Exhibit E - Part 2

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

"0" Blower-Hiss /Fans will turn off by FL(r), and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by FL(f), and you will "take control" of Blower-Hiss/Fans.

Bit 6 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by FL(r).
"1" Dynamic Brakes will turn on by FL(r).

Bit 7 Output 8: Doppler, Start Up

"0-1" or "1-0" If FL(r) is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" FL(r) is double pressed[48], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

48 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.4 CV 35 Output Location for F1[49]

This CV specifies whether outputs 1 thru 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)	Whistle/Horn	Bell	Directional Lighting	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**

- 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)[50], you can specify that F1 control the following features.

Bit 0 Output 1: Directional Lighting

"0" The Directional Lighting System will turn off by F1.
"1" The Directional Lighting System will turn on by F1.

Bit 1 Output 2: Directional Lighting

"0" The Directional Lighting System will turn off by F1.
"1" The Directional Lighting System will turn on by F1.

Bit 2 Output 3; Bell

"0" The Bell will turn off by F1.
"1" The Bell will turn on by F1.

Bit 3 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F1
"1" Whistle/Horn will turn on by F1.

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

"0-1" or "1-0" If F1 is changed when engine is moving, coupler crash sounds are produced. If F1 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

49 Write bit operation is supported for CV 35.
50 Features that are different in the Neutral state are shown in parentheses

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

"0" Blower-Hiss/Fans will turn off by F1, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F1, and you will "take control" of Blower-Hiss/Fans.

Bit 6 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F1.
"1" Dynamic Brakes will turn on by F1.

Bit 7 Output 8: Doppler, Start Up

"0-1" or "1-0" If F1 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F1 is double pressed[51], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

51 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.5 CV 36 Output Location for F2[52]

This CV specifies whether outputs 1 thru 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)	Whistle/Horn	Bell	Directional Lighting	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**

- 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 engine 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)[53], you can specify that F2 control the following features.

Bit 0 Output 1: Directional Lighting

"0" The Directional Lighting System will turn off by F2.
"1" The Directional Lighting System will turn on by F2.

Bit 1 Output 2: Directional Lighting

"0" The Directional Lighting System will turn off by F2.
"1" The Directional Lighting System will turn on by F2.

Bit 2 Output 3; Bell

"0" The Bell will turn off by F2.
"1" The Bell will turn on by F2.

Bit 3 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F2
"1" Whistle/Horn will turn on by F2.

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

"0-1" or "1-0" If F2 is changed when engine is moving, coupler crash sounds are produced. If F2 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

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

52 Write bit operation is supported for CV 36.
53 Features that are different in the Neutral state are shown in parentheses

"0" Blower-Hiss/Fans will turn off by F2, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F2, and you will "take control" of Blower-Hiss/Fans.

Bit 6 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F2.
"1" Dynamic Brakes will turn on by F2.

Bit 7 Output 8: Doppler, Start Up

"0-1" or "1-0" If F2 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F2 is double pressed[54], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

54 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.6 CV 37 Output Location for F3[55]

This CV specifies whether outputs 1 thru 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)	Whistle/Horn	Bell	Directional Lighting	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**

- Any feature can be assigned to any output in CV 53, except for hardwired features (shown with gray background in top row). 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)[56], you can specify that F3 control the following features.

Bit 0 Output 1: Directional Lighting

"0" The Directional Lighting System will turn off by F3.
"1" The Directional Lighting System will turn on by F3.

Bit 1 Output 2: Directional Lighting

"0" The Directional Lighting System will turn off by F3.
"1" The Directional Lighting System will turn on by F3.

Bit 2 Output 3; Bell

"0" The Bell will turn off by F3.
"1" The Bell will turn on by F3.

Bit 3 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F3
"1" Whistle/Horn will turn on by F3.

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

"0-1" or "1-0" If F3 is changed when engine is moving, coupler crash sounds are produced. If F3 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

55 Write bit operation is supported for CV 37.
56 Features that are different in the Neutral state are shown in parentheses

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

"0" Blower-Hiss/Fans will turn off by F3, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F3, and you will "take control" of Blower-Hiss/Fans.

Bit 6 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F3.
"1" Dynamic Brakes will turn on by F3.

Bit 7 Output 8: Doppler, Start Up

"0-1" or "1-0" If F3 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F3 is double pressed[57], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

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

57 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.7 CV 38 Output Location for F4[58]

This CV specifies whether outputs 4 thru 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: **00000100 = 4**

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

Cruise Control (Disconnect-Standby-Shut Down)	Mute	Squealing Brakes – Air Brakes (Brake Set)	Doppler (Start Up)	Dynamic Brakes	Blower-Hiss/Fans	Coupler Crash Coupler Fire (Coupler Arm)	Whistle/Horn
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**

- 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)[59], you can specify that F4 control the following features.

Bit 0 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F4
"1" Whistle/Horn will turn on by F4.

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

"0-1" or "1-0" If F4 is changed when engine is moving, coupler crash sounds are produced. If F4 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

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

"0" Blower-Hiss/Fans will turn off by F4, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F4, and you will "take control" of Blower-Hiss/Fans.

58 Write bit operation is supported for CV 38.
59 Features that are different in the Neutral state are shown in parentheses

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F4.
"1" Dynamic Brakes will turn on by F4.

Bit 4 Output 8: Doppler, Start Up

"0-1" or "1-0" If F4 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F4 is double pressed[60], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 5 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F4 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F4 is changed when engine is in Neutral, a Long Air Let-off[61] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 6 Output 10: Audio Mute or

"0" Audio Mute will turn off by F4.
"1" Engine sounds will reduced to "Mute Volume" by F4.

Bit 7 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F4 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F4 is double pressed[62], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

60 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
61 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.
62 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.8 CV 39 Output Location for F5[63]

This CV specifies whether outputs 4 thru 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)

Cruise Control (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)	Whistle/Horn
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**

- 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)[64], you can specify that F5 control the following features.

Bit 0 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F5
"1" Whistle/Horn will turn on by F5.

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

"0-1" or "1-0" If F5 is changed when engine is moving, coupler crash sounds are produced. If F5 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

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

"0" Blower-Hiss/Fans will turn off by F5, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F5, and you will "take control" of Blower-Hiss/Fans.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F5.
"1" Dynamic Brakes will turn on by F5.

Bit 4 Output 8: Doppler, Start Up

"0-1" or "1-0" If F5 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F5 is double pressed[65], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

63 Write bit operation is supported for CV 39.
64 Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F5 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F5 is changed when engine is in Neutral, a Long Air Let-off[66] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 6 Output 10: Audio Mute

"0" Audio Mute will turn off by F5.
"1" Engine sounds will reduced to "Mute Volume" by F5.

Bit 7 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F5 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F5 is double pressed[67], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

65 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
66 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.
67 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.9 CV 40 Output Location for F6[68]

This CV specifies whether outputs 4 thru 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)

Cruise Control (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)	Whistle/Horn
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**

- 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 engine and Engine 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)[69], you can specify that F6 control the following features.

Bit 0 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F6
"1" Whistle/Horn will turn on by F6.

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

"0-1" or "1-0" If F6 is changed when engine is moving, coupler crash sounds are produced. If F6 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

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

"0" Blower-Hiss/Fans will turn off by F6, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F6, and you will "take control" of Blower-Hiss/Fans.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F6.
"1" Dynamic Brakes will turn on by F6.

Bit 4 Output 8: Doppler, Start Up

"0-1" or "1-0" If F6 is changed, Doppler shift will occur in a moving engine. In Neutral, if

68 Write bit operation is supported for CV 40.
69 Features that are different in the Neutral state are shown in parentheses

"0-1-0" or "1-0-1" F6 is double pressed[70], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 5 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F6 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F6 is changed when engine is in Neutral, a Long Air Let-off[71] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 6 Output 10: Audio Mute

"0" Audio Mute will turn off by F6.
"1" Engine sounds will reduced to "Mute Volume" by F6.

Bit 7 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F6 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F6 is double pressed[72], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

70 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
71 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.
72 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.10 CV 41 Output Location for F7[73]

This CV specifies whether outputs 4 thru 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)

Cruise Control (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)	Whistle/Horn
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**

- 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 engine and a Long Air Let-off for a Brake Set in Neutral. Therefore, by default F7 controls Squealing Brakes or Air Brakes for a moving engine and a 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)[74], you can specify that F7 control the following features.

Bit 0 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F7
"1" Whistle/Horn will turn on by F7.

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

"0-1" or "1-0" If F7 is changed when engine is moving, coupler crash sounds are produced. If F7 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

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

"0" Blower-Hiss/Fans will turn off by F7, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F7, and you will "take control" of Blower-Hiss/Fans.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F7.
"1" Dynamic Brakes will turn on by F7.

Bit 4 Output 8: Doppler, Start Up

"0-1" or "1-0" If F7 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F7 is double pressed[75], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

73 Write bit operation is supported for CV 41.
74 Features that are different in the Neutral state are shown in parentheses

Bit 5 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F7 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F7 is changed when engine is in Neutral, a Long Air Let-off[76] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 6 Output 10: Audio Mute

"0" Audio Mute will turn off by F7.
"1" Engine sounds will reduced to "Mute Volume" by F7.

Bit 7 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F7 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F7 is double pressed[77], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

75 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
76 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.
77 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.11 CV 42 Output Location for F8[78]

This CV specifies whether outputs 4 thru 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)

Cruise Control (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)	Whistle/Horn
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**

- 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)[79], you can specify that F8 control the following features.

Bit 0 Output 4; Whistle/Horn

"0" The Whistle/Horn will turn off by F8
"1" Whistle/Horn will turn on by F8.

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

"0-1" or "1-0" If F8 is changed when engine is moving, coupler crash sounds are produced. If F8 is changed when engine is in Neutral, Coupler Arm or coupler Fire occurs.

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

"0" Blower-Hiss/Fans will turn off by F8, and you will "take control" of Blower-Hiss/Fans.
"1" Blower-Hiss/Fans will turn on by F8, and you will "take control" of Blower-Hiss/Fans.

Bit 3 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F8.
"1" Dynamic Brakes will turn on by F8.

Bit 4 Output 8: Doppler, Start Up

"0-1" or "1-0" If F8 is changed, Doppler shift will occur in a moving engine. In Neutral, if

78 Write bit operation is supported for CV 42.
79 Features that are different in the Neutral state are shown in parentheses

"0-1-0" or "1-0-1" F8 is double pressed[80], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 5 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F8 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F8 is changed when engine is in Neutral, a Long Air Let-off[81] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 6 Output 10: Audio Mute

"0" Audio Mute will turn off by F8.
"1" Engine sounds will reduced to "Mute Volume" by F8.

Bit 7 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F8 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F8 is double pressed[82], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

80 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
81 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.
82 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.12 CV 43 Output Location for F9[83]

This CV specifies whether outputs 7 thru 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	Number Board Lights	SMPH Report (Status Report)	Cruise Control (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**

- Any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 11 are Cruise Control for a moving engine and Disconnect-Standby-Shut Down for an engine in Neutral. Therefore, by default F9 controls Cruise Control and Disconnect-Standby-Shut Down.
- 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)[84], you can specify that F9 control the following features.

Bit 0 Output 7: Dynamic Brakes

"0" Dynamic Brakes will turn off by F9.
"1" Dynamic Brakes will turn on by F9.

Bit 1 Output 8: Doppler, Start Up

"0-1" or "1-0" / "0-1-0" or "1-0-1" If F9 is changed, Doppler shift will occur in a moving engine. In Neutral, if F9 is double pressed[85], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 2 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F9 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F9 is changed when engine is in Neutral, a Long Air Let-off[86] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

83 Write bit operation is supported for CV 43.
84 Features that are different in the Neutral state are shown in parentheses
85 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
86 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.

Bit 3 Output 10: Audio Mute

"0" Audio Mute will turn off by F9.
"1" Engine sounds will reduced to "Mute Volume" by F9.

Bit 4 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F9 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F9 is double pressed[87], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

Bit 5 Output 12: Status Report

"0" Status Report is unaffected by F9.
"1" When you press F9, you will hear the engine announce its current status. In Forward/Reverse, the engine's speed in scale MPH is announced. In Neutral, the engine announces its Primary Address (CV1) or Extended Address (CV17-18), its Consist Address (CV19) if it has one, and whether it is in Disconnect, Standby or Shutdown.

Bit 6 Output 13: Number Board Lights

"0" Number Board Lights will shut off by F9.
"1" Number Board Lights will turned on by F9.

Bit 7 Output 14: Cab Lights

"0" Cab Lights will shut off by F9 and you will "take control" of Automatic Cab Lights.
"1" Cab Lights will turned on by F9 and you will "take control" of Automatic Cab Lights.

87 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.13 CV 44 Output Location for F10[88]

This CV specifies whether outputs 7 thru 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	Number Board Lights	SMPH Report (Status Report)	Cruise Control (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**

- Any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 12 is a Short Air Let-off, or are special for specific types of locomotives such as Pop Off for Steam Engines.
- 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 will turn off by F10.
"1" Dynamic Brakes will turn on by F10.

Bit 1 Output 8: Doppler, Start Up

"0-1" or "1-0" / "0-1-0" or "1-0-1" — If F10 is changed, Doppler shift will occur in a moving engine. In Neutral, if F10 is double pressed[90], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 2 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" — If F10 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F10 is changed when engine is in Neutral, a Long Air Let-off[91] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

88 Write bit operation is supported for CV 44.
89 Features that are different in the Neutral state are shown in parentheses
90 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
91 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.

Bit 3 Output 10: Audio Mute

"0"	Audio Mute will turn off by F10.
"1"	Engine sounds will reduced to "Mute Volume" by F10.

Bit 4 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0"	For a moving engine, if F10 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1"	In Neutral, each time F10 is double pressed[92], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

Bit 5 Output 12: Status Report

"0"	Status Report is unaffected by F10.
"1"	When you press F10, you will hear the engine announce its current status. In Forward/Reverse, the engine's speed in scale MPH is announced. In Neutral, the engine announces its Primary Address (CV1) or Extended Address (CV17-18), its Consist Address (CV19) if it has one, and whether it is in Disconnect, Standby or Shutdown.

Bit 6 Output 13: Number Board Lights

"0"	Number Board Lights will shut off by F10.
"1"	Number Board Lights will turned on by F10.

Bit 7 Output 14: Cab Lights

"0"	Cab Lights will shut off by F10 and you will "take control" of Automatic Cab Lights.
"1"	Cab Lights will turned on by F10 and you will "take control" of Automatic Cab Lights.

92 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.14 CV 45 Output Location for F11[93]

This CV specifies whether outputs 7 thru 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	Number Board Lights	SMPH Report (Status Report)	Cruise Control (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**

- Any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 13 is a Short Air Let-off, or are special for specific types of locomotives such as Boiler Blow Down for Steam Engines.
- 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 will turn off by F11.
"1" Dynamic Brakes will turn on by F11.

Bit 1 Output 8: Doppler, Start Up

"0-1" or "1-0" / "0-1-0" or "1-0-1" If F11 is changed, Doppler shift will occur in a moving engine. In Neutral, if F11 is double pressed[95], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 2 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F11 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

If F11 is changed when engine is in Neutral, a Long Air Let-off[96] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 3 Output 10: Audio Mute

93 Write bit operation is supported for CV 45.
94 Features that are different in the Neutral state are shown in parentheses
95 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-Pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.
96 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.

"0" Audio Mute will turn off by F11.
"1" Engine sounds will reduced to "Mute Volume" by F11.

Bit 4 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F11 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F11 is double pressed[97], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

Bit 5 Output 12: Status Report

"0" Status Report is unaffected by F11.
"1" When you press F11, you will hear the engine announce its current status. In Forward/Reverse, the engine's speed in scale MPH is announced. In Neutral, the engine announces its Primary Address (CV1) or Extended Address (CV17-18), its Consist Address (CV19) if it has one, and whether it is in Disconnect, Standby or Shutdown.

Bit 6 Output 13: Number Board Lights

"0" Number Board Lights will shut off by F11.
"1" Number Board Lights will turned on by F11.

Bit 7 Output 14: Cab Lights

"0" Cab Lights will shut off by F11 and you will "take control" of Automatic Cab Lights.
"1" Cab Lights will turned on by F11 and you will "take control" of Automatic Cab Lights.

97 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

4.15 CV 46 Output Location for F12[98]

This CV specifies whether outputs 7 thru 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	Number Board Lights	SMPH Report (Status Report)	Cruise Control (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**

- Any feature can be assigned to any output in CV 53. In CV 53, the default settings for Output 14 is a Short Air Let-off, or are special for specific types of locomotives such as Boiler Blow Down for Steam Engines.
- 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 will turn off by F12.
"1" Dynamic Brakes will turn on by F12.

Bit 1 Output 8: Doppler, Start Up

"0-1" or "1-0" If F12 is changed, Doppler shift will occur in a moving engine. In Neutral, if
"0-1-0" or "1-0-1" F12 is double pressed[100], Quantum will clear all "Take Control" operations and produce engine Start Up sounds (if in Shut Down).

Bit 2 Output 9: Squealing Brakes and Air Brakes, Long Air Let-off or Special Feature

"0-1" or "1-0" If F12 is changed for a moving engine and throttle is set above zero speed step, Squealing Brake Sounds are triggered but no real braking occurs.
If the throttle is set to zero speed step, any transition from 1 to 0 or 0 to 1 causes brakes to switch from "increase brake level" to "maintain brake level" to "increase brake level", etc. If the throttle is increased from zero, Air Brakes are released.

98 Write bit operation is supported for CV 46.
99 Features that are different in the Neutral state are shown in parentheses
100 Double-pressing ensures that Start Up is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

If F12 is changed when engine is in Neutral, a Long Air Let-off[101] Sound occurs simulating the setting of the Air Brakes. However no braking effect occurs.

Bit 3 Output 10: Audio Mute

"0" Audio Mute will turn off by F12.
"1" Engine sounds will reduced to "Mute Volume" by F12.

Bit 4 Output 11: Cruise Control, Disconnect-Standby-Total Shut Down

"0-1" or "1-0" For a moving engine, if F12 is changed, Cruise Control will toggle on or off.
"0-1-0" or "1-0-1" In Neutral, each time F12 is double pressed[102], Quantum will go through a series of shut down effects, starting with Disconnect, followed by Standby and finally Total Shut Down.

Bit 5 Output 12: Status Report

"0" Status Report is unaffected by F12.
"1" When you press F12, you will hear the engine announce its current status. In Forward/Reverse, the engine's speed in scale MPH is announced. In Neutral, the engine announces its Primary Address (CV1) or Extended Address (CV17-18), its Consist Address (CV19) if it has one, and whether it is in Disconnect, Standby or Shutdown.

Bit 6 Output 13: Number Board Lights

"0" Number Board Lights will shut off by F12.
"1" Number Board Lights will turned on by F12.

Bit 7 Output 14: Cab Lights

"0" Cab Lights will shut off by F12 and you will "take control" of Automatic Cab Lights.
"1" Cab Lights will turned on by F12 and you will "take control" of Automatic Cab Lights.

101 Some locomotives have special effects assigned to this output such as Water Injector Sounds for a Steam Engine.
102 Double-pressing ensures that Shut Down is not entered or exited accidentally. Doubling-pressing is defined as two Function Key presses within two seconds. Note that the Function 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 the Function.

5 CV 49-64, QSI Configuration Variables

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.

The NMRA specified CV specifications relate to the operation of functions that must be standard to all DCC products such as ID numbers, number of speed steps, and acceleration and deceleration values.

However, many model railroad products today, and a much larger number in the future, will require manufacturer unique CV's to configure their product's special features. The command structure and protocols for operation of non-specified features are standardized through the NMRA, but the individual manufacturers will specify the actual behavior and configuration. An example is the system volume for the Quantum Sound System. This feature is not specified by the NMRA and it is left to the discretion of the product designer to determine how it will be implemented and what parameters are necessary to customize its performance. For this reason, the NMRA has provided a number of CV's for the manufacturers to allow configuring of their own products, using CV's 49 through 64. Additional CV's 112-128 have recently been made available for manufacturers as well.

Unfortunately the total number of manufacturer unique CV's made available may not be sufficient for future needs. Also, the grouping of the CV's may not be as well organized as new features are added. For instance, if we included CV's for particular sound effects followed by CV's to set their volume levels, we could easily consume a large number of the available allocated CV's. If at a later date, we decided to add configuration variables to enhance some sound feature, that CV may have to be placed at the end of the list, far from the CV's related to that feature.

5.1.1 Primary and Secondary Indices

Instead of filling up the manufacturer unique CV's in a linear or chronological order, we have elected to use a table indexing system that allows the user to change the operation and behavior of each customizable feature in a consistent way. We have included both a Primary Index set by CV 49 and a Secondary Index (SI) set by CV 50. Numbers or values placed in these two indices do not, by themselves, have any effect on the operation of the Quantum System. Rather, they are used along with CV's that do affect some Quantum characteristic. They simply act as a pointer to individual sounds, features, outputs or whatever that will be affected by the CV under consideration.

5.1.1.1 Primary Index

The Primary Index is used as a table index to expand the number of choices available for a CV.

For example, consider QSI CV 52, which controls the volume levels for different sound features. CV 52 can have any of sixteen volume-settings as specified by the first four bits. Although 52 does specify a volume level, it does not know which feature to apply that volume setting to unless there is a way to point at the desired sound feature. That "pointing" is accomplished by using the Primary Index (PI), which is set in CV 49. The user first selects the sound he wants to affect from a table of the different sound features available and enters its corresponding number into the Primary Index, CV 49. He then uses CV 52 to change that particular sound volume. He can enter one value after another into CV 52 until he gets the desired volume for the feature selected. The user can then select a new sound from the table, write its corresponding value into CV 49 and then use CV 52 to change the volume of this second sound.

We use a shorthand notation when writing a CV that has a Primary Index. The CV is first written followed by a decimal point followed the Primary Index value. For instance, if we had set CV 52 to a volume level of 6 for the Bell (Sound Identifier Number[103] = 8), we would write CV 52.8 = 6.

5.1.1.2 Secondary Index

The Secondary Index is used as a second table index where there is a secondary choice of behavior that can apply. For instance, CV 53 is used to assign features to both an output and a motive state of the engine. When we assign a feature in CV 53, we need a pointer (Primary Index) to select the desired output and another pointer (Secondary Index) to specify the state (Forward/Reverse or Neutral).

A useful way to help understand this concept is to picture assigning Secondary and Primary Indexes as row and column values in a two dimensional table for a particular CV (shown as CV X in this case). The Primary Index (PI) is shown as row values and the Secondary Index (SI) is shown as column values. The value of the CV for each PI and SI is shown as a table entry where the row and column (PI and SI) values are included (i.e. "CV Value 1,3" means the Values of CV X assigned for PI = 1 and SI = 3).

CV X Date Register

Primary Index set by CV 49	Secondary Index set by CV 50					
	0	1	2	3	:	255
0	CV Value 0,0	CV Value 0,1	CV Value 0,2	CV Value 0,3	CV Value 0,n	CV Value 0,255
1	CV Value 1,0	CV Value 1,1	CV Value 1,2	CV Value 1,3	CV Value 1,n	CV Value 1,255
2	CV Value 2,0	CV Value 2,1	CV Value 2,2	CV Value 2,3	CV Value 2,n	CV Value 2,255
3	CV Value 3,0	CV Value 3,1	CV Value 3,2	CV Value 3,3	CV Value 3,n	CV Value 3,255
:	CV Value m,0	CV Value m,1	CV Value m,2	CV Value m,3	CV Value m,n	CV Value m,255
255	CV Value 255,0	CV Value 255,1	CV Value 255,2	CV Value 255,3	CV Value 255,n	CV Value 255,255

Not all of the 256 row and 256 columns are shown. The row labeled "m" and column labeled "n" indicate any row or column between 3 and 255. Although there is only one CV (shown as CV X in this case), a different value can be stored for each row and column choice, providing up to 256 X 256 possible choices for the CV.

To use CV X, first select the PI and SI you want and assign these values to CV 49 and CV 50 respectively. Now when you enter a value into CV X, it will only apply to that particular selection of CV X for the choices you made for the SI and PI values.

To see how this works in practice, consider CV 53 as an example. The table below shows how different QSI Features have been assigned to different outputs and locomotive states for our factory defaults. The Primary Index column has 14 choices for the 14 different Outputs. The Secondary Index is shown across the top and has only two values (0 for a Motive State, and 1 for Neutral); an N/A means there are no other directional states available and hence no other Secondary ID's besides 0 and 1.

Each Feature ID (see listing of Feature ID's in CV 53) to be controlled by an output is shown as a location in the table corresponding to the desired output and the desired directional state in which it will be active. For instance, we have assigned Mute (ID 64) to Output 10 and to operate in all states (Forward and Reverse, and Neutral). Doppler (ID 65) has been assigned to Output 8 but only in Forward and Reverse. A completely different feature, Engine Start Up (ID

103 See the list of Individual Sound Identifiers in CV 52.

144) has been assigned to Neutral. This means that a moving engine will produce a Doppler Shift Effect when Output 8 is activated, but will produce an Engine Start up effect if in Neutral when Output 8 is activated.

Feature Assignments using CV 53 Primary and Secondary Indexes:

		Secondary Index set by CV 50					
		0	**1**	**2**	**3**	**.....**	**255**
		Forward/ Reverse only	Neutral only	N/A	N/A		N/A
0	N/A						
1	Output 1	96	96				
2	Output 2	97	97				
3	Output 3	3	3				
4	Output 4	1	1				
	Output 5	211	211				
	Output 6	8	8				
Primary Index set by CV 49	Output 7	5	5				
8	Output 8	65	144				
9	Output 9	216	9				
10	Output 10	64	64				
11	Output 11	177	145				
12	Output 12	178	178				
13	Output 13	105	105				
14	Output 14	101	101				
15	N/A						
:							
255	NA						

Let's say you wanted to assign a Short Air Let-Off (QSI Feature[104] Number 10) into CV 53 to operate only in Neutral in Output 7. Currently, Output 7 is already assigned "Dynamic Brakes" for both Forward/Reverse and Neutral. To place Short Air Let-off in the Neutral Position for Output 7, first set CV 49 to 7 (Output 7) and then set CV 50 to 1 (Neutral). Now set 10 (Short Air Let-Off) into CV 53.

In summary, to assign a feature to an output, we first chose which output it would apply to, followed by the motive state it will operate in. We use the Primary Index (PI) to select the Output followed by the Secondary Index (SI) to select the motive state and then enter the Feature ID number into CV 53. We then select the next SI for the other motive state and enter the next Feature ID into CV 53.

We use a shorthand notation when writing a CV that has a Primary and Secondary Index. The CV is first written followed by a decimal point followed by the Primary Index value followed by a decimal point followed by the Secondary Index. For instance, in the above example where we entered the Short Air Let-off (10) into CV 53 to be active in Output 7 (PI = 7) and to operate in the Neutral Position (SI = 1), we would write "CV 53.7.1 = 10. When CV's are spoken out in Ops Mode Programming, the same shorthand method is used. If you inquired about the value in CV 53 for this example, you would hear "CV five three point seven point one equals ten".

104 See CV 53 listing of QSI Feature ID's).

5.2 CV 49 QSI Primary Index

Use CV 49 to specify the Primary Index or Row Number for CV's that use a table index to expand the number of choices.

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, using CV 49 as an index for CV 52 allows specifying the volume for up to 256 Individual Sounds.

Primary Index	Table of Volumes
0	Volume for Individual Sound[0]
1	Volume [1]
2	Volume [2]
3	Volume [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 table of values. The elements of the table are referred to as CV NN.PI, where NN is the CV number. 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 CV's that use two pointers or table indices to expand the number of available choices.

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 2-dimensional table of up to 256x256 related values. CV 49 is the row index and CV 50 is the column index.

	Secondary Index				
Primary 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]	...
...	...	...	...	...	...

- Where Value [n,m] represents the data entered in each position with PI =n, and SI =m.
- In this document the terms CV 50 and Secondary Index mean the same thing. SI is the abbreviation for Secondary Index.
- To simplify description of a CV that is a 2-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. During verbal acknowledge of CV's or during CV Numeric Verbal Readout (CV 64), the value of data in a 2-dimensional table is spoken out with the word "point" to distinguish between the CV number, the Primary Index and the Secondary Index. For example, the location of the Feature Assigned to Output 5 in NFF/NFR is written CV 53.5.1 and spoken out as "CV five three point five point 1".

See Example Next Page:

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

	Secondary Index	
Primary 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
4	Feature Assigned to Output 4 in FWD/REV	Feature Assigned to Output 4 in NFF/NFR
5	Feature Assigned to Output 5 in FWD/REV	Feature Assigned to Output 5 in NFF/NFR
6	Feature Assigned to Output 6 in FWD/REV	Feature Assigned to Output 6 in NFF/NFR
7	Feature Assigned to Output 7 in FWD/REV	Feature Assigned to Output 7 in NFF/NFR
8	Feature Assigned to Output 8 in FWD/REV	Feature Assigned to Output 8 in NFF/NFR
9	Feature Assigned to Output 9 in FWD/REV	Feature Assigned to Output 9 in NFF/NFR
10	Feature Assigned to Output 10 in FWD/REV	Feature Assigned to Output 10 in NFF/NFR
11	Feature Assigned to Output 11 in FWD/REV	Feature Assigned to Output 11 in NFF/NFR
12	Feature Assigned to Output 12 in FWD/REV	Feature Assigned to Output 12 in NFF/NFR
13	Feature Assigned to Output 13 in FWD/REV	Feature Assigned to Output 13 in NFF/NFR
14	Feature Assigned to Output 14 in FWD/REV	Feature Assigned to Output 14 in NFF/NFR

5.4 CV 51 QSI System Sound Control

Use CV 51 to control the Quantum Sound System, Mute Volume and Special Sound Effects

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

Use CV 51.0 to change the overall 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.

Example: Set the Operations Mode System volume to 64 (50% of max).
1) Set CV 49 to 0. 2) Set CV 51 to 64.

The Operations Mode System Volume is the overall sound volume when the engine 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. If your Command Station supports programming Quantum in Service Mode, you can program the System Volume. You just won't hear the change in volume until you enter Operations Mode.

Note: Setting the system volume in this CV will also apply to the system volume during conventional Analog operation. The converse is also true. Setting the Analog System Volume using Analog program options described in the Analog Operation section of your locomotive's instruction manual will affect the system volume in DCC operation.

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 selected by a Function Key. When Mute is activated 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 System 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. The default Mute Volume is 0 **(0%)**. A "0" in this CV will mute all sound effects to zero volume.

Example: Set the Operations Mode System volume to 32 (25% of max).
1. Set CV 49 to 1 2. Set CV 51 to 32

The Mute Volume applies when the engine is in normal operation on the main (Operations Mode). When you change the Mute Volume on the main and "Mute" has been activated by its assigned Function Key, you will immediately hear the change in volume.

If your Command Station will support programming Quantum in Service Mode, you can program the Mute Volume. You just won't hear the change in Mute volume until you enter Operations Mode and activate the Mute feature.

5.4.3 CV 51.2 Special Sound Effects Enable [105] (PI = 2)

Use CV 51.2 to turn on/off special sound effects.

Default Value: **1**

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	Reserved for future use	Reserved for future use	Reserved for future use	Reserved for future use	Reserved for future use	Coded Horn for Gas Turbine Start Up[106]	Horn Triggered Doppler

- Write 2 to CV 49 to specify the Primary Index for **Special Sound Effects Enable.**
- 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 function key and reapplying to produce the Doppler effect.
- Set data in Bit 1 as follows:

  "0" = Horn Triggered Doppler Effect is disabled
  "1" = Horn Triggered Doppler Effect is enabled.

- All other bits are reserved. Data in bits 2-7 are not used. Any data entered in these bits will be ignored.
- Default is "1", Horn Triggered Doppler enabled.

Example: Disable Horn Triggered Doppler.
1) Set CV 49 to 2. 2) Set CV 51 to 0.

105 Write bit operation is supported for Special Sound Effects Enable.
[106] See Gas Turbine Operation in Appendix II for further explanation of this feature.

5.5 CV 52.PI QSI Individual Sound Volume Control

Use CV 52 to specify volumes 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**

To change the volume level of an individual sound, do the following:

1. Set CV#49 to the identifier for the individual sound (see table below).
2. Set data in Bits 0-3 of CV#52 as follows:
   "0" = No sound
   "1 – 15" = Sets volume level from the lowest level at "1" to the highest level at "15"

- 4 bits of volume are used, providing 16 volume levels. The volume levels are in 2db increments.
- All other bits are reserved. Data in bits 4-7 are not used. Any data entered in these bits will be ignored.

Example: Set the bell volume to the 6th volume level and then set the Whistle volume to 10th level (i.e. set CV 52.8 to 6 followed by setting CV 52.0 to 11)
1. Set CV 49 to 8 to select the Bell sound. 2. Set CV 52 to 6 to select the 6th volume level for the Bell. 3. Set CV 49 to 0 select the Whistle/Horn sound. 4. CV 52 to 10 to select the 10th volume level for the Whistle/Horn.

Example: For dual Air Pump Steam Engines, turn the volume off on one pump to create single pump action.
1. Set CV 49 to 17 to select the second pump sound. 2. CV 52 to zero to select no volume.

5.5.1 Individual Sound Identifiers

Primary Index (CV 49 value)	Sound	Typical Defaults Levels[107]
0	Whistle/Horn[108]	11
8	Bell	11
10	Chuff/Diesel Motor/Traction Motor[109]	11
14	Turbo	11
16	Air Pump 1	11
17	Air Pump 2	11
19	Steam Blower (hiss)/ Fans[110]	8
21	Long Air Let-off	11
22	Short Air Let-off	11
24	Squealing Brakes	11
26	Steam Dynamo	8
28	Dynamic Brakes	8
29	Boiler Pop-off	11
30	Blow down	11
31	Injector	11
34	Coupler Sounds	11
37	Air Brakes	11

107 Default levels for individual sounds may be set to different levels at the factory then are shown here depending on the acoustic nature of each locomotive. Check the value of your default settings in your individual locomotive's instruction manual.
108 Whistle in Steam Locomotives; Horn in Diesel and Electric Locomotive.
109 Chuff in Steam Locomotives; Diesel Motor in Diesel Locomotives; Traction Motor in Electric Locomotives.
110 Steam Blower in Steam Locomotives; Cooling Fans in Diesel and Electric Locomotives.

5.6 CV 53.PI.SI Output Feature Assignment

Use CV 53 to assign QSI features to the 14 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**

- Write the Decoder Output Number (5…14) to CV 49. Outputs 1…4 are pre-assigned and cannot be changed.
- Write the Engine State (0 for Forward/Reverse, 1 for Neutral (NFF/NFR) to CV 50. Certain features can only be assigned to an output for a specific state.
- Write the QSI Feature Identifier Number to CV 53.
- 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?

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 53.5.1 to 9 and set CV 53.5.2 to 10).

1) Set Primary Index CV 49 to "5" to select output 5.
2) Set Secondary Index CV 51 to "0" to select Forward/Reverse.
3) Set CV 53 to "9" (00000101) for Long Air Let-Off.
4) Set Secondary Index CV 51 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 when the engine is in Neutral, the Function key mapped to output 5 will produce a Short Air-Let-Off a Long Air Let-Off when the engine is moving in Forward and Reverse.

5.6.1 QSI Feature Identification Numbers

The following table lists the QSI Features, which 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 engine; 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 ID	Feature	Allowed Directional States	Comments
0	Null Output	All	No feature, no sound effect.
1	Whistle/Horn	All	Pre-assigned to output 4.
3	Bell	All	Pre-assigned to output 3.
5	Dynamic Brakes	All	Dynamic Brakes are usually applied to diesel or electric locomotives. Even though it has no meaning for a Steam Engine, it has some utility when the Steam Engine is in a Consist. Here Dynamic Brakes cause the chuff sound to lower in labor or volume to be consistent with other engines that have Dynamic Brakes. Dynamic Brakes can also be applied in Neutral for diesels in "Disconnect" which will allow the motor to rev up under Dynamic Brake loading.
8	Blower Hiss/Diesel Cooling Fans	All	Blowers are used on steam engines to vent steam through the smoke stack to provide extra draft for the fire when engine is idle. It produces a familiar hissing sound. Diesel and Electric Cooling Fans are used to keep diesels and/or traction motors from overheating. Cooling fans are accompanied by vents opening and closing.
9	Long Air Let-off	All	Use a long air let-off to simulate operating some steam appliances like power reverse.
10	Short Air Let-off	All	Short air let-off for turn on or turn off of some appliances. Combine with brakes to simulate venting air prior to brake sounds.
12	Pop-off	NFF/NFR	This is the sound of the boiler Pop-off values venting excess steam. Although this can be applied to all directional states, it occurs more typically in Neutral.
13	Blow down	NFF/NFR	This is venting of residue that collects at the bottom of the boiler, usually in Neutral.
14	Injector	NFF/NFR	This is the sound effect of water being injected into the boiler. This can happen anytime but it is more obvious in Neutral.
64	Mute	All	Ideal for muting sounds of a running engine when the phone rings. When an engine is muted, all sounds go silent. We have added a feature in CV 51.1 that provides a custom mute volume; when Mute is engaged, the sounds go to a lower sound but not completely off.
65	Doppler Shift	FWD/REV	Doppler, when activated, produces volume increase and pitch change on a moving train to simulate the sound a train makes when passing

			close to an observer. Doppler has no meaning or utility in Neutral.
96	Directional Headlight	All	Pre-assigned to output 1. Steam Loco's Directional Lights also include Dynamo Start Up Sounds.
97	Directional Reverse Light	All	Pre-assigned to output 2. Steam Loco's Directional Lights also include Dynamo Start Up Sounds.
98	Headlight	All	Turns headlight on/off.
99	Dim Headlight	All	Turns headlight dim/bright.
100	Reverse Light	All	Turns reverse light on/off.
101	Automatic Cab Lights	All	May not be available for all models. Cab Lights turn off in Forward/Reverse after 15 seconds and turn on in Neutral after 10 seconds.
102	Directional Mars Light	All	Come on Bright and Strobing in Direction of travel. Dim in Neutral or when direction is Reverse.
103	Mars Light	All	Turns Mars Light On/Off.
104	Strobe Mars Light	All	Selects Mars Light Strobing or Steady.
105	Number Board Lights	All	May not be available for all models.
107	Directional Headlight + Directional Mars Light	All	Multiple lights feature: a combination of feature 96 and feature 102. If the engine has a Mars Light, this is the feature assigned to output 1 by default.
108	Directional Headlight + Directional Ditch Lights	All	Multiple lights feature: a combination of feature 96 and feature 109. If the engine has Ditch Lights, this is the feature assigned to output 1 by default.
109	Directional Ditch Lights	All	Ditch Lights on in Forward and off in Neutral and Reverse. Ditch Lights strobe by alternating from "Left Light On; Right Light Off" to "Left Off; Right On", with Horn in Forward and remain strobing for 5 seconds after Horn signal is terminated.
110	Ditch Lights	All	Turns Ditch Lights on/off.
111	Strobe Ditch Lights	All	If Ditch Lights are on, this feature will cause the two Ditch Lights to strobe by alternating from "Left Light On; Right Light Off" to "Left Off; Right On".
144	Start Up	NFF/NFR	The Start Up feature produces engine start up sound effects for an engine that has been Shut Down (see 145).
145	Shut Down	NFF/NFR	Shut Down features Consists of three parts that proceeds successively with each use of the Function Key to the stages of: 1) "Disconnect" which allow a diesel motor to rev or steam engine to vent steam without engaging the motor, 2) "Standby" which produces low background sounds of an idling engine, and 3) Total Shut Down.
176	Air Brakes	FWD/REV	If speed step = 0, and engine moving, Air Brake features increases deceleration from CV 4 and CV 24 value progressively as long as Air Brakes active. When turned off, deceleration continues at last braking level. Turning up throttle or entering Neutral resets brakes to off.
177	Cruise Control	FWD/REV	Cruise control locks the engine into its current

			speed when activated. Cruise control works only in Regulated Speed Control and Speed Control, and not Standard Throttle Control. Cruise Control has no meaning or utility in Neutral.
178	Scale Miles Per Hour Report and Status Report	All	In FWD/REV, the engine's speed in scale MPH is announced. In Neutral, the engine announces its Primary Address (CV1) or Extended Address (CV17-18), its Consist Address (CV19) if it has one, and whether it is in Disconnect, Standby or Shutdown
211	Coupler Effect	All	Although this feature can be applied to all directional states, it has different effects depending on when it is used. If only assigned to FWD/REW it will produce a coupler crash sound. If also enabled in Neutral, it will arm and fire a coupler sound. If it is armed in Neutral, it can be also be fired in FWD/REV.
215	Squealing Brakes	FWD/REV	This feature can be re-triggered over and over again anywhere in the record to extend the brake squeal sound. Do not waste this feature in Neutral where squealing brakes have no meaning.
216	Squealing Brakes + Air Brakes	FWD/REV	Combination of features 215 and 176.
217	Pumps	NFF/NFR	This can be two or one compressor depending on the locomotive. Note that when two pumps are available, each one can be assigned different volumes in CV 52.

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 Factory Default Settings

		Secondary Index (SI) (CV 50 Value)		
		0	1	2 255
Primary Index (PI) (CV 49 Value)		Forward/Reverse only	Neutral only	N/A
1	Output 1	Directional Headlight (96)*	Directional Headlight (96)*	
2	Output 2	Directional Reverse Light (97)*	Directional Reverse Light (97)*	
3	Output 3	Bell (3)*	Bell (3)*	
4	Output 4	Whistle/Horn (1)*	Whistle/Horn (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 (13)	
9	Output 9	Squealing Brakes + Air Brakes (216)	Long Air Let-off (9)	
10	Output 10	Mute 64)	Mute (64)	
11	Output 11	Cruise Control ** (177)	Disconnect/Standby/ Shut Down (145)	
12	Output 12	Status Report ** (178)	Status Report **(178)	
13	Output 13	Number Board Lights ** (105)*	Number Board Lights **(105)*	
14	Output 14	Directional Cab Lights ** (101)*	Directional Cab Lights ** (101)*	

* These output designations are pre-assigned by QSI to the features indicated and cannot be changed.

** These features may not be included with your model locomotive. Also check you locomotive instruction manual to determine if special features have been assigned to some Outputs.

Note: If no feature is assigned to some Outputs on your locomotive, a Short Air Let-off (10) is usually used as a placeholder. In other words, Outputs that have no standard or special features will activate a Short Air Let-off sound when their assigned Function Keys are pressed.

5.7 CV 55.PI QSI Feature Configuration

Use CV 55 to specify behavior of Quantum features. Use CV 49 to select the QSI feature ID number.

5.7 CV 55.110.5: Ditch Light Strobe Hold Time

This CV specifies the number of seconds the ditch lights remains strobing after a horn blast ends.

Default Value: **5**

CV 55.110.5 Ditch Light Strobe Time

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved for future use	Reserved for future use	Reserved for future use	**D4**	**D3**	**D2**	**D1**	**D0**

- Set CV 55 to the number of seconds you want the Ditch Light Strobe to continue after the horn command is stopped. Range is from 0 to 31 seconds. Default is 5 seconds (00000101 binary, 05 hex).
- Setting the Ditch Light Strobe Hold time will apply to both Analog and DCC operation.

5.8 CV 56.PI QSI Configuration

Use CV 56 to specify Quantum Configuration settings. Use CV 49 to select among the configuration bytes.

5.8.2 CV 56.4: QSI Throttle Mode (PI = 4)

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**

- Use this configuration byte to control Quantum Engine behavior.
- Set data in Bits 0 and 1as follows:

  "0" = Standard Throttle Control.
  "1" = Speed Control.
  "2" = Regulated Throttle Control.

Standard Throttle Control (STC) is the common way to control the power delivered to the model locomotive's motor. Under STC, the "power" to the motor is controlled by the throttle setting (speed step) as specified in a speed table. Under throttle control, 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, under throttle control, the speed of the locomotive will vary from changes in track voltage, due to power pack resistance, track resistance, inconsistent or intermittent pickups and changes in motor load current.

Speed Control (SC) uses internal motor control electronics to maintain the same speed regardless of varying load or track voltage conditions. Under speed control, the throttle setting (in 128 speed step mode) sets the engines speed in scale miles per hour equal to the throttle setting[111]. Default resolution is in 1-smph increments. If your throttle is set at 35, the engine will go 35 smph (scale miles per hour) . At 14 or 28 speed steps, you will need to multiple your throttle settings by 9 and 4.5 respectively to determine the locomotive speed.

Under Speed control, CV 2 (V-Start), CV 25 (speed tables), Forward Trim CV 66, Reverse Trim 95, and User Defined Speed Tables CV 67 – CV 94, have no meaning and are ignored.

Note: Although some prototype engines can achieve 128 miles per hour, most were not designed for these speeds. Hence, increasing the speed setting above the fastest speed obtainable by the model will have no effect. In addition, if your command station cannot supply sufficient voltage for your engine to reach its highest speed value, high speed settings will not produce the indicated speed.

Although Speed Control is a big improvement over Standard Throttle Control, it can cause problems when engines are in Consists or used as mid train helps or pushers. The problem occurs because engines can be slightly mismatched in speed. An engine that wants to go 36 mph wants to pull the engine that is going 35 mph up to speed and will continue to apply more power to do so. The engine going 35 mph wants to slow the engine going 36 mph and continues to reduce power to do. This can cause a huge mismatch in engine power. Under these conditions, something must give which usually means that wheels will slip. If traction is good for all locomotives, the motor power can be very high for some locomotives in the Consist while others are barely working.

111 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 = 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.

Regulated Throttle Control (RTC) combines the best of both Standard Throttle Control and Speed Control. The engine still uses speed control circuitry to maintain the engine's speed but the speed is allowed to increase or decrease slowly in response to loading. Under RTC, if the engine encounters a grade, it does not stop immediately but instead decreases speed slowly in response to the extra loading. If an engine 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. The speed step command in RTC is a requested power setting just like Standard Throttle Control except that the engine acts like it weights thousands of pounds in response to changing speed.

This is not the same as inertia settings where the engine throttle settings vary slowly over time. Under Inertia[112] settings with Standard Throttle Control, the model locomotive would still stop suddenly if it encountered an obstacle since there is no speed control circuitry to maintain its motion.

RTC provides an advantage when operating Consists. Now if engines are slightly mismatched in speed and feel unequal loading, they respond to equalize the loading. Within a very short time, all engines are working together.

RTC uses all CV's pertaining to throttle, including V-Start, V-High, and all QSI pre-programmed speed curves and user definable speed curves.

- All other bits are reserved. The values of these bits are ignored.
- Default is "1", Speed Control.

Example: Select Regulated Throttle Control
1. Write 4 to CV 49.
2. Write 2 to CV 56.

5.8.3 CV 56.10: Speed Step to Scale MPH Scale Factor (PI = 10)

Default Value: **64**

CV 56.10: Speed Step to Scale MPH 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 with **Speed Control** to change the amount that smph speed changes as a function of speed steps. The value of this byte is interpreted as N/64, which means N = 64 is equivalent to a Scale Factor of 1.0. Some examples of Speed Control with different scale factors 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 when you want a more useful throttle range for an engine under Speed Control. This Scale Factor will have no effect if the engine is under Throttle Control or Regulated Throttle Control.

[112] Refer to CV 3, CV 4, CV 23 and CV 24 for Inertia Settings.

You can also use the Scale Factor to increase the accuracy of its speed. If your engine actual scale miles per hour are running a little under the speed step settings, you can change the scale factor to slightly increase all speeds. This is also useful when trying to match engines in Consists when all are operating under speed control.

A Scale Factor less than 1.0 is useful when the top speed of the engine is much less than 126 smph. For example, suppose an engine 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 is useful when the top speed of the engine is much greater than 126 smph. For example, suppose an engine has a top speed of 200 smph. With a Scale Factor of 1.0 the engine 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" for command stations with an LCD display is to easily know the engine's speed. If you do not have a visual readout, it is best to set the Scale Factor to provide the best throttle range.

5.8.3 CV 56.12: Chuff Interval Scale Factor[113] (PI = 12)

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 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 value of this byte is interpreted as N/32, which means N = 32 is equivalent to a Scale Factor of 1.0.

Some examples of chuff rate with 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 change 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 change the scale factor to 33 (1.03) to slightly decrease the number of chuffs per revolution.

Note: We recommend that you set your chuff rate at some speed value greater than 2 smph.

[113] Available on all version 6 software which includes all Atlas, Life Like and BLI PRR K4 and C&O Texas and all following models.

5.8.4 CV 56.128: Reset to Factory Default (PI = 128)

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
0	**0**	**0**	**0**	**0**	**0**	**0**	**D0**

- Use this configuration byte to reset CV's to factory default values.
- Use the Secondary Index to select a range of CV's. 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 Control
56	Reset CV 56, QSI Configuration
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 3 whistle hoots 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. If this happens, reset CV's in separate groups or use Ops Mode Programming.

Example: Reset Quantum to original factory defaults (i.e. Reset all CV's)

1. Set CV 49 to 128.
2. Set CV 50 to 255.
3. Set CV 56 to 113.

Example: Reset the Individual Sound Volumes to factory defaults

1. Set CV 49 to 128.
2. CV 50 to 52.
3. Set CV 56 to 113.

5.8.5 CV 56.129: Engine ID Access (PI = 129)

Default Value: **N/A**

CV 56.129: Engine 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 engine's ID on the main, and programming on the programming track is impossible due to insufficient power from your command station.
- This index 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, and bit 5 of CV 19 is cleared to 0, making the engine's ID the data byte just written, 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. If programming acknowledgement is enabled, you will hear "CV 56 point 129 point 17" but will not hear the value entered. The data byte must be in the range of 0xC0 to 0xE7.

When CV 56.129.18 is written, the data byte is written to CV 18, making the engine'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 programming acknowledgement is enabled, you will hear "CV 17 equals <long address>".

When programming the Extended Address, you must set CV 56.129.17 before you set CV 56.129.18.

See the CV17and 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 Hex[114] 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 address (see CV 29).

Example: Set your engine'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".
4. Set CV 29 to 2 decimal (00000010, 0x02) for Primary Address Enable and 28/128 Speed Step.

Your engine's short ID is now 23 and ready to operate.

Step-by-Step procedure for entering your long in CV 56.129 in Ops Mode.

114 Hex and Binary numbers are not shown in the following examples. If you require Hex or Binary, use the conversion table in Appendix V.

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 CV17 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 engine'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 engine's Long ID is now 3985 and ready to operate.

Example 2: Set your engine'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 engine's Long ID is now 5344 and ready to operate.

5.8.6 CV 56.254[115]: About Quantum Decoder (PI = 254)

Use this CV in Service Mode to read back information about your Quantum Decoder. 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 a VERIFY_BYTE or VERIFY_BIT operation.
- To select which byte of information to retrieve, write data to CV 50 as follows:

  "4" = Retrieve Product Model High Byte.
  "5" = Retrieve Product Model Low Byte.
  "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).

- The Firmware 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. Store the returned value in H.
4. Write 5 to CV 50.
5. Read back CV 56. Store the returned value in L.
6. The Product Model = (H * 256) + L.

5.8.7 CV 56.255: Play Build Information (PI = 255)

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
0	**0**	**0**	**0**	**0**	**0**	**D1**	**D0**

- Information from this CV is delivered as audio verbal output and is restricted to Operations Mode.
- Write data to CV 56 as follows:

115 This CV is not in BLI Hudson software ho300a02.

"0" = Play Product Identifier: you will hear the Product Identification number (e.g. "300" or "400"). This identifies the type of engine and the sounds programmed into the software.
"1" = Play Version; you will hear two sets of numbers separated by the word "point". The first number set is the version number and the second is the build number (e.g. "one point five" means Version 1, Build 5).
"2" = Play Build Date This is the date the software was released. You will hear, three sets of numbers, each separated 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, 1, or 2 will be ignored and there will be no verbal output.

  Note: While the Build Information is playing, all incoming DCC packets are ignored.

Example: Play Version
7. Write 255 to CV 49.
8. Write 1 to CV 56.
9. Hear Version spoken out: for Version 1, Build 6, you would hear "one point six".

5.9 CV 62[116] QSI Control[117]

Use this CV to enable or disable Programming Verbal Acknowledgement.

Default Value: 1

CV 62: QSI Control Register

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	0	0	D0

- Write data to CV 62 as follows:

  "0" = Disable Programming Verbal Acknowledgement

  "1" = Enable Programming Verbal Acknowledgement

Example: To Disable Programming Verbal Acknowledgement
1. Set CV#62 to 0.

Note: Unlike Analog Operation, we do not have a separate and fixed Program Volume since there is no verbal reporting from the Programming Track. Verbal reporting is available during Ops Mode Programming. The overall System Volume sets the volume for these verbal responses. If you cannot hear your Ops Mode verbal responses, you will need to turn up the System Volume during programming.

Note: If you cannot hear verbal responses during Ops Mode programming, check to see if you have activated the Mute feature.

116 This CV does not exist in version ho300a02 (Hudson Steam). For that version use CV#56.0 System Configuration.
117 Write bit operation is supported for CV 62.

5.10 CV 64 CV Numeric Verbal Readout (Verbal CV Inquiry)

Use this CV to hear the value of any CV spoken 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**

5.10.1 Standard NMRA CV's

- Write the number of any standard NMRA CV to CV 64.

Note: While the Verbal Readout is playing, all incoming DCC packets are ignored.

Example: Hear the current setting for CV 2 V-Start.

1. Write 2 to CV 64.
2. Hear the value spoken out: if the value of CV 2 were "32", you would hear "CV two equals three two".

- Writing either 17 or 18 to CV 64 will produce a verbal response indicating the full value of the Extended Address.

5.10.2 QSI CV's

- 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.

Note: While the Verbal Readout is playing, all incoming DCC packets are ignored.

Example: Hear the current setting for the bell volume.

1. Write 8 to CV 49
2. Write 52 to CV 64
3. Hear the bell volume spoken out: if the bell volume were 13, you would hear "CV five two point eight equals one three".

Note: Unlike Analog Operation, we do not have a separate and fixed Program Volume since there is no verbal reporting from the Programming Track. Verbal reporting is available during Ops Mode Programming. The overall System Volume sets the volume for these verbal responses. If you cannot hear your Ops Mode verbal responses, you will need to turn up the System Volume during programming.

Note: If you cannot hear verbal responses during Ops Mode programming, check to see if you have activated the Mute feature.

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**

- 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 engines, and to match the engine'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 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

CV 67 – 94 allows the user to specify a speed table that is suitable for the operation his 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 is set to 1 and CV 25 bit 1 is set to 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