Diameter (PI = 26, SI = 0,1)

Use this CV to specify the locomotive's wheel diameter to 0.01 of a scale inch.

Default Value:

NA

The scale wheel diameter requires 2 bytes. CV56.26.0 is the least significant byte, and CV56.26.1 is the most significant byte.

CV 56.26.0: Scale Wheel Diameter Low Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 56.26.1: Scale Wheel Diameter High Byte Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The scale wheel diameter = low byte + (high byte * 256). This 16 bit number represents the scale wheel diameter in units of 0.01 inch.

For example, a value of 6300 represents a diameter of 63.00 scale inches. You would set CV56.26.0 to "156" and CV56.26.1 to "24", according to the calculations

$$\begin{aligned}\text{Low byte} &= 6300 \text{ modulo } 256 = 156 \\ \text{High byte} &= 6300 / 256 = 24\end{aligned}$$

This CV is the scale diameter of the locomotive's wheel. If you measure your model locomotive's wheel diameter using a caliper or ruler, multiply your measured inches by the scale of the locomotive.

For Q3 decoders, this CV replaces CV56.24 Wheel Diameter and CV56.25 Locomotive Scale.

If Programming Verbal Acknowledgement is enabled (see CV62), program CV56.26.1 first, then CV56.26.0. The locomotive reads out the two byte value when the low byte is programmed.

Example: Set CV56.26.0-1 to 32.00 scale inches.

Multiply 32.00 by 100 to get 3200.

Divide 3200 / 256 to get 12. This is the value of the high byte CV56.26.1.

Multiply 256 * 12 to get 3072. Subtract this from 3200 to get 3200 - 3072 = 128. This is the value of the low byte CV56.26.0.

Set CV49 to 26.

Set CV50 to 1.

Set CV56 to 12. (This sets CV56.26.1 to 12.)

Set CV50 to 0.

Set CV56 to 128. (This sets CV56.26.0 to 128.)

5.8.17 CV 56.32.0: Room Temperature²⁹³ (PI = 32, SI = 0)

Use this CV to specify the room temperature in degrees Celsius.

Default Value:

26

CV 56.32.0: Room Temperature Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

When this CV is written a flag is set to read the Internal Temperature at the next power-on and store the value read in long term memory. The stored value is then used to calibrate future Internal Temperature readings.

Note: after setting this CV power off your locomotive and let it set for several minutes to cool down. Then power the locomotive up at which time the Internal Temperature will be calibrated for the room temperature value in CV56.32.0.

The internal temperature can be read out as part of the F10 status report by setting CV55.178.0 bit 3 to "1".

The locomotive's firmware continuously monitors the internal temperature. If the internal temperature exceeds 90 degrees Celsius, the horn hoots, and a high temperature motor shut down is executed. The locomotive stops and the internal temperature is announced every 10 seconds. After a high temperature shut down occurs, the locomotive must be powered off before normal operation can resume.

²⁹³ The internal temperature feature is currently only available in G-Scale and O-Scale locomotives.

5.8.18 CV 56.36.0: Consist Address Active for F13-F20 (PI = 36, SI = 0)

Specifies the Function Keys that are enabled when a locomotive is addressed by its Consist ID.

Default Value:

0

CV 56.36.0: Consist Address Active for F13-F20 Register²⁹⁴

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
F20	F19	F18	F17	F16	F15	F14	F13

- If a "0" is placed in any bit, that function key is disabled when the locomotive is addressed by its Consist ID.
- If a "1" is placed in any bit, that function key is enabled when the locomotive is addressed by its Consist ID.

²⁹⁴ Write bit operation is supported for CV56.36.0.

5.8.19 CV 56.36.1: Consist Address Active for F21-F28 (PI = 36, SI = 1)

Specifies the Function Keys that are enabled when a locomotive is addressed by its Consist ID.

Default Value:

0

CV 56.36.1: Consist Address Active for F21-F28 Register²⁹⁵

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
F28	F27	F26	F25	F24	F23	F22	F21

- If a “0” is placed in any bit, that function key is disabled when the locomotive is addressed by its Consist ID.
- If a “1” is placed in any bit, that function key is enabled when the locomotive is addressed by its Consist ID.

²⁹⁵ Write bit operation is supported for CV56.36.1.

5.8.20 CV 56.128: Reset to Factory Default (PI = 128)

Use this CV to reset CV's to factory default values.

Default Value:

NA

CV 56.128: Reset to Factory Default Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use the Secondary Index to select a range of CV's²⁹⁶. Only those CV's in the selected range will be reset; those CV's outside the range are left unchanged.

SI	Reset Operations:
51	Reset CV 51, System Sound Control
52	Reset CV 52, Individual Sounds
53	Reset CV 53, Function Output Mappings
55	Reset CV 55, QSI Feature Configuration
56	Reset CV 56, QSI Configuration
58	Reset CV 58, Odometer
253	Reset all standard NMRA CV's
254	Reset all QSI CV's
255	Reset all CV's

- Write the QSI Manufacturer Number, 113, to CV 56, to execute the reset operation.
- In Operations Mode you will hear "Reset" spoken when the reset operation completes.

Note: "Reset all CV's" may not work correctly in Service Mode on some command stations, because the command station may turn off the track power before the operation is complete. In this case, reset CV's in separate groups or use Ops Mode Programming.

Note: Q2 firmware built after 1-Jun-08 supports only SI = 255, Reset All CV's.

Example: Reset Quantum decoder to original factory defaults (i.e. reset all CV's)

- Set CV 49 to 128.
- Set CV 50 to 255.
- Set CV 56 to 113. In Ops Mode, you will hear "Reset" when reset is completed.

Example: Reset the Individual Sound Volumes to factory defaults

- Set CV 49 to 128.
- Set CV 50 to 52.
- Set CV 56 to 113.

²⁹⁶ Q2 firmware built after 1-June-08 only supports SI = 255.

5.8.21 CV 56.129: Locomotive ID Access (PI = 129)

Default Value:

N/A

CV 56.129: Locomotive ID Access Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use this index with CV 56 if your controller will not allow you to program your locomotive's ID on the main, and programming on the programming track is impossible due to insufficient power from your command station.
- This feature is only supported during Operations Mode programming. It will not work during Service Mode programming.
- Use CV 50 to select between Short Address (CV 50 = 1), High Byte Extended Address (CV 50 = 17) and Low Byte Extended Address (CV 50 = 18).
- When CV 56.129.1 is written, the data byte is written to CV 1. If programming acknowledgement is enabled, you will hear "CV 1 equals <short address>". The data byte must be in the range 1 to 127.
- When CV 56.129.17 is written, the data byte is merely stored in temporary memory. There is no verbal program announcement. The data byte must be in the range of 0xC0 to 0xE7.
- When CV 56.129.18 is written, the two data bytes are written to CV 17 and CV 18, making the locomotive's ID the 2 byte address consisting of the byte written to CV 56.129.17 and the byte written to CV 56.129.18. If you want to verify the full address in Ops Mode, set CV 64 to 17 (or 18) and hear "CV 17 (or 18) equals <long address>".

Note: When programming the Extended Address, you must set CV 56.129.17 before you set CV 56.129.18.

See the CV 17 and CV 18 documentation for description of how to compute and enter the MSB (most significant byte) and the LSB (least significant byte) of your Extended Addresses.

Step-by-step procedure for entering your short (Primary) address in CV 56.129 in Ops Mode.

- 1) Find out if your command station accepts Decimal, Binary or Hex²⁹⁷ inputs for CV entries.
- 2) Set CV 49 to 129.
- 3) Set CV 50 to 1.
- 4) Set CV 56 to your short address. Hear the address spoken back.
- 5) Change CV 29, bit 5 to "0" to allow operation with your new primary address (see CV 29).

Example: Set your locomotive's ID to the short address "23".

1. Set CV 49 to 129 decimal (10000001, 0x81).
2. Set CV 50 to 1.
3. Set CV 56 to 23 decimal (00010111, 0x17). Hear "CV One equals two, three". At this point, the locomotive must be selected as 23 to proceed to step 4.

If you were using the extended addressing to do steps 1-3, then set CV 29 to 34 decimal (00000010, 0x02) for Primary Address Enable and 28/128 Speed Step.

Your locomotive's short ID is now 23 and ready to operate.

²⁹⁷ Hex and Binary numbers are not shown in the following examples. If you require Hex or Binary, use the conversion table in Appendix IX.

Step-by-step procedure for entering your long (Extended) Address in CV 56.129 in Ops Mode.

1. Find out if your command station accepts Decimal, Binary or Hex inputs for CV entries.
2. Determine the MSB and LSB for your Extended Address (See CV 17/18 instructions and example).
3. Set CV 49 to 129.
4. Set CV 50 to 17.
5. Enter CV 17 (Most Significant Byte) as a Decimal, Binary or Hex number required by your command station. You will hear no verbal response.
6. Next enter CV 18 (Least Significant Byte) as a Decimal, Binary or Hex number. Hear the new full address spoken back.
7. Change CV 29, bit 5 to "1" to allow operation with your new Extended Address (see CV 29).

The following table shows examples for some common train numbers. Just follow the procedure above when entering CV 17 and CV 18.

ID Number	CV 17 (MSB) (Dec)	CV 18 (LSB) (Dec)	CV 17 (MSB) (Hex)	CV 18 (LSB) (Hex)	CV 17 (MSB) (Binary)	CV 18 (LSB) (Binary)
3985	207	145	CF	91	11001111	10010001
3989	207	149	CF	95	11001111	10010101
3708	206	124	CE	7C	11001110	01111100

Example 1: Set your locomotive's long address to "3985" (Also see example under CV 17 and 18.)

1. Set CV 49 to 129 decimal (10000001, 0x81).
2. Set CV 50 to 17 decimal (00010001, 0x11).
3. Set CV 56 to 207 decimal (11001111, 0xCF), which is the MSB for your address (you will hear no verbal feedback).
4. Set CV 50 to 18 decimal (00010010, 0x12).
5. Set CV 56 to 145 decimal (10010001, 0x91), which is the LSB for your address. Hear "CV one, seven equals three, nine, eight, five".
6. Set CV 29 to 34 decimal (00100010, 0x22) for Extended Address Enable and 28/128 Speed Step.

Your locomotive's Long ID is now 3985 and ready to operate.

Example 2: Set your locomotive's long address to "5344" (See example under CV 17 and 18.)

1. Set CV 49 to 129 decimal (10000001, 0x81).
2. Set CV 50 to 17 decimal (00010001, 0x11).
3. Set CV 56 to 212 decimal (11010100, 0xD4), which is the MSB for your address (you will hear no verbal feedback).
4. Set CV 50 to 18 decimal (00010010, 0x12).
5. Set CV 56 to 224 decimal (11100000, 0xE0), which is the LSB for your address. Hear "CV one, seven equals five, three, four, four".
6. Set CV 29 to 34 decimal (00100010, 0x22) for Extended Address Enable and 28/128 Speed Step.

Your locomotive's Long ID is now 5344 and ready to operate.

5.8.22 CV 56.254: About Quantum Decoder (PI = 254)

Use this CV in Service Mode to read back information about your Quantum locomotive. Use CV 50 to select among the data bytes to retrieve.

Default Value:

NA

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Information from this CV is retrieved in Service Mode as a response to VERIFY_BYTE or VERIFY_BIT operations.
- To select which byte of information to retrieve, write data to CV 50 as follows:
 - “2” = Retrieve Hardware Profile High Byte.
 - “3” = Retrieve Hardware Profile Low Byte.
 - “4” = Retrieve Product Model High Byte.
 - “5” = Retrieve Product Model Low Byte.
 - “6” = Retrieve Firmware Minor Version Number.
 - “8” = Retrieve Firmware Build Number.
 - “10” = Retrieve Firmware Build Date.Month (1...12).
 - “11” = Retrieve Firmware Build Date.Day (1...31).
 - “12” = Retrieve Firmware Build Date.Year (02 = 2002).
 - “14” = Retrieve Firmware Sound Set Number Low Byte.
 - “15” = Retrieve Firmware Sound Set Number High Byte.
 - “16” = Retrieve Firmware Last Modified Date.Month (1...12).
 - “17” = Retrieve Firmware Last Modified Date.Day (1...31).
 - “18” = Retrieve Firmware Last Modified Date.Year (02 = 2002).
- The Firmware Major Version Number can be retrieved from CV 7, Manufacturer’s Version Number.

Example: Retrieve the Product Model

1. Write 254 to CV 49.
2. Write 4 to CV 50.
3. Read back CV 56. Save the returned value as H.
4. Write 5 to CV 50.
5. Read back CV 56. Save the returned value as L.
6. The Product Model = (H * 256) + L.

5.8.23 CV 56.255: Play Build Information (PI = 255)

Use this CV in Ops Mode to hear the locomotive speak out information about its firmware.

Default Value:

NA

CV 56.255: Play Build Information Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Write data to CV 56 as follows:
 - “0” = Play Product Model. You will hear the Product Model number (e.g. “300” or “400”). This identifies the locomotive model and the sounds programmed into the software.
 - “1” = Play Firmware Version. You will hear three sets of numbers separated by the word “point”. The first number is the major version number, the second is the minor version number, and the third is the build number (e.g. “seven point one point five” means Major Version 7, Minor Version 1, Build Number 5).
 - “2” = Play Firmware Build Date. This is the date the software was created. You will hear three sets of numbers, each separated by a pause. The first number set is the month, followed by the day of the month, followed by the year (e.g. “six” pause “one five” pause “zero two” means June 15, 2002).
 - “3” = Play Hardware Profile number.
 - “4” = Play Sound Set number. This number identifies variations on the sounds programmed into the software for a model. The original firmware for a model has Sound Set number “0”.
 - “5” = Play Firmware Last Modified Date. This is the date the software was modified by a program such as Q2Upgrade. You will hear three sets of numbers, each separated by a pause. The first number set is the month, followed by the day of the month, followed by the year (e.g. “six” pause “one five” pause “zero two” means June 15, 2002).
- Any value other than 0..5 will be ignored and there will be no verbal output.

Note: While the Build Information is playing, all incoming DCC packets are ignored, so wait until the locomotive stops speaking before writing another CV.

Example: Play Firmware Version

7. Write 255 to CV 49.
8. Write 1 to CV 56.
9. Hear Version spoken out: for Major Version 7, Minor Version 1, Build Number 6, you would hear “seven point one point six”.

5.9 CV 58.PI.SI Odometer (Q2 and Q1)²⁹⁸

5.9.1 CV 58.1.SI Odometer (Q2 and Q1)

This CV is used to read back or read out the odometer value. It is also used to reset the odometer to 0.

Default Value:

0

CV 58.1.0: Odometer Byte 0 (Least Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.1.1: Odometer Byte 1 Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.1.2: Odometer Byte 2 (Most Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

All Q2 firmware (and Q1 firmware built after 23-Jul-09) have a BEMF driven on-board odometer. The average BEMF reading each second is converted to Scale Miles per Hour (SMPH) and added to a total stored in long term memory.

Q2 steam locomotives may be equipped with a Chuff CAM. This CAM signals the decoder processor at each of 4 positions of a wheel revolution, thus providing 4 chuffs per revolution. This CAM can also be used as an on-board odometer, given that the diameter of the wheel (CV56.24.0-1) and the locomotive scale (CV56.25.0-1) are known.

BEMF odometer mode is the default. If your locomotive has a Chuff CAM, you can select the CAM odometer mode, by setting CV56.0 bit 5 to "1".

5.9.1.1 Odometer Reset

Reset the odometer to "0" by writing "0" to CV58.1.0.

Set CV49 to "1"
Set CV50 to "0"
Set CV58 to "0"

Actually, a write of any value to CV58.1.0, CV58.1.1, or CV58.1.2 will reset the odometer to "0".

In Ops Mode, the locomotive will respond by saying "Reset".

The odometer is also reset to "0" when all CV's are reset to factory default values.

5.9.1.2 Ops Mode Odometer Read Out

In Ops mode you can have the locomotive verbally read out the odometer value. There are two ways to do this.

(1) Make the odometer reading part of the F10 status report by setting CV55.128.0 bit 4 to "1". Then whenever you press F10, the locomotive will speak out the odometer value.

(2) Write "58" to CV64.1.0. (CV64 is the CV Numeric Verbal Readout).

²⁹⁸ The Odometer feature is not available in Q1a firmware built prior to 23-Jul-09.

Set CV49 to "1"
Set CV50 to "0"
Set CV64 to "58"

By either way, the locomotive speaks out either the scale miles or the scale kilometers traveled, to the nearest 0.01 of a scale mile or scale kilometer. The default is "miles". If you want the locomotive to speak out the scale kilometers traveled, set CV56.0 bit 1 to "1".

5.9.1.3 Service Mode Odometer Read Back

The raw odometer value can be read back in DCC Service Mode. These three CV's contain the raw odometer value:

CV58.1.0 byte_0 (low order byte)
CV58.1.1 byte_1
CV58.1.2 byte_2 (high order byte)

The raw odometer value is thus

$$\text{Raw Odometer Value} = \text{byte_0} + (\text{byte_1} * 256) + (\text{byte_2} * 256 * 256)$$

The number of scale miles this represents depends on the Odometer Mode (CV56.0 bit 5).

5.9.1.3.1 BEMF Odometer Mode (CV56.0 bit 5 = "0")

For BEMF odometer mode, the number of scale miles is

$$\text{Miles} = \text{Raw Odometer Value} / 3600$$

From this we can calculate the maximum number of scale miles before the odometer rolls over.

$$\text{Max_Miles} = 16777215 / 3600 = 4660.33$$

To convert to kilometers, multiply the miles by 1.609.

$$\text{Kilometers} = \text{Miles} * 1.609$$

5.9.1.3.2 CAM Odometer Mode (CV56.0 bit 5 = "1")

For CAM odometer mode, the number of scale miles is

$$\text{Miles} = (\text{Raw Odometer Value} * \text{Diameter} * \text{Scale} * \text{PI}) / (4 * 12 * 5280)$$

The "4" is needed because there are 4 CAM ticks per wheel revolution. The "12" is needed because there are 12 inches per foot. The "5280" is needed because there are 5280 feet per mile. "PI" is 3.1415926.

Diameter is the Wheel Diameter read back from CV56.24.0 (low byte) and CV56.24.1 (high byte). The diameter is

$$\text{Diameter} = \text{low byte} + (\text{high byte} * 256)$$

This number represents the wheel diameter in units of 0.001 inch. For example a value of "1000" represents a diameter of 1.0 inches.

Scale is the Locomotive Scale read back from CV56.25.0 (low byte) and CV56.25.1 (high byte). The scale is

$$\text{Scale} = \text{low byte} + (\text{high byte} * 256)$$

This number represents the locomotive scale in units of 0.01. For example, a value of 2900 represents a scale of 29.0.

Thus, we have

$$\text{Diameter} = (\text{CV56.24.0 value} + (\text{CV56.24.1 value} * 256)) / 1000$$

$$\text{Scale} = (\text{CV56.25.0 value} + (\text{CV56.25.1 value} * 256)) / 100$$

$$\text{Miles} = (\text{Raw Odometer Value} * \text{Diameter} * \text{Scale} * \text{PI}) / (4 * 12 * 5280)$$

The maximum number of scale miles before the odometer rolls over depends on the wheel diameter and the locomotive scale.

$$\text{Max_Miles} = (16777215 * \text{Diameter} * \text{Scale} * \text{PI}) / (4 * 12 * 5280)$$

To convert to kilometers, multiply the miles by 1.609.

$$\text{Kilometers} = \text{Miles} * 1.609$$

5.10 CV 58.PI.SI Odometer (Q3)

5.10.1 CV 58.1.SI Odometer

This CV is used to read back or read out the odometer value. It is also used to write the odometer value.

Default Value:

0

CV 58.1.0: Odometer Byte 0 (Least Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.1.1: Odometer Byte 1 Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.1.2: Odometer Byte 2 (Most Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

All Q3 decoders have a BEMF driven on-board odometer. Following each BEMF reading, CV56.17.SI MPH/BEMF Ratio is used to accumulate the distance traveled. Every second the distance traveled to the nearest 0.01 scale mile is stored in Long Term Memory.

Q2 steam locomotives may be equipped with a Chuff CAM. This CAM signals the decoder processor at each of 4 positions of a wheel revolution, thus providing 4 chuffs per revolution. This CAM can also be used as an on-board odometer, given that the scale diameter of the wheel (CV56.26.0-1) is known.

BEMF odometer mode is the default. If your locomotive has a Chuff CAM, you can select the CAM odometer mode, by setting CV56.0 bit 5 to "1".

5.10.1.1 Odometer Reset

Reset the odometer to "0" by writing "0" to each of CV58.1.0, CV58.1.1, and CV58.1.2.

- Set CV49 to "1"
- Set CV50 to "0"
- Set CV58 to "0"
- Set CV50 to "1"
- Set CV58 to "0"
- Set CV50 to "2"
- Set CV58 to "0"

The odometer is automatically reset to "0" when all CV's are reset to factory default values.

5.10.1.2 Ops Mode Odometer Read Out

In Ops mode you can have the locomotive verbally read out the odometer value. There are two ways to do this.

- (1) Make the odometer reading part of the F10 status report by setting CV55.128.0 bit 4 to "1". Then whenever you press F10, the locomotive will speak out the odometer value.
- (2) Write "58" to CV64.1.0. (CV64 is the CV Numeric Verbal Readout).

Set CV49 to "1"
Set CV50 to "0"
Set CV64 to "58"

By either way, the locomotive speaks out either the scale miles or the scale kilometers traveled, to the nearest 0.01 of a scale mile or scale kilometer. The default is "miles". If you want the locomotive to speak out the scale kilometers traveled, set CV56.0 bit 1 to "1".

5.10.1.3 Service Mode Odometer Read Back

The raw odometer value can be read back in DCC Service Mode. These three CV's contain the raw odometer value:

CV58.1.0 byte_0 (low order byte)
CV58.1.1 byte_1
CV58.1.2 byte_2 (high order byte)

The raw odometer value is thus

$$\text{Raw Odometer Value} = \text{byte_0} + (\text{byte_1} * 256) + (\text{byte_2} * 256 * 256)$$

The number of scale miles this represents depends on the Odometer Mode (CV56.0 bit 5).

5.10.1.3.1 BEMF Odometer Mode (CV56.0 bit 5 = "0")

For BEMF odometer mode, the number of scale miles is

$$\text{Miles} = \text{Raw Odometer Value} / 100$$

From this we can calculate the maximum number of scale miles before the odometer rolls over.

$$\text{Max_Miles} = 16777215 / 100 = 167772.15$$

To convert to kilometers, multiply the miles by 1.609.

$$\text{Kilometers} = \text{Miles} * 1.609$$

5.10.1.3.2 CAM Odometer Mode (CV56.0 bit 5 = "1")

For CAM odometer mode, the number of scale miles is

$$\text{Miles} = (\text{Raw Odometer Value} * \text{Diameter} * \text{PI}) / (4 * 12 * 5280)$$

The "4" is needed because there are 4 CAM ticks per wheel revolution. The "12" is needed because there are 12 inches per foot. The "5280" is needed because there are 5280 feet per mile. "PI" is 3.1415926.

Diameter is the Scale Wheel Diameter read back from CV56.26.0 (low byte) and CV56.26.1 (high byte). The diameter is

$$\text{Diameter} = \text{low byte} + (\text{high byte} * 256)$$

This number represents the scale wheel diameter in units of 0.01 inch. For example a value of "100" represents a diameter of 1.0 inches.

Thus, we have

$$\begin{aligned} \text{Diameter} &= (\text{CV56.26.0 value} + (\text{CV56.26.1 value} * 256)) / 100 \\ \text{Miles} &= (\text{Raw Odometer Value} * \text{Diameter} * \text{PI}) / (4 * 12 * 5280) \end{aligned}$$

The maximum number of scale miles before the odometer rolls over depends on the scale wheel diameter.

$$\text{Max_Miles} = (16777215 * \text{Diameter} * \text{PI}) / (4 * 12 * 5280)$$

To convert to kilometers, multiply the miles by 1.609.

$$\text{Kilometers} = \text{Miles} * 1.609$$

5.10.2 CV 58.5.SI Trip Odometer

This CV is used to read back or read out the trip odometer value. It is also used to write the odometer value.

Default Value:

0

CV 58.5.0: Trip Odometer Byte 0 (Least Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.5.1: Trip Odometer Byte 1 (Most Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

All Q3 decoders have a BEMF driven on-board odometer. Following each BEMF reading, CV56.17.SI SMPH/BEMF Ratio is used to accumulate the distance traveled. Every second the distance traveled to the nearest scale foot is stored in Long Term Memory.

The maximum number of feet before the trip odometer rolls over to 0 is 65535 feet.

5.10.2.1 Trip Odometer Reset

Reset the trip odometer to “0” by writing “0” to each of CV58.5.0 and CV58.5.1.

- Set CV49 to “5”
- Set CV50 to “0”
- Set CV58 to “0”
- Set CV50 to “1”
- Set CV58 to “0”

The trip odometer is automatically reset to “0” when all CV’s are reset to factory default values.

The trip odometer is automatically reset to “0” at the start of the speed calibration procedure.

5.10.2.2 Ops Mode Trip Odometer Read Out

In Ops mode you can have the locomotive verbally read out the trip odometer value. There are two ways to do this.

(1) Make the trip odometer reading part of the F10 status report by setting CV55.128.0 bit 6 to “1”. Then whenever you press F10, the locomotive will speak out the trip odometer value.

(2) Write “58” to CV64.5.0. (CV64 is the CV Numeric Verbal Readout).

- Set CV49 to “5”
- Set CV50 to “0”
- Set CV64 to “58”

By either way, the locomotive speaks out either the scale feet or the scale meters traveled. The default is “feet”. If you want the locomotive to speak out the scale meters traveled, set CV56.0 bit 1 to “1”.

5.10.2.3 Service Mode Trip Odometer Read Back

The trip odometer value can be read back in DCC Service Mode. These two CV’s contain the trip odometer value in feet:

CV58.5.0 byte_0 (low order byte)
CV58.5.1 byte_1 (high order byte)

The trip odometer value in feet is thus

$$\text{Trip Odometer feet} = \text{byte_0} + (\text{byte_1} * 256)$$

The trip odometer value in meters is

$$\text{Trip Odometer meters} = (\text{byte_0} + (\text{byte_1} * 256)) * 0.3048$$

5.10.3 CV 58.10.SI Power Conversion Stopping Distance

This CV specifies the stopping distance when DCC signal is lost.

Default Value:

0

CV 58.10.0: Power Conversion Stopping Distance Byte 0 (Least Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.10.1: Power Conversion Stopping Distance Byte 1 (Most Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

If CV29 bit 2 Power Source Conversion is “1” and the locomotive enters a section of track where no DCC signal is detected, then the locomotive comes to a stop if the track polarity is opposite to the locomotive’s direction of travel.

If the value of CV58.10.0-1 = “0”, the locomotive stops in an indeterminate distance at a rate determined by CV4 and CV24.

Otherwise, the locomotive stops after traveling the distance in scale feet specified in CV58.10.0-1.

Valid values for this CV are 0...65535.

See Appendix VI Using DC Power Conversion for Block Signal Control for further information.

5.10.4 CV 58.20.SI BEMF to SMPH Calibration Distance

This CV specifies the distance used when the trip odometer BEMF to SMPH calibration procedure is performed.

Default Value:

696

CV 58.20.0: BEMF to SMPH Calibration Distance Byte 0 (Least Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 58.20.1: BEMF to SMPH Calibration Distance Byte 1 (Most Significant Byte) Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

The trip odometer BEMF to SMPH calibration procedure” is described under “CV56.7.SI: SMPH/BEMF Ratio”.

The procedure involves moving the locomotive a pre-determined distance, the same distance as specified by CV58.20.0-1.

At the end of the procedure, the locomotive automatically adjusts CV56.7.0-1 by multiplying by the CV58.20.0-1 value divided by the distance traveled as measured by the locomotive’s trip odometer:

$$\text{new CV56.7.0-1 value} = \text{current CV56.7.0-1 value} * (\text{CV58.20.0-1 value} / \text{distance_traveled})$$

Valid values for CV58.20.0-1 are 0...65535, although very small values will result in very inaccurate calibration results.

5.11 CV 62 QSI Control²⁹⁹

Use this CV to control Programming Verbal Acknowledgement and CV Numeric Readout.

Default Value:

1

CV 62: QSI Control Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	0	0	0	0	D2	0	D0

- Bit 0 = Programming Verbal Acknowledgement Enable
 - “0” = disable Programming Verbal Acknowledgement.
 - “1” = enable Programming Verbal Acknowledgement.

If Programming Verbal Acknowledgement is enabled, and you write a value to a CV, the locomotive announces the CV number and its new value. For example, if you set CV 2 to 18, the locomotive will respond with the spoken message “C V two equals one eight”.

If you write a value to a QSI unique CV that uses a Primary Index, the locomotive announces the CV number followed by the Primary Index followed by the new value. For example, if you set CV 52.8 to 9, the locomotive will respond with the spoken message “C V five two point eight equals nine”.

If you write a value to a QSI unique CV that uses a Primary Index and a Secondary index, the locomotive announces the CV number followed by the Primary Index followed by the Secondary Index followed by the new value. For example, if you set CV 53.12.0 to 104, the locomotive will respond with the spoken message “C V five three point one two point zero equals one zero four”.

If you hear a verbal response like “C V three one” but not followed by “equals” and a value, that means that the CV, in this case CV 31, is not implemented.

Note: During the time a Programming Verbal Acknowledgement is playing, all incoming DCC packets are ignored. If your DCC controller attempts to program several CV’s at a time, the second, third, etc. CV’s may not be programmed. You should disable Programming Verbal Acknowledgement when using this kind of controller.

- Bit 2 = CV Numeric Readout Control:
 - “0” = announce both the CV number and the CV value (default).
 - “1” = announce only the CV value.

This bit is used to specify whether or not the decoder announces the CV number as well as the CV value for a CV64 operation.

For example, suppose the value of CV2 is “32”. If this bit were “0”, and you wrote “2” to CV64, you would hear “C V two equals three two”. If this bit were “1”, you would hear “three two”.

- Bit 7 = Bootloader Mode:
 - “0” = The application firmware runs (default).
 - “1” = The bootloader firmware runs.

This bit is set to 1 by Q2Upgrade to switch Q3 decoders to bootloader mode for upgrading firmware. After the firmware upgrade is complete, Q2Upgrade clears the bit to 0. For normal operation, including DCC Service Mode and DCC Operations Mode, this bit should be 0.

²⁹⁹ Write bit operation is supported for CV 62.

Programming Verbal Acknowledgement and CV Numeric Readout are available only during Ops Mode. In Service Mode, there is not sufficient track power to run the Quantum Sound System.

The overall System Volume determines the volume for these verbal responses. If you cannot hear the Ops Mode verbal responses, you will need to turn up the System Volume (see CV 51.0).

If you cannot hear verbal responses during Ops Mode programming, check to see if you have activated the Mute feature.

Example: To Disable Programming Verbal Acknowledgement

1. Set CV 62 to 0.

Example: To Disable Programming Verbal Acknowledgement and specify CV Numeric Readout of the CV Value only.

1. Set CV 62 to 4.

5.12 CV 64 CV Numeric Verbal Readout (Verbal CV Inquiry)

Use this CV to hear the locomotive speak the value of any CV as a decimal number. This works only in Operations Mode.

Default Value:

NA

CV 64: Numeric Verbal Readout Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- To hear the locomotive speak the value of a Standard NMRA CV:
 - Write the number of the CV to CV 64.
 - The decoder will respond something like “C V three five equals four”.
 - If the decoder responds something like “C V three one” but not followed by “equals” and a value, that means that the CV, in this case CV 31, is not implemented.
- To hear the locomotive speak the value of a QSI Unique CV:
 - Determine the Primary Index for the value you want to know. If a Primary Index is required, write the Primary Index number to CV 49.
 - Determine the Secondary Index for the value you want to know. If a Secondary Index is required, write the Secondary Index number to CV 50.
 - Write the number of the QSI CV to CV 64.
 - The decoder will respond something like “C V five two point eight equals five”.
 - If the decoder responds something like “C V five two point 1” but does not follow this with “equals and a value, this means that the CV, in this case CV 52.1, is not implemented.”
- Writing either 17 or 18 to CV 64 will produce a verbal response indicating the full value of the Extended Address.
- The overall System Volume determines the volume for these verbal responses. If you cannot hear the Ops Mode verbal responses, you will need to turn up the System Volume (see CV 51.0).
- If you cannot hear verbal responses during Ops Mode programming, check to see if you have activated the Mute feature.
- CV62 bit 2 controls whether decoder speaks out the CV number as well as the CV value.

Note: While the Verbal Readout is playing, all incoming DCC packets are ignored, so wait until the locomotive stops speaking before writing another CV.

Example: Hear the current setting for CV 2 V-Start.

- Write 2 to CV 64.
- Hear the value spoken out: if the value of CV 2 were “32”, you would hear “C V two equals three two”.

Example: Hear the current setting of the bell volume.

- Set CV 49 to 8. (The Individual Sound Identifier for Bell is “8”; see table in CV 52)
- Set CV 64 to 52.
- Hear the Bell volume spoken out: if the bell volume were 13, you would hear “C V five two point eight equals one three”.

6 CV's 66-95: NMRA Standard CV's

This section describes in detail additional NMRA standard CV's supported by Quantum locomotives.

6.1 CV 66 Forward Trim

Forward Trim specifies a scale factor by which a voltage drive level should be multiplied when the controller is driving the unit in the Forward Direction.

Default Value:

128

CV 66: Forward Trim Register

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
D7	D6	D5	D4	D3	D2	D1	D0

- The Forward Trim factor preserves the same curve shape as specified in the speed table but allows a simple multiplying factor to scale it larger or smaller for “trimming” its speed behavior in Forward. This allows making fine adjustments to match the speed of other locomotives, and to match the locomotive’s Reverse speed characteristics.
- The multiplying scale factor is $n/128$ where “n”, the Forward Trim Factor, can be any number entered into CV 66 from 0 to 255. If $n = 128$, then multiplying scale factor is 1 resulting in no change to the speed curve.
- If Forward Trim Factor is “0”, then Forward Trim is not implemented.
- If Forward Trim Factor is between 1 and 128 than the voltage applied to the motor is decreased by a multiplying factor that varies from .00775 to .99225.
- If Forward Trim Factor is between 130 and 255 than the voltage applied to the motor is increased by a multiplying factor that varies from 1.0078 to 1.977.
- CV 66 only applies if the speed tables are activated in CV 29 by setting bit 4 = 1.

6.2 CV 67-94 User Defined Speed Table

Use CV's 67–94 to specify a custom speed table that is suitable for your locomotive.

CV 67-94: User Defined Speed Registers

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
D7	D6	D5	D4	D3	D2	D1	D0

- The speed table consists of 28 data points for each of 28 speed steps. A value of 255 means full voltage applied to the motor while a value of 0 means no additional voltage applied to the motor over the V-Start voltage (CV 2).
- If you select 14 speed steps, every other data value is used. If you select 128 speed steps, extra points will be interpolated between each of the 28 data points to provide a smooth curve consisting of 255 points.
- The User Defined Speed Table must be enabled by setting CV 29 bit 5 to 1 and CV 25 bit 1 to 0 or 1.
- Default Values:

CV #	Speed Step	Default Value
CV 67	Speed Step 1	0
CV 68	Speed Step 2	9
CV 69	Speed Step 3	18
CV 70	Speed Step 4	28
CV 71	Speed Step 5	37
CV 72	Speed Step 6	47
CV 73	Speed Step 7	56
CV 74	Speed Step 8	66
CV 75	Speed Step 9	75
CV 76	Speed Step 10	85
CV 77	Speed Step 11	94
CV 78	Speed Step 12	103
CV 79	Speed Step 13	113
CV 80	Speed Step 14	122
CV 81	Speed Step 15	132
CV 82	Speed Step 16	141
CV 83	Speed Step 17	151
CV 84	Speed Step 18	160
CV 85	Speed Step 19	170
CV 86	Speed Step 20	179
CV 87	Speed Step 21	188
CV 88	Speed Step 22	198
CV 89	Speed Step 23	207
CV 90	Speed Step 24	217
CV 91	Speed Step 25	226
CV 92	Speed Step 26	236
CV 93	Speed Step 27	245
CV 94	Speed Step 28	255

6.3 CV 95 Reverse Trim

Reverse Trim specifies a scale factor by which a voltage drive level should be multiplied when the controller is driving the unit in the Reverse direction.

Default Value:

CV 95: Reverse Trim Registers

Bit 7 (MSB)	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0 (LSB)
D7	D6	D5	D4	D3	D2	D1	D0

- The Reverse Trim factor preserves the same curve shape as specified in the speed table but allows a simple multiplying factor to scale it larger or smaller for “trimming” its speed behavior in Reverse. This allows making fine adjustments to match the speed of other locomotives, and to match the locomotive’s Forward speed characteristics.
- The multiplying scale factor is $n/128$ where “n”, the Reverse Trim Factor, can be any number entered into CV 66 from 0 to 255.
- If the Reverse Trim Factor is “0”, then Reverse Trim is not implemented.
- If the Reverse Trim Factor is between 1 and 128 than the voltage applied to the motor is decreased by a multiplying factor that varies from .00775 to .99225.
- If the Reverse Trim Factor is between 130 and 255 than the voltage applied to the motor is increased by a multiplying factor that varies from 1.0078 to 1.977.
- CV 95 only applies if the speed tables are activated in CV 29 by setting bit 4 = 1.

7 CV's 112-256: QSI Unique CV's

This section describes in detail additional QSI Unique CV's supported by Quantum locomotives.

7.1 CV 115.PI.SI Feature to Port Mapping

Use CV 115 to map features, such as lights, to port numbers corresponding to pins on the decoder board. .

CV 115 is implemented as a two-dimensional array of registers with both CV 49 and CV 50 used to access these registers. The CV 49 Primary Index corresponds to QSI feature identification numbers.

Default Value:

Depends on Feature and Model

CV 115.PI.SI: Feature to Port Mapping

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Valid values are 0...N, where N is the maximum port number for that model. Values 1...N specify ports which correspond to pins on the decoder board. See the document "Quantum FX Lighting" for a list of pins for each type of decoder board, the corresponding port numbers, and a photograph showing where the pins are located on the board.
- A value of 0 does not correspond to a pin on the board and means the feature is disabled.
- The default values are dependent on the feature and the model.
- Two or more features should not be mapped to the same port. If this condition is not met, the visual results are undefined. One feature's effects might override the other's effects or the two effects might be combined into a confusing hybrid effect.
- Changing the feature to port mapping in Ops mode does not have a visible effect until the decoder's next power cycle. However, an Ops mode Reset to Factory Defaults operation, which restores the default Feature to Port mappings, does have an immediate visual effect.

The following table lists the PI and SI values for all applicable features:

CV115.PI.SI	Feature
CV115.5.0	Dynamic Brakes Fans
CV115.8.0	Cooling Fans
CV115.70.0	Front Headlight
CV115.70.1	Front Headlight #2 ³⁰⁰
CV115.73.0	Rear Headlight (Reverse Light)
CV115.73.1	Rear Headlight #2 ³⁰¹
CV115.76.0	Front Mars Light
CV115.80.0	Rear Mars Light
CV115.84.0	Front Left Ditch Light
CV115.84.1	Front Right Ditch Light ³⁰²
CV115.88.0	Rear Left Ditch Light
CV115.88.1	Rear Right Ditch Light ³⁰³
CV115.92.0	Front OHBL
CV115.92.1	Front OHBL2 ³⁰⁴
CV115.92.2	Front OHBL3
CV115.92.3	Front OHBL4
CV115.96.0	Rear OHBL
CV115.96.1	Rear OHBL2 ³⁰⁵
CV115.96.2	Rear OHBL3
CV115.96.3	Rear OHBL4
CV115.100.0	Front Number Board Lights
CV115.102.0	Rear Number Board Lights
CV115.104.0	Front Marker Lights
CV115.104.1	Front Marker Lights2
CV115.104.2	Front Marker Lights3
CV115.106.0	Rear Marker Lights
CV115.106.1	Rear Marker Lights2
CV115.106.2	Rear Marker Lights3
CV115.109.0	Truck Lights
CV115.113.0	Step Lights
CV115.116.0	Front Cab Light
CV115.118.0	Rear Cab Light
CV115.120.0	Engine Room Lights
CV115.121.0	Engine Room2 Lights
CV115.122.0	Firebox
CV115.122.1	Firebox2 ³⁰⁶
CV115.255.0	Decoder Cooling Fan

³⁰⁰ The second light of a dual front headlight pair.

³⁰¹ The second light of a dual rear headlight pair.

³⁰² Two ports are required for a pair of front ditch lights.

³⁰³ Two ports are required for a pair of rear ditch lights.

³⁰⁴ Four ports are required for a front OHBL in Prime Beacon X4 mode.

³⁰⁵ Four ports are required for a rear OHBL in Prime Beacon X4 mode.

³⁰⁶ Firebox flicker can use one port, but two ports give a better effect.

7.2 CV 116.PI Individual Sound Balance Control

For Quantum systems with two stereo speaker outputs, CV116.PI functions as volume balance controls for individual sounds.

CV 116.PI: Individual Sound Balance Registers

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- Each CV 116.PI can have any value from -127 to +127. A positive value is indicated by a 0 in bit 7 while a “1” indicates a negative value.
- To specify a negative balance, add 128 to the unsigned balance value. For example, to specify a balance of -60, add 128 to 60 to obtain 188.
- Negative values decrease the volume of the individual sound coming out of speaker 1 and positive values decrease the volume of the sound coming out of speaker 2. For example, a value of 31 decreases the volume coming out of speaker 2 to $((127 - 31) * 100) / 127 = 75\%$, while leaving the volume coming out of speaker 1 at 100%.
- The default value of 0 results in both speaker 1 and speaker 2 having 100% of the individual volume specified in the CV52.PI Individual Sound Volume Control.
- The numbers used for PI in CV119 are the same Individual Sound Identifiers used in CV52 Individual Sound Volume Control.

Example: Set the bell balance control so that 100% of the bell sound comes from speaker 1 and 0% comes from speaker 2.

1. Set CV 49 to 8 to select the bell sound.
2. Set CV 116 to 255 to specify the bell balance.

Example: For dual Air Pump Steam Locomotives, have the first pump sound come entirely from speaker 1 and the second pump sound come entirely from speaker 2.

3. Set CV 49 to 16 to select the first pump sound.
4. Set CV 116 to 127 to specify the first pump balance.
5. Set CV 49 to 17 to select the second pump sound.
6. Set CV 116 to 255 to specify the second pump balance.

7.3 CV 117.PI.SI QSI Individual Sound Selection

For Quantum systems having onboard sound libraries, use CV117.PI.SI is to select sounds from these libraries.

CV 117.PI.SI: Individual Sound Selection

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- Use CV117.PI.0 to read back (Service Mode) or have the decoder speak out (Ops Mode) the maximum index for a sound. The value of this CV is the number of selections available for the sound.
- Use CV117.PI.1 to select a sound from an onboard library. Valid values are 0...Max_Index, where Max_Index is the value of CV117.PI.0.
- The numbers used for PI in CV119 are the same Individual Sound Identifiers used in CV52 Individual Sound Volume Control.
- For diesel locomotives, the following onboard libraries are available:
 - Horn (PI=0) and Alternate Horn (PI = 40)
 - Bell (PI=8)
 - Motor (PI=10)
 - Air Pump (PI=16)
 - Cooling Fan (PI=19)
 - Dynamic Brake (PI=28)
- For steam locomotives, the following onboard libraries are available:
 - Whistle (PI=0) and Alternate Whistle (PI = 40)
 - Bell (PI=8)
 - Chuff (PI=10)
 - Air Pump (PI=16)
 - Steam Generator (PI=26)
- If you select index 1 (CV117.PI.1=1), you select the native sound for the firmware running in the decoder. If you select index 2...Max_Index, you select a sound from the onboard library.
- For most sounds, selecting sound 0 (CV117.PI.1=0) is equivalent to selecting sound 1, the native sound. The one exception is the bell; selecting sound 0 for the bell (CV117.8.1=0) selects a non-prototypical bell used for feedback purposes in certain operations.
- Setting CV117.PI.1 to a value greater than CV117.PI.0 has the same effect as setting CV117.PI.1 to 0.
- If you select a sound in Ops Mode, and the sound is playing, the sound will change immediately to the new selection. If you select a different motor (PI=10) in a diesel locomotive, the motor sounds may not work correctly until you power cycle the decoder.

Example: Command the decoder to speak out the number of chuffs available.

3. Set CV 49 to 10 to select the chuff library
4. Set CV 50 to 0.
5. Set CV 64 to 117 to cause the decoder to speak out the max chuff index.

Example: Select bell 2.

7. Set CV 49 to 8 to select the bell library.
8. Set CV 50 to 1.
9. Set CV 117 to 2 to select a bell from the bell library.

7.4 CV 118.PI.SI Individual Sound Pitch Shift

Use this CV to pitch shift an individual sound from its nominal pitch

CV 118.PI.0: Individual Sound Pitch Shift Low Byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

CV 118.PI.1: Individual Sound Pitch Shift High Byte

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	0	0	0	0	D2	D1	D0

Valid values for this CV range from -1200 to +1200. A positive value is indicated by a 0 in bit 7 of the high byte while a "1" indicates a negative value.

To specify a negative pitch shift, add 32768 to the unsigned pitch shift value. For example, to specify a pitch shift of minus 60, add 32768 to 60 to obtain 32828.

Each unit of this CV represents 0.01 (1 cent) of an equally tempered semitone. A value of 100 shifts the pitch up 1 semitone. A value of 1200 shifts the pitch up 1 octave.

The numbers used for PI in CV118 are the same Individual Sound Identifiers used in CV52 Individual Sound Volume Control.

Primary Index	Sound	Comment
8	Bell ³⁰⁷	Applicable to generic pneumatic and generic pull bells only. See CV55.3.1 Bell Type.
10	Chuff ³⁰⁸	
11	Chuff2	

Example #1: Shift the bell pitch up 3 semitones (300 cents).

1. Set CV49 to 8 to select the bell sound.
2. Set CV50 to 0 to select the low byte.
3. Set CV118 to 44 to specify the low byte value (300 modulo 256 = 44).
4. Set CV50 to 1 to select the high byte.
5. Set CV118 to 1 to specify the high byte value (300/256 = 1).

Example #2: Shift the chuff2 pitch down 1/2 semitone (-50 cents).

1. Set CV49 to 11 to select the chuff2 sound.
2. Set CV50 to 0 to select the low byte.
3. Set CV118 to 50 to specify the low byte value (50 modulo 256 = 50).
4. Set CV50 to 1 to select the high byte.
5. Set CV118 to 128 to specify the high byte value (50/256 = 0, set bit 7 to 1 for minus).

³⁰⁷ Version 9.2.0 firmware for models 1123 and 1127 built 20-Jan-2013 used CV118.8.0-1 in a slightly different manner. For this firmware:

- Valid values for this CV range from -2047 to +2047. A positive value is indicated by a 0 in bit 7 of the high byte while a "1" indicates a negative value.
- To specify a negative pitch shift, add 32768 to the unsigned pitch shift value. For example, to specify a pitch shift of minus 60, add 32768 to 60 to obtain 32828.
- The units have no relationship to cents, semitones, and octaves.

³⁰⁸ Firmware for steam locomotives built before 20-Jan-2013 (version 8.9.2 and earlier, and version 9.1.1 and earlier) supported an 8 bit version of CV118.10 and CV118.11. For this firmware:

- The secondary index (SI) is not used.
- Valid values for this CV range from -127 to +127. A positive value is indicated by a 0 in bit 7 while a "1" indicates a negative value.
- To specify a negative pitch shift, add 128 to the unsigned pitch shift value. For example, to specify a pitch shift of minus 60, add 128 to 60 to obtain 188.
- The units have no relationship to cents, semitones, and octaves.

7.5 CV 120.PI.SI Ready to Move Scenario

The Ready to Move Scenario is triggered by turning the bell on in NFF/NFR. Use CV51.20 Motive State Change Warning Signals to enable this scenario.

As the scenario progresses and before you increase the throttle to enter FWD/REV, the headlight and hazard lights change to their FWD/REV states, two (NFF) or three (NFR) horn blasts are played, and an air brake release sound plays.

The scenario terminates when one of these events occur:

- 1) You press a function key to turn the bell off.
- 2) You press a function key to blow the horn.
- 3) You increase the throttle to leave NFF/NFR.

The factory default values for CV120 gives a scenario for NFF consisting of:

- A 4.0 second silent period after which the front headlight turns on bright³⁰⁹.
- A 2.0 second silent period after which the front hazard lights turn on.
- A 2.0 second silent period.
- A 1.0 second horn blast.
- A 2.5 second silent period.
- A 1.0 second horn blast.
- A 3.0 second silent period after which a brake release sound is played.

The factory default values for CV120 gives a scenario for NFR consisting of:

- A 4.0 second silent period after which the rear headlight (reverse light) turns on bright³¹⁰.
- A 2.0 second silent period after which the rear hazard lights turn on.
- A 2.0 second silent period.
- A horn hoot (0.9 second).
- A 1.0 second silent period.
- A second horn hoot (0.9 second).
- A 1.0 second silent period.
- A third horn hoot (0.9 second).
- A 3.0 second silent period after which a brake release sound is played.

You can use CV120 to specify the duration of each horn blast and the duration of each silent period to the nearest 0.1 second.

For each horn blast you can also specify whether a normal horn blast is played, or whether a hoot is played instead of a short horn blast or a fancy ending is played at the end of a long horn blast.

You can also specify that the bell turn off automatically after the locomotive leaves neutral.

³⁰⁹ This is the default behavior. The actual behavior of the front headlight depends on the value of CV55.70.1.

³¹⁰ This is the default behavior. The actual behavior of the rear headlight depends on the value of CV55.73.1.

This table summarizes which CV's affect which portion of the scenario:

NFF	NFR
CV120.1.0 Silent Period 1 Duration	
Front Headlight turns on	Rear Headlight turns on
CV120.2.0 Silent Period 2 Duration	
Front Hazard Lights turn on	Rear Hazard Lights turn on
CV120.3.0 Silent Period 3 Duration	
CV120.4.0 First Horn Blast Duration	CV120.4.1 First Horn Blast Duration
CV120.5.0 Silent Period 4 Duration	CV120.5.1 Silent Period 4 Duration
CV120.6.0 Second Horn Blast Duration	CV120.6.1 Second Horn Blast Duration
Reserved	CV120.7.1 Silent Period 5 Duration
Reserved	CV120.8.1 Third Horn Blast Duration
CV120.9.0 Silent Period 6 Duration	
CV120.10.0 Bell Hold Time	

The following CV's are common to the NFF and NFR scenarios:

- CV120.1.0 Silent Period 1 Duration
- CV120.2.0 Silent Period 2 Duration
- CV120.3.0 Silent Period 3 Duration
- CV120.9.0 Silent Period 6 Duration
- CV120.10.0 Bell Hold Time

These CV's are unique to the NFF (two horn blast) scenario:

- CV120.4.0 First Horn Blast Duration
- CV120.5.0 Silent Period 4 Duration
- CV120.6.0 Second Horn Blast Duration

These CV's are unique to the NFR (three horn blast) scenario:

- CV120.4.1 First Horn Blast Duration
- CV120.5.1 Silent Period 4 Duration
- CV120.6.1 Second Horn Blast Duration
- CV120.7.1 Silent Period 5 Duration
- CV120.8.1 Third Horn Blast Duration

7.5.1 CV 120.PI.SI Silent Period Duration

Use these CV's to specify the duration of the silent periods.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D7 specify the duration. Valid values are 0 to 255.
- Each value represents time to the nearest 0.1 second. For example, a value of "15" represents 1.5 seconds.

7.5.2 CV 120.PI.SI Horn Blast Duration

Use these CV's to specify the duration of the horn blasts.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D6 specify the duration. Valid values for the duration are 0 to 127. If the duration is 0, the horn blast will not be played.
- The duration value represents time to the nearest 0.1 second. For example, a value of "30" represents 3.0 seconds.
- If D7 is "1", and D0...D6 has a value less than or equal to 9 (0.9 second) but greater than 0, then a hoot record is played.
- If D7 is "1", and D0...D6 has a value greater than or equal to 10 (1.0 second), then a fancy ending is played at the end of the long horn blast³¹¹.
- Setting D7 to "1" is equivalent to adding "128" to the value of the CV.
- The duration specified is the time from the start of the horn blast to the start of the next silent period. Because the length of horn records vary, the actual duration of the horn blast may be longer (or shorter if a hoot is played) than this time.

³¹¹ A few horns/whistles do not have a fancy ending record. In those cases, the normal ending for a long horn blast is played.

7.5.3 CV 120.10.0 Bell Hold Time³¹²

Use this CV to specify the time the bell continues to play after leaving neutral.

Default Value:

0

CV 120.10.0: Bell Hold Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Hold Time							

- If the value of this CV is not 0, then the bell will turn off automatically after the locomotive leaves neutral. Each unit represents 0.1 second. For example, if the CV value = 53, the bell will turn off automatically 5.3 seconds after the locomotive leaves neutral.
- If the value of this CV = 0, then the bell will continue to play until turned off manually using a function key.
- Default value = 0.
- Valid values are 0...255 representing 0.0...25.5 seconds.

³¹² CV120.10.0 is not available in firmware built before 17-July-2014.

7.6 CV 127.PI.SI QSI Component Sound Volume Control

Use CV 127 to specify volume levels for component sounds.

CV 127.PI.SI: Component Sound Volume Registers

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	V3	V2	V1	V0

- CV 127 is implemented as a two-dimensional table of component sound volume registers, with both CV 49 and CV50 used as indices to these registers. The CV 49 Primary Index corresponds to the overall individual sound. The CV50 Secondary Index corresponds to the component sound.
- For a given PI, CV52.PI is a master volume control for the entire individual sound, and CV127.PI.SI controls the volume of the component sound within the individual sound. For example, CV52.10 controls the overall prime mover1 volume, while CV127.10.0 controls the motor idle volume within the prime mover1 sound.
- To change the volume level of an component sound, do the following:
 - 1) Set CV 49 to the identifier for the individual sound (see table next page).
 - 2) Set CV 50 to the identifier for the component sound (see table next page).
 - 3) Set data in Bits 0-3 of CV 127 as follows:

“0”	= No sound
“1 – 15”	= Sets the volume level from the lowest level at “1” to the highest level at “15”
- 4 bits of volume level are used, providing 16 volume levels. The volume levels correspond to 2db increments.
- All other bits are reserved. Data in bits 4-7 are not used. Any data entered in these bits will be ignored.
- For most CV127.PI.SI CV's the default value is 11.

Example: Set the Prime Mover1 Exhaust Max RPM volume to 6.

1. Set CV 49 to 10 to select Prime Mover1.
2. Set CV 50 to 12 to select Exhaust Max RPM.
3. Set CV 127 to 6 to set the exhaust max RPM volume.

7.6.1 User-defined Horn Component Volume Identifiers

Primary Index	Secondary Index	Sound
0	1	Chime1 Volume
0	2	Chime2 Volume
0	3	Chime3 Volume
0	4	Chime4 Volume
0	5	Chime5 Volume
0	6	Chime6 Volume

7.6.2 Prime Mover1 Component Volume Identifiers

Primary Index	Secondary Index	Sound
10	0	Motor1 Idle Volume
10	1	Motor1 Mid RPM Volume
10	2	Motor1 Max RPM Volume
10	10	Exhaust1 Idle Volume
10	11	Exhaust1 Mid RPM Volume
10	12	Exhaust1 Max RPM Volume
10	20	Labored Exhaust1 Idle Volume
10	21	Labored Exhaust1 Mid RPM Volume
10	22	Labored Exhaust1 Max RPM Volume
10	30	Rod Knock1 Min RPM Volume
10	31	Rod Knock1 Mid RPM Volume
10	32	Rod Knock1 Max RPM Volume
10	60	Generator1 Idle Volume
10	62	Generator1 Max RPM Volume
10	70	Turbo1 Idle Volume
10	72	Turbo1 Max RPM Volume

7.6.3 Prime Mover2 Component Volume Identifiers

Primary Index	Secondary Index	Sound
11	0	Motor2 Idle Volume
11	1	Motor2 Mid RPM Volume
11	2	Motor2 Max RPM Volume
11	10	Exhaust2 Idle Volume
11	11	Exhaust2 Mid RPM Volume
11	12	Exhaust2 Max RPM Volume
11	20	Labored Exhaust2 Idle Volume
11	21	Labored Exhaust2 Mid RPM Volume
11	22	Labored Exhaust2 Max RPM Volume
11	30	Rod Knock2 Min RPM Volume
11	31	Rod Knock2 Mid RPM Volume
11	32	Rod Knock2 Max RPM Volume
11	60	Generator2 Idle Volume
11	62	Generator2 Max RPM Volume
11	70	Turbo2 Idle Volume
11	72	Turbo2 Max RPM Volume

7.6.4 User-defined Alternate Horn Component Volume Identifiers

Primary Index	Secondary Index	Sound
40	1	Chime1 Volume
40	2	Chime2 Volume
40	3	Chime3 Volume
40	4	Chime4 Volume
40	5	Chime5 Volume
40	6	Chime6 Volume

7.7 CV 128.PI.SI QSI Component Sound Balance Control

For Quantum systems with two stereo speaker outputs, CV128.PI.SI functions as balance controls for component sounds.

CV 128.PI.SI: Component Sound Balance Registers

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

- CV 128 is implemented as a two-dimensional table of balance registers, with both CV 49 and CV50 used as indices to these registers. The CV 49 Primary Index corresponds to the overall individual sound. The CV50 Secondary Index corresponds to the component sound.
- For a given PI, CV116.PI is a master balance control for the entire individual sound, and CV128.PI.SI controls the balance of the component sound within the individual sound. For example, CV116.10 controls the overall prime mover1 balance, while CV128.10.0 controls the motor idle balance within the prime mover1 sound.
- Each CV 116.PI can have any value from -127 to +127. A positive value is indicated by a 0 in bit 7 while a "1" indicates a negative value.
- To specify a negative balance, add 128 to the unsigned balance value. For example, to specify a balance of -60, add 128 to 60 to obtain 188.
- Negative values decrease the volume of the individual sound coming out of speaker 1 and positive values decrease the volume of the sound coming out of speaker 2. For example, a value of 31 decreases the volume coming out of speaker 2 to $((127 - 31) * 100) / 127 = 75\%$, while leaving the volume coming out of speaker 1 at 100%.

Example: Set the Prime Mover1 Labored Exhaust Balance to 255.

4. Set CV 49 to 10 to select Prime Mover1.
5. Set CV 50 to 20 to select Labored Exhaust.
6. Set CV 128 to 255 to set the labored exhaust balance.

7.7.1 User-defined Horn Component Balance Identifiers

Primary Index	Secondary Index	Sound
0	1	Chime1 Balance
0	2	Chime2 Balance
0	3	Chime3 Balance
0	4	Chime4 Balance
0	5	Chime5 Balance
0	6	Chime6 Balance

7.7.2 Prime Mover1 Component Balance Identifiers

Primary Index	Secondary Index	Sound
10	0	Motor1 Balance
10	10	Exhaust1 Balance
10	20	Labored Exhaust1 Balance
10	30	Rod Knock1 Balance
10	60	Generator1 Balance
10	70	Turbo1 Balance

7.7.3 Prime Mover2 Component Balance Identifiers

Primary Index	Secondary Index	Sound
11	0	Motor2 Balance
11	10	Exhaust2 Balance
11	20	Labored Exhaust2 Balance
11	30	Rod Knock2 Balance
11	60	Generator2 Balance
11	70	Turbo2 Balance

7.7.4 User-defined Alternate Horn Component Balance Identifiers

Primary Index	Secondary Index	Sound
40	1	Chime1 Balance
40	2	Chime2 Balance
40	3	Chime3 Balance
40	4	Chime4 Balance
40	5	Chime5 Balance
40	6	Chime6 Balance

7.8 CV 129.PI.SI Diesel Motor Configuration

7.8.1 CV 129.1.0 Speed Steps Per Notch³¹³

Use this CV to specify the number of speed steps between notches for your diesel locomotive.

Default Value:

10

CV 129.1.0: Speed Steps Per Notch Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies how DCC speed steps in 128 speed step mode map to notch levels for automatic diesel motor notching. In 14 or 28 speed step mode, the speed step is converted to 128 speed step format before this CV is applied.
- Valid values are 1...255. A value of 0 effectively disables automatic notching.
- The formula used to map the speed steps to notches is:

```
if ( CV55.21.0 != 0 ) {  
    if ( Speed_Step == 0 ) {  
        Notch_Level = 0;  
    } else {  
        Notch_Level = ((Speed_Step - 1) / CV55.21.0) + 1;  
    }  
}
```

- The default value of 10 maps speed steps to notch levels as follows:

Speed Step	Notch Level
0	0
1...10	1
11...20	2
21...30	3
31...40	4
41...50	5
51...60	6
61...70	7
71...126	8

- A value of 8 maps speed steps to notch levels as follows:

Speed Step	Notch Level
0	0
1...8	1
9...16	2
17...24	3
25...32	4
33...40	5
41...48	6
49...56	7
57...126	8

- A value of 15 maps speed steps to notch levels as follows:

Speed Step	Notch Level
0	0
1...15	1
16-30	2
31-45	3
44...60	4
61...75	5

³¹³ CV129.1.0 replaces CV55.21.0 in version 9 firmware.

76...90	6
91-105	7
106-126	8

7.8.2 CV129.2.0 Low Idle Timeout³¹⁴

Use this CV to specify the time after entering neutral when a diesel motor automatically drops to low idle.

Default Value:

Depends on Locomotive

CV 129.2.0: Low Idle Timeout Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies the time that a diesel motor automatically drops to low idle after entering neutral (speed step 0 and locomotive stopped).
- Each unit represents 1 second. For example, if the CV has value 8, then the motor will drop to low idle 8 seconds after entering neutral.
- If the value of this CV is 0, the motor does not automatically drop to low idle.
- All function keys and the throttle remain enabled after the motor drops to low idle. By contrast, in the Standby stage of shutdown, where the diesel motor is also in low idle, most function keys and the throttle are disabled.
- The motor remains in low idle until one of the following events occurs:
 - The throttle is increased to speed step > 0.
 - F6 is double pressed, assuming the Startup (144) feature is assigned to F6.
- If you double press F6 after the locomotive enters neutral and before the countdown reaches 0, the motor will not drop to low idle.
- If the locomotive is in Disconnect (F9 double press) when the countdown reaches 0, the motor will drop to low idle. If the locomotive is then put into Standby, the motor remains in low idle.
- This CV is supported only by Q3 firmware running on FX decoders.

³¹⁴ CV129.2.0 replaces CV55.21.1 in version 9 firmware.

7.8.3 CV 129.10.0 Motor Sound Effects³¹⁵

Use this CV to select motor sound effects.

Default Value:

Depends on Locomotive

CV 129.10.0: Motor Sound Effects Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Transition Activation Sound	Transition Activation Sound

- Bits 0 and 1 of this CV select one of the following motor transition activation sound effects:
 - 0 – No transition activation sound.
 - 1 – Air Activated Transition
 - 2 – Electro-mechanically Activated Transition

³¹⁵ CV129.10.0 is only supported in version 9 firmware.

7.8.4 CV 129.50.0 Transition 1 SMPH³¹⁶

Use this CV to specify the speed at which the diesel motor automatically makes a transition.

Default Value:

Depends on Locomotive

CV 129.50.0: Transition 1 SMPH Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies the speed in scale miles per hour that a diesel motor automatically makes a transition. For example, if this CV has value 22, then the motor will make a transition when the locomotive's speed reaches 22 SMPH.
- If the value of this CV = 0, then the motor will not make a transition.

³¹⁶ CV129.50.0 is only supported in version 9 firmware.

7.8.5 CV 129.51.0 Transition 2 SMPH³¹⁷

Use this CV to specify the speed at which the diesel motor automatically makes a second transition.

Default Value:

Depends on Locomotive

CV 129.51.0: Transition 3 SMPH Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies the speed in scale miles per hour that a diesel motor automatically makes a second transition. For example, if this CV has value 47, then the motor will make a second transition when the locomotive's speed reaches 47 SMPH.
- If the value of this CV = 0, then the motor will not make a second transition.
- If the value of CV129.50.0 Transition 1 SMPH = 0, the motor will not make a transition even though CV129.51.0 is not 0; that is, both CV's must be non-zero for the motor to make a first and then a second transition.
- If the value of CV129.51.0 is less than or equal to the value of CV129.50.0, the motor will not make a second transition.

³¹⁷ CV129.51.0 is only supported in version 9 firmware.

7.8.6 CV 129.55.0 Transition RPM Drop Time³¹⁸

Use this CV to specify the time for the diesel motor to drop in RPM when automatically making a transition.

Default Value:

Depends on Locomotive

CV 129.55.0: Transition 3 SMPH Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- This CV specifies the time for a diesel motor to drop in RPM just before automatically making a transition.
- Each unit of this CV represents 0.04 second (40ms). For example, if this CV has value 50, then the motor will take 2.0 seconds to drop the RPM.

³¹⁸ CV129.55.0 is only supported in version 9 firmware.

7.9 CV 130.PI.SI User-defined Horn Component Pitch

7.9.1 CV 130.1-6.0 UDH Chime 1-6 Semitone³¹⁹

Use these CV's to specify the semitone of each of 6 chimes for the user-defined horn.

Default Value:

Depends on locomotive

CV 130.1-6.0: UDH Chime 1-6 Semitone Registers

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

These six CV's specify the semitone for each of 6 chimes. Valid CV values are:

CV130.1-6.0 Value	Semitone
0	None: the chime is not used.
1	C3
2	C#3
3	D3
4	D#3
5	E3
6	F3
7	F#3
8	G3
9	G#3
10	A3
11	A#3
12	B3
13	C4
14	C#4
15	D4
16	D#4
17	E4
18	F4
19	F#4
20	G4
21	G#4
22	A4
23	A#4
24	B4
25	C5
26	C#5
27	D5
28	D#5

If a value other than those listed is specified, a value of 22 (A4) is used.

For example, a Nathan M3 horn has 3chimes: C#4, D#4, and A4. This corresponds to:

CV130.1.0 = 14 (Chime1 plays C#4.)
 CV130.2.0 = 16 (Chime2 plays D#4.)
 CV130.3.0 = 22 (Chime3 plays A4.)
 CV130.4.0 = 0 (Chime4 is not used.)
 CV130.5.0 = 0 (Chime5 is not used.)
 CV130.6.0 = 0 (Chime6 is not used.)

7.9.2 CV 130.1-6.1 UDH Chime 1-6 De-tune³²⁰

Use these CV's to specify the de-tune amount of each of 6 chimes for the user-defined horn.

³¹⁹ CV130 is only supported in version 9 firmware.

³²⁰ CV130 is only supported in version 9 firmware.

Default Value:

Depends on locomotive

CV 130.1-6.1: UDH Chime 1-6 De-tune Registers

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

These six CV's specify the de-tune amount for each of 6 chimes.

The value of each CV represents number of cents (0.01 of a semitone).

Valid values are from minus 50 cents (minus 0.5 semitone) to plus 50 cents (plus 0.5 semitone).

Positive values have bit 7 set to 0. Negative values have bit 7 set to 1 (add 128). The CV value for plus 50 cents is thus "50". The CV value for minus 50 cents is thus "178" (50 + 128).

For example, a Nathan M3 horn has 3chimes: C#4, D#4, and A4. The C#4 is de-tuned by minus 30 cents, and the A4 by minus 40 cents. The D#4 is not de-tuned. This corresponds to:

- CV130.1.1 = 158 (Chime1 de-tuned by minus 30 cents.)
- CV130.2.1 = 0 (Chime2 not de-tuned.)
- CV130.2.1 = 168 (Chime3 de-tuned by minus 40 cents.)

7.10 CV 131.PI.SI User-defined Alternate Horn Component Pitch

7.10.1 CV 131.1-6.0 UDAH Chime 1-6 Semitone³²¹

Use these CV's to specify the semitone of each of 6 chimes for the user-defined alternate horn.

Default Value:

Depends on locomotive

CV 131.1-6.0: UDAH Chime 1-6 Semitone Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

These six CV's specify the semitone for each of 6 chimes. See CV130 for a list of valid values.

For example, a Leslie A-125-5A horn has 5 chimes: B3, C#4, D#4, F4, and A4. This corresponds to:

CV131.1.0 = 12	(Chime1 plays B3.)
CV131.2.0 = 14	(Chime2 plays C#4.)
CV131.3.0 = 16	(Chime3 plays D#4.)
CV131.4.0 = 18	(Chime4 plays F4.)
CV131.5.0 = 22	(Chime5 plays A4.)
CV131.6.0 = 0	(Chime6 is not used.)

³²¹ CV131 is only supported in version 9 firmware.

7.10.2 CV 131.1-6.1 UDAH Chime 1-6 De-tune³²²

Use these CV's to specify the de-tune amount of each of 6 chimes for the user-defined alternate horn.

Default Value:

Depends on locomotive

CV 131.1-6.1: UDAH Chime 1-6 De-tune Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sign	D6	D5	D4	D3	D2	D1	D0

These six CV's specify the de-tune amount for each of 6 chimes.

The value of each CV represents number of cents (0.01 of a semitone).

Valid values are from minus 50 cents (minus 0.5 semitone) to plus 50 cents (plus 0.5 semitone).

Positive values have bit 7 set to 0. Negative values have bit 7 set to 1 (add 128). The CV value for plus 50 cents is thus "50". The CV value for minus 50 cents is thus "178" (50 + 128).

For example, a Leslie A-125-5A horn has 5 chimes: B3, C#4, D#4, F4, and A4. The B3 is de-tuned by minus 20 cents, the D#4 by minus 10 cents, and the A4 by plus 10 cents. The C#4 and F4 are not de-tuned. This corresponds to:

CV131.1.1 = 148	(Chime1 de-tuned by minus 20 cents.)
CV131.2.1 = 0	(Chime2 not de-tuned.)
CV131.3.1 = 138	(Chime3 de-tuned by minus 10 cents.)
CV131.4.1 = 0	(Chime4 not de-tuned.)
CV131.5.1 = 10	(Chime5 de-tuned by plus 10 cents.)

³²² CV131 is only supported in version 9 firmware.

7.11 CV 133.PI.SI Chuff Configuration

7.11.1 CV 133.1.0 Locomotive Type

Use this CV to specify the locomotive type for your steam locomotive. **Error! Bookmark not defined.**

Default Value:

1

CV 133.1.0: Locomotive Type Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV selects the locomotive type for steam locomotives. Valid values are:

- 0 – Small
- 1 – Medium
- 2 – Large

7.11.2 CV 133.2.0 Chuff Intensity

Use this CV to specify the chuff intensity.

Default Value:

1

CV 133.2.0: Chuff Intensity Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

This CV specifies the chuff intensity. Valid values are 0, 1, and 2.

7.12 CV 135.PI.SI Upon Stopping Scenario³²³

The Upon Stopping Scenario is triggered by turning the bell on in FWD/REV. Use CV51.20 Motive State Change Warning Signals to enable this scenario.

After you enter NFF/NFR, a single horn blast is played, the headlight and hazard lights change to their NFF/NFR states, and a long air letoff sound plays.

The factory default values for CV135 gives a scenario consisting of:

- A 2.0 second silent period before a single horn blast is played.
- A 2.0 second silent period after which the front hazard lights change to their NFF/NFR states.
- A 1.0 second silent period after which the front headlight changes to its NFF/NFR state.
- A 2.0 second silent period after which a long air letoff sounds plays.

You can use CV135 to specify the duration of the horn blast and the duration of each silent period to the nearest 0.1 second.

For the horn blast you can also specify whether a normal horn blast is played, or whether a hoot is played instead of a short horn blast or a fancy ending is played at the end of a long horn blast.

You can also specify that the bell turn off automatically after the scenario ends.

³²³ CV135.PI.SI is not available in firmware built before 1-August-2014.

7.12.1 CV 135.PI.SI Silent Period Duration

Use these CV's to specify the duration of the silent periods.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D7 specify the duration. Valid values are 0 to 255.
- Each value represents time to the nearest 0.1 second. For example, a value of "15" represents 1.5 seconds.

7.12.2CV 135.PI.SI Horn Blast Duration

Use these CV's to specify the duration of the horn blasts.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

- D0...D6 specify the duration. Valid values for the duration are 0 to 127. If the duration is 0, the horn blast will not be played.
- The duration value represents time to the nearest 0.1 second. For example, a value of "30" represents 3.0 seconds.
- If D7 is "1", and D0...D6 has a value less than or equal to 9 (0.9 second) but greater than 0, then a hoot record is played.
- If D7 is "1", and D0...D6 has a value greater than or equal to 10 (1.0 second), then a fancy ending is played at the end of the long horn blast³²⁴.
- Setting D7 to "1" is equivalent to adding "128" to the value of the CV.
- The duration specified is the time from the start of the horn blast to the start of the next silent period. Because the length of horn records vary, the actual duration of the horn blast may be longer (or shorter if a hoot is played) than this time.

³²⁴ A few horns/whistles do not have a fancy ending record. In those cases, the normal ending for a long horn blast is played.

7.12.3 CV 135.6.0 Bell Hold Time

Use this CV to specify the time the bell continues to play after the scenario ends.

Default Value:

0

CV 135.6.0: Bell Hold Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Hold Time							

- If the value of this CV is not 0, then the bell will turn off automatically after the scenario ends. Each unit represents 0.1 second. For example, if the CV value = 53, the bell will turn off automatically 5.3 seconds after the scenario ends.
- If the value of this CV = 0, then the bell will continue to play until turned off manually using a function key.
- Default value = 0.
- Valid values are 0...255 representing 0.0...25.5 seconds.

Appendix I

Recommended DCC Command Stations

Command Station	Recommended	Will Support Service Mode w/ Quantum	Comments ³²⁵
NCE™	Yes	Yes (See Comments)	Horn and Bell buttons are available but bell button assigned to F3 (see QSI CV 37 example). Newer NEC's apparently support programming track but older command stations do not. Programming on the main is easy and straightforward.
Wangrow™	Yes	No	Horn and Bell buttons are available but bell button assigned to F3 (see QSI CV 37 example). No Service Mode but programming on the main is easy and straightforward.
Digitrax™	Yes	Yes	<p>F0 = Lights, F1 = Bell, F2 = Horn. DT300 will operate in Service mode but will not read back value. Long address is automated with the DT300 and DT400 throttles, which properly writes CVs 18, 17, and 29. Click to the 4-digit mode, set address, and answer yes to the enable 4 digit address prompt. It also automatically resets CV 29 if you return to 2-digit address.</p> <p>An exception is the obsolete DT100 throttle, which will only program Quantum decoders in Ops Mode. Use QSI CV 56.129 to program either CV 1 or CV 17/18. Note that the DT100 only programs in hex, except for addresses, which are in decimal. This makes it easy to enter address in Ops mode.</p> <p>We have qualified the following Digitrax systems with Quantum decoders (all support F0-F12): Super Chief with DT400 Zephyr with DT400 DCS100 with DT400 Chief with DT400</p> <p>See Digitrax for more information on QSI compatibility at www.digitrax.com.</p>
MRC™	Yes	No	MRC does not provide a separate programming function. All programming is done in Ops mode with no acknowledgement feedback. A resistor is included to limit current for a Programming Track, which may limit the current below the allowable level for Quantum decoder programming. For the Quantum system, the resistor may be left out. For other decodes, the user should follow the MRC instructions.
Lenz™ LZ100, LV200, LZV100	Yes	Yes (See Comments)	F0 = Lights, F1 = Bell, F2 = Horn. Lenz will program in Service mode providing that a suitable resistor is added in series to the Programming Track (LV100 requires 20 ohms and LV200 requires 10 ohms). Note that CV 1, 17 and 18 cannot be programmed on the main in the standard way

³²⁵ Many comments and opinions regarding operation with different command stations are the result of user's letters to QSI or comments on various railroad web forums. QSI is not responsible for the accuracy of these comments, which are included here only as a starting point for the customer to verify to his own satisfaction the compatibility of these products for use with the QSI Quantum System.

			(see QSI CV 56.129 for alternative way to program ID numbers). Newer Lenz does support F0-F12 Function Keys.
Atlas TM	Yes	Yes (See Comments)	Early models of the Atlas command station had some problems with programming. Reports from Atlas on their recent versions indicate no problems. Limited number of function keys available.
Bachmann TM	Yes	Yes	E-Z DCC. Works with wireless hand held throttle as well as standard command station.
Zimo TM	Yes	Yes	All products work with Quantum decoders.

Appendix II A

Programming a Long Address on Digitrax

Select the Loco's Short Address (Usually 3)

- Press "Loco" then "3" then "Enter".

Program "On the main" the new Long Address.

- Press "PROG" until "Po" and the Loco's address is shown on the LCD.
- Press right turn knob down until it reads "ad4 = ???"
- Type in desired four digit address and press "Enter". Loco verbally responds with "CV 18 = XXXX" where XXXX is the four digit address.

Once the long address is programmed, you must enable the locomotive to use it.

Enable the Long Address.

- Next, press the right turn knob until it reads "ad2 = 000"
- Scroll with left knob until you get to "029 = ???", turn right knob until readout = "029 = 034"; press Enter, locomotive says "CV 29 = 34".
- Press "Exit" to leave program mode.

Select Loco with the new Long Address.

- Press "LOCO" and enter new long address to run locomotive.

Returning to the Short Address

Select the Loco's Long Address (The value you programmed above)

- Press "Loco" then the Long Address then "Enter".

Program "On the main" to Enable the Short Address.

- Press "PROG" until "Po" and the Loco's address is shown on the LCD.
- Scroll with left knob until you get "CV29 = ???"; scroll with right knob until you get "029 = 002"; press Enter; locomotive verbally responds with "CV 29 = 2".
- Press "Exit" to leave program mode.

Select Loco with the Short Address.

- Press "LOCO" and enter Short Address to run locomotive.

Appendix II B

Programming a Long Address on North Coast Engineering (NCE)

Select the Loco's Short Address (Usually 3)

- Press "Loco" then "3" then "ENTER".

Program "On the main" the new Long Address.

- Press the "Program" button. Display reads "Program on Main".
- Press "ENTER".
- Display shows current "003" I.D. on the display.....Press "ENTER"
- Press 1 for Address. Display shows "Set ADDR"
- Press "1" to set Long Address.
- Enter four digit address. Press "Enter" Hear "CV 18 equals XXXX" where XXXX is the four digit address you entered.
- You are now back in Run Mode. Select loco 3. Press "ENTER".
- Once the long address is programmed, you must enable the locomotive to use it.

Enable the Long Address.

- Press the "Program" button. Display reads "Program on Main".
- Press "ENTER".
- Display shows current 003 I.D. on the display. Press "ENTER"
- Press "3" for Configuration. Display shows "ENTER=NORM 1=REV".
- Progress through and set each variable until you reach "ADDRESS?".
- Enter "1" for "LONG" address. This enables using the long address.
- Leave Ops Mode Programming by pressing the red "Emergency Stop" button.
- Select locomotives long address and operate.

You are now out of program mode and have completed "the Long Address" sequence.

Returning to the Short Address

Select the Loco's Long Address (The value you programmed above)

- Press "Loco" then enter the Loco's Long Address (The value you programmed above) then press "Enter".

Program "On the main" to Enable the Short Address.

- Press the "Program" button. Display reads "Program on Main".
- Press "ENTER"
- Display shows current Long Address I.D. on the display. Press "Enter"

- Press “3” for Configuration. Display shows “ENTER=NORM 1=REV”.
- Progress through each variable until you reach “ADDRESS?”.
- Press “ENTER” for “SHORT” address. This enables using the short address.
- Leave Ops Mode Programming by pressing the red “Emergency Stop” button.
- Select locomotives short address and operate.

The above procedure was evaluated with an upgraded³²⁶ NCE POWER PRO series of DCC command stations. If the above procedure does not work properly, contact NCE to see if they can upgrade your software.

Appendix III

DCC Troubleshooting

Operations Mode

My headlight does come on when I start my locomotive but mysteriously goes off whenever I blow the horn or turn on the bell. Also, if I try to turn off the headlight, it sometimes requires two pressings for the F0 or FL key.	Pressing the horn or toggling the bell will cause your command station to send out a Function Group One command, which contains the lighting information. Not all command stations automatically send this information unless FL, F1, F2, F3 or F4 is pressed. Regarding turning off the lighting with the F0 key, the state for the light may already be off at the base station but not sent. When you press the F0 key, it toggles the lights on and sends that command and hence the lights stay on. It takes a second press of the F0 key to send another command to turn off the lights.
My brakes, bell, air release, or other sounds come on sometimes for no apparent reason while operating my locomotive.	See above. Some functions may already be turned on but not sent. When you request any function, the entire function group that contains that function will be sent and this may trigger other features already enabled within that group. Hence, you might request the light be turned on and hear squealing brakes or the bell turn on or off. If your base station display shows the toggled condition for each of the function keys, you can determine which feature will turn on or off when a Function Group One or a Function Group Two is sent.
My locomotive makes no sounds except an air release when power is applied and will not operate.	You have your locomotive in Shut Down. Double press the F6 Start-Up key to start your locomotive.
My locomotive runs but makes no sounds.	You have Mute on or have turned down your System Volume or individual feature sound volumes. You may have a broken wire to the speakers or a faulty speaker.
When I turn up my throttle to higher values, the locomotive does not speed up but instead, the directional lighting comes on.	Your locomotive is set for 14 speed steps but your base station is set for 28 or 128.
When I turn on my lighting system with the F0 or FL Key, the locomotive speeds up at low throttle settings.	Your locomotive is set for 28 or 128 speed steps but your base station is set for 14.
Sometimes my locomotive slows down when I blow the whistle or horn, particularly at high volume levels.	The Quantum Sound system takes additional power to blow the whistle or horn and this loads your power pack. This can lower the voltage on the track and your locomotive will slow down. Purchase a power pack with good line regulation to prevent this problem.
When I blow the horn, the horn continues to play for a half second to a second. The reaction to releasing the horn button appears to be sluggish. This makes it difficult to play a sequence of horn blasts.	If CV51.2 bit 0 is "1", then Horn Triggered Doppler and Horn Fancy Ending are enabled. The decoder waits an additional 0.5 second at the end of each horn blast before ending the horn blast to see if the doppler trigger or fancy horn ending trigger is being applied. By setting CV51.2 bit 0 to "0", disabling the horn triggered doppler and horn fancy ending, this 0.5 second delay is eliminated, making the horn more reactive to horn button releases.
In Speed Control Mode, there are no speed changes above certain throttle settings.	The top speed of your locomotive is dependent on the gear ratio, load on the locomotive and the available voltage applied to the track. Asking the locomotive to go faster results in no change. (See CV 56.10, BEMF to SMPH Scale Factor to change throttle range).
Under speed control, I do not get 1 scale mile per hour (smph); I get a larger number about 5 to 10 smph.	Check your speed step setting on your base station. To get 1 smph you need to be in 128 speed steps.
In Standard Throttle Control Mode, there are no speed changes above a certain throttle settings.	Try a different speed curve or define your own to provide full range of throttle motion.
My locomotive operates with no problem in DCC, but does not operate at all under Analog control.	Make sure Analog operation is enabled. CV 29 bit 2 must be set to 1.
My Lionel Gas Turbine will not operate over 25 smph under RTC or Speed Control.	This is correct for diesel operation. This is an internal limit on top speed when the locomotive is under diesel operation. The prototype would not travel over 25 mph under diesel power. Switch to turbine operation to gain higher speeds.
F8 key on Digitrax does not mute the locomotive.	The Digitrax DT400 model we examined behaves incorrectly when the F8 key is pressed sending 1010DDDD instead of

<p>The F7 Key does not apply brakes.</p>	<p>1011DDDD. Ask Digitrax for a Software Upgrade. Make sure your throttle is at speed step zero before applying brakes. Also, earlier Quantum systems only required that the F7 be pressed to trigger the brakes. Later Quantum decoders required F7 to be on (1) before brakes will apply. If F7 was already on when the throttle was turned down it will not automatically apply brakes. Pressing it would turn F7 off (0) so a second pressing was required to turn in on.</p>
<p>When I set CV 17 and 18, the Extended Address, I must explicitly set CV29 bit 6 to 1 before the Extended Address is effective. With non-QSI decoders, I don't have to do this. Why isn't it automatic with QSI decoders? ,</p>	<p>If CV62 bit 0 is "1", which enables Programming Verbal Acknowledgement, then your QSI decoder speaks out "C V 1 7 equals x x x" when you program the extended address. During the time the acknowledgement is being spoken, all incoming DCC packets are discarded. If your controller attempts to program CV29 during this time, the packet for CV29 is discarded by the decoder. Set CV 62 bit 0 to 0, and your QSI decoder will not discard the CV 29 packet.</p>

Service Mode Operation using the Program Track

<p>My Quantum equipped locomotive will not program in Service Mode with my command station.</p>	<p>Some command stations do not provide sufficient current to power the Quantum system. If you are using a command station that has selectable track voltage for the different scales try using the O-Scale or G-Gauge alternative. If this does not work, use Ops Mode programming. You can also purchase from Tony's Train Exchange^{®327}, a simple, inexpensive power booster (PowerPak™ by DCC Specialties) that will allow you to program on the program track with any DCC command station.</p>
<p>Occasionally, when programming a CV, the reported value is off by one digit.</p>	<p>This is a timing issue with some command stations. Either program in Ops Mode or consider using a PowerPak from DCC Specialties.</p>
<p>When I try to do a complete reset of all CV's using CV 56.128.255 in Program Mode, not all of the CV's reset to factory values.</p>	<p>Resetting all CV's takes considerable time. Some command stations only allow a fixed short amount of time to power the programming track after a command is sent. When you ask for a complete reset, not all of the CV's will be reset if the power shuts down part way through the procedure. We recommend doing a full reset in Ops mode. Or you can do individual reset operations such as "all NMRA CV reset", and "all QSI CV reset", etc. until you have all groups of CV's reset to factory defaults.</p>

³²⁷ Tony's Train Exchange; 1-800-978-3427; info@ttx-dcc.com .

Appendix IV

Using the Quantum Hardware Reset and Volume Controls:

Quantum software can be programmed by the operator to reset the system to factory defaults. As a safety precaution, Quantum decoders also have a backup hardware method to do a system reset. Either method can be used to reset the locomotive to original factory settings. In case your Quantum Sound and Train Control System misbehaves and simply turning the power off from 5 to 15 seconds does not return it to normal operation, you can reset your locomotive using CV 56.128. Or you can use the hardware Reset Jumper found on earlier Quantum Systems or the Magnetic Wand to activate a reed switch included on more modern Quantum Systems.

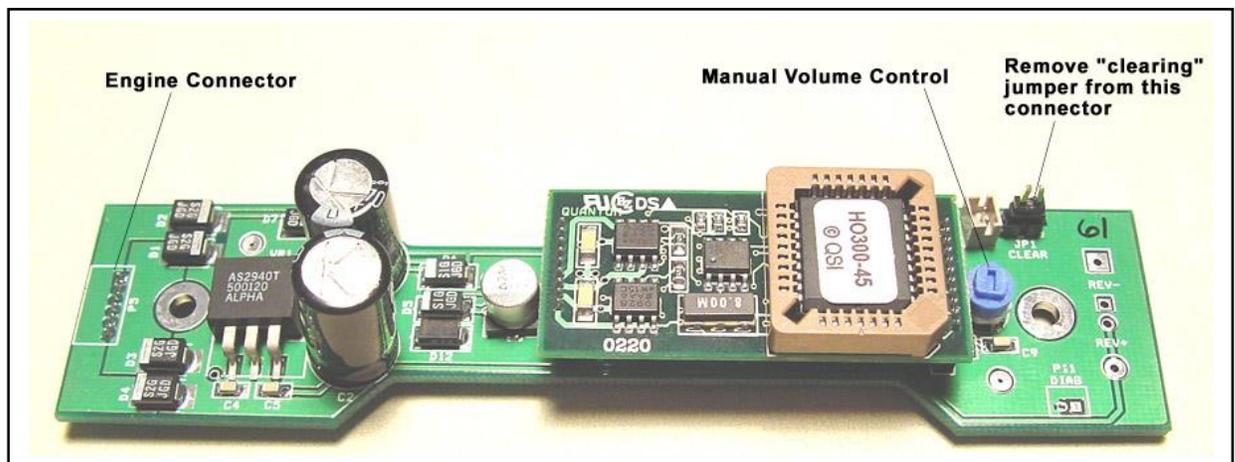
Quantum system volume can be adjusted using software by programming CV 51.0 or by a hardware volume adjustment. Earlier Quantum systems used a potentiometer volume control and later models use a magnetic wand.

Reset Jumper Models

Both early Quantum Steam and Diesel locomotives used jumpers and volume potentiometers to control reset and sound volume. The diagram below shows a Quantum circuit board used in some Steam Locomotive tenders. The jumper and volume potentiometer is located on the bottom board as shown in the diagram below.

To Reset the Locomotive:

- Turn off the main track power.
- For Steam Locomotives, remove the tender body or water filler hatch to reveal the circuit board. If it is a plastic tender, there are no screws; it is a press fit to the chassis. Die cast tenders will have retaining screws under the chassis. Most Diesels will have a removable access panel over the Quantum circuit board on the roof. The location of the access panel will be shown in the Steam or Diesel Model Specification sheet that was included with your locomotive instructions.
- To reset the Quantum system to its default values, locate the black “clearing” jumper (see below) and remove by pulling it up.
- Reapply main track power, and press a function key, for example, F0, to send the locomotive an Ops Mode command. After a few seconds the locomotive should say the word “reset”.
- Turn main track power off and reinstall jumper, and tender cab or access panel. The locomotive has now been returned to original factory settings including all Analog and DCC settings.



Note: Do not try to perform the jumper reset operation on the Program Track under Service Mode power. Always perform this operation under full power.

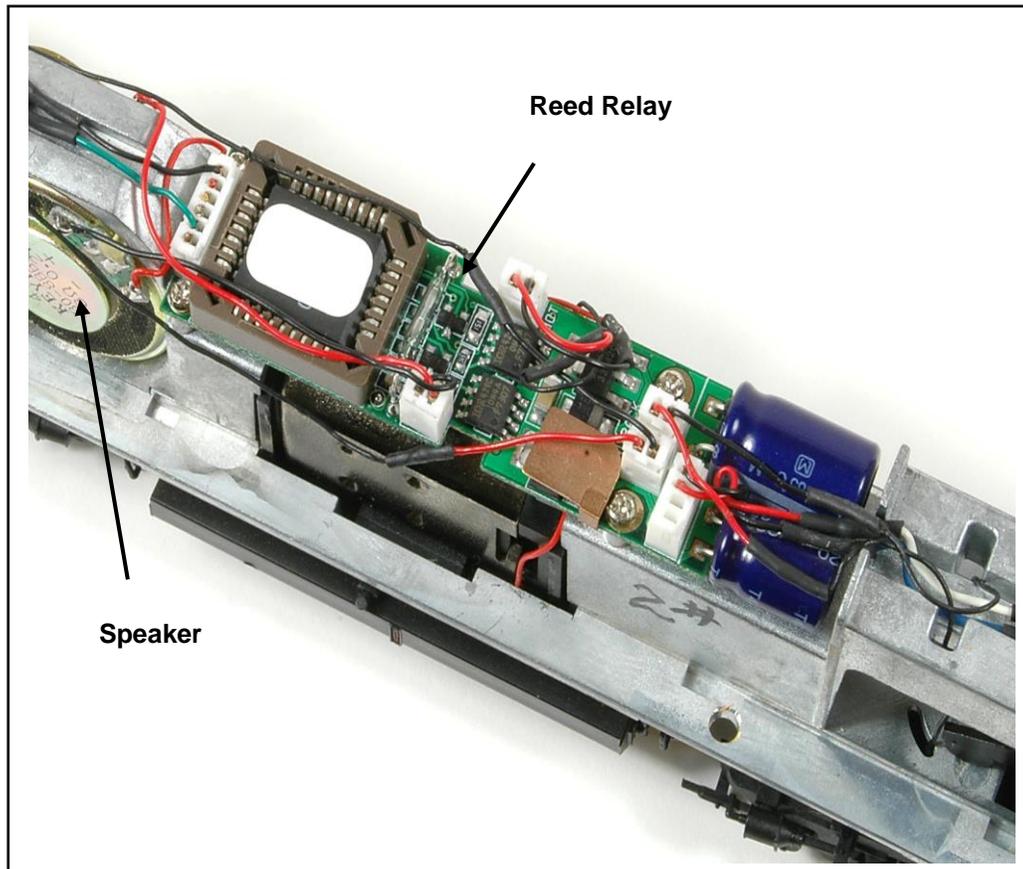
To Adjust the Volume Using the Potentiometer:

- Locate the Manual Volume Control under the access panel on the roof of your Diesel or Electric locomotive or under the water hatch on Steam locomotive tender as shown in the Model Specification sheet that was included with your instructions.
- Turn on main track power. You may want to turn on and leave on some of the significant sound effects such as horn/whistle and bell.
- Use a small screwdriver to turn the volume clockwise to increase volume or turn it counterclockwise to decrease the volume.
- Replace the access panel or water hatch cover.

Note: Volume can also be adjusted digitally using the programming methods described in the programming sections of this manual.

Magnetic Wand Models

Modern Quantum Steam and Diesel models use a glass enclosed reed relay to reset the Quantum System or adjust the volume. The reed relay will close its contacts when the magnet supplied with your locomotive is placed in close proximity. The advantage of this method of adjusting your locomotives volume or resetting it to factory defaults is that you do not need an access panel to gain access to the controls. Also the wand does not need to touch the body; it can be held a reasonable distance from the roof area to prevent possibly marring the painted surface.



Quantum small diesel board with a reed relay mounted in a narrow-body diesel

To Reset the Locomotive:

- Locate the reed relay area as shown in the *Diesel or Steam Model Specifications* sheet that was included with your model.
- Turn off the track power.
- Place the Magnetic Wand over the reed switch area, re-apply track power, and press a function key, for example, F0 to send the locomotive an Ops Mode command. Leave the wand there until you hear the word "reset". Remove the magnetic wand; your locomotive is now reset.

The locomotive has now been returned to original factory defaults including all DCC and Analog values.

Note: Do not try to perform this reset operation on the Program Track under Service Mode power. Always perform this operation under full power.

To Adjust the Volume Using the Magnetic Wand:

- Locate the reed relay area on the locomotive's roof as shown in the *Diesel or Steam Model Specifications* sheet that was included with your model.
- Power up locomotive and leave in Neutral.
- Place the enclosed Magnetic Wand over this reed switch area on the roof of the locomotive perpendicular to the track and wait as you hear the volume increase or decrease in incremental amounts as the Horn hoots about every second. Move the wand away and again place it over the reed area to change the direction (louder or softer) of the volume change. Remove the wand when you reach the desired volume level.

Appendix V

Recommended Reading:

Ames, S., Friberg, R., and Loizeaux, E. *Digital Command Control*. Allt om Hobby 1998

Ireland, Zana (Editor In Chief), *The Digitrax Big Book of DCC*, Digitrax, 1999.

Strang, Lionel, *DCC Made Easy*, Kalmbach Publishing 2003

Polsgrove, Mike, *DCC Projects & Applications*, Kalmbach Publishing, 2006.

Appendix VI

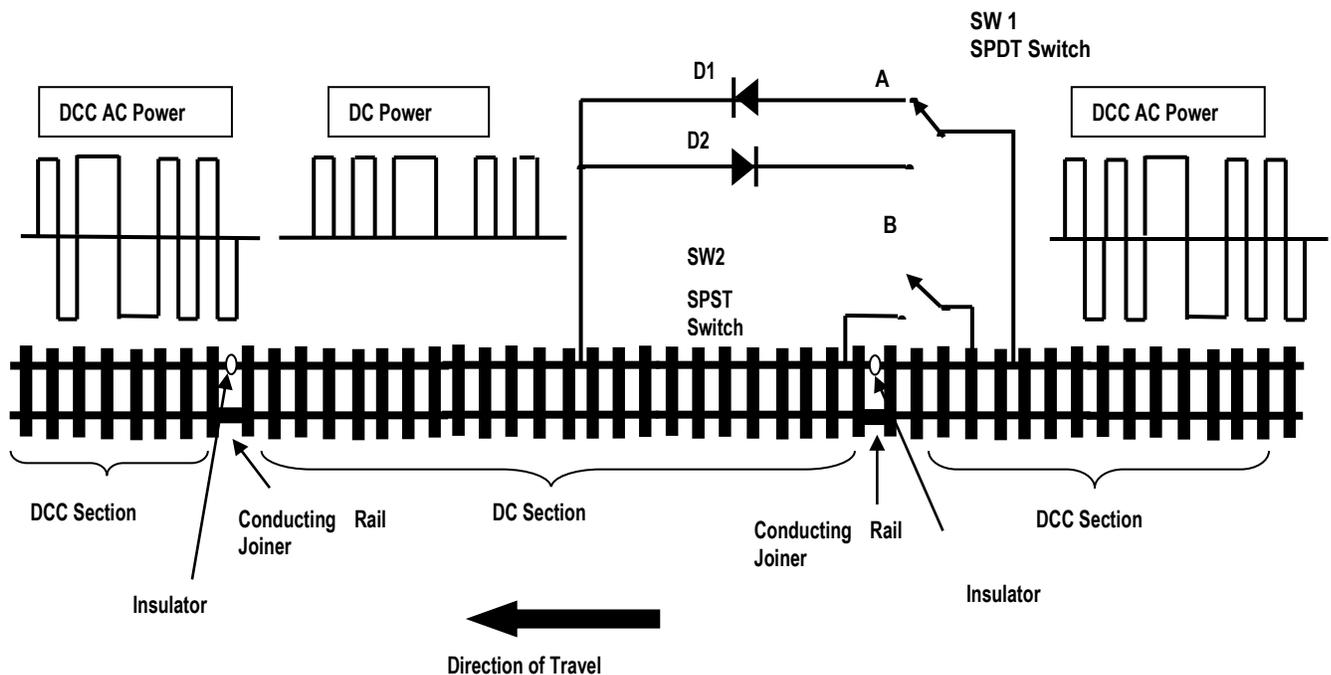
Application Notes:

Using DC Power Conversion for Block Signal Control

CV 29, Bit 2 =1. Applications for DC Power Conversion: Block Signal Control

DCC Power Conversion as described under CV 29, bit 2, was implemented into Quantum decoders in a way that allows for simple block signal control. Using DC power conversion allows the operator to enable a red signal light to stop a train smoothly, using its internal momentum settings, without having to use the throttle. If Bit 2=1 for CV 29, a DCC controlled locomotive will automatically engage DC Power Conversion when it enters a section of track that is powered with standard DC. If the polarity would normally power the analog locomotive in the direction it is going when it enters the DC section, the locomotive will continue through the DC block at the same speed. If the polarity would normally power the locomotive in the Reverse direction, the locomotive will smoothly come to a stop in the DC section.

The diagram below shows a DCC section connected to a DC section of track. The DC section is powered from the DCC power signal rather than from a separate power supply or battery. For this application, it is only necessary to insulate the one rail as shown by the two insulated rail joiners at either end of the DC section; the other rail is electrically connected to the DCC section by conducting rail joiners.



When switch 2 (SW 2) is open, the DCC signal is half-wave rectified by diodes D1 or D2 to produce a positive DC signal to the DC section when Switch 1 is at position A or a negative DC signal when Switch 1 is at position B. If Switch 2 is closed, the DCC signal is connected directly to the DC section and D1 and D2 have no effect on applying DC power to the DC section.

If DC power conversion is enabled in CV 29 (bit 2 = 1) and SW 2 is open, the polarity on the DC section can be used to stop the Quantum equipped locomotive or let it precede, depending on the position of SW 1. If the locomotive is entering the DC section from the right, and SW 1 is set to A, the locomotive will continue at its current speed setting through the DC section. The locomotive, of course, will not respond to DCC signals until it leaves the DC section and reenters the DCC powered section at the far left. On the other hand, if SW 1 is set to B, the polarity on the DC section is opposite the locomotive's direction and the locomotive will slow to a stop at its DCC momentum setting. If the polarity is reversed again to be consistent with the locomotive's direction, the locomotive will accelerate at its current DCC momentum setting to leave the DC section. Alternately, SW 2 could have been closed to cause DCC signals to be applied to the stopped locomotive, which would also have caused the locomotive to accelerate at its current DCC momentum value to its DCC speed setting.

Since the DC portion is powered from the DCC signal, there are no short circuit problems between the DCC powered section and the DC section as the locomotive wheels pass over the track insulators. In addition, since the Quantum locomotive is equipped with large filter capacitors, the reduced power of half-wave rectification will not affect the power available to operate the locomotive so there is minimal slow down effect. Also, if the train is made up of a series of Quantum locomotives in a Consist, and the polarity is set to stop the train, each locomotive in turn will couple the DCC signal through to the DC section until the last locomotive has passed over the boundary. Only then will the entire Consist come to a stop.

The above diagram is simplified to make it easy to describe the basic concept. Switch 1 can be a relay powered by a train detector on the next block to do automatic train control. In addition, Switch 1 could have extra contacts to control red and green signals for the actual block signal. Switch 2 could also be part of a relay network for all DC blocks to disable or enable block signal operation.

D1 and D2 should be rated at 2 amps minimum and have a breakdown voltage of 30 volts or more.

Appendix VII

Binary, Hexadecimal, Decimal Conversions

Decimal	Hex	Binary									
0	00	00000000	64	40	01000000	128	80	10000000	192	C0	11000000
1	01	00000001	65	41	01000001	129	81	10000001	193	C1	11000001
2	02	00000010	66	42	01000010	130	82	10000010	194	C2	11000010
3	03	00000011	67	43	01000011	131	83	10000011	195	C3	11000011
4	04	00000100	68	44	01000100	132	84	10000100	196	C4	11000100
5	05	00000101	69	45	01000101	133	85	10000101	197	C5	11000101
6	06	00000110	70	46	01000110	134	86	10000110	198	C6	11000110
7	07	00000111	71	47	01000111	135	87	10000111	199	C7	11000111
8	08	00001000	72	48	01001000	136	88	10001000	200	C8	11001000
9	09	00001001	73	49	01001001	137	89	10001001	201	C9	11001001
10	0A	00001010	74	4A	01001010	138	8A	10001010	202	CA	11001010
11	0B	00001011	75	4B	01001011	139	8B	10001011	203	CB	11001011
12	0C	00001100	76	4C	01001100	140	8C	10001100	204	CC	11001100
13	0D	00001101	77	4D	01001101	141	8D	10001101	205	CD	11001101
14	0E	00001110	78	4E	01001110	142	8E	10001110	206	CE	11001110
15	0F	00001111	79	4F	01001111	143	8F	10001111	207	CF	11001111
16	10	00010000	80	50	01010000	144	90	10010000	208	D0	11010000
17	11	00010001	81	51	01010001	145	91	10010001	209	D1	11010001
18	12	00010010	82	52	01010010	146	92	10010010	210	D2	11010010
19	13	00010011	83	53	01010011	147	93	10010011	211	D3	11010011
20	14	00010100	84	54	01010100	148	94	10010100	212	D4	11010100
21	15	00010101	85	55	01010101	149	95	10010101	213	D5	11010101
22	16	00010110	86	56	01010110	150	96	10010110	214	D6	11010110
23	17	00010111	87	57	01010111	151	97	10010111	215	D7	11010111
24	18	00011000	88	58	01011000	152	98	10011000	216	D8	11011000
25	19	00011001	89	59	01011001	153	99	10011001	217	D9	11011001
26	1A	00011010	90	5A	01011010	154	9A	10011010	218	DA	11011010
27	1B	00011011	91	5B	01011011	155	9B	10011011	219	DB	11011011
28	1C	00011100	92	5C	01011100	156	9C	10011100	220	DC	11011100
29	1D	00011101	93	5D	01011101	157	9D	10011101	221	DD	11011101
30	1E	00011110	94	5E	01011110	158	9E	10011110	222	DE	11011110
31	1F	00011111	95	5F	01011111	159	9F	10011111	223	DF	11011111
32	20	00100000	96	60	01100000	160	A0	10100000	224	E0	11100000
33	21	00100001	97	61	01100001	161	A1	10100001	225	E1	11100001
34	22	00100010	98	62	01100010	162	A2	10100010	226	E2	11100010
35	23	00100011	99	63	01100011	163	A3	10100011	227	E3	11100011
36	24	00100100	100	64	01100100	164	A4	10100100	228	E4	11100100
37	25	00100101	101	65	01100101	165	A5	10100101	229	E5	11100101
38	26	00100110	102	66	01100110	166	A6	10100110	230	E6	11100110
39	27	00100111	103	67	01100111	167	A7	10100111	231	E7	11100111
40	28	00101000	104	68	01101000	168	A8	10101000	232	E8	11101000
41	29	00101001	105	69	01101001	169	A9	10101001	233	E9	11101001
42	2A	00101010	106	6A	01101010	170	AA	10101010	234	EA	11101010
43	2B	00101011	107	6B	01101011	171	AB	10101011	235	EB	11101011
44	2C	00101100	108	6C	01101100	172	AC	10101100	236	EC	11101100
45	2D	00101101	109	6D	01101101	173	AD	10101101	237	ED	11101101
46	2E	00101110	110	6E	01101110	174	AE	10101110	238	EE	11101110
47	2F	00101111	111	6F	01101111	175	AF	10101111	239	EF	11101111
48	30	00110000	112	70	01110000	176	B0	10110000	240	F0	11110000
49	31	00110001	113	71	01110001	177	B1	10110001	241	F1	11110001
50	32	00110010	114	72	01110010	178	B2	10110010	242	F2	11110010
51	33	00110011	115	73	01110011	179	B3	10110011	243	F3	11110011
52	34	00110100	116	74	01110100	180	B4	10110100	244	F4	11110100
53	35	00110101	117	75	01110101	181	B5	10110101	245	F5	11110101
54	36	00110110	118	76	01110110	182	B6	10110110	246	F6	11110110
55	37	00110111	119	77	01110111	183	B7	10110111	247	F7	11110111
56	38	00111000	120	78	01111000	184	B8	10111000	248	F8	11111000
57	39	00111001	121	79	01111001	185	B9	10111001	249	F9	11111001
58	3A	00111010	122	7A	01111010	186	BA	10111010	250	FA	11111010
59	3B	00111011	123	7B	01111011	187	BB	10111011	251	FB	11111011
60	3C	00111100	124	7C	01111100	188	BC	10111100	252	FC	11111100
61	3D	00111101	125	7D	01111101	189	BD	10111101	253	FD	11111101
62	3E	00111110	126	7E	01111110	190	BE	10111110	254	FE	11111110
63	3F	00111111	127	7F	01111111	191	BF	10111111	255	FF	11111111

Appendix VIII

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