Scope
This section of the manual is designed to provide the advanced user with additional insight into the operation and capabilities of the LC Series of SoundTraxx Digital Sound Decoders. By necessity, it is somewhat technical in nature and assumes a working knowledge of the NMRA DCC Standards and RPs as well as a familiarity with binary and hexadecimal number systems.

The novice user should not be dissuaded from studying this section as it will help add to his knowledge of DCC technology and enable him to take greater advantage of its capabilities.

Copies of the NMRA DCC Standards and Recommended Practices may be obtained by contacting:

Technical Department
NMRA Headquarters
4121 Cromwell Road
Chattanooga, TN 37421 USA
Phone: (615) 892-2846

As always, our Technical Support staff will be happy to answer any specific questions you may have regarding the SoundTraxx DSD-LC.

Applicable Standards
The SoundTraxx DSD-LC has been designed to meet the requirements of the following NMRA Standards and RPs as defined by July, 1999:

Standard S-9.1	DCC Electrical Standard
Standard S-9.2	DCC Communication Standard
RP-9.1.1	Electrical Interface and Wire Color Code
RP-9.2.1	DCC Extended Packet Format
RP-9.2.2	DCC Configuration Variable
RP-9.2.3	DCC Service Mode
RP-9.2.4	DCC Fail-Safe Operating Characteristics

Bit Timing
The DSD uses a quartz crystal timing reference and will recognize DCC packet bits that fall within the following timing constraints:

"1" Bit, 52µS to 64µS
"0" Bit, 90µS to 12000µS

Packets containing bits that fall outside of this range will be rejected.

Addressing Modes
The DSD recognizes the following address modes and ranges as defined by RP-9.2.1:

Broadcast Address 00
Decoder Addresses 01-127
Consist Addresses 01-127
Extended Addresses 0xC000 - 0xE7FF

Packets contain addresses outside of these ranges will be ignored.

Command Instructions
The DSD will process valid packets containing the following instruction codes as defined by RP-9.2.1:

000 Decoder and Consist Control
All currently defined forms of this instruction are processed except 00000110b, Set Advanced Acknowledgment. This instruction is ignored.

001 Advanced Operation Instructions
The DSD will process only the 128 Speed Step Control form (00111111b) of this instruction. All other sub-instructions will be ignored.

010 Reverse Speed and Direction Instruction
The DSD will process all forms of this instruction.

011 Forward Speed and Direction Instruction
The DSD will process all forms of this instruction.

100 Function Group One
The DSD will process all forms of this instruction.

101 Function Group two
The DSD will process all forms of this instruction.

110 Reserved Instruction
The DSD will process all forms of this instruction.

111 Configuration Variable Access
The DSD will parse both the short form and long form of this instruction.

Only short form instructions formatted as 11110010b (CV 23 access) or 11110011b (CV 24 access) will be processed. All other short form instruction will be ignored.

All long form instructions will be processed. However, attempts to write to the following CVs in operations mode will be ignored:

CV 1	Primary Address
CV 7	Mfg. Version ID

Write operations to other CVs may be ignored if an attempt is made to write illegal values. See individual CV descriptions for details on illegal values.

The DSD will send a basic acknowledgment upon successfully processing an operations mode CV access instruction provided the locomotive is stopped. Otherwise, no acknowledgment is sent.

Programming Modes
The DSD supports all six programming modes defined in RP-9.2.1 and RP-9.2.3:

Address Mode
Register Mode
Paged Mode
Direct Mode
Ops Mode Long Form
Ops Mode Short Form

Not all CVs can be programmed using all modes. Table A lists all CVs supported by the DSD, their applicable programming mode address as well as the factory default values.

When entering service mode, the DSD will turn off all auxiliary functions and sounds to reduce its current draw to as low a level as possible.

If the DSD receives an instruction packet to read or write a CV not listed in Table A, the instruction packet will be ignored and no acknowledgment will be generated.

Upon completion of a paged mode operation, the DSD will reset the page register to 01.

The address query instruction is *not* supported by the DSD.

Miscellaneous Operating Notes
Consist operation is enabled whenever the consist address (CV 19, bits 0:6) is loaded with a non-zero value. Per the NMRA standard, when the consist address is enabled, the DSD will no longer parse speed/direction packets sent to its primary address. Additionally, the DSD will ignore long form CV access instructions sent to its consist address. Because the DSD instruction parser assigns a higher priority to the consist address, this can cause unexpected behavior under certain conditions:

When the DSD is set up for 14 speed step mode with the consist address active, the DSD outputs will no longer respond to FL function commands sent to the primary address. This may be remedied by using a different speed step mode or enabling FL consist functions (see CV 22).

If the consist address is set to the same value as the primary address, the DSD will no longer process long form operations mode CV access instructions sent to the primary address. As a result, the user will be required to use service mode CV access instructions to clear the consist address. If the extended address is enabled (see CV 29), this will not be a problem.

Analog Mode Operation
The DSD does *not* support Analog Mode operation and will remain inoperative when placed on a conventional DC track.

CVs Support
The following table lists all CVs used by the DSD. Details regarding each CV can be found on subsequent pages.

Table A. ***CVs Used by the LC Series Digital Sound Decoder***

CV#	Name	Default Value	*Program Mode Address* Direct Mode	Register Mode	Paged Mode Page:Register (Note 1)
1	Primary Address	3	01	0	1:0
2	Vstart	7	02	1	1:1
3	Acceleration Rate	0	03	2	1:2
4	Braking Rate	0	04	3	1:3
7	Version ID	Varies	07	6	2:3
8	Manufacturer ID	141	08	7	3:0
9	Motor PWM Period	180	09		3:1
11	Time Out Period	0	11		3:3
17	Extended Address MSB	192	17		5:1
18	Extended Address LSB	3	18		5:2
19	Consist Address	0	19		5:3
21	Consist Func. Active	0	21		6:1
22	Consist FL Active	0	22		6:2
23	Consist Acceleration	0	23		6:3
24	Consist Deceleration	0	24		7:0
25	Speed Table Select	0	25		7:1
29	Configuration Data #1	2	29	4	8:1
30	Error Information	0	30		8:2
33	F0(f) Output Location	1	33		9:1

CV#	Name	Default Value	*Program Mode Address* Direct Mode	Register Mode	Paged Mode Page:Register (Note 1)
34	F0(r) Output Location	2	34		9:2
35	F1 Output Location	8	35		9:3
36	F2 Output Location	4	36		10:0
37	F3 Output Location	0	37		10:1
38	F4 Output Location	8	38		10:2
39	F5 Output Location	2	39		10:3
40	F6 Output Location	4	40		11:0
41	F7 Output Location	16	41		11:1
42	F8 Output Location	32	42		11:2
49	HL Hyperlight Select	1	49		13:1
50	BL Hyperlight Select	1	50		13:2
51	FX1 Hyperlight Select	1	51		13:3
52	FX2 Hyperlight Select	1	52		14:0
59	Flash Rate/Hold Time	66	55		15:3
66	Forward Trim	128	66		17:2
67	Speed Step 1	9	67		17:3
68	Speed Step 2	18	68		18:0
69	Speed Step 3	27	69		18:1
70	Speed Step 4	36	70		18:2
71	Speed Step 5	45	71		18:3
72	Speed Step 6	55	72		19:0
73	Speed Step 7	64	73		19:1
74	Speed Step 8	73	74		19:2
75	Speed Step 9	82	75		19:3
76	Speed Step 10	91	76		20:0
77	Speed Step 11	100	77		20:1
78	Speed Step 12	109	78		20:2
79	Speed Step 13	118	79		20:3
80	Speed Step 14	127	80		21:0
81	Speed Step 15	137	81		21:1
82	Speed Step 16	146	82		21:2
83	Speed Step 17	155	83		21:3
84	Speed Step 18	164	84		22:0
85	Speed Step 19	173	85		22:1
86	Speed Step 20	182	86		22:2
87	Speed Step 21	191	87		22:3
88	Speed Step 22	200	88		23:0
89	Speed Step 23	209	89		23:1
90	Speed Step 24	219	90		23:2
91	Speed Step 25	228	91		23:3
92	Speed Step 26	237	92		24:0
93	Speed Step 27	246	93		24:1
94	Speed Step 28	255	94		24:2
95	Reverse Trim	128	95		24:3
105	User Identifier #1	0	105		27:1

CV#	Name	Default Value	*Program Mode Address* Direct Mode	Register Mode	Paged Mode Page:Register (Note 1)
106	User Identifier#2	0	106		27:2
112	Sound Config. 1	1	112		29:0
113	Sound Config. 2	2	113		29:1
114	Sound Config. 3	4	114		29:2
115	Sound Config. 4	1	115		29:3
116	Sound Config. 5	Varies	116		30:0
120	Whistle/Horn Volume	192	120		31:0
121	Bell Volume	128	121		31:1
122	Exhaust Volume	128	122		31:2
123	Background Volume	128	123		31:3

Note1: Paged mode address is shown as PP:RR where PP is the page number and RR is the data register 0-3.

CV 1
PRIMARY ADDRESS CONTROL

■ Address Mode	■ Direct Mode
■ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	❒ Ops Mode Long Form

Description
Contains the decoder's primary address between 1 and 127:

bit 7 bit 0

0	**A6**	**A5**	**A4**	**A3**	**A2**	**A1**	**A0**

Bit 0-6: A0-A6, Decoder Address
Bit 7: Not used. Must be set to 0!

The decoder will process all valid instruction packets containing an address that matches the value contained in this register when CV 29, bit 5 is set to 0.

Programming this register with a new value will automatically clear the Consist Address (CV 19) to 0 and clear the Extended Address Enable bit in CV 29 (bit 5).

The decoder will ignore commands that attempt to program this register with values outside the range of 1 to 127.

Note that this CV cannot be changed in operations mode.

Default Value: 03

Related CVs: See also CV 29, Consist Address, Extended Address

CV 2
VSTART

❒ Address Mode	■ Direct Mode
■ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Vstart defines the initial voltage level applied to the motor at speed step 1 as a fraction of available supply voltage:

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: Motor Start Voltage

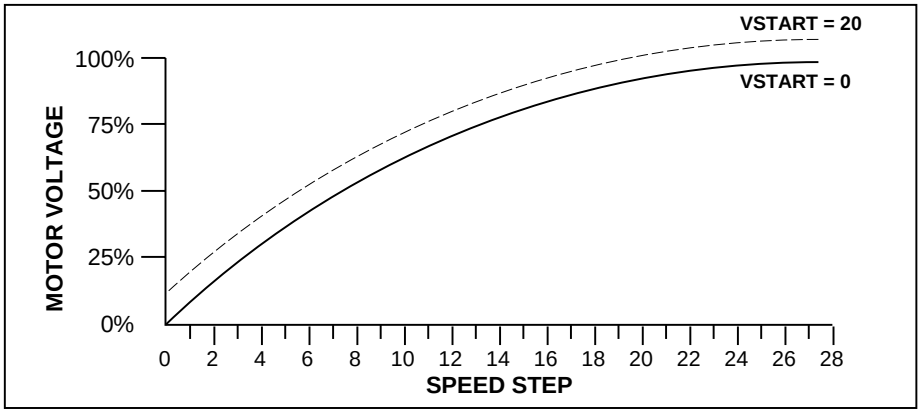
Vstart may contain any value from 0 to 255 (0 - 0xFF).

The starting voltage applied to the motor may be computed as:

$$\textbf{Starting Voltage} = \textbf{Supply Voltage} \times \frac{\textbf{CV2}}{\textbf{255}}$$

where CV 2 is the contents of the Vstart register. A value of 0 corresponds to a zero starting voltage and 255 corresponds to the maximum available voltage.

For speed steps greater than 1, the DSD will continue to sum the initial starting voltage level into the throttle computations which has the effect of offsetting all points on a given speed curve by the level set by Vstart as illustrated in the figure below.



Default value: 07

CV 3
BASELINE ACCELERATION RATE

❒	Address Mode	■	Direct Mode
■	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Contains a value between 0 and 255 (0 - 0xFF) that sets the decoder's acceleration rate:

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: Baseline Acceleration Rate

Acceleration rate may be computed as:

$$\textbf{seconds/speed step} = \frac{\textbf{CV 3} * 0.896}{\textbf{Number of Speed Steps}}$$

When this CV is set to 0, the locomotive speed will respond nearly instantly to *increases* in the throttle setting. When set to 255, it will take approximately 3.8 minutes to accelerate to full speed from a standing stop.

It is recommended that this CV be set to a nonzero value when operating the DSD in 14 or 28 speed step modes as the throttle will interpolate between speed steps during acceleration to produce a smoother overall response. The Dynamic Digital Exhaust sound effect will also be more prevalent with higher acceleration settings.

Default value: 0

Related CVs: See also Baseline Braking Rate, Consist Acceleration Rate, Consist Brake Rate.

CV 4
BASELINE
BRAKING RATE

❒ Address Mode	■ Direct Mode
■ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Contains a value between 0 and 255 (0 - 0xFF) that sets the decoder's braking rate:

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: Baseline Braking Rate

Braking rate may be computed as:

$$\textbf{seconds/speed step} = \frac{\textbf{CV 4 * 0.896}}{\textbf{Number of Speed Steps}}$$

When this CV is set to 0, the locomotive speed will respond nearly instantly to *decreases* in the throttle setting. When set to 255, it will take approximately 3.8 minutes to brake to a stop from full speed.

It is recommended that this CV be set to a nonzero value when operating the DSD in 14 or 28 speed step modes as the throttle will interpolate between speed steps during braking to produce a smoother overall response. The Dynamic Digital Exhaust sound effect will also be more prevalent with higher braking rates.

Default value: 0

Related CVs: See also Baseline Acceleration, Consist Acceleration Rate, Consist Brake Rate.

CV 7
MANUFACTURER VERSION ID (Read Only)

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Contains 8 bit software version identifier.

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: Version Code

32 = DSD-100LC Steam, V2.0
33 = DSD-B280LC, DSD-B3TSLC, V2.0
34 = DSD-100LC Diesel, V2.0
35 = DSD-AT100LC, DSD-LL110LC, DSD-KT100LC, V2.0
36 = DSD-LL100LC, V2.0
37 = DSD-C628LC, V2.0

This CV is read only and cannot be modified.

CV 8
MANUFACTURER ID

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Contains the NMRA issued Manufacturer ID code assignment (141) for SoundTraxx/Throttle Up!:

bit 7 bit 0

1	0	0	0	1	1	0	1

Writing a value of 8 to this CV will reset all CVs to their default value. All other write operations will be ignored.

CV 9
PWM PERIOD

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Determines the PWM period of the motor drive signals:

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: PWM Period

The motor PWM period in milliseconds is computed as:

Period = (255 - CV9) * 0.2408

This CV may be programmed with any value between 0 and 230 corresponding to a PWM period range of 52.2mS to 5.12mS. The motor drive frequency can be found by taking the reciprocal of the period. The drive frequency can thus be programmed from 19.1 Hz to 195 Hz.

The decoder will ignore commands that attempt to program this register with values greater than 230.

The correct value for this register will vary depending upon the locomotive the DSD is installed in and it may take some experimentation to find the optimal value. Generally, the selected value will require a trade-off decision between motor torque and audible noise. Lower numbers will produce more torque but may cause the motor and driveline to resonate and buzz loudly. On smaller engines that lack traction, sufficient torque can be produced to cause the drive wheels to slip. Higher numbers, on the other hand, will tend to reduce the buzzing noise but there may be some loss in power, especially at low speeds. The following values are provided as a guide line to help establish a starting point for determining the best PWM period value:

Scale	CV9 Value
N, HOn3	180-200
HO, S	175-185
O	160-175
G	120-160

Note: CV 9 also affects the modulation period of the Hyperlight effects. When using the Hyperlight effects, it is recommended that CV 9 be programmed with values greater than 155 as an annoying flicker may otherwise result.

Default Value: 180, Corresponds to 65Hz drive frequency.

CV 11
PACKET TIME OUT VALUE

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Contains a value between 0 and 255 corresponding to the time period that is allowed to elapse between receipt of a valid packet addressed to the DSD before a throttle shutdown occurs.

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: Packet Time-out Value

The time out period is computed in seconds as:

Time Out Period = CV11 X 10

A CV value of 0 disables the time out period and the locomotive will run indefinitely without receiving another packet.

For all other values, the DSD maintains an internal timer which is reset every time the DSD receives a valid broadcast address packet or other valid packet whose address matches its primary address or, if enabled, the extended address or consist address.

In the event no valid packets are received within the prescribed time period, the DSD will bring the locomotive to a stop at the rate set by CV 4 and CV 24. The state of the auxiliary function outputs will remain unchanged.

Default value: 00

CV 17,18 EXTENDED ADDRESS

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
CV 17 and 18 make up a 'paired' CV, meaning that the two CV registers taken together hold one piece of data, in this case, the 14 bit extended decoder address:

CV 17 Extended Address MSB

bit 7 bit 0

A15	A14	A13	A12	A11	A10	A09	A08

CV 18 Extended Address LSB

bit 7 bit 0

A7	A6	A5	A4	A3	A2	A1	A0

A0-A15: Extended Address Value

The extended address allows the decoder to be assigned one of 10,179 addresses ranging from 0xC000 to 0xE7FF (Note however, that most command stations will only recognize addresses 0000 through 9999.). The extended address will only be recognized by the decoder when CV 29, bit 5 is set to 1. Once this bit is set, the decoder will no longer recognize its primary address until CV 29, bit 5 is cleared.

CV 17 contains the most significant byte and must be loaded with values within the range of 0xC0 and 0xE7. CV 18 contains the least significant byte and may contain any value.

To determine the extended address value, add the desired four digit address to the number 49152. Divide this number by 256 and record the quotient and the remainder. CV 17 is then programmed with the quotient value and CV 18 is programmed with the remainder value.

Example: Compute CV 17 and 18 register values for extended address 7152.

1. Add 7152 to 49152: Sum = 56304.
2. Divide 56304 by 256: Quotient = 219 Remainder = 240
3. Program CV 17 to 219 (0xDB)
4. Program CV 18 to 240 (0xF0)

Note: Most command stations will handle these computations automatically when setting the extended address. However, it's still nice to know how to derive them.

Because CV 17 and 18 make up a paired CV, programming order is important. CV 17 must be written to first, followed by a write to CV 18. The decoder will ignore commands that attempt to program these register out of order or with values outside the allowed range of 0xC000 to 0xE7FF These CVs may be changed in operations mode only when CV 29, bit 5 is cleared (i.e., CV 1, Primary Address is enabled).

Default Value: 0xC000 (Long Address 0003)
Related CVs: See also Primary Address, CV 29, Consist Address.

CV 19
CONSIST ADDRESS

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Contains address and direction data for consist operation:

bit 7 bit 0

CDIR	A6	A5	A4	A3	A2	A1	A0

Bit 0-6: A0-A6, Consist Address Value
Bit 7: CDIR, Consist Direction
0 = Normal Direction
1 = Reverse Direction

The CDIR bit defines orientation of the locomotive within a consist and specifies whether the direction bit in a speed/direction data packet should be inverted.

Bits A0-A6 assigns the consist address from 0 to 127 (0-0x7F).

If A0-A6 = 00, consist commands are ignored. Otherwise, if the decoder receives a valid command packet whose address matches the consist address, the packet will be processed as any other packet with the following exceptions:

Long Form CV Access instructions will be ignored.

The direction bit in a speed/direction or advanced operation packet is inverted if CDIR = 1.

Only the auxiliary functions enabled in CV 21 and CV 22 are allowed to change.

When the consist address is active, speed/direction and advanced operations packets sent to the decoder's primary address (or extended address, if enabled) will be ignored. All other instruction packets sent to the decoder's primary (or extended) address including CV access and function control will continue to be processed as normal.

In summary, setting CV 19 to 00 or 128 (0x80) disables consist addressing. Setting CV to a value between 1 and 127 (0x01-0x7F) enables consist addresses 1 to 127 (0x01-0x7F) with the locomotive oriented facing *forward* in the consist. Setting CV to a value between 129 and 255 (0x81-0xFF) enables consist addresses 1 to 127 with the locomotive oriented facing *backwards* in the consist.

Default Value: 00
Related CVs: See also Primary Address, Consist Function Active, Consist FL Function Active.

CV 21
CONSIST FUNCTION ACTIVE

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Defines which functions may be controlled by packets sent to the decoder's consist address. Disabled functions may be controlled only from decoder's primary or extended address:

bit 7 bit 0

F8	F7	F6	F5	F4	F3	F2	F1

Bit 0: F1, Consist Function 1 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 1: F2, Consist Function 2 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 2: F3, Consist Function 3 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 3: F4, Consist Function 4 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 4: F5, Consist Function 5 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 5: F6, Consist Function 6 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 6: F7, Consist Function 7 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 7: F8, Consist Function 8 Enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

This register is useful for differentiating the lead engine in the consist from the other engines. For example, by setting this register in the lead locomotive to 02 and the same register in all other engines to 00, only the whistle on the lead locomotive will blow when the command to turn on Function 2 is sent to the consist.

Default Value: 00
Related CVs: See also Consist Address, Consist FL Function Active.

CV 22
CONSIST F0
FUNCTION ACTIVE

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Defines whether the F0 function may be controlled by packets sent to the decoder's consist address. Disabled functions may be controlled only from decoder's primary or extended address:

bit 7 bit 0

0	0	0	0	0	0	F0(r)	F0(f)

Bit 0: F0(f), F0 Forward enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

Bit 1: F0(r), F0 Reverse enable Bit
0 = function is disabled for consist operation.
1 = function is enabled for consist operation.

This register is useful for differentiating the Headlight and Backup Light functions in the lead engine of the consist from the other engines. For example, by setting this register in the lead locomotive to 01 and the same register in all other engines to 00, only the headlight in the lead engine will be on and only when the consist is moving forward.

Default Value: 00

Related CVs: See also Consist Address, Consist Function Active.

CV 23
CONSIST
ACCELERATION RATE

❒	Address Mode	■	Direct Mode
❒	Register Mode	■	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Contains a value between -127 to +127 corresponding to the decoder's consist acceleration offset:

bit 7 bit 0

sign	D6	D5	D4	D3	D2	D1	D0

Bits 0-6: D0-D6, Consist Acceleration value
Bit 7: Sign
0 = positive value
1 = negative value

When the consist address is active, the consist acceleration rate is added to or subtracted from the decoder's base acceleration rate depending on the sign bit. The acceleration is then computed as:

$$\textbf{seconds/speed step} = \frac{\textbf{(CV3 + CV 23) * 0.896}}{\textbf{Number of Speed Steps}}$$

If the sum of CV 3 and CV 23 is negative, then the acceleration rate is set to 0 (i.e., acceleration is instant.) If the sum of CV 3 and CV 23 exceeds 255, then the acceleration rate is set to the maximum value of 255.

This CV has no effect when the consist address is set to 0.

In summary, a CV value between 0 and 127 (0x7F) will *increase* the decoder's base acceleration rate. Values between 128 (0x80) and 255 (0xFF) will *decrease* the decoder's base acceleration rate.

Default value: 0

Related CVs: See also Baseline Acceleration Rate, Baseline Braking Rate, Consist Brake Rate.

CV 24
CONSIST
BRAKING RATE

❒ Address Mode	■ Direct Mode
❒ Register Mode	■ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Contains a value between -127 to +127 corresponding to the decoder's consist braking offset:

bit 7 bit 0

sign	D6	D5	D4	D3	D2	D1	D0

Bits 0-6: D0-D6, Consist Braking value
Bit 7: Sign
0 = positive value
1 = negative value

When the consist address is active, the consist braking rate is added to or subtracted from the decoder's baseline braking rate depending on the sign bit. The braking rate is then computed as:

$$\textbf{seconds/speed step} = \frac{\textbf{(CV4 + CV 24) * 0.896}}{\textbf{Number of Speed Steps}}$$

If the sum of CV 4 and CV 24 is negative, then the braking rate is set to 0 (i.e., braking is instant.) If the sum of CV 3 and CV 23 exceeds 255, then the braking rate is set to the maximum value of 255.

This CV has no effect when the consist address is set to 0.

In summary, a CV value between 0 and 127 (0x7F) will *increase* the decoder's base braking rate. Values between 128 (0x80) and 255 (0xFF) will *decrease* the decoder's base braking rate.

Default value: 0
Related CVs: See also Baseline Acceleration Rate, Baseline Braking Rate, Consist Acceleration Rate.

CV 25
SPEED TABLE
SELECT REGISTER

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Used to select one of 15 Speed Curves:

bit 7 bit 0

MRSS	0	0	USER	TBL3	TBL2	TBL1	TBL0

Bits 3-0: TBL3:TBL0, Preset Speed Curves Select Bits

0000	=	Speed Curves not used
0001	=	Speed Curves not used
0010	=	Linear Speed Curve
0011	=	Logarithmic Curve 1
0100	=	Logarithmic Curve 2
0101	=	Logarithmic Curve 3
0110	=	Logarithmic Curve 4
0111	=	Logarithmic Curve 5
1000	=	Logarithmic Curve 6
1001	=	Logarithmic Curve 7
1010	=	Exponential Curve 1
1011	=	Exponential Curve 2
1100	=	Exponential Curve 3
1101	=	Exponential Curve 4
1110	=	Exponential Curve 5
1111	=	Exponential Curve 6

Bit 4: USER, User Loadable Speed Table Select

0	=	Enable Speed curve defined by TBL3:TBL0
1	=	Enable Speed curve defined by CVs 67-94.

Bits 5-6: Not Used. These bits are ignored.

Bit 7: Mid Range Speed Step
This bit is not implemented and always reads as 0.

CV 25 may be programmed with any value between 0 and 31 (0x1F). Values between 02 and 15 (0x0F) allow the user to select from one of 14 predefined speed curves as depicted below. The logarithmic curves provide a shallower speed response as the throttle is increased. These curves are useful for locomotives that require a high starting voltage to get moving or matching a highly geared locomotive to one that has less gearing. The exponential curves are useful for slowing down locomotives that have a “slot car” response.

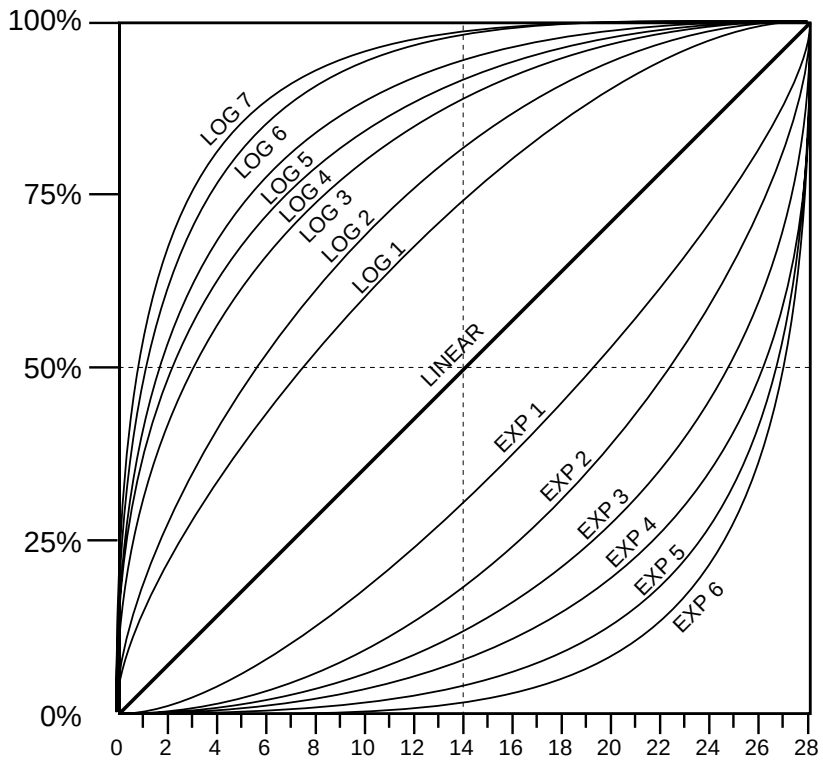
Setting this CV to a value between 16 and 31 (0x10-0x1F) will enable the speed curve programmed into CVs 67-94. This curve may modified by the user to get virtually any response desired.

Note that in order for the selected curve to be active, bit 4 of CV 29 must also be set to 1. If CV 29, bit 4 is 0, the throttle response will be linear (straight line).

The speed curves can be used in 14, 28 and 128 speed step modes.

Bit 7 is defined by the NMRA RPs as the Mid Range Speed Step select bit. The DSD does not implement this feature and will ignore commands that attempt to program this bit with a 1 (i.e.,

data values between 128-255 or 0x80-0xFF).



Default value: 0
Related CVs: See also CV 29, Loadable Speed Table.

CV 29 CONFIGURATION REGISTER 1

❒ Address Mode	■ Direct Mode
■ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
CV 29 contains miscellaneous decoder configuration bits:

bit 7 bit 0

0	0	EAM	STE	ACK	APS	FL	DIR

Bit 0: DIR, Direction Bit
0 = normal operation
1 = direction bit in Speed/Direction instruction is inverted before processing.

Bit 1: F0, F0 Location
0 = F0 state is controlled by bit 4 of Speed/Direction Instruction (14 Speed Step Mode)
1 = F0 state is controlled by bit 4 of Function Group 1 Instruction (28 and 128 Speed Step Modes)

Bit 2: APS, Alternate Power Source enable (not used)
0 = NMRA Digital Only
1 = Alternate Power Source enabled as set by CV 12

Bit 3: ACK, Advanced Acknowledge Mode enable (not used)
0 = Advanced Acknowledge mode disabled.
1 = Advanced Acknowledge mode enabled.

Bit 4: STE, Speed Table Enable
0 = Speed Table not used.
1 = Use custom speed table selected by CV 25.

Bit 5: EAM, Extended Address Mode enable
0 = Decoder responds to Primary Address in CV 1
1 = Decoder responds to Extended Address in CV 17-18

Bit 6: Reserved for future use.

Bit 7: Multifunction Decoder - Always reads as 0.

When the DIR bit is set, the locomotive and headlight will run in a direction opposite to the speed/direction instruction received. This bit is mostly useful for diesel locomotives that are run long hood forward and has little use for steam operation.

The F0 bit should be cleared to 0 if you are using the decoder in 14 speed step mode. If you are using 28 or 128 speed step modes, this bit should be set to 1.

The STE bit must be set to 1 in order to enable any of the speed curves selected using CV 25. Otherwise, the DSD will provide a linear (straight-line) throttle response.

The EAM bit must be set to 1 in order to activate extended address capability. Note that once this bit is set, the decoder will respond to commands sent to the extended address only and commands sent to the primary address will be ignored. This can be a problem if you are using a

command station that does not support extended addressing and the bit gets accidentally set. In such a case, you must connect the DSD to a programming track to gain access to the CV and clear the bit.

The DSD does not support advanced acknowledgment or alternate power conversion and the ACK and APS bits will always read as 0.

Default value: 2
Related CVs: See also Extended Address, Loadable Speed Table.

CV 30
ERROR INFORMATION

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Contains manufacturer defined error codes and provides feedback in the event an operational failure occurred within the DSD. It is also used to re-configure the decoder for non-NMRA compliant options:

bit 7 bit 0

I2C	ROMCS	WDOG	0	MAP2	GRP3	EEROM	CVEXT

Bit 0: CVEXT, CV Address Extension
0 = System normal.
1 = CVs 112-128 are accessed using CV addresses 49-65. CVs 49-65 cannot be accessed when this bit is set.

Bit 1: EEROM, EEROM Data Corrupted
0 = System normal.
1 = CV Data in EEROM has become corrupted. All CVs will be reset to default values.

Bit 2: GRP3, Function Group 3 Disable
0 = System Normal
1 = DSD ignores Group 3 steerage bit (Function Group 2 Instruction, bit 4) for operation with early Digitrax Chiefs and Zimo MX-1 Command Stations.

Bit 3: MAP2, Alternate Function Map Select
0 = NMRA-defined Function Map
1 = SoundTraxx-defined Function Map

Bit 4: Reserved.

Bit 5: WDOG, Watch Dog Timer Reset
0 = System normal.
1 = Watchdog time-out occurred.

Bit 6: ROMCS, Program Checksum Failure
0 = System Normal
1 = Program Checksum Test Failed

Bit 7: I2C, I2C Bus Acknowledge Failure
0 = System Normal
1 = No acknowledge detected from I2C bus.

If the DSD is operating properly, all error bits should read as 0. If an error is detected, it is usually a good idea to reset the decoder (tip the locomotive) and verify the error has recurred.

A WDOG error usually occurs when the DSD experiences a large electrical glitch or static electricity discharge. It is not cause for concern unless it occurs frequently (several times within an operating session) in which case you should contact the factory for further assistance.

An EEROM error indicates that the CV data somehow became corrupted. If such an event occurs,

the DSD will reset all CV data to the default settings, flash both headlights for 30 seconds, and resume normal operation. If this occurs, reprogram the CVs as needed. If the problem recurs repeatedly, this could indicate a problem with the DSD. Contact the factory for further assistance. This bit can also be used to deliberately reset all other CV values to their default values with a single operation. This is done by programming CV 30 with 02 in service or operations mode and turning power to the DSD off and back on.

A ROMCS error indicates a hardware failure has occurred and will usually be accompanied by strange sounding noises. Contact the factory for further assistance.

An I2C error also indicates a hardware failure and the DSD will be unable to remember any changes made to the CV settings. Contact the factory for further assistance.

When CVEXT=1, CVs 112 to 128 may be programmed as if they were CVs 49 through 65. The data in CV49-65 will be temporarily replaced by data in CV 112-128. The original data in CV 49-66 remains unchanged and can be restored. This is useful when trying to set sound CVs with command stations than cannot access CVs above 99.

When MAP2=1, the DSD uses an alternate function map which allows more commonly used outputs to map over a larger range of function keys. See page 27.

CV 33-42
FUNCTION OUTPUT MAP

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

General Discussion
CVs 33-42 allow the user to customize which DSD outputs or sound effects are controlled by which function keys. Each function input, F0 through F8, is assigned a unique CV that allows the corresponding function control to be redirected to up to eight different DSD function outputs or sound effects. This allows a single function key to control more than one output if desired.

This feature is especially useful when the DSD is used with a controller that has less than eight function keys as the user can select which DSD outputs and sounds are important and re-map them to the available function keys. Some outputs or sounds can be sensibly tied to another output thus freeing up a function. For example, the dynamo sound could be configured to turn on whenever the headlight or backup light was on.

It is also possible to control a given output with more than one function key. In this case, the output will be turned on when any of the corresponding function inputs are active. The output will turn off only when all relevant inputs have also been turned off.

The F0 function has two CVs - one for forward direction and one for reverse. Function outputs mapped to these registers will be directional unless the same output is mapped to both CVs.

Note that all function inputs cannot be mapped to all outputs. The matrix below graphically indicates which inputs can control which outputs:

DSD-LC Function Mapping

Function Key	Control CV	Headlight	Backup Light	Whistle/Airhorn	Bell	FX1	FX2	Dynaimic Brake (Diesel Only)	Reserved	RPMs (+) (Diesel Only)	RPMs (-) (Diesel Only)	Dimmer	Mute
F0 (f)	33	**1**	2	4	8	16	32	64	128				
F0 (r)	34	1	**2**	4	8	16	32	64	128				
F1	35	1	2	4	**8**	16	32	64	128				
F2	36	1	2	**4**	8	16	32	64	128				
F3	37				1	2	4	8	16	32	64	128	
F4	38				1	2	4	**8**	16	32	64	128	
F5	39				1	**2**	4	8	16	32	64	128	
F6	40				1	2	**4**	8	16	32	64	128	
F7	41							1	2	4	8	**16**	32
F8	42							1	2	4	8	16	**32**

To use map, 1) Find the column that corresponds to the effect output that you wish to control. 2) Locate the row which corresponds to the function key you wish to use. 3) Note the number located in the box at the intersection of the row and column you have selected. 4) Program the CV listed next to the function key with the value found in step 3.

*Note: Numbers in **BOLD** = default setting.*

ALTERNATE FUNCTION MAP

When CV 30, bit 3 is set to 1, the DSD uses an alternate function map which allows the more commonly used outputs to map over a larger range of function keys. The utility of the function keys F3, F7 and F8 is greatly improved. This function mapping is especially recommended for use with 12-function cabs.

DSD-LC Alternate Function Mapping

Function Key	Control CV	Headlight	Backup Light	Whistle/Airhorn	Bell	FX1	FX2	Dynaimic Brake (Diesel Only)	Reserved	RPMs (+) (Diesel Only)	RPMs (-) (Diesel Only)	Dimmer	Mute
F0 (f)	33	1	2	4	8	16	32	64	128				
F0 (r)	34	1	2	4	8	16	32	64	128				
F1	35	1	2	4	8	16	32	64	128				
F2	36	1	2	4	8	16	32	64	128				
F3	37	1	2	4	1	2	4	8	16				
F4	38				1	2	4	8	16	32	64	128	
F5	39				1	2	4	8	16	32	64	128	
F6	40				1	2	4	8	16	32	64	128	
F7	41				1	2	4	1	2	32	64	128	32
F8	42				1	2	4	1	2	4	8	16	32

Note that when the alternate map is enabled, CVs 33-42 will continue to hold data from the original function map and must be reprogrammed individually to get the desired response.

CV 33
F0(f) OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F0(fwd) function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

		FX2	FX1	BEL	WH	BL	HL

Diesel:

bit 7 bit 0

	DB	FX2	FX1	BEL	WH	BL	HL

Bit 0: HL, Head light output
0 = Output is unaffected by F0(fwd).
1 = Output is activated when F0(fwd) is on.

Bit 1: BL, Backup light output
0 = Output is unaffected by F0(fwd).
1 = Output is activated when F0(fwd) is on.

Bit 2: WH, Whistle/Horn Sound Effect
0 = Sound is unaffected by F0(fwd).
1 = Sound is activated when F0(fwd) is on.

Bit 3: BEL, Bell Sound Effect
0 = Sound is unaffected by F0(fwd).
1 = Sound is activated when F0(fwd) is on.

Bit 4: FX1, Effect 1 output
0 = Output is unaffected by F0(fwd).
1 = Output is activated when F0(fwd) is on.

Bit 5: FX2, Effect 2 output
0 = Output is unaffected by F0(fwd).
1 = Output is activated when F0(fwd) is on.

Bit 6: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F0(fwd).
1 = Sound is activated when F0(fwd) is on.

Bit 7: Reserved.

Default Value: 1
Related CVs: See also CVs 34-42.

CV 34
F0(r) OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F0(rev) function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

		FX2	FX1	BEL	WH	BL	HL

Diesel:

bit 7 bit 0

	DB	FX2	FX1	BEL	WH	BL	HL

Bit 0: HL, Head light output
0 = Output is unaffected by F0(rev).
1 = Output is activated when F0(rev) is on.

Bit 1: BL, Backup light output
0 = Output is unaffected by F0(rev).
1 = Output is activated when F0(rev) is on.

Bit 2: WH, Whistle/Horn Sound Effect
0 = Sound is unaffected by F0(rev).
1 = Sound is activated when F0(rev) is on.

Bit 3: BEL, Bell Sound Effect
0 = Sound is unaffected by F0(rev).
1 = Sound is activated when F0(rev) is on.

Bit 4: FX1, Effect 1 output
0 = Output is unaffected by F0(rev).
1 = Output is activated when F0(rev) is on.

Bit 5: FX2, Effect 2 output
0 = Output is unaffected by F0(rev).
1 = Output is activated when F0(rev) is on.

Bit 6: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F0(rev).
1 = Sound is activated when F0(rev) is on.

Bit 7: Reserved.

Default Value: 2
Related CVs: See also CVs 33, 35-42.

CV 35
F1 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F1 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

		FX2	FX1	BEL	WH	BL	HL

Diesel:

bit 7 bit 0

	DB	FX2	FX1	BEL	WH	BL	HL

Bit 0: HL, Head light output
0 = Output is unaffected by F1.
1 = Output is activated when F1 is on.

Bit 1: BL, Backup light output
0 = Output is unaffected by F1.
1 = Output is activated when F1 is on.

Bit 2: WH, Whistle/Horn Sound Effect
0 = Sound is unaffected by F1.
1 = Sound is activated when F1 is on.

Bit 3: BEL, Bell Sound Effect
0 = Sound is unaffected by F1.
1 = Sound is activated when F1 is on.

Bit 4: FX1, Effect 1 output
0 = Output is unaffected by F1.
1 = Output is activated when F1 is on.

Bit 5: FX2, Effect 2 output
0 = Output is unaffected by F1.
1 = Output is activated when F1 is on.

Bit 6: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F1.
1 = Sound is activated when F1 is on.

Bit 7: Reserved.

Default Value: 8
Related CVs: See also CVs 33-34, 36-42.

CV 36
F2 OUTPUT LOCATION

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Maps the F2 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

		FX2	FX1	BEL	WH	BL	HL

Diesel:

bit 7 bit 0

	DB	FX2	FX1	BEL	WH	BL	HL

Bit 0: HL, Head light output
0 = Output is unaffected by F2.
1 = Output is activated when F2 is on.

Bit 1: BL, Backup light output
0 = Output is unaffected by F2.
1 = Output is activated when F2 is on.

Bit 2: WH, Whistle/Horn Sound Effect
0 = Sound is unaffected by F2.
1 = Sound is activated when F2 is on.

Bit 3: BEL, Bell Sound Effect
0 = Sound is unaffected by F2.
1 = Sound is activated when F2 is on.

Bit 4: FX1, Effect 1 output
0 = Output is unaffected by F2.
1 = Output is activated when F2 is on.

Bit 5: FX2, Effect 2 output
0 = Output is unaffected by F2.
1 = Output is activated when F2 is on.

Bit 6: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F2.
1 = Sound is activated when F2 is on.

Bit 7: Reserved.

Default Value: 4
Related CVs: See also CVs 33-35, 37-42.

CV 37
F3 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F3 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7							bit 0
DIM					FX2	FX1	BEL

Diesel:

bit 7							bit 0
DIM	EX+	EX-		DB	FX2	FX1	BEL

Bit 0: BEL, Bell Sound Effect
0 = Sound is unaffected by F3.
1 = Sound is activated when F3 is on.

Bit 1: FX1, Effect 1 output
0 = Output is unaffected by F3.
1 = Output is activated when F3 is on.

Bit 2: FX2, Effect 2 output
0 = Output is unaffected by F3.
1 = Output is activated when F3 is on.

Bit 3: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F3.
1 = Sound is activated when F3 is on.

Bit 4: Reserved.

Bit 5: EX+, Engine Exhaust Notch Up
0 = Sound is unaffected by F3.
1 = RPMs are advanced one notch when F3 is on.

Bit 6: EX-, Engine Exhaust Notch Down
0 = Sound is unaffected by F3.
1 = RPMs are reduced one notch when F3 is on.

Bit 7: DIM, Headlight Dimmer Function
0 = Lighting outputs are unaffected by F3.
1 = Lighting outputs set up as "Dimmable Headlights" are dimmed when F3 is on.

Default Value: 0
Related CVs: See also CVs 33-37, 37-42.

CV 38
F4 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F4 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

DIM					FX2	FX1	BEL

Diesel:

bit 7 bit 0

DIM	EX+	EX-		DB	FX2	FX1	BEL

Bit 0: BEL, Bell Sound Effect
0 = Sound is unaffected by F4.
1 = Sound is activated when F4 is on.

Bit 1: FX1, Effect 1 output
0 = Output is unaffected by F4.
1 = Output is activated when F4 is on.

Bit 2: FX2, Effect 2 output
0 = Output is unaffected by F4.
1 = Output is activated when F4 is on.

Bit 3: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F4.
1 = Sound is activated when F4 is on.

Bit 4: Reserved.

Bit 5: EX+, Engine Exhaust Notch Up
0 = Sound is unaffected by F4.
1 = RPMs are advanced one notch when F4 is on.

Bit 6: EX-, Engine Exhaust Notch Down
0 = Sound is unaffected by F4.
1 = RPMs are reduced one notch when F4 is on.

Bit 7: DIM, Headlight Dimmer Function
0 = Lighting outputs are unaffected by F4.
1 = Lighting outputs set up as "Dimmable Headlights" are dimmed when F4 is on.

Default Value: 8
Related CVs: See also CVs 33-37, 39-42.

CV 39
F5 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F5 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

DIM					FX2	FX1	BEL

Diesel:

bit 7 bit 0

DIM	EX+	EX-		DB	FX2	FX1	BEL

Bit 0: BEL, Bell Sound Effect
0 = Sound is unaffected by F5.
1 = Sound is activated when F5 is on.

Bit 1: FX1, Effect 1 output
0 = Output is unaffected by F5.
1 = Output is activated when F5 is on.

Bit 2: FX2, Effect 2 output
0 = Output is unaffected by F5.
1 = Output is activated when F5 is on.

Bit 3: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F5.
1 = Sound is activated when F5 is on.

Bit 4: Reserved.

Bit 5: EX+, Engine Exhaust Notch Up
0 = Sound is unaffected by F5.
1 = RPMs are advanced one notch when F5 is on.

Bit 6: EX-, Engine Exhaust Notch Down
0 = Sound is unaffected by F5.
1 = RPMs are reduced one notch when F5 is on.

Bit 7: DIM, Headlight Dimmer Function
0 = Lighting outputs are unaffected by F5.
1 = Lighting outputs set up as "Dimmable Headlights" are dimmed when F5 is on.

Default Value: 2
Related CVs: See also CVs 33-38, 40-42.

CV 40
F6 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F6 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

DIM					FX2	FX1	BEL

Diesel:

bit 7 bit 0

DIM	EX+	EX-		DB	FX2	FX1	BEL

Bit 0: BEL, Bell Sound Effect
0 = Sound is unaffected by F6.
1 = Sound is activated when F6 is on.

Bit 1: FX1, Effect 1 output
0 = Output is unaffected by F6.
1 = Output is activated when F6 is on.

Bit 2: FX2, Effect 2 output
0 = Output is unaffected by F6.
1 = Output is activated when F6 is on.

Bit 3: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F6.
1 = Sound is activated when F6 is on.

Bit 4: Reserved.

Bit 5: EX+, Engine Exhaust Notch Up
0 = Sound is unaffected by F6.
1 = RPMs are advanced one notch when F6 is on.

Bit 6: EX-, Engine Exhaust Notch Down
0 = Sound is unaffected by F6.
1 = RPMs are reduced one notch when F6 is on.

Bit 7: DIM, Headlight Dimmer Function
0 = Lighting outputs are unaffected by F6.
1 = Lighting outputs set up as "Dimmable Headlights" are dimmed when F6 is on.

Default Value: 4
Related CVs: See also CVs 33-39, 41-42.

CV 41
F7 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F7 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

		MUT	DIM				

Diesel:

bit 7 bit 0

		MUT	DIM	EX+	EX-		DB

Bit 0: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F7.
1 = Sound is activated when F7 is on.

Bit 1: Reserved.

Bit 2: EX-, Engine Exhaust Notch Down
0 = Sound is unaffected by F7.
1 = RPMs are reduced one notch when F7 is on.

Bit 3: EX+, Engine Exhaust Notch Up
0 = Sound is unaffected by F7.
1 = RPMs are advanced one notch when F7 is on.

Bit 4: DIM, Headlight Dimmer Function
0 = Lighting outputs are unaffected by F7.
1 = Lighting outputs set up as "Dimmable Headlights" are dimmed when F7 is on.

Bit 5: MUT, Audio Mute
0 = Sound is unaffected by F7.
1 = Sound is muted when F7 is on.

Bit 6: Reserved.

Bit 7: Reserved.

Default Value: 16
Related CVs: See also CVs 33-40, 42.

CV 42
F8 OUTPUT LOCATION

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Maps the F8 function to any of eight DSD auxiliary function outputs as defined by a 1 in the corresponding bit position:

Steam:

bit 7 bit 0

		MUT	DIM				

Diesel:

bit 7 bit 0

		MUT	DIM	EX+	EX-		DB

Bit 0: DB, Dynamic Brake Sound Effect
0 = Sound is unaffected by F8.
1 = Sound is activated when F8 is on.

Bit 1: Reserved.

Bit 2: EX-, Engine Exhaust Notch Down
0 = Sound is unaffected by F8.
1 = RPMs are reduced one notch when F8 is on.

Bit 3: EX+, Engine Exhaust Notch Up
0 = Sound is unaffected by F8.
1 = RPMs are advanced one notch when F8 is on.

Bit 4: DIM, Headlight Dimmer Function
0 = Lighting outputs are unaffected by F8.
1 = Lighting outputs set up as "Dimmable Headlights" are dimmed when F8 is on.

Bit 5: MUT, Audio Mute
0 = Sound is unaffected by F8.
1 = Sound is muted when F8 is on.

Bit 6: Reserved.

Bit 7: Reserved.

Default Value: 32
Related CVs: See also CVs 33-41.

CV 49-52
HYPERLIGHT
EFFECT SELECT

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Used to set the Hyperlight lighting effect and control mode for their respective output:

CV 49, Headlight Effect Select
CV 50, Backup Light Effect Select
CV 51, FX1 Effect Select
CV 52, FX2 Effect Select

NOTE: CVs 51 and 52 are not implemented in all models.

bit 7 bit 0

	R17	XING	PHSE	EF3	EF2	EF1	EF0

Bit 0-3: EF[3..0] Effect Type Select
0000 = On/Off output
0001 = Rule 17 Dimmable headlight
0010 = Mars Light
0011 = Pyle Gyralite
0100 = Oscillating Headlight
0101 = Single Flash Strobe
0110 = Double Flash Strobe
0111 = Western Cullen D312 Rotary Beacon
1000 = Prime Stratolite
1001 = Type I Ditch Light
1010 = Type II Ditch Light
1011 = FRED (End of Train flasher)
1100 = Engine Exhaust Flicker
1101 = Firebox Flicker
1110 = Smart Firebox Flicker
1111 = reserved

Most of the effects are self-descriptive. However a few need some additional notes:

Dimmable Headlight - The function output is normally an on/off output. If the output is on, the output level will be reduced about 60% whenever the dimmer function (Function 7) is on.

Type I and Type II Ditch lights. These are identical when operating. However, if the grade crossing logic is enabled, the Type I ditch light will revert to a steady on state when it is not flashing whereas the Type II lights will turn off.

Engine Exhaust - This effect produces a random flicker whose intensity is proportional to the engine RPMs. It is best used by placing a red/orange lamp under the model's exhaust port out of direct view. As the engine is revved up, it will glow brighter, imitating unmuffled exhaust gases and sparks.

Bit 4: Phase, Phase Select Bit
0 = Phase A
1 = Phase B

The Phase Select bit alters the timing of the effect so that it is 180 degrees out of

phase with the other effects. This allows you to have two light effects that blink back and forth if desired. Set one effect to phase A and the other to phase B.

Bit 5: XING, Grade Crossing Logic Enable
0 = Crossing Logic disabled
1 = Crossing Logic enabled when Horn function is on.

The Grade Crossing Logic bit causes the lighting effect to become active only when the horn has been sounded (and the corresponding lighting function key is also on). A typical use would be to cause the ditch lights to flash at a grade crossing. The grade crossing logic can be used with almost all the Hyperlight effects. The on/off, dimmable headlight, FRED, engine exhaust, and firebox flicker effects will not be affected. The other effects will either turn off (strobes and beacons) or revert to a steady on state (mars light, ditch lights, etc.) as appropriate to prototype practice.

Bit 6: Rule 17 Mode (CV 49 and 50 only)
0 = Rule 17 Mode disabled
1 = Rule 17 Mode enabled

Rule 17 Mode converts the headlight and backup light to independent, non-directional lights. When this mode is active, the headlight is controlled as if it were FX1 (Function 5) and the backup light as FX2 (Funciton 6).

Bit 7: Reserved.

Default Value: 1

Related CVs: See also CV 59.

CV 59
FLASH RATE AND CROSSING HOLD TIME

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
CV59 is used to adjust both the Hyperlight effect's flash rate and also the hold time for grade crossing logic.

bit 7 bit 0

HT3	HT2	HT1	HT0	FR3	FR2	FR1	FR0

Bit 0-3: FR0-3, Flash Rate Select
Sets the overall flash rate of the Hyperlight effects.
0000 = Maximum Flash Rate
:
1111 = Minimum Flash Rate

Bit 4-7: HT0-3, Hold Time Select
Sets the time an effect will stay on after the horn button is released (if it is set up to do so) and has a range of zero to 15 seconds.
0000 = Minimum Hold Time = 0
:
1111 = Maximum Hold Time = 15 Seconds

Default Value: 66

Related CVs: See also CVs 49-52.

CV 66
FORWARD TRIM

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
Contains a value, n, between 0 and 255 that specifies a scaling factor interpreted as n/128 by which the forward drive voltage is multiplied.

bit 7 bit 0

D7	D6	D5	D4	D3	D3	D1	D0

D0-D7: Forward Trim Scalar

The forward trim scalar allows the decoder's overall throttle response in the forward direction to be adjusted up or down for the purpose of matching one locomotive's speed curve to another. See graph below.

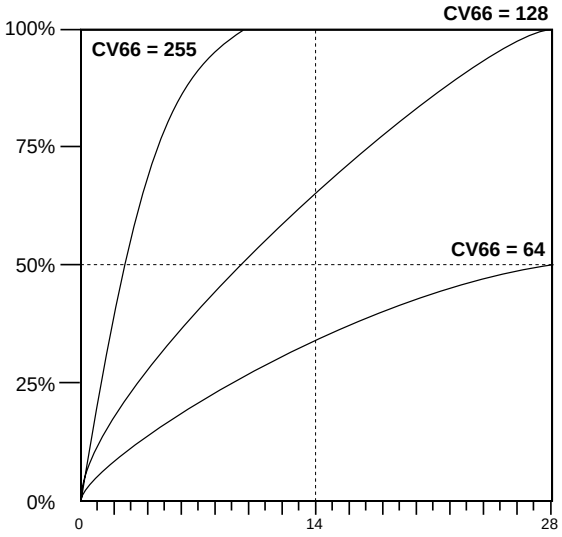
A trim value of 128 (0x80) yields a scaling factor of 1.0 which will have no net effect on the speed response.

Trim values between 129 and 255 (0x81-0xFF) have the effect of increasing the motor voltage by a factor ranging between 1.01 to 1.99.

Trim values between 1 and 127 (0x01-0x7F) will decrease the motor voltage by a factor between 0.008 and 0.99.

A trim value of 0 disables the trim scalar computation.

This CV is used only when speed tables are enabled (CV 29, Bit 4 = 1). Otherwise, this CV will have no effect.



Default Value: 128

Related CVs: See also Reverse Trim CV 95, CV 29, CV 25.

CV 67-94
LOADABLE SPEED TABLE

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
The loadable speed table is made up of 28 CVs. Each CV contains a value, n, between 0 and 255 that specifies the percentage of the maximum throttle voltage interpreted as n/255 that is to be applied to the motor when the speed step in use corresponds to that CV.

bit 7 bit 0

D7	D6	D5	D4	D3	D3	D1	D0

D0-D7: Speed Table Data

The loadable speed table may be used in the 14, 28 and 128 speed step modes. When 14 speed step mode is in effect, the DSD will use a curve defined by every other speed table value starting with speed step 1.

When 28 step mode is enabled, the DSD will simply use one table value for each speed step.

When 128 step mode is enabled, the DSD will interpolate 4-5 points between each speed table entry to build a 128 point curve.

Note that the DSD will not use the loadable speed table until bit 5 in *both* CV 25 and CV 29 are set to 1.

Default values: The default values provide a linear (straight line) response. Individual CVs are loaded as follows:

CV	Speed Step	Value
CV 67	(Speed Step 1):	9
CV 68	(Speed Step 2):	18
CV 69	(Speed Step 3):	27
CV 70	(Speed Step 4):	36
CV 71	(Speed Step 5):	45
CV 72	(Speed Step 6):	55
CV 73	(Speed Step 7):	64
CV 74	(Speed Step 8):	73
CV 75	(Speed Step 9):	82
CV 76	(Speed Step 10):	91
CV 77	(Speed Step 11):	100
CV 78	(Speed Step 12):	109
CV 79	(Speed Step 13):	118
CV 80	(Speed Step 14):	127
CV 81	(Speed Step 15):	137
CV 82	(Speed Step 16):	146
CV 83	(Speed Step 17):	155
CV 84	(Speed Step 18):	164
CV 85	(Speed Step 19):	173
CV 86	(Speed Step 20):	182
CV 87	(Speed Step 21):	191
CV 88	(Speed Step 22):	200

CV 89	(Speed Step 23):	209
CV 90	(Speed Step 24):	219
CV 91	(Speed Step 25):	228
CV 92	(Speed Step 26):	237
CV 93	(Speed Step 27):	246
CV 94	(Speed Step 28):	255

Related CVs: See also CV 25, CV 29.

CV 95
REVERSE TRIM

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Contains a value, n, between 0 and 255 that specifies a scaling factor interpreted as n/128 by which the reverse drive voltage is multiplied.

bit 7 bit 0

D7	D6	D5	D4	D3	D3	D1	D0

D0-D7: Reverse Trim Scalar

The reverse trim scalar allows the decoder's overall throttle response in the reverse direction to be adjusted up or down for the purpose of matching one locomotive's speed curve to another.

A trim value of 128 (0x80) yields a scaling factor of 1.0 which will have no net effect on the speed response.

Trim values between 129 and 255 (0x81-0xFF) have the effect of increasing the motor voltage by a factor ranging between 1.01 to 1.99.

Trim values between 1 and 127 (0x01-0x7F) will decrease the motor voltage by a factor between 0.008 and 0.99.

A trim value of 0 disables the trim scalar computation.

This CV is used only when speed tables are enabled (CV 29, Bit 4 = 1). Otherwise, this CV will have no effect.

Default Value: 128

Related CVs: See also Forward Trim CV 66, CV 25, CV 29.

CV 105
USER
IDENTIFIER #1

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Provides storage for user supplied data such as purchase date, serial numbers, spouse's birthday, etc. This CV otherwise has no effect on the DSD operation.

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: User Identifier data

This CV may be programmed with any value between 0 and 255.

NOTE: This CV is not implemented on all models.

Default Value: 0

Related CVs: See also User Identifier #2.

CV 106
USER
IDENTIFIER #2

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
Provides storage for user supplied data such as purchase date, serial numbers, spouse's birthday, etc. This CV otherwise has no effect on the DSD operation.

bit 7 bit 0

D7	D6	D5	D4	D3	D2	D1	D0

D0-D7: User Identifier data

This CV may be programmed with any value between 0 and 255.

NOTE: This CV is not implemented on all models.

Default Value: 0

Related CVs: See also User Identifier #1.

CV 112
SOUND CONFIGURATION BYTE 1
AUTO SOUND ENABLE

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
This CV is used to enable the DSD's automatic background sound effects. A 1 in the corresponding bit position enables the selected sound effect:

Steam:

bit 7 bit 0

AECS	0	0	0	0	0	0	AP1

Bit 0: AP1, Airpump Sound Enable
0 = Airpump sound disabled
1 = Airpump sound enabled

Bits 1-6: Reserved.

Bit 7: AECS, Articulated Exhaust Control
0 = Rod Engine Chuff
1 = Articulated Exhaust Chuff

Diesel:

bit 7 bit 0

Bits 0-7: Reserved.

Default Value: 1

CV 113
SOUND CONFIGURATION BYTE 2
CONTROL MODES

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
This CV is used to selectively enable the DSD's various background sound effects. A 1 in the corresponding bit position enables the selected sound effect:

bit 7 bit 0

0	0	0	0	0	0	DDE	Q

Bit 0: Q, Quiet Bit
0 = Sound turns on a few seconds after power is turned on.
1 = Sound turns on only when the DSD receives a packet with a matching address.

Bit 1: DDE, Dynamic Digital Exhaust Enable
0 = DDE sound processor is disabled.
1 = DDE sound processor is enabled.

Bits 2-7: Reserved.

Default Value: 2

CV 114
SOUND CONFIGURATION BYTE 3
BELL RING RATE

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
This CV is used to control the bell ringer speed:

bit 7 bit 0

0	0	0	0	BR3	BR2	BR1	BR0

Bit 0-3: BR0:BR3, Bell Ring Rate
Controls the ringing rate of the bell sound.
0000 = Fastest Ring Rate
:
1111 = Slowest Ring Rate

Bits 4-7: Reserved.

Default Value: 4

Related CVs: See Also Bell Volume Control, CV 121

CV 115
SOUND CONFIGURATION BYTE 4
WHISTLE/HORN SELECT

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
This CV is used to select a light, medium or heavy whistle (steam), or a single chime, three chime or five chime airhorn (diesel).

bit 7 bit 0

0	0	0	0	0	WH2	WH1	WH0

Bits 0-2: WH0:WH2, Whistle/Airhorn Selection
000 = Light/Single Chime
001 = Medium/Three Chime
010 = Heavy/Five Chime

Bits 3-7: Reserved.

Default Value: 0

CV 116
SOUND CONFIGURATION BYTE 5
EXHAUST CONTROL

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
This CV specifies the number of speed steps needed to advance the engine rpm notches, as well as selecting between manual or automatic engine notching:

Steam:

bit 7 bit 0

CAM	EX6	EX5	EX4	EX3	EX2	EX1	EX0

Bits 0-6: EX0:EX6, Auto Exhaust Rate
Controls the chuff rate of the steam exhaust.
0000000 = Slowest Chuff Rate
:
1111111 = Fastest Chuff Rate

For Auto-Exhaust synchronization, the chuff rate will be generated in proportion the throttle setting. The CV is loaded with any value between 0 and 127 (0x7F). Higher values will yield higher chuff rates for a given throttle setting. A value of 0 will disable the exhaust sound.

The correct synchronization rate may be computed as:

$$\textbf{CV Value} = 115.9 \times \frac{\textbf{SPD}}{\textbf{DIA}}$$

Where SPD is the locomotive's speed in scale miles-per-hour at maximum throttle and DIA is the locomotive's driver wheel diameter in scale inches. For geared engines, the CV value should also be multiplied by the locomotive's gear ratio.

Bit 7: CAM, Cam Enable (not available on all models)
0 = Auto Exhaust Enable
1 = Cam Synchronized Exhaust Enabled

Diesel:

bit 7 bit 0

			LOCK	AN3	AN2	AN1	AN0

Bits 0-3: AN0-3, Auto Notching Enable
0000 = Auto Notching Disabled
0001 = One Speed Step per Throttle Notch (for 128 speed step mode)
1111 = 15 Speed Steps per Throttle Notch (for 128 speed step mode)

These bits specify the percentage of throttle needed to advance or retard the engine exhaust sound one throttle 'notch'.

When auto notching is enabled, engine will start up when throttle is first increased. It will increase in proportion to the throttle speed. The engine RPMs may be shut off by

pressing emergency stop once.

When auto notching is disabled, the Engine RPMs+ (Function 3) and RPMs- Function 4) are used to manually increase/decrease the engine RPM sound.

Bit 4: LOCK = Engine RPM Interlock
0 = Interlock disabled
1 = Interlock enabled

This bit is used to interlock the engine RPMs and the throttle setting when manual notching is used such that:

1. Locomotive cannot be moved unless engine has been started.
2. Engine cannot be shut off unless throttle is zero.

Besides the fun of forcing the engineer to follow an operating protocol, this bit is also useful in preventing inadvertent engine shutoff while the train is moving.

Bits 5-7: Reserved.

Default Value: 0 (Steam), 7 (Diesel)

CV 120
WHISTLE/HORN
VOLUME CONTROL

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
This CV is used to set the volume level of the whistle or airhorn:

bit 7 bit 0

VOL7	VOL6	VOL5	VOL4	VOL3	VOL2	VOL1	VOL0

Bits 0-7: VOL0:VOL7, Whistle Volume Control
0 = Minimum volume
255 = Maximum volume

Default Value: 128 (50%)

CV 121
BELL
VOLUME CONTROL

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
This CV is used to set the volume level of the bell:

bit 7 bit 0

VOL7	VOL6	VOL5	VOL4	VOL3	VOL2	VOL1	VOL0

Bits 0-7: VOL0:VOL7, Bell Volume Control
0 = Minimum volume
255 = Maximum volume

Default Value: 128 (50%)

CV 122
EXHAUST
VOLUME CONTROL

❒ Address Mode	■ Direct Mode
❒ Register Mode	❒ Ops Mode Short Form
■ Paged Mode	■ Ops Mode Long Form

Description
This CV is used to set the volume level of the steam or diesel exhaust:

bit 7 bit 0

VOL7	VOL6	VOL5	VOL4	VOL3	VOL2	VOL1	VOL0

Bits 0-7: VOL0:VOL7, Exhaust Volume Control
0 = Minimum volume
255 = Maximum volume

Default Value: 128 (50%)

CV 123
BACKGROUND SOUND VOLUME CONTROL

❒	Address Mode	■	Direct Mode
❒	Register Mode	❒	Ops Mode Short Form
■	Paged Mode	■	Ops Mode Long Form

Description
This CV is used to set the volume level of the background sound effects such as the airpump (steam) and the dynamic brakes (diesel):

bit 7 bit 0

VOL7	VOL6	VOL5	VOL4	VOL3	VOL2	VOL1	VOL0

Bits 0-7: VOL0:VOL7, Background Sound Volume Control
0 = Minimum volume
255 = Maximum volume

Default Value: 128 (50%)

Revison A

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