SD40 Drop-In Configuration Variables List

This is the complete list of all CVs used in the SD40 Drop-In. The factory settings are what the SD40 Drop-In decoder has when it is new or reset.

Note: All CV settings are remembered without battery voltage

CV #	Factory Setting	Value Range	Description
CV1	3	0-99	1-99 Primary Address
CV2	9	0-255	Motor Starting Voltage MSV
CV3	2	0-255	Motor Acceleration Rate
CV4	2	0-255	Motor Deceleration Rate
CV5	255	0-255	Maximum Motor Voltage Vmax
CV6	128	0-255	Mid-point Motor Voltage Vmid
CV8	135	135	CVP Manufacturer ID [RESET]
CV11	0	0-255	Loss of Signal Timer (seconds)
CV17	0	0-255	Loco Address Hi-Byte
CV18	0	0-255	Loco Address Lo Byte
CV29	2	0-255	Decoder configuration
CV35	0	0-15	F1 Function Key Action
CV36	0	0-15	F2 Function Key Action
CV37	0	0-15	F3 Function Key Action
CV38	15	0-15	F4 Function Key Action
CV39	1	0-15	F5 Function [Activate Cruise Control]
CV40	0	0-15	F6 Function Key Action
CV41	0	0-15	F7 Function Key Action
CV42	0	0-15	F8 Function Key Action
CV43	4	0-15	F9 Function [Toggle AUX ELITE#2]
CV44	2	0-15	F10 Function [Smoke Toggle]
CV45	3	0-15	F11 Function [Toggle CAB ELITE#1]
CV46	0	0-15	F12 Function Key Action
CV47	3	1-15	ELITE Period (x512ms)
CV48	4	0-15	CAB ELITE#1 Special Effect
CV49	4	0-15	AUX ELITE#2 Special Effect
CV50	4	0-15	-
CV51	4	0-15	-
CV52	0	0-255	-
CV53	3	1-15	DLITE Flash Rate (x250ms)
CV54	0	0-1	DLITE Mode 0=on, 1=off
CV55	15	0-255	DLITE Flash TimeOut (seconds)
CV56	0	0-255	Bump Amount
CV57	0	0 - 127	Bump duration in us
CV58	0	0-16	RF Frequency number
CV59	3	1-15	Headlites Effect Period (x512ms)
CV60	0	0-15	Headlights Mode 0=normal/autorev
CV61	4	0-15	Headlight Front Effect
CV62	4	0-15	Headlight Rear Effect
CV63	0	0-1	Cruise Mode - 0 Norm, 1=Track
CV64	4	1-16	Cuise Track Rate (ms)
CV65	2	1-3	Cruise Track Step Size

CV Value	Function Key Action
0	No Function
1	Activate Cruise Control
2	Toggle Smoke Generator on/off
3	Toggle CAB ELITE #1 on/off
4	Toggle AUX ELITE #2 on/off
5	-
6	-
7	Dim Headlighs on/off
15	Ditch Lights Flash Trigger
8-14	reserved

CV Value	Special Lighting Effects
0	Off 0%
1	Dim 6%
2	Dim 25%
3	Dim 50%
4	On 100%
5	Strato Light
6	Oscillating Light
7	FRED
8	Rotary Dome light 1
9	Gyra Light
10	Mars Light
11	Rotary Dome Light 2
12	Strobe Single Pulse
13	Strobe Double Pulse
14	Reserved
15	Random flicker

CV Value	Cruise Control Mode
0	Normal (cruise off with change)
1	Tracking mode (Cruise stays on with change)

CV Value	Head/Rear Lites Action
0	Normal, autoreverse
1	Normal with rule17
2	Front headlight on always
3	Front headlight on always with rule17
4	Rear headlight on always
5	Rear headlight on always with rule17
6	Front and Rear both on always
7	Front and Rear both on always with rule17
8	Front/Back Reversed with Auto Reverse
9	Front/Back Reversed w/ Auto Reverse & rule 17
8-15	reserved

April 2014 r1

AirWire® 900

SD40 Drop-In™ Decoder Users Guide

Specifically For The USA-Trains SD40 Drop-In Decoder

Quick Find Index

This User Guide *only* applies to the USA-Trains SD40 Drop-In. For CVP's other Drop-In decoders, please see the generic "Drop-In Users Guide."

How To Use This Manual

This guide covers the new AirWire SD40 Drop-In Decoders. The original Drop-In User guide does not apply to the SD40 decoder. Also, this users guide does not discuss the SD40 Drop-In Decoder installation. The SD40 installation guide comes with each SD40 Drop-In board. If you have lost yours, a copy can be obtained from the CVP website in the AirWire Drop-In documentation section.

There are 4 sections in this book. We strongly recommend you page through this manual and note what is covered in each section. You may not need the information yet, but this book will help prevent confusion and answer questions regarding how to accomplish a specific effect or task.

Section 1: Decoder Basic Setup

This section describes all of the basic setup information including changing the decoder address, the decoder frequency and how the decoder responds to throttle function keys. This section concludes with how to reset the decoder back to the original factory settings.

Section 2: Motion Control Fine Tuning

This section has all of the details regarding the many ways in which you can customize the performance of your Drop-In decoder and locomotive. For example, with a few keystrokes on the throttle, the locomotive can be fine-tuned so that it will begin moving when the speed control is advanced to the first speed step. Perhaps you want to limit the top speed, or maybe change which throttle key controls a special feature. This section has all the details on these items plus many more.

Section 3: Special Lighting Effects

This section covers the use and setting of all the rich variety of lighting options that can be used with the USA-Trains locomotive. Details for how to use the optional AUX and Ditch/Safety light drivers are included along with where to get the special wiring kits.

Section 4: Reference Items

This section includes more detail about the P8 Sound Decoder setup as well as additional CVs not mentioned elsewhere. The back cover includes a complete list of all CVs.

Terminology and Funny Words

The next page discusses a few terms that may be new to you. Although you can skip this section, a few minutes of reading will be worth the time.

Need Help? Contact Your Dealer/Installer First!

Should you have any questions regarding AirWire or installations, your dealer is your best source of information, tips and techniques. Also, almost all dealers will do installations or can recommend good installers. It might take a little more time cost a bit more, but you'll be assured of an installation that works and works well.

A smart person reads instructions.
A genius follows instructions.

Addtional CVs Not Detailed Elsewhere

Decoder Address CV1
Range is 1-9999 . . . . . [3]

When SERVICE PROGRAM is used to set the decoder address, the throttle actually sends a group of commands to set CV1, CV17, CV18 and CV29. That is why you hear as many as 3 chirps when CV1 is set to the desired address from 1 to 9999. Do not use address 0, it is not supported.

Loss of Signal Timer (LOS) CV11
Range is 0-255 seconds . . . . . [0]

Failsafe Operation - If your locomotive goes out of range of the throttle or the throttle is no longer transmitting, you can set the locomotive to either continue running or stop after a preset amount of time. The timer range is 1 seconds to 255 seconds. A value of zero means the locomotive runs forever, or until the battery runs down.

If CV11 = 0 this selects continuous operation. In other words, the locomotive continues to operate at the last received speed command forever. The assumption is that it will eventually come back into range of the locomotive. Another reason to use continuous running is because you want to control several trains with a single throttle. Changing the throttle's address to control a new address means the original address is no longer being used. This is the same as turning the throttle off or going out of range. With the decoder set to operate continuously, the locomotive will continue to run at the last received speed command. To regain control, first set the speed knob and direction close to the locomotive's current speed and then select the new address.

If CV11 value is not equal to zero, then the locomotive will come to a smooth halt after the timer value counts down to zero.

Loco Address High Byte CV17
Range is 0-255 . . . . . [0]

Loco Address Low Byte CV18
Range is 0-255 . . . . . [0]

CV17 and CV18 are automatically set based on the setting of CV1 to the desired locomotive address. We do not recommend that manually changing these CVs. Use CV1 when programming the decoder address so they are set automatically.

Decoder Setup CV29
Range is 0-255 . . . . . [2]

CV29 is a multipurpose CV whose value sets several options at once. The SD40 Drop-In sets this CV automatically for you so there should be no need to change it. However, if you accidentally change it and the locomotive no longer runs, you can either reset it back to a value of 2 or use a factory reset to erase all changes and restore CV29 to is default value of 2.

Decoder Frequency Number CV58
Range is 0-16 . . . . . [0]

CV58 holds the assigned frequency number for the SD40 Drop-In decoder. If a number larger than 16 is attempted, the decoder rejects it and automatically sets itself to frequency 0. If you have forgotten the frequency, see page 8 for the procedure to temporarily force the SD40 Drop-In to a known frequency.

The list below shows the specfic P8's CVs that are shared with the SD40 Drop-In decoder. The P8 and the Drop-In use these CVs for different purposes. Turn off the P8 power switch when programming these Drop-In decoder CVs.

CV50 CV52 CV49 CV53

SD40 Drop-InDecoder and Phoenix P8 Operation Tips

P8 Setup Recommendations

- The throttle will directly program the Phoenix P8 address when you use SERVICE PROGRAM of CV1 for the SD40 Drop-In. Just make sure the sound power switch is turned on. Any further customization of the P8 must be done with the Phoenix software. .
- You must set the MTS mode to "disabled" so the DCC commands work correctly.
- Make sure all trigger pins are disabled since all commands come via the throttle.
- Save your configuration file under the locomotive number before disconnecting the computer interface.
- The table of throttle function key assignments to sound effects works well for most P8 installations. You must use the P8 computer interface to make these assignments. These are not programmable from the throttle.

P8 and SD40 Drop-In Shared CVs

The P8 shares some CV numbers with the SD40 Drop-In. These CVs are CV49 through CV53. If both power switches are turned on, sending programming commands, OPS or SERVICE, to one decoder will program both. Use the following procedure to avoid inadvertent changes.

First, program the the P8's CV numbers to their desired values. Then, turn off the sound power switch (to turn off the P8) and then program the CVs in the SD40 Drop-In.

Recommended P8 Effects Assignment Changes From Default

All P8 settings done with Computer Interface

P8 MTS mode	Disabled	Stopping horn volume	0
Shutoff Delay	0	Toot holdoff	0
DCC Timeout	0	Airpop	F11
DCC address	3	Compressor Trigger	F6
REVUP DCC	none	Dynamic Brake	F9
REVDWN DCC	none	Brake Release	F10
Bell	Manual	All Function buttons	Latched except F2
Bell Stop Speed	0	Peak Wattage	2W
Stopping Bell Duration	OFF	Compresson Pin	Auto
Startup bell duration	OFF	Brake Release Pin	Auto
Triggered bell duration	OFF	Wheel Squeel	not assigned
Autobell speed limit	OFF	Airpop Pin	Auto
Bell holdoff	0	Track Noise	100%
FWD horn volume	0	Detector Pin	none
REV horn volume	0		

Recommended P8 Function Key Assignments - All Done From The PC Interface To The P8

F1	Bell	Toggles Bell on/Off	Latched
F2	Horn	Push for horn, release to stop	Momentary
F3	Coupler clang	Push to trigger sound	Latched
F4	Grade Crossing	Push to trigger grade crossing horn	Latched
F5	Station Announce	Push to trigger sound	Latched
F6	Compressor	Push to trigger sound	Latched
F7	Volume Up	Push starts vol ramp up, push to stop ramp	Latched
F8	Volume Down	Push starts vol ramp down, push to stop ramp	Latched
F9	Dynamic Brake	Push to trigger sound	Latched
F10	Brake Release	Push to trigger sound	Latched
F11	Air Pop Valve	Push to trigger sound	Latched
F12	Shut down	Toggle Prime Mover Shutdown or startup	Latched

CVP Products does not provide customer support for the P8 sound module. Please contact Phoenix Sound Systems directly via email or phone.

(800) 651-2444 Email: phoenixsound@phoenixsound.com

Some Terms and Definitions

Throughout this section there will be some terms used with which you might not be familiar. This page lists a few of these and their definition.

"CV#" is the abbreviation for Configuration Variable Number: A CV number is a unique and specific memory location, designated by the "number" into which CV values are stored that control how the decoder operates the locomotive. Rather than spell out Configuration Variable Number 1, we shorten this to CV1. So anytime you see CV1, you will know this refers to the configuration variable number 1; and CV1 is what is programmed when you wish to change the locomotive address.

"CV Value" is the abbreviation for Configuration Variable Value:" A CV value is a number loaded into the specified memory location inside the decoder. This value controls or selects various decoder capabilities. In some cases, the value selects from a table of options such as lighting effects or which throttle key activates a locomotive function. CV values are retained inside the decoder even if the power is disconnected or another throttle is used. Thus the locomotive will operate exactly the same no matter which throttle is used. A complete listing of all CV numbers and values used in the SD40 Drop-In decoder are on the back cover.

Here is a typical listing of a Drop-In Decoder configuration variable. The first line lists the action of function controlled by the CV number which follows after the dots. The 2nd line immediately following the CV number provides the CV value range and the value in square braces is the original factory setting. Each CV description is in the same format. The example below shows that to change the locomotive address, CV1 is programmed and that the value range is 1 to 9999 and the original factory setting for the locomotive address is 3.

Changing the Locomotive Address CV1

Range is 1 to 9999 when using an AirWire throttle . . . . . [3]

Setting, Loading or Programming CVs: We use these words when discussing changing the operation of the Drop-In decoder. There is nothing difficult or hard to learn about programming CVs. In fact, you aren't really programming anything - you are simply sending the decoder a number to make it perform in a certain way. In simple terms, you are changing how the decoder works. CV values are sent to the Drop-In decoder using the AirWire900 throttle - nothing else is required.

Service Programming Mode [T5000 Throttle SVC PROGRAM] is a method of changing CV values within the decoder without regard to the decoders locomotive address. This is commonly used when resetting the decoder back to the original factory settings since you might not know or care what the present decoder address is. The one precaution is that any decoder that is powered up and on the same frequency will "hear" the programming commands and be changed.

OPS Programming Mode [T5000 Throttle OPS PROGRAM] is a method of changing CV values within the decoder that requires the correct address be used. This is the recommended method of programming since it affects only the decoder with the specified address. Other decoders, sharing the same frequency, will ignore the programming commands.

Speed Step is the phrase that describes a specific setting for the throttle's speed control. Although the throttle has 3 different speed step settings (14, 28 and 128), the most common setting is 28. This means that the throttle has 28 different speed steps from step-0 which is OFF, to step-28 which is full speed. Inside the decoder, each speed step is translated into a specific motor voltage. The decoder includes several selectable features with which you can modify how the decoder interprets the throttle speed step which in turn modifies the actual motor voltage.

Setting The Throttle To A New Frequency or Address...

Just changing the throttle will not change the decoder in any way! You must "program" the decoder's address and/or frequency CVs. Once programmed, the decoder will remember the programming forever or until you reprogram it again.

Quick-Start Guide - Changing The Address & Frequency

The "Quick Start" section assumes you have installed your new decoder and are ready to run your locomotive.

Step 1: Set the Decoder Address [T5000 Example. *For other models, see throttle manual*]

- Make sure the throttle is on the same frequency as the decoder. Assuming you have just finished installation, the SD40 decoder will be on frequency 0 and on the factory setting of address 3. If you have a P8 sound module connected, be sure it is powered on also. The P8 address will be changed at the same time as the Drop-In decoder's address.
- Select SVC PROGRAM mode on your throttle. Press menu twice and then push the number 4.
- Push 1 and push ENT to select CV1 for changing the address.
- Enter the decoder address that you want to use. The address must be unique. The cab number is always a good idea. Once you have entered the numbers, push ENT.
- The decoder chirps 2 times for an address from 1 to 99 or 3 times for an address from 100 to 9999, Address 0 is not allowed. If you accidentally use 0, start over and use the desired address. When you hear the chirps, the decoder has accepted the new address.
- Press ESC to exit the programming mode.

Step 2: Set the Desired Decoder Frequency If Frequency 0 Is Not Wanted

- Assuming you have just finished installation and you have not changed the frequency, the decoder is set for frequency 0. If you want to use a different frequency, follow these simple steps.
- Set your throttle to the new decoder address.
- Select OPS PROGRAM mode. On the T5000, push MENU once and then 0.
- Enter 58 followed by ENT. CV58 is where the desired frequency is stored in the decoder.
- Enter the frequency number and push ENT. The decoder chirps once to indicate receipt of the new frequency.
- Push ESC to exit OPS mode.

Step 4: Set the Throttle And Run!

- Set your throttle to the new decoder frequency.
- **Speed and direction** are controlled from the throttle. Use the throttle's knob to change speed. To change direction, push down on the speed knob. "Forward" direction is defined as if you were sitting in the locomotive cab.
- **Headlights, and marker lights** are toggled on and off with the throttle's 0 key. This is "Function 0" which we shorten to F0 The headlights automatically switch between front and rear when direction key is pushed.
- **The dome flasher, cab interior and number boards** are turned on and off with Function 11 or F11. To activate F11, first push the * key followed by the 1 key on the T5000 throttle.
- **The smoke generator** is turned on and off with F10. To activate F10, first push the * key followed by the 0 key on the T5000. Once turned on, the smoke generator has an automatic timeout. However, if the smoke fluid has run out, the locomotive's own smoke generator controller will turn off even if the decoder's timer has not run out.
- **Cruise control** activation is easy. Once the locomotive is running at the desired speed, push the 5 key on the throttle - abbreviated as F5 - to activate cruise control. A beep will be heard when cruise control is activated. To deactivate cruise control simply change the speed or direction. A beep will be heard when cruise control is deactivated. At very slow speeds, you may hear a double beep. This means that the locomotive is going too slow for reliable cruise control so you need to increase the speed slightly and push F5 again.

You can store the frequency and decoder address in the T5000 throttle memory by pushing the LOCO MEM key twice. This is not mandatory but does make it easier to recall the address and automatically set the proper frequency.

Hooking Up The Ditch Light Output

The Ditch/safety Light (DL) output is designed to drive cool and efficient white LEDs. The DL output is turned on with the headlight function - F0. The default function key assignment for DL activation is F4. However, you can change this at any time.

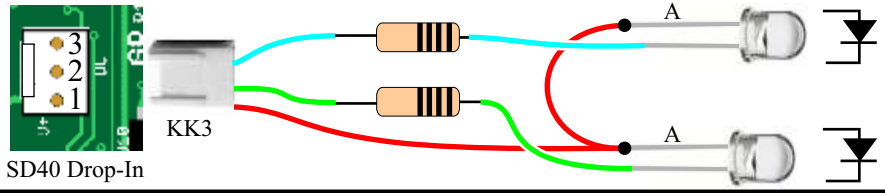
LEDs will look best for ditch lights. The driver signal makes the LED fade in and out just like the ditch lights on a prototypical locomotive. LEDs are also available in a variety of sizes so you can achieve the desired appearance and brightness.

Making Connections

The DL output requires the use of the optional KK3 wiring harness. It has the matching plug for the DL header as well as about 24 inches of wire. It can be ordered from your dealer or CVP Products. Order part number KK3.

Recommended Wiring

Pin 1 is connected to BAT + through the Decoder power switch. Pin 2 is the right ditch light driver output. Pin 3 is the left ditch light driver output. A limit resistor is required for each LED. When using the standard CVP 14.8V lithium battery, a 750 ohm resistor is recommended. Higher resistor values will diminish the brightness. Use quarter-watt resistors and place them in series with each LED.



Customizing Ditch/Crossing Lights Operation

The factory setting for the SD40 Drop-In Ditch/Safety lights will turn on both when the headlights are turned on. This can be changed with the Ditch Light Mode CV. The default activation throttle key is 4 or F4. Turn on the headlights and then pushing F4 initiates the ditch light flashing. When activated with F4, the ditch lights begin to alternately flash on and off. The flash rate is about a 3/4 second on followed by a 3/4 second off. This flashing continues for about 15 seconds. Any time when the ditch lights are flashing, pushing F4 resets the timer for another 15 seconds of flashing. Once the timer expires, the ditch lights return to it normal setting as set by the mode CV.

Turning off the headlight with F0 turns off the ditch lights as well as terminating the flashing effect if it was active. There are three CVs used to customize Ditch Light operations.

Ditch Light Flash Rate CV53
Range is 1-15 . . . . . [3]
The value sets the rate or frequency at which ditch lights flash when activated. A value of one sets the highest rate or about 1/4 of a second. A value of 4 sets the rate to about 1 second. The original factory setting sets the flash rate to about 3/4 of a second. A value of 0 shouldn't be used although if you accidentally enter 0, the SD40 Drop-In will automatically change it to a value of 1.

Ditch Light Mode CV54
Range is 0-1 . . . . . [0]
A value of zero sets the ditch lights to turn on with the headlights. This is the original factory value. A value of 1 keeps the ditch lights off until they are activated and begin flashing. Once the flashing has timed out, the ditch lights turn off.

Ditch Light Timeout CV55
Range is 1- 255 . . . . . [15]
This value sets the length of time, in seconds, for the duration of the ditch light flashing once triggered. A value of 0 shouldn't be used although if you accidentally enter 0, the SD40 Drop-In will automatically change it to a value of 1.

Ditch Lights Turn ON With The Headlights - F0 and are activated with F4

Assigning Special Effects To CAB and AUX LITES

There are a variety of special lighting effects that can be applied to the CAB and the AUX lighting outputs. The factory wiring for the CAB LITE output is shared with the front/rear number boards, the dome flasher and the cab interior light. Any effect applied to the CAB LITE will appear on *all* of these shared lights. The AUX output is not connected to any of the existing factory lights so it is best for user installed lights.

To use an effect, first select the proper CV number for the specific LITE. Next find the desired effect in the effects table and note its CV value. Finally, load this value into the CV number. The original factory CV value is 4 for each of the LITE effects. This means they turn on at full brightness when activated.

CAB LITE Effect CV48
Range is 0-15 . . . . . [4]

AUX LITE Effect CV49
Range is 0-15 . . . . . [4]

Effect Timing Rate CV47
Range is 1-15 . . . . . [3]

Lighting effects that include a repeating pattern have a variable rate or speed at which the pattern is repeated. The rate or speed at which the pattern is repeated is based on the value set into CV47. Examples of repeating patterns that apply to lighting effects are Mars and Gyra lights. The period range is 1 to 15 and is in units of 1/2 second. For example a period value of 2 gives a repeating pattern of about once per second. Bigger numbers represent slower repeat times. The period CV does not apply when the selected effect is either full bright, dim or random flickering.

A value of 0 shouldn't be used. However, although if you accidentally enter 0, the decoder will automatically change it to a value of 1.

This table table summarizes the lighting effects and the CV value to activate the lighting effect. Also shown is whether the timing rate applies to these effects. All of these effects are optimized for LED lighting.

Special Lighting Effects	CV Value	Cv47 Applies
Off 0%	0	No
Dim 6%	1	No
Dim 25%	2	No
Dim 50%	3	No
On 100%	4	No
Strato Light	5	Yes
Oscillating Light	6	Yes
FRED	7	Yes
Rotary Dome light 1	8	Yes
Gyra Light	9	Yes
Mars Light	10	Yes
Rotary Dome Light 2	11	Yes
Strobe Single Pulse	12	Yes
Strobe Double Pulse	13	Yes
Reserved	14	No
Random flicker	15	No

The SD40 factory light wiring has combined the Cab Interior Light, the front and back number boards, and the dome flasher into a single circuit. Any special lighting effect assigned to the CAB light will be applied to ALL of the lights on the circuit.

Frequency Selection Using The T5000 Throttle

Each throttle/decoder pair must be on a unique frequency so as not to jam other throttle/decoder pairs.

The SD40 Drop-In decoder features remote frequency selection directly from the throttle. If you have our previous generation decoders, the most obvious difference will be the absence of the frequency selection switch. Read and follow these instructions carefully and you will immediately see the benefit of being able to set the decoder frequency without ever having to open up the locomotive. The decoder frequency is remembered even if the battery is disconnected.

17 Unique Frequencies Are Available - The frequencies are numbered from 0 to 16 for a total of 17.

Write The Frequency Down - While you may remember the frequency next week; how about in 6 months? Use a sticky label on which to record the frequency set into the decoder. If you use a locomotive address other than the obvious cab number, write it down too. Place the label somewhere on the locomotive where it can be seen. We put our label on the bottom of the fuel tank or tender.

Setting The Frequency - The desired frequency is stored inside the decoder in configuration variable number 58 which is abbreviated CV58. You need to know the decoder's address as well as its current frequency in order to use OPS PROGRAM mode to set CV58.

Caution: The throttle's frequency must be set on the present decoder frequency so that it will "hear" or receive the programming command to change the frequency. If you have forgotten the present decoder's frequency, see the section below for how to reset the decoder's frequency. OPS programming is the safest method to change the decoder's frequency without fear of changing another SD40 Drop-In decoder that might hear a SERVICE PROGRAM command.

T5000 Key Sequence For OPS PROGRAM Mode

1. Set throttle to decoder address.
2. Set throttle to decoder's present frequency.
3. Push MENU once and then push 0 to select OPS PROGRAM mode..
4. Enter 58 followed by ENT.
5. Enter the frequency number and push ENT. The decoder chirps once to indicate receipt of the new frequency. The range is 0 to 16.

   Note: If you enter a frequency value larger than 16, the decoder will not accept it and, instead, will reset the frequency to 0. It still chirps even if this occurs.
6. Push ESC to cancel OPS mode.
7. Change throttle to new frequency and operate locomotive.
8. Write down the new frequency.

Optional: push LOCO MEM key twice to store locomotive address along with its new frequency in your T5000 throttle.

Quick-Start - Resetting The SD40 Drop-In Frequency

There may come a time when the decoder no longer responds to what you believe is the correct frequency, or you can not remember the correct frequency.

Step 1 - turn off all AirWire throttles. This is very important since it is the absence of a throttle signal, plus turning the power off and then back on (a power cycle), that allows the decoder to temporarily jump to frequency 0 where you can set a new frequency.

Step 2 - Turn off the SD40 Drop-In power switches if they were on.

Step 3 - Turn on the SD40 Drop-In and wait at least one minute. You will hear *5* chips at the end of one minute. At the end of the chirps, the decoder will be temporarily on frequency 0.

Step 4 - Turn on your throttle, and set it to frequency 0.

Step 5 - Use SERVICE PROGRAM to set CV58 to the desired frequency. The decoder will chirp when the command is accepted.

More details about this procedure are on page 8.

Frequency Selection Using The T9000 Throttle

The SD40 decoder uses frequencies numbered from 0 to 16 and these are the numbers used when setting the SD40 to the desired frequency. However, the T9000 throttle uses different numbers for the frequencies, depending on what command is used to set the T9000 transmit frequency.

To use just the SD40's first 8 frequencies, 0 thru 7, then you may use the same frequency number for both the SD40 and the T9000 throttle. However, you must use the SEL-1 command to set the desired frequency into the T9000 and you are limited to just the first 8 frequencies.

To use all 17 available frequencies, 0 thru 16, on the SD40 decoder, you must set the T9000 throttle transmit frequency to the appropriate number from the table below using the SEL- 0 command.

SD40 Frequency	T9000 SEL-1 Mode	T9000 SEL-0 Mode
0	0	74
1	1	68
2	2	50
3	3	39
4	4	27
5	5	21
6	6	15
7	7	3
8		93
9		87
10		81
11		61
12		56
13		44
14		33
15		9
16		54

T9000 Key Sequence For OPS PROGRAM Mode

1. Set throttle to decoder address.
2. Set throttle to decoder's present frequency. Be sure you use the appropriate SEL command and use the frequency number from the table above.
3. Push OPR followed by the SEL key.
4. One at a time push the following keys: *, 5, 8, *. In the display, Cn means configuration number which is what we call a CV. The T9000 LCD can't display the V.
5. Push the # key, then the desired frequency number, and then # again. The decoder chirps to indicate receipt of the new frequency.

   Note that the decoder's CV58 is always set to a frequency number from 0 to 16. Do not confuse the T9000 transmit frequency number with the decoder's frequency number.
6. Push OPR key to exit OPS mode.
7. Change the throttle to the new frequency (see below) and operate the locomotive.
8. Write down the new frequency.

Note The Different T9000 Command To Use SD40 Drop-In Frequencies 8 to 16

You will be delighted to know that your T9000 is already capable of accessing all of the available SD40 frequencies. Your T9000 has an undocumented command, SEL-0, that is used to set its transmit frequency to these new frequencies. Note that there is no direct match between the T9000's new frequency numbers and the SD40 decoder's frequency numbers.

Using The AUX Lighting Output

The AUX LITE output is designed to drive cool and efficient white LEDs. The LED looks best for all of the available lighting effects. You can use incandescent lamp in place of an LED but it will run the battery down quicker and appear dimmer. Also, the special lighting effects will not appear as nice as they do when using an LED.

The AUX driver can be assigned to any function key. See page 9 for how to set up the decoder to respond to the desired throttle function key.

The circuit for the AUX LITE driver is simply a switch to battery minus and is rated at one amp. It is not protected against short circuits. The LEDs connect between the battery plus and the light driver through an external resistor.

Multiple lights may be powered from a light driver output by wiring the LEDs in parallel or in series. Make sure not to exceed the 1.0 Amp rating of the driver.

LED Symbol and Appearance

LED Symbol

Physical Appearance

An LED turn on when positive current flows from the anode A to the cathode (K). A limit resistor is used to set the amount of current through the LED. As little as 0.02 amps (0.02A) or 20 milliamps (20mA) is needed to make the white LED illuminate brightly.

Limit Resistor Value

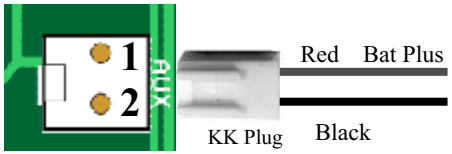
The LED must always be used with a series limit resistor. The value of the limit resistor depends on the battery voltage. Without the resistor, the LED will immediately burn out and possibly damage the AUX LITE driver circuit.

For the standard CVP battery, the resistor is about 750 ohms which is a standard 5% value. The resistor should be rated at one-quarter watt. Below is the equation used if you are using a different battery or want to use a different LED current.

R (in ohms) = [Battery Voltage] - [LED voltage VF] divided by [desired current in Amps]

Making Connections

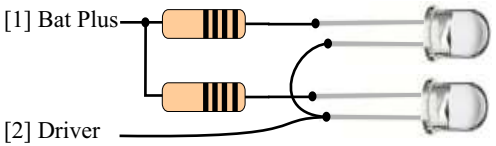
The AUX header has two pins. Pin 1 connects to BAT + through the decoder's power switch. Pin 2 connects to the AUX LITE driver. An optional 2-wire plug with about 12 inches of wire that matches the decoder's AUX header is available from CVP Products or your dealer. Order part number KK2.



Using LEDs in Parallel

Mutiple LEDs are best connected in parallel. Each LED must have its own limit resistor. Otherwise, they will not share the current equally resulting in different brightness for each one.

For parallel LEDs, the resistor will be the same value as if there was only a single LED.



F9 Activates AUX Lighting Output

Headlight Lighting Effects Examples and Tips

This page describes a few examples of headlight effects and some interesting combinations of headlight effects.

Front Headlight With Mars Light

This is relatively easy. First, lookup the CV that controls the front headlight effect which is CV61. Next, look up the value for CV61 to implement the Mars light. From the lighting effects table the desired action is a value of 10. Use your throttle to load the value of 10 into CV61. Once loaded, the effect becomes active the moment you turn on the headlights. The Mars effect only applies to the front headlight. If the locomotive direction set to reverse, the front headlight goes out and the rear headlight turns on steady at 100% brightness since CV62 has not been changed.

Changing the Mars Light Period

Now let's change the period of the Mars light and slow it way down. From the table on the adjacent page the CV that controls the headlight period is CV59. A value of 5 will be used which will be a very slow rate of 2.5 seconds - (5 x 0.5s). Use your throttle to load a value of 5 into CV59.

Turn on the front headlight again and observe the change in Mars light pattern.

Front Headlight With Mars Light and Auto-Dimming

CV60 is used to change the operating mode of the two headlights. Auto-dimming is a headlight operating mode that means that when the locomotive speed is at idle, the headlights will automatically dim. If there is an effect applied to the headlight, it will be turned off. The moment the speed is increased, the headlight comes on at full brightness and with whatever effect is active. For this example, simply load CV60 with a value of 1. This value sets up normal, auto-reversing operation as well as auto-dimming when the locomotive is stopped.

Multi-Unit Consist With Directional Lighting For Leading and Trailing Units

In this example, there are 3 locomotives that are consisted together. The locomotives all face the same direction. The desire is for the leading unit to have the front headlights on, when in the forward direction and its rear headlight off when going in the reverse direction. For the trailing unit, only the rear headlight is on when going in the reverse direction and the front headlight is off when going forward. The middle unit has the headlights turned off. The CV numbers and their values are shown for the leading and trailing locomotives. All locomotives share the same frequency.

Leading Locomotive	CV#	Value	Trailing Locomotive	CV#	Value
Headlight Mode	CV60	0	Headlight Mode	CV60	0
Front Headlight Effect	CV61	4	Front Headlight Effect	CV61	0
Rear Headlight Effect	CV62	0	Rear Headlight Effect	CV62	4

Incandescent Lamp Glow

You might notice a faint glow from some of the locomotive lights even when turned off. THis is normal and is a result of the original factory wiring inside the locomotive. There is no harm and it will only be noticeable if running at night in the dark.

Resetting SD40 Drop-In To Original Factory Settings

CV8 is used to restore or reset the Sd40 Drop-In decoder to its original settings as it comes from the factory. All CV values that you may have entered will be erased. The original factory values for each and every CV are then restored. The back cover has a complete listing of all CVs and their original factory values. After issuing the factory reset command, the address is changed to 3 and the frequency is changed to 0. The factory reset with CV8 only works on the SD40 Drop-In decoder. It will not affect or reset any attached sound decoders. See the sound decoder manual for how to reset the sound decoder.

If you know your decoder's address and its present radio frequency, then set your throttle on the same address and frequency. In this mode you will use OPS PROGRAM commands to issue the reset and no other decoders will be affected even if they are powered up and on the same radio frequency..

If you do not remember the radio frequency, you must use the "forgotten frequency" method described on page 8.

Reset Decoder To Factory Defaults. CV8

Only a single value is accepted [all others are rejected] . . . . . [135]

First, set your T5000 throttle to the decoder's present frequency and address.

1. Push MENU once followed by 0 to select OPS PROGRAM mode.

2. Press 8 and then ENT which selects CV8 for programming

3. Press 1,3,5 then ENT to initiate the reset. Only a value of 135 will initiate the reset. All other values are rejected. When you press ENT, the decoder will chirp to signify that it has been reset.

4. Press * to exit OPS PROGRAM mode.

At this time, the decoder has been reset to factory defaults. It will be on address 3 and frequency 0. Reset your throttle to address 3 and frequency 0 to confirm that decoder has been reset.

Factory Reset Does Not Reset The P8 Sound Decoder

The attached P8 Sound Module will not be reset using this procedure. However, the moment you program the SD40 Drop-In decoder's address, the P8 will also be programmed to the new address. Any further changes to the P8 must be done using the P8 programming jack.

Forgotten SD40 Drop-In Decoder Frequency

There may come a time when you do not remember the SD40 decoder's assigned frequency. If this happens, use the following technique to reset the decoder's frequency.

How This Works: This problem is easily solved with what we call the "Jump Mode." When Jump Mode is activated, the decoder temporarily "jumps" to frequency 0. Once the decoder has jumped, use service program mode to change its frequency to whatever you wish.

To Reset Frequency Using Jump Mode And SERVICE PROGRAM

- Step 1: Turn off **all** AirWire throttles. This is very important since it is the absence of any throttle signal that forces the SD40 Drop-In to temporarily jump to frequency 0. *Make sure there are no lurking locomotives, powered up and set to frequency 0. If so, their frequencies will be change too.*
- Step 2 - Turn off the SD40 Drop-In decoder using the power switch and then turn it back on.
- Step 3 - Wait a minimum of one minute. At the end of one minute, the decoder will chirp 5 times. At the end of the chirps, the decoder is on frequency 0 temporarily. You must wait the full minute before moving to step 4.
- Step 4 - Turn on your throttle, and set the throttle frequency to 0.
- Step 5 - Use **SVC PROGRAM** to set CV58 to the desired frequency. Be sure and reset your throttle to the new frequency. Don't forget to reset your throttle to the new frequency too.
- Step 6 - Power cycle the decoder to activate the new frequency. Make sure to change your throttle to the new frequency.

Using OPS PROGRAM To Set The Frequency During Jump Mode

If you are confident you know the decoder's address, then you can use OPS PROGRAM to change the decoder's frequency. OPS PROGRAM is the safest way to change the frequency and insures no other decoders will have their frequency changed. But the catch is you must know the decoder's address. If you are not sure, or have forgotten the address, then use the SERVICE PROGRAM mode above.

- Step 1: Turn off **all** AirWire throttles. This is very important since it is the absence of any throttle signal that forces the decoder to temporarily jump to frequency 0.
- Step 2 - Turn off the SD40 Drop-In decoder using the power switch and then turn it back on.
- Step 3 - Wait a minimum of one minute. At the end of one minute, the decoder will chirp 5 times. At the end of the chirps, the decoder is on frequency 0 temporarily. You must wait the full minute before moving to step 4.
- Step 4 - Turn on your throttle, set it to frequency to 0 and enter the decoder's address.
- Step 5 - Use **OPS PROGRAM** to set CV58 to the desired frequency. Be sure and reset your throttle to the new frequency. A power cycle is not needed.

Notes About The Jump Mode

- The jump mode is canceled and normal operation resumes if a throttle is turned on that matches the present decoder setting **within one minute** of the decoder power being turned on.
- If the decoder jumps to frequency 0 because you waited too long to turn on the throttle, just cycle the decoder power and make sure the throttle is turned on within one minute.
- The jump to frequency 0 is temporary and **nothing is changed** in the decoder. However the decoder will stay on frequency 0, until power is cycled or you change the frequency by setting CV58 to a new value. If you did not change the frequency, the decoder will revert back to its previously stored frequency as soon as its power is cycled off then back on.
- The decoder will not jump to frequency 0 if a throttle having a frequency that matches the decoder is turned on within one minute of turning on the decoder even if the address is different.
- If a frequency number higher than 16 is used when setting the frequency, it is ignored and the decoder uses frequency 0.

After turning the power off, then back on, if the SD40 Drop-In decoder "hears" a throttle on its frequency, within one minute of a power cycle, it will not jump to frequency 0 even after the throttle is turned off or changed to another frequency. The address doesn't matter.

Special Headlight Effects

There are a variety of special lighting effects that can be applied to the SD40 Drop-In decoder's headlight drivers.

To apply an effect, determine which headlight is to have the effect, front or rear or both, find the desired effect in the effects table, note the CV value and then load this value into the CV 61 or 62 or both.

Front Headlight Effect CV61
Range is 0-15 . . . . . [4]

Rear Headlight Effect CV62
Range is 0-15 . . . . . [4]

Headlights Effect Timing Rate CV59
Range is 1-15 . . . . . [3]

Lighting effects that offer a repeating pattern can have the rate or speed at which the pattern is repeated. The rate is based on the value set into CV59. This CV controls the rate of a repeating pattern. Examples of repeating patterns that apply to light effects are Mars and Gyra lights. The period range is 1 to 15 and is in units of 1/2 second. For example a period value of 2 gives a repeating pattern of about once per second. Bigger numbers represent slower repeat times. The period CV does not apply when the selected effect is either full bright, dim or random flickering. A value of 0 shouldn't be used although if you accidentally enter 0, the SD40 Drop-In will automatically change it to a value of 1.

The following table summarizes the lighting effects and the CV value to activate the lighting effect. Also shown is whether the timing rate applies to these effects. All of these effects are optimized for

Special Lighting Effects	CV Value	CV59 Applies
Off 0%	0	No
Dim 6%	1	No
Dim 25%	2	No
Dim 50%	3	No
On 100%	4	No
Strato Light	5	Yes
Oscillating Light	6	Yes
FRED	7	Yes
Rotary Dome light 1	8	Yes
Gyra Light	9	Yes
Mars Light	10	Yes
Rotary Dome Light 2	11	Yes
Strobe Single Pulse	12	Yes
Strobe Double Pulse	13	Yes
Reserved	14	No
Random flicker	15	No

All Lighting Effects Are Optimized For High Brightness LEDS

Customizing Headlight Operation Mode

The SD40 Drop-In Decoder allows the front headlight and the rear backup light to operate in several different modes. The different modes control if and when the headlight dims and how the headlight and backup light operate. For example, the front headlight and the rear headlight can both be on at the same time or the front headlight can remain on, independent of the direction of travel. How the headlights behave are determined by the value stored in CV60.

Headlight Mode CV60

Range is 0-15. . . . . [0]

As with all setup options, the desired operating mode is selected from a CV value table and the appropriate number is stored in CV60 of the decoder's memory. The mode can be changed at any time.

CV60 only affects the headlight and the backup light operating modes. It has no effect on any other locomotive light.

Special lighting effects can be applied to the front and rear headlights and are described on the next page.

Normal Operation: The front headlight turns on at full brightness and the selected effect, if any, is applied. Normal operation also includes default headlight autoreverse. Autoreverse means that the front headlight is on when the throttle is set for the forward direction and off when set for the reverse direction. Conversely, when using autoreverse, the rear headlight light is off when in the throttle is set for the forward direction and on when set for reverse.

Auto-Dim Headlight Mode [rule 17]: When this option is selected, the headlight automatically dims when the throttle is set to zero speed. When dimmed, the headlight glows at a reduced brightness and without any special effects. Turning up the speed knob automatically restores the headlight and its assigned lighting effect to full brightness. This feature is optimized for white LEDs. Locomotives that use incandescent bulbs for headlights may appear very dim when using this feature.

Front and Rear Headlight Actions	CV Value
Normal, autoreverse	0
Normal with rule17	1
Front headlight on always	2
Front headlight on always with rule17	3
Rear headlight on always	4
Rear headlight on always with rule17	5
Front and Rear both on always	6
Front and Rear both on always with rule17	7
Front/Back Reversed with Auto Reverse	8
Front/Back Reversed w/ Auto Reverse & rule 17	9
reserved	8-15

Head Lights Are Turned On With F0

F0 is shorthand for throttle function key 0. To turn headlights on or off the headlights, push the 0 key on your throttle.

Lights Are Normally Off

When the SD40 Drop-In decoder is powered up, all lights are off.

Assigning Throttle Function Keys To Drop-In Actions

Use this step-by-step sequence to assign or change what a function or action throttle key does. The assignment and the action are stored in the decoder's memory even if power is turned off.

The SD40 Drop-In decoder has many memory locations so we use the term CV# where # is a specific memory location. So CV40 means Drop-In decoder memory location number 40. The value stored at this location dictates what the Drop-In decoder does when it receives a throttle's function key command.

Always start by thinking through what you want your throttle to do to the Drop-In decoder. For this example, here's what is wanted:

"On the throttle, I want the 6 key to turn on the smoke generator."

Notice the underline of the important items: which throttle key is to be used, and what the decoder action will be when that key is pushed. For this example, F6 is the throttle's 6 key. Now you are ready to set the Drop-In decoder so that it performs the desired action when F6 is pressed.

Step 1: Find F6 in the assignment table.

From the table, the Drop-In decoder uses CV40 for F6 .

Step 2: Find the desired action in the action table and note the value. This will be what is stored in CV40.

For this example, since the smoke generator is to be toggled, which means turned on and off, the CV value of 2 is to be used.

Step 3: Turn on the Drop-In decoder's power. Set your throttle to the decoder's frequency and locomotive address if it has not yet been set. This is very important since if either the frequency or the locomotive address is wrong, the decoder will not hear the throttle's OPS PROGRAM command.

Step 4: OPS PROGRAM CV40 to a value of 2. The decoder will chirp indicating it heard and accepted the command. Escape out of OPS PROGRAM and verify that the decoder's action is correct when the 6 key is pressed on the throttle.

This same sequence is used to assign or change what the function keys will do.

Function Key Assignment Table

Description	CV#
F1 Function Key Action	CV35
F2 Function Key Action	CV36
F3 Function Key Action	CV37
F4 Function Key Action	CV38
F5 Function Key Action	CV39
F6 Function Key Action	CV40
F7 Function Key Action	CV41
F8 Function Key Action	CV42
F9 Function Key Action	CV43
F10 Function Key Action	CV44
F11 Function Key Action	CV45
F12 Function Key Action	CV46

The SD40 factory wiring combines the interior cab light, the dome flasher and the front and rear number boards. All will turn on when F11 is on. The flashing is built into the LED.

Function Key Action Table

Function Key Action	CV Value
No Function	0
Activate Cruise Control	1
Toggle Smoke Generator on/off	2
Toggle Cab Lites on/off	3
Toggle AUX Lites on/off	4
-	5
-	6
Dim Headlights on/off	7
Ditch Lights Flash Trigger	15
reserved	8-14

Factory Settings

F4	Activate Ditch Light Flash
F5	Activate Cruise COntrol
F9	Toggle AUX Light
F10	Toggle Smoke Generator
F11	Toggle Cab Light

Locomotive Motion Control and Fine Tuning

There are 3 CVs that determine how the locomotive motor responds to a throttle speed command. Following the NMRA-DCC standard, these are: CV2 (Vstart or motor-starting-voltage MSV) CV6 (Vmid), and CV5 (Vmax). The full scale motor voltage value ranges from 0 to 255 so these 3 variables also have a value range of 0 to 255. You may set these values to suit your desired locomotive performance as well as to help with speed matching of different locomotives.

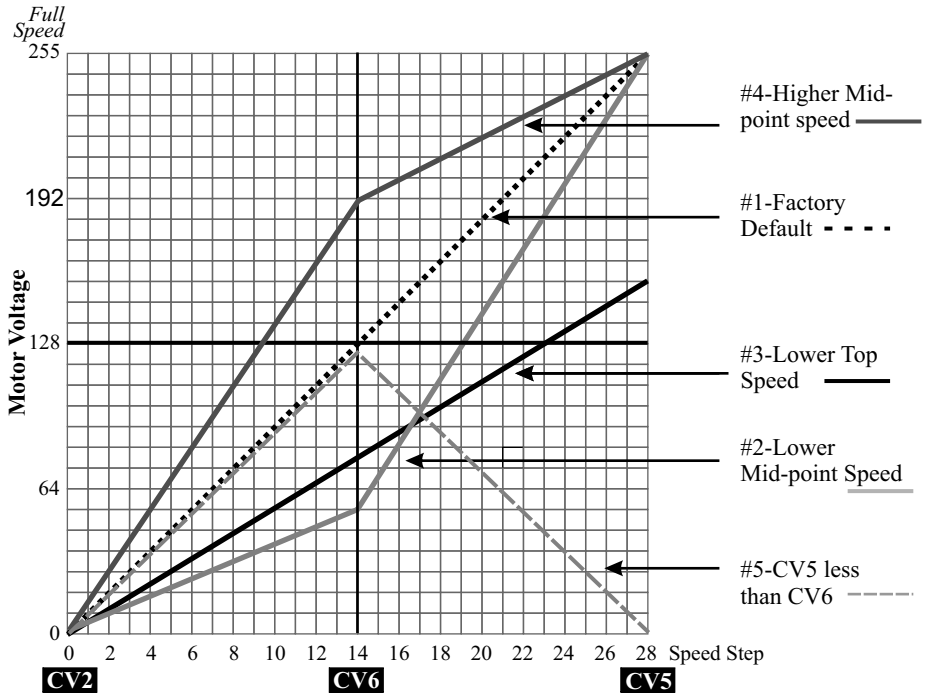
Note: regardless of the throttle's speed step setting, the SD40 Drop-In will automatically adjust for the 14 speed step or the 28 speed step settings.

Motor Starting Voltage Value (MSV) CV2
Range is 0-255 . . . . . [9]

CV2 sets the MSV of the motor voltage that corresponds to speed step 1 (in a 28 speed step setting). This is the first speed step from off, or zero voltage. You can decide if you wish the motor to be moving at a good rate of speed or just barely moving by changing the MSV. A small MSV value means only a small extra increase in motor voltage. A larger MSV value means the motor receives a higher motor voltage.

Mid-point Motor Voltage Value (Vmid) CV6
Range is 0-255 . . . . . [128]

The mid-point voltage, or half speed, corresponds to speed step 14 (in a 28 speed step setting). CV6 is used to set this voltage with 128 being the factory default value. If a lower half speed is needed, for example in speed matching application, set CV6 to a smaller value. Speed curve #3 lowers the half speed to 55. So at speed step 14, the locomotive is running at 25% of the maximum motor voltage. Conversely, if the locomotive is running too slow at speed step 14, CV6 can be raised to increase the half speed.



SD40 Drop-In Cruise Control

The SD40 Drop-In decoder comes equipped with a new and advanced cruise control design for maintaining the speed of a locomotive. Just like the cruise control in an automobile, once activated the locomotive will maintain the same average speed independent of the load or the terrain of your layout. It will cruise up hill and down hill as well as snake through tight curves and turnouts while maintaining the same average speed automatically without user's intervention.

New on the SD40 Drop-In are two extra CVs, CV64 and CV65. These allow you to finely tune your cruise control to your specific locomotive.

The SD40 Drop-In is shipped from factory with the cruise control disabled until you activate it with a function key (F5 is the factory default activation key). When activated the decoder will chirp one time. Pressing the function key again will not deactivate the cruise control. Deactivation depends on the selected cruise mode. The cruise mode is explained below. Once deactivated, the cruise control can only be reactivated again by pressing the function key. The decoder chirps each time it goes into or out of cruise control.

Cruise Mode Select CV63
Range is 0 - 1 . . . . . [0]

There are two different types or modes of cruise control.

Cruise mode 0 (factory default setting), when activated, will hold the locomotive speed constant and independent of the load, grade or track curves. If the throttle speed is change, up or down, or the direction is reversed, cruise control is deactivated. Mode 0 is easy to use. Once the train reaches the desired speed, push F5 (or what ever key you have assigned to activate cruise control) to enable cruise.

Cruise mode-1 is unique in that once cruise is active, you may change the cruising speed without deactivating cruise control. This allows fine tuning of the cruise speed, either higher or lower. As with the other mode, push F5 to enable cruise mode. In this mode, you can make changes to the initial speed using the throttle speed knob. You may increase or decrease the speed. Taking the throttle to 0 or reversing the direction will turn off cruise mode. To turn it back on, just push F5 again. The decoder chirps each time it goes into or out of cruise control.

Cruise Tracking Rate CV64
Range is 1 - 16 . . . . . [4]

CV64 selects the tracking rate with which the cruise control checks the locomotive speed. The value for CV64 has a range of 1 to 16 and the factory default value is set at 4. The lower the value of CV64 is, the more often the cruise control checks and corrects the locomotive cruise speed. We have found that the optimal setting to be about 4 although you can try different values since your locomotive and layout conditions might be somewhat different than ours.

Cruise Adaptation Step Size. CV65
Range is 1- 3 . . . . . [2]

CV65 is the adaptation step size, which sets the amount of correction when a motor speed adjustment has to be made. The default value of 2 works well for most locomotives. A value of 1 means the speed corrections are finer but it will take longer to adapt to a large change in speed. A value of 3 creates larger corrections and tracks speed changes much faster but with 50% less precision than a value of 2.

CAUTION: Do not use a value of 0 for either CV 64 or 65. If you accidentally use 0, the SD40 Drop-In will automatically reject it and instead use the factory default values.

Don't Use Cruise Control With Mult-unit Consists

If locomotives are in a multiunit consist, cruise-control may fight each other. However, if all locos are relatively closely matched, cruise mode 1 may be the best mode. Experiment to determine which cruise mode works best for your fleet.

Locomotive Speed Matching Tips

Using CV2, CV6 and CV5, you can match the speeds of two or more different locomotives. One important consideration is to determine which locomotive in a consist is the slowest. It is to this slow locomotive that you will match the other members of the consist. Always match a locomotive to the slowest member of the consist since we cannot make a slow locomotive run faster than its top speed. The following examples illustrate some of the possible ways to match up locomotives.

You may find that matching locomotives at the top and mid point speeds is close enough. By all means you may stop if you are happy with the performance after steps 1 and 2. The procedures below allow you to precisely match locomotive speeds at all speed steps, not just two. The penalty is a bit more time but you will be impressed with the results.

Use OPS mode programming to make changes to the CVs.

Step 1: Match locomotives at step 14

Using the slower locomotive as reference, match the faster locomotive to the speed of the slower one at speed step 14 using CV6. Since we are modifying CV6 of the faster locomotive, we should reduce the value of CV6 until it matches the speed of the slower locomotive. At this point, both locomotives should be running at the same speed at speed step 14.

Step 2: Match locomotives at top speed

Using the slower locomotive as reference, match the faster locomotive to the speed of the slower one at speed step 28 using CV5. Since we are modifying CV5 of the faster locomotive, we should reduce the value of CV5 until it matches the speed of the slower locomotive. At this point, both locomotives should be running at the same speed at speed step 28.

Step #3: Fine tuning the top speed setting only (2 methods)

Using the slower locomotive as reference, compare the speed of both locomotives at speed step 21 (middle of the high speed setting). If both locomotives are running at more or less the same speed then no fine tuning is necessary. If not then fine tuning the high speed setting may be done next. There are two ways, using CV5 or CV6 only.

Using CV5 only is the first method and results in minor speed differences at step 28.

Reference Locomotive Is Either Slower or Faster At Step 21: Decrease the value of CV5 of the other locomotive to match the speed of the reference. Conversely, if the reference locomotive is running faster at speed step 21, then increase CV5 of the other locomotive to match the speed of the reference. Using this method can result in minor speed difference in top speed.

Using CV6 is an alternative method and results in minor speed differences at step 14.

Reference locomotive is running slower or faster at at speed step 21, then lower CV6 of the other locomotive to match the speed of the reference. Conversely, if the reference locomotive is running faster at speed step 21, then increase CV6 of the other locomotive to match the speed of the reference.

Step #4: Fine tuning the low speed setting only (2 methods).

Using the slower locomotive as reference, compare the speed of both locomotives at speed step 7 (middle of the low speed setting). If both locomotives are running at more or less the same speed then no fine tuning is necessary. If not then fine tuning the low speed setting may be done next. There are two ways, using CV6 or CV2 only.

Using CV6 is the first method and results in minor speed differences at step 14.

Reference locomotive is running slower at speed step 7: lower CV6 of the other locomotive to match the speed of the reference. Conversely, if the reference locomotive is running faster at speed step 7, then increase CV6 of the other locomotive to match the speed of the reference.

Using CV2 is the alternative method and results in minor speed difference at step 1.

Reference locomotive is running slower at speed step 7: lower CV2 of the other locomotive to match the speed of the reference. Conversely, if the reference locomotive is running faster at speed step 21, then increase CV2 of the other locomotive to match the speed of the reference.

Locomotive Motion Control and Fine Tuning *continued*

Maximum Motor Voltage Value (Vmax) CV5
Range is 0-255 . . . . . [255]

The top speed voltage (full speed) corresponds to speed step 28 (in a 28 speed step setting). CV5 is used to set this voltage and 255 is the factory default. If a lower top speed is needed, for example in speed matching application, set CV5 to a smaller value. Speed curve #2 lowers the top speed to 155. So at speed step 28, the locomotive is running at 60% of the maximum motor voltage. It should be noted that every speed step from 1 to 28 will be slower accordingly.

Setting CV5 to a value less than CV6 is OK but the resultant speed curve will be an upside down V. Curve #5 on the previous page shows the extreme case with CV5 equal 0 and CV6 equal to 128, The motor will reach top speed at step 14 and then gradually slow down to a stop at step 28.

Customizing The Speed Curve To Your Requirements

Customizing a speed curve is easily done by modifying one or more of the three configuration variables. It helps to visualize the speed curve as having two separate halves as shown in the graph with the split at the 50% throttle speed position. The left half is controlled by CV2 and CV6 and responds to the first 14 speed steps (in the 28 speed step setting). The right half is controlled by CV6 and CV5 and responds to speed steps 15 to 28 (in the 28 speed step setting).

I want finer slow speed control: With CV2 and CV5 unchanged, the step size of speed steps 0 to 14 in the left half of the speed curve can be reduced to give finer control by simply reducing the value of CV6 from the default 128 to a smaller value. For example, by reducing CV6 to 100, each of the 14 steps will be reduced by a value of 2. As a result of reducing CV6 to 100, the step size for speed steps from 15 to 28 in the right half of the speed curve increase by a value of 2. The result is curve #3. Thus, you gain finer speed control at the low end of the throttle range at the expense of bigger steps at the high end. For yard operations, you will find this setting to offer precision slow speed control right when you needed it.

I want finer high speed control: With CV2 and CV5 unchanged, the step size of speed steps 15 to 28 in the right half of the speed curve can be reduced to give finer control by simply increasing the value of CV6 from the default 128 to a larger value. For example, by increasing CV6 to 156, each of the 14 steps will be increased by a value of 2. The result is curve #4. It is important to remember that as a result of increasing CV6 to 156, the step size for steps 0 to 14 in the left half of the speed curve would be increased by a value of 2.

I want both finer speed steps for slow and high speed control: With CV2 unchanged, the step size of speed steps 0 to 28 can be reduced to give finer control by simultaneously reducing the values of CV6 and CV5 to a smaller value. For example, by reducing CV6 from a default of 128 to 100, and CV5 from a default of 255 to 227, the step size for the entire speed curve is now reduced by a value of 2 to give finer control. The result is curve # 2. By reducing CV5 to a smaller value, the top speed at the high end is lower which will result in less torque at high throttle settings.

CV2 has remained unchanged in the above examples. The next set of examples, shows what you can do by modifying CV2. These are not graphed but are discussed to show that you can create an unlimited variety of speed curves using just 3 different CVs.

I want a higher MSV with finer slow and high speed control: With CV5 unchanged, the step size of speed steps 0 to 28 can be reduced to give finer control by simultaneously increasing the values of CV2 and CV6 to a larger value. For example, by increasing CV2 from a default of 9 to 37, and CV6 from a default of 128 to 156, the step size for the entire speed curve is now reduced by a value of 2 to give finer control. By increasing CV2 to a larger value, the MSV is now higher for the low end starting speed of speed step 1.

I want higher MSV and reduced top speed with finer slow and high speed control: With CV6 unchanged, the step size of speed steps 0 to 28 can be reduced to give finer control by simultaneously increasing CV2 to a larger value and reducing CV5 to a smaller value. For example, by increasing CV2 from a default of 9 to 37, and reducing CV5 from a default of 255 to 227, the step size for the entire speed curve is now reduced by a value of 2 to give finer control. This also results in a reduced top speed at speed step 28 and an increased starting speed at speed step 1.

Motor Acceleration and Deceleration Control

Locomotive inertia and momentum are simulated using CV3 and CV4. Inertia is the rate at which a locomotive accelerates when changing from a slow speed to a higher speed. Contrast that with momentum which is the rate at which a locomotive decelerates from a high speed to a lower speed.

CV3 deals with the rate of acceleration when the speed is increased. In other words how quickly does the operator intend for the locomotive to accelerate. The smaller the value of CV3 the quicker a locomotive will accelerate. Similarly, CV4 deals with the rate of deceleration and the smaller the value of CV4 the quicker the locomotive will decelerate.

Motor Acceleration Rate. CV3
Range is 1-255 . . . . . [2]

This CV sets the rate of change of locomotive speed when the throttle speed is increased. This is called the acceleration rate. Small values mean the rate of change is fast. A higher value leads to a slower rate of change.

In most cases, users prefer a *slower* rate of change for the acceleration rate. Common values are 3, 4 and 5. Large values result in extremely long delays for speed changes to take effect which are generally uncomfortable for users. The acceleration rate applies equally in the forward and reverse directions.

Motor Deceleration Rate CV4
Range is 1-255 . . . . . [2]

This CV sets the rate of change of speed upon when the throttle speed is decreased. This is called the deceleration rate. Small values mean the rate of change is faster. A higher value leads to a slower rate of change.

In most cases, users prefer a *faster* deceleration rate compared to the acceleration rate. The factory default of 2 is seldom changed. High values will result in extremely long delays for locomotives to slow down. If you imagine your favorite locomotive speeding towards another train, you will want to be able to quickly stop the train. This is why the factory setting of 2 is seldom changed. Users want to slowly start the train, but quickly stop it. The value applies equally in the forward and reverse directions.

GearSaver Protection

If for some reason, you set CV3 or CV4 to 0 in an attempt to achieve instantaneous stop or quick acceleration, SD40 Drop-In will automatically set CV3 or CV4 to 1 instead, in order to protect the locomotive gears from being stripped. So the effective range for CV3 and CV4 is from a value of 1 to 255.

Also, if you reverse the locomotive direction without first stopping it, GearSaver protects you again. In this situation, SD40 Drop-In will ramp the speed down to zero before reversing the direction and

Beware Of Large Values

Large values for acceleration or deceleration rates will result in very slow response to throttle changes. Extreme values will result in the locomotive never starting, or, never stopping - neither of which is very comfortable to the operator.

Fine Tuning Slow Speed Operation With Bumping

Many users assume that CV2 is used to control how the locomotive starts up at slow speeds. However, you should not use CV2 for that purpose. Instead take advantage of the advanced SD40 Drop-In feature of motor bumping.

We have completely redesigned the bumping algorithm to provide for precision slow speed control. The new algorithm uses a sophisticated algorithm that you can customize using CV56 and CV57. The new bumping feature perfectly compliments the ultra high resolution speed curve created with CV2, CV5 and CV6.

With motor bumping, you can achieve silky smooth performance at very low speeds. There are two CVs for this feature, the motor bump value, CV56 and the motor bump duration, CV57. Your SD40 Drop-In will automatically transition from the slow-speed bump to the high resolution speed curve operation as the locomotive gains speed.

Motor Bump Value CV56
Range is 0-255 . . . . . [0]

This value sets the amount of momentary motor voltage increase, called a bump, applied at each speed step to the help motor overcome friction. It helps get the motor rotating at a lower voltage and/or a lower speed step. Once the locomotive is moving, the bump automatically goes away. A value of 0 turns off the motor bump. A value of 128 will literally apply half of full speed to the motor.

Motor Bump Duration CV57
Range is 0-127 . . . . . [0]

This value selects the duration of time that the bump value is applied when the bump is active. A value of 0 disables the bump completely, no matter what is set in CV56.

Experimenting With Motor Bumping

To use the motor bump feature, the following procedure is recommended. It helps to have a throttle that shows the speed step being sent such as the T5000 or the T9000.

Step 1: Set the throttle to speed step 1 and observe the locomotive's wheels. They may or may not be turning.

Step 2: Set CV56 to a value of 15 and CV57 to a value of 50. Observe the locomotive wheels and see if they are now turning. Stop and then return the throttle to step 1. Look for consistent forward motion and make sure that the bump is sufficient for smooth operation over the entire length of the track at speed step 1.

Step 3: If the wheels are not yet turning, increase either CV56 or CV57 or both by a value of 5 and check again. You should make changes to the CV values in increments of 5. Smaller increments may not cause any noticeable changes.

There is a tradeoff between the bump value and the bump duration. If a small bump value is applied, then a longer bump duration will be needed. Or, if a large bump value is used, it can be applied for a shorter duration .

Careful choices of CV56 and CV57 will give not only fine control at slow speeds but allow the full range of precision speed control over the entire speed curve. Think of the motor bump as an added feature that provides an extra boost of energy to get the locomotive moving at low speeds.

New Motors Should Be Broken In Before Using

A new motor usually doesn't have motor brushes that conform well to the circular shaft of the commutator. The brushes tend to draw more than normal current, and exhibit arcing. As a result, the motor causes lots of radio noise and can even trip the SD40 Drop-In over-current protection circuit. To prevent this from occurring, just run the motor for an hour or so at full speed and in each direction. This will seat the motor brushes and greatly reduce radio noise generation.