



DCC Mobile Decoder

SoundTraxx Mobile Decoder

MC1 Series User's Guide

Software Release 1.00

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All Aboard!

Overview

Congratulations on the purchase of your SoundTraxx® Mobile Decoder™. This **User's Guide** will walk you through the various aspects of programming your decoder, as well as some tips on troubleshooting. For the power user, the **Mobile Decoder Technical Reference** will provide a list of all the CVs available for use with Mobile decoders and their exact function and make-up for those who wish to have a complete reference for advanced programming techniques. For instruction on installation and wiring diagrams, please refer to either the individual decoder's packaging or the SoundTraxx Mobile Decoder Quick Start/Installation Guide.

Technical Bulletins and Application Notes covering various topics are also published from time to time, and these may be downloaded free of charge from our website at www.soundtraxx.com.



Operation

Using Your SoundTraxx Mobile Decoder

Your SoundTraxx decoder has been shipped with all CVs pre-programmed so you can begin using your locomotive immediately without having to worry about what adjustments to make. Function Assignments are as follows:

Mobile Decoders

<i>Function Key</i>	<i>Effect</i>
F0	Headlight/Backup Light
F2	Grade Crossing Effect
F7	Dimmer
F11	Motor Braking

While these are the default settings, you may wish to make changes to the function mapping later. For now, simply set your controller to Locomotive 3, place the locomotive on the mainline and away you go! Now that you have control of your decoder, let's see what happens!

Turn on the Lights

Press F0 on your cab to turn on the Headlight. Reverse locomotive direction and the headlight turns off as the backup light turns on. While waiting on a siding, you can press F7 to dim the headlight for an oncoming train.

As you see, no programming is necessary to begin enjoying your decoder! However... after you have had a chance to play with your decoder for a little while, you may wish to make some changes such as selecting a new address or altering a lighting effect. The following section will introduce you to CVs and how and why you might wish to change them.



Basics of Programming

Programming the CVs

What is a CV?

CV stands for Configuration Variable, which is the industry-adopted term for a decoder's user-programmable memory locations. CVs allow you to customize individual decoder properties such as the address, momentum, throttle response, and much more. Once a CV has been programmed, the setting will be permanently remembered even after the power has been turned off. A CV can be modified as often as necessary by simply reprogramming it with a new value.

With the large number of CVs available, first inspection of the available options may cause confusion and little panic! Relax. As you have already seen the decoder has been shipped with all CVs pre-programmed so you can begin using your locomotive immediately without having to worry about what adjustments to make.

The following paragraphs break the decoder's CVs into various subsystems so it is only necessary to change a few CV's at a time. As you become comfortable with it's operation, move onto a new section and begin exploring the options and capabilities found there. For more technically inclined users, detailed information on any CV can be found in the **Mobile Decoder Technical Reference**.

Bits and Bytes

One of the most confusing aspects of programming a CV is figuring out what all the different bits, bytes and x's found in the various decoder manuals mean. The problem is compounded further by differences in each command station manufacturer's user interface. For users unfamiliar with such terms, a short math lesson (ugh!) is in order before proceeding:

Each decoder CV stores a numeric value that can be represented in one of three forms:

Decimal - This is the form everyone is familiar with and we use in our day-to-day lives. Numbers are represented as a sequence of digits composed of the numerals 0,1,2,3,4,5,6,7,8, and 9.

Hexadecimal - Also referred to as simply "hex", this is a more specialized number representation that, in addition to 0 through 9, also uses the characters A-F. It has the advantage that a given decimal number can be more compactly represented. For example, the decimal number 127 converts to a simple 7F in hex (one less digit). This allows user interfaces with a limited number of digits (i.e., the LCD on your cab) to display a wider range of numbers.

Binary - Binary numbers get their name from the fact they use only two digits 0 and 1 called 'bits' and is the fundamental number system used by all computers including the ones found inside a digital decoder. Because there



are only two bit values, it takes more digits to represent a number using binary. The decimal number 127, for example, is written as 01111111 in binary notation. A 'byte' is a binary number made up of eight bits. And a 'nibble' is half a byte or four bits. Really! We didn't make that up.

Coincidentally, each CV is made up from one byte or eight bits and can store any number between 0 and 255. Most of the CVs contain a single piece of data that can be easily represented in any of the three forms, i.e., CV 3, the acceleration rate, can be loaded with any value from 0 to 255 and it always affects the same thing - the acceleration rate.

On the other hand, some CVs use individual bits to control different features. This allows up to eight individual features to be controlled by a single CV and is done to conserve the number of CVs. As the bit variables can take on only one of two values (0 and 1) they are usually used for simple variables that are either On or Off, enabled or disabled or something similar. Unfortunately, bit variables are difficult to represent in any form other than binary and still preserve any meaning. Because most DCC system user interfaces don't use binary representation, these numbers are the most difficult to work with and require a tedious series of additions to convert to the decimal or hex form used by most systems.

We have tried to use the decimal number system in this manual when describing the proper values to program into a given CV; however, you will occasionally find values listed in the Technical Reference in binary, hex and decimal values. Hex numbers can be distinguished from a decimal number by noting a 0x prefix. Thus 0x10 is the hex version of sixteen and not ten as one might guess. Binary numbers are represented using a 'b' suffix. 100b is really the number four and not one hundred. To further assist the math-impaired, we have provided a handy-dandy conversion table in Appendix A that allows one to quickly convert between decimal, hex and binary.

When working with individual bits such as in CV 29, we suggest the following procedure for determining the correct value to program. Referring to the CV description, write down the value desired for each individual bit. Consider for example, the case of CV 29. We would like to set this CV so that speed tables are enabled and the 28 speed-step mode is in effect. Referring to the Technical Reference, we see that bit 4 and bit 1 should be set to 1 and all other bits are cleared to zero. Remembering that we are dealing with binary, write down the individual bit values and we get:

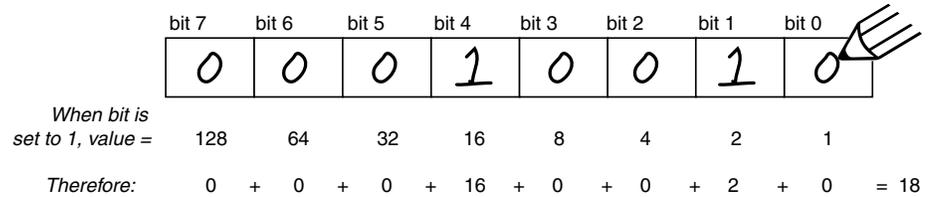
bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0	0	0	1	0	0	1	0

We then look up the binary value 00010010b in Appendix A and see that it corresponds to the decimal value 18 (0x12 in hex). This is the value to use when programming the CV.



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If you don't have the conversion chart available, you can also calculate the value in the following manner. Reading from right to left, each bit has a decimal value associated with it, beginning with a 1 and doubling this value as you go from bit 0 to bit 7. This value is only counted when the bit is a '1'. Looking at the figure below, you can see that using this method, bit 1 has a value of 2 and bit 4 has a value of 16. Adding these two numbers together gives the correct decimal value of 18.



Programming Methods

There are two methods for changing the decoder's CVs:

Service Mode Programming - This programming mode usually requires the locomotive to be placed on a special programming track or connected to a dedicated programmer. Your decoder can support four types of service mode instructions:

Address Mode - Can change CV 1 (Primary Address) only.

Register Mode - Can change CVs 1,2,3,4,7,8 and 29 only.

Paged Mode - Uses a page register to indirectly modify any CV.

Direct Mode - Can directly change any CV.

Operations Mode Programming - Sometimes called 'Ops Mode' or 'Programming on the Main', this programming mode allows the CVs to be changed while the locomotive is operating on the layout even when other locomotives are present. The neat thing about this mode is that the CVs can be changed in the middle of operation allowing the engineer for example, to increase the momentum rate of a locomotive after it couples to a train. The main disadvantage of operations mode programming is that the CV data cannot be read back to verify its value.

Reading CVs

Certain command stations also allow you to read a CV during Service Mode Programming, which is useful to verify its current setting. If you have trouble reading or verifying CVs, the problem may be due to the design of your command station and not the decoder itself. Decoders communicate back to the command station using what's called an acknowledgment pulse, which is defined in NMRA RP-9.2.3 as "an increased load on the programming track of at least 60mA for at least 5ms." The decoder generates the acknowledgment pulse by momentarily applying power to the motor. You can often visually verify that the decoder is properly responding to your programmer by observing a slight twitch in the motor shaft when a read or write command is given.



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If your decoder is otherwise working properly (i.e., responds properly on the mainline to speed and direction commands) but your command station is having troubles reading CV data from the decoder, it may be due to incompatibilities between the electrical requirements of the decoder and the electrical characteristics of your programming track. In such an event, we suggest you simply go ahead and program the data into the CVs anyway. Usually the decoder will accept the data and function properly when placed back on the main track.

Finally, if you continue to experience difficulties, try a different programming mode. If your system supports it, the best way to program the CVs is Operations Mode, as it allows you to immediately see the results of your changes. It is important, however, to realize that not all programming modes will program all CVs. Additionally, the specific programming mode you use will depend upon the type of DCC system you are using. Some of the newer DCC systems can automatically select the proper programming mode so all you need to do is specify the CV number and its new value. On the other hand, some systems support only a few of the programming modes and may restrict which CVs you can program. If in doubt, refer to your DCC system's manual or contact the manufacturer to determine which methods they support.

Programming Procedure

As each DCC system is different, the procedure for programming a CV will vary depending upon the system. Unfortunately, we cannot provide detailed instructions to cover every command station and have to assume that you have some level of understanding regarding its capabilities and operating procedures. For specific programming procedures, please consult your DCC system manual.

Locking and Unlocking CVs

The CV Lock/Unlock is a relatively new feature available in some DCC decoders which allows you to program a decoder without the danger of overwriting the programming in another. This is especially useful in installations where multiple decoders are used. For example, if you have installed a function decoder in addition to the mobile decoder, you may wish to lock the CVs after programming to prevent accidentally programming one or the other.

To use the CV Lock feature implemented in CV 15 and 16, Bit 0 of CV 30 must first be set to 1 (the default value is 0). This is to avoid inadvertently locking the decoder when the CV Lock feature is not needed.

CV 15 and 16 are used for locking and unlocking the decoder. CV 15 is the Unlock Code and may be programmed to any value between 0 and 255 regardless of whether the decoder is locked or unlocked. CV 16 is the Lock Code and may be set to any value between 0 and 7 but only when the decoder is unlocked. Attempts to program CV 16 with a value greater than 7 will be ignored.



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The decoder is unlocked when the value in CV 15 matches the value in CV 16. Otherwise the decoder is locked and can not be programmed in either operations mode or service mode. Further, a locked decoder can not be reset to its factory defaults until it is first unlocked. These decoders are shipped from the factory with all CVs unlocked, that is, CV 15 and 16 are both set to 0.

☛ Note that if the decoder is unlocked, changing the value in CV 16 will instantly lock the decoder. You must then set CV 15 to the same value as was just programmed into CV 16 to unlock the decoder again.

If you decide to use the CV Locking feature for a multi-decoder installation, each decoder installed inside that locomotive must first have its Lock Code in CV 16 set prior to installation of any other decoders. Otherwise, all the decoders will have the same Lock Code and the feature will not work. The easiest way to go about this is to first install one decoder and program its Lock Code. Then install the next decoder and program its Lock Code. Since the first decoder is now locked it will be unaffected by the programming of the second decoder (unless you accidentally set the Lock Code of the two decoders to the same value. If this happens you will need to disconnect one decoder and start over). Continue in this manner until all decoders have been installed and their Lock Codes have been set.

It is a good idea to set up a standardized system so you don't forget the Lock Code settings. You might, for example, set all motor decoders to a CV Lock Value of 1, sound decoders to a value of 2 and function decoders to a value of 3. Keeping CV 15 set to 0 will guarantee the decoder stays locked until you are ready to begin programming.

Example: Let's say you will be installing a motor decoder, a sound decoder and a function decoder in one locomotive. Using the previously described system, you would first install the motor decoder and set its Lock Code by programming CV 16 to 1. Since CV 15 is currently set to 0 (the default value), the decoder is immediately locked. Now install the sound decoder and set its Lock Code by programming CV 16 to 2. Since CV 15 is still set to 0, this decoder is also immediately locked. Now install the function decoder and set its Lock Code by programming CV 16 to 3. At this point, all three decoders are installed and locked. Starting with the motor decoder, set CV 15 (the Unlock Code) to 1 to unlock and program the motor decoder. When you are finished set CV 15 to 2 and program the sound decoder. Finally, set CV 15 to 3 and program the function decoder. When you are done, set CV 15 back to 0 to lock all the decoders.

If You Forget the Lock Code

As there are only eight possible combinations, you can easily determine a forgotten Lock Code setting using trial and error with the following procedure:

Place the locomotive on the Programming Track and set CV 15 to 0. Then try to read the value in CV 16. If CV 16 does not read back, the decoder is locked. Set CV 15 to 1 and try reading CV 16 once more. Again, if CV 16 does not read back, the decoder is still locked. Program CV 15 to 2 and try



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reading CV 16 again. Continuing in the manner, you should eventually find the value stored in CV 16 as it can only be programmed between 0 and 7. If you have tried setting CV 15 to all eight values between 0 and 7 and the decoder still does not respond, there may be a problem with the installation, the program track or the decoder itself and further investigation will be required.

If you do not have access to a programming track with read-back capabilities (or are uncertain as to whether it is working properly) you can also use operations mode to discover the Lock Code by alternately programming CV 15 and setting another CV to a value where there is a known response.

Troubleshooting Tip

Be aware that even if you are not planning to use the CV Lock feature, it can still be accidentally activated by inadvertently programming CV 15 or 16 with a non-default value. If you have a decoder that is otherwise working (i.e. responding to throttle and function commands) but has suddenly stopped accepting CV changes, then first run through the procedure under *“If you Forget the Lock Code”* to determine if the decoder has been locked.

Resetting the CVs or Starting Over

Occasionally, something goes wrong and the decoder will not respond as expected. Usually, this is caused by one or more CVs being programmed to the wrong value. The CVs can be quickly reset to their factory default values using the following procedure.

1. Program CV 30 to 2 (or CV 8 to 8) using either Service Mode or Operations Mode
2. Place locomotive on a powered section of track. If locomotive is already on the mainline, cycle power to the decoder by turning power to the track off and then back on.
3. After power is restored to the track there should be no indication of activity other than the power LED turning on for a period of six seconds.
4. Once the six-second period has elapsed, the headlight and backup light will blink 16 times indicating that the CVs were successfully reset.
5. The decoder should now respond to short address 3 just as it did when it was first unpacked.
6. If you cannot get the decoder to reset, check to see that it has not been inadvertently locked (see *“If You Forget the Lock Code”* in the previous section).



Basic Programming

Step 1: Configuring the Address

The first group of CVs you will want to change are those that set your Mobile decoder's address:

CV 1, Primary Address
CV 17:18, Extended Address

The decoder may be set up to recognize either the primary address (also called the short address), which provides a range of 1 to 127 or the extended (long) address, which has a range of 0001 to 9999! Whether you use the primary or extended address will first depend on whether or not your DCC system uses extended addressing (not all of them do - if in doubt, see your command station owner's manual.) Second, it will depend on your preferences and the numbering scheme you use for setting your decoder addresses. The extended address has the advantage that you can use all four digits of a locomotive's road number for the decoder address making it easy to remember. Be aware that some DCC systems do not support the full range of available addresses.

Primary Address

To use the primary address, simply set CV 1 to the desired address between 1 and 127.

Programming Notes: Both the primary and extended address may be changed at any time using service mode.

Some DCC systems will also allow the decoder address to be modified using operations mode programming (consult your system manual for details). Please note that when programming in operations mode, the following restrictions apply:

If the decoder's primary address is enabled (i.e., CV 29, bit 5 is 0), only the extended address may be changed using operations mode programming.

If the decoder's extended address is enabled (i.e., CV 29, bit 5 is 1), only the primary address may be changed using operations mode programming.

Extended Address

The extended address is actually made up of two CVs, 17 and 18. Unless you are an experienced user, you should not try to program these CVs



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individually as a specific protocol is required in order for the decoder to accept the new data (See the Technical Reference for details). Since most command stations that support extended addressing will automatically generate the correct protocol, simply follow their instructions for setting the extended address.

Once the extended address is stored in CV 17 and 18, bit 5 of CV 29 must be set to 1 so the decoder will recognize the extended address format. Otherwise, the decoder will continue to respond only to its primary address. See the next section, Configuring the Decoder.



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Step 2: Configuring the Decoder

The next CV you will want to change is **CV 29, Decoder Configuration Byte**. CV 29 is one of those complicated bit variables mentioned earlier and is used in conjunction with other CVs to set a multitude of decoder characteristics including Locomotive Direction, Speed Step Mode Selection, Speed Table Enable and Alternate Power Mode Enable.

Bit 7							Bit 0
0	0	EAM	STE	ACK	APS	F0	DIR

Locomotive Direction - Causes the decoder to invert direction commands so that the locomotive runs in reverse when it receives a command to move forward and vice-versa. This operating mode is most useful for setting up diesel engines that ran with the long hood section forward. However, it is also useful for electronically correcting installations where the motor wires were accidentally reversed and avoids tearing apart the locomotive a second time.

Speed Step Mode Selection - As it is a digital system, your decoder splits the throttle voltage over its minimum and maximum range into discrete speed steps. The decoder can be configured so there are 14, 28 or 128 individual speed steps. The largest number of steps will give the smoothest throttle response. Since not all DCC systems have the ability to control 28 or 128 speed steps, your choice will depend upon the technical capabilities of your command station.

Speed Table - Sets the decoder to use the speed table specified by CV 25 (see “Configuring the Throttle”, page 17).

Primary or Extended Address - Sets the decoder to recognize its primary address in CV 1 or extended address in CV 17:18 (see “Configuring the Address”, page 13).

Alternate (Analog) Power Mode - Enables the decoder to work with an alternate power mode (such as DC operation) as set by CV 12 when a DCC signal is not present. This feature is only found in the MC2 and MC3 series of mobile decoders.

To assist the novice user, we have created Table A on the next page that lists the correct value for CV 29 to get the desired operating modes.

To use the table, simply find the row that has the modes you want and program CV 29 with the listed value.

The advanced user should refer to the Technical Reference for more details. Remember, table values are in decimal. If your command station uses Hex (Hexadecimal), you will need to convert the value shown using Appendix A.



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Table A. Quick-Reference Table for CV 29 Values					
Address Type	Use Speed Tables?	Analog Mode?	Speed Steps	Locomotive Direction	CV 29 Value
Primary (CV1)	No	No	14	Normal	0
Primary (CV1)	No	No	14	Reversed	1
Primary (CV1)	No	No	28/128	Normal	2
Primary (CV1)	No	No	28/128	Reversed	3
Primary (CV1)	No	Yes	14	Normal	4
Primary (CV1)	No	Yes	14	Reversed	5
Primary (CV1)	No	Yes	28/128	Normal	6
Primary (CV1)	No	Yes	28/128	Reversed	7
Primary (CV1)	Yes	No	14	Normal	16
Primary (CV1)	Yes	No	14	Reversed	17
Primary (CV1)	Yes	No	28/128	Normal	18
Primary (CV1)	Yes	No	28/128	Reversed	19
Primary (CV1)	Yes	Yes	14	Normal	20
Primary (CV1)	Yes	Yes	14	Reversed	21
Primary (CV1)	Yes	Yes	28/128	Normal	22
Primary (CV1)	Yes	Yes	28/128	Reversed	23
Extended (CV17:18)	No	No	14	Normal	32
Extended (CV17:18)	No	No	14	Reversed	33
Extended (CV17:18)	No	No	28/128	Normal	34
Extended (CV17:18)	No	No	28/128	Reversed	35
Extended (CV17:18)	No	Yes	14	Normal	36
Extended (CV17:18)	No	Yes	14	Reversed	37
Extended (CV17:18)	No	Yes	28/128	Normal	38
Extended (CV17:18)	No	Yes	28/128	Reversed	39
Extended (CV17:18)	Yes	No	14	Normal	48
Extended (CV17:18)	Yes	No	14	Reversed	49
Extended (CV17:18)	Yes	No	28/128	Normal	50
Extended (CV17:18)	Yes	No	28/128	Reversed	51
Extended (CV17:18)	Yes	Yes	14	Normal	52
Extended (CV17:18)	Yes	Yes	14	Reversed	53
Extended (CV17:18)	Yes	Yes	28/128	Normal	54
Extended (CV17:18)	Yes	Yes	28/128	Reversed	55



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Step 3: Configuring the Throttle

There are seven CVs that characterize the Mobile decoder's throttle response and 28 more used to create a custom speed table:

- CV 2, VStart
- CV 3, Acceleration Rate
- CV 4, Braking Rate
- CV 25, Speed Table Select
- CV 29, Configuration Data
- CV 66, Forward Trim
- CV 95, Reverse Trim
- CV 67-94, Loadable Speed Table

This may sound like a lot of CVs but don't worry; it's not necessary to change all of them if you don't want to. We've already talked about speed step selection in CV 29 (Step 2).

Set the Start Voltage

Your decoder provides CV 2, Vstart, to set the starting voltage that is applied to the motor at Speed Step 1 and is used to compensate for inefficiencies in the locomotive's motor and driveline. CV 2 may be programmed with any value between 0 and 255 with each step in value being about 0.5% of the maximum available motor voltage. To calculate the value of CV 2, you can use the formula:

$$\text{CV 2} = 255 \times \frac{\text{Desired Starting Voltage}}{\text{Maximum Motor Voltage}}$$

If your DCC system supports Operations Mode Programming, an alternative method for setting Vstart is to turn your throttle to the first speed step and then use the operations mode programming feature to increase the value in CV 2 until the locomotive just begins to move.

Set the Acceleration and Braking Rates

Your decoder provides two CVs to simulate the momentum due to train weight. CV 3, Acceleration Rate, controls how fast the locomotive responds to increases in throttle settings and CV 4, Braking Rate, controls how fast the locomotive will respond to decreases in the throttle setting.

Both CVs can be programmed with any value between 0 and 255 with 255 corresponding to the slowest acceleration or braking rate. Lower settings yield a more responsive locomotive, which is useful for switching. When both CVs are set to 0, the locomotive will respond nearly instantly to any throttle changes. A setting of 255, on the other hand, will require several minutes for a locomotive to reach full speed from a standing stop!

If you are using 14 or 28 Speed Step modes, setting CV 3 and CV 4 to any



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value greater than 0 will also improve the decoder's throttle response. While it is accelerating or braking, The decoder interpolates between speed steps so in effect, your locomotive will respond as if it were being controlled with 128 speed steps. No more sudden lurching from one speed step to another!

Select the Speed Table

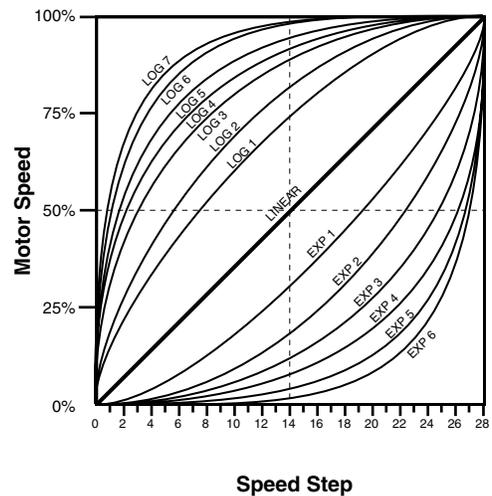
Your decoder provides 14 preset and one loadable speed table that can be used for several purposes:

1. Speed matching one locomotive to another.
2. Changing the feel of the throttle. For example, you could configure a switching locomotive so there are more speed steps available at lower speeds for switching and fewer steps at high speeds where the locomotive is seldom operated.
3. Compensating for an improperly designed driveline so the locomotive will operate within its prototypical speed range.

Preset Speed Tables

CV 25, Speed Table Select, is used to select which speed curve will be used by the decoder. CV 25 may be programmed with any value between 2 and 15 to select one of the preset speed curves shown in Table B, below.

Table B. Speed Table Selection	
CV 25	Speed Curve Type
2	Straight Line
3	Logarithmic Curve 1
4	Logarithmic Curve 2
5	Logarithmic Curve 3
6	Logarithmic Curve 4
7	Logarithmic Curve 5
8	Logarithmic Curve 6
9	Logarithmic Curve 7
10	Exponential Curve 1
11	Exponential Curve 2
12	Exponential Curve 3
13	Exponential Curve 4
14	Exponential Curve 5
15	Exponential Curve 6
16	User Loadable Speed Table



The exact throttle response for each curve is shown graphically. The logarithmic curve provides a rapid throttle response at low speeds, while the exponential curve provides a rapid throttle response at higher speeds.



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In order for the speed table selection in CV 25 to take effect, bit 4 of CV 29 must be set to 1. Refer to the previous section “Configuring the Decoder” or the Technical Reference to determine the correct value for CV 29.

Set the User Loadable Speed Curve

The User Loadable Speed Table allows you to create virtually any throttle response curve you can imagine. You will first need to design and program the Loadable Speed Table. The Loadable Speed Table consists of 28 data points contained in CVs 67 through 94, each defining the percentage of motor voltage applied at a given speed step. Each data point can contain a value of 0 to 255 corresponding to 0 to 100% of available motor voltage.

In 28 speed-step mode, each data point directly corresponds to a speed step. In 128 speed-step mode, each data point corresponds to every four and a half speed steps. The motor voltage for intermediate steps is interpolated by the decoder to produce a smooth curve. In 14 speed-step mode, alternate (odd numbered) data points correspond to speed steps 1-14. Important: all 28 data points must be programmed even for 14 speed-step mode or an unpredictable throttle response may occur while accelerating or braking.

To create a speed curve, begin by assuming that the decoder will be operated in 28-speed step mode. Don't worry if you are using another mode - your decoder will automatically take care of the translation between modes.

1. Start by making a table containing 28 entries - one entry for each speed step.
2. For each entry, record the desired throttle response as a percentage of full speed, i.e., 0 to 100%.

CV#	Speed Step	% Full Speed	CV Value
67	1	4	9
68	2	7	18
69	3	11	27
70	4	14	36
71	5	18	45
72	6	22	55
73	7	25	64
74	8	39	73
75	9	32	82
76	10	36	91
77	11	39	100
78	12	43	109
79	13	46	118
80	14	50	127
81	15	54	137
82	16	57	146
83	17	61	155
84	18	64	164
85	19	67	173
86	20	71	182
87	21	75	191
88	22	78	200
89	23	82	209
90	24	86	219
91	25	89	228
92	26	93	237
93	27	96	246
94	28	100	255



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3. Compute and record the CV value for each step using the following formula:

$$\text{CV Value} = 255 \times \frac{\text{Percentage of Full Speed (from Step 2)}}{100}$$

4. Program CV 67 with the value computed in step 3 for the first data entry (Speed Step 1).
5. Program CV 68 with the value computed in step 3 for the second data entry (Speed Step 2).
6. Repeat step 5 for each of the remaining 26 CVs from CV 69 to CV 94 until they have been programmed with their respective values.
7. Set CV 25 to 16 to select the user loadable speed table.
8. Set bit 4 of CV 29 to 1 to enable speed table use. Refer back to the previous section "Configuring the Decoder" to determine the correct value for CV 29.

Table C may be followed as an example and lists the CV values for a straight-line response.

Adjust the Forward and Reverse Trim

Your Mobile Decoder provides two CVs for adjusting or 'trimming' the forward and reverse speeds.

CV 66, Forward Trim
CV 95, Reverse Trim

These CVs multiply all data points in the speed tables by a factor of $n/128$ (n is the CV value) allowing the overall speed curve to be adjusted up or down without reloading all 28 data points again. These CVs will not have any effect when the speed tables are disabled (i.e., CV 29, bit 4 = 0)

These CVs may contain any value between 0 and 255. Trim values between 129 and 255 will increase speed curve values between 100% and 200% in approximately 1% steps. Trim values between 1 and 127 will decrease speed curve values between 1% and 99%. A value of 128 yields a scaling factor of 1.0 and has no effect on the speed curve.

Using different values for the forward and reverse trim will yield different forward and reverse speeds.



Basic Programming

Step 4: Configuring for Consist Operation

The decoder supports advanced consist operations, which use five related CVs:

- CV 19, Consist Address
- CV 21, Consist Function Control 1
- CV 22, Consist Function Control 2
- CV 23, Consist Acceleration Rate
- CV 24, Consist Braking Rate

Consists Explained

A consist is a group of locomotives that are set up to respond to throttle commands as a single unit. Consists make it easy for one operator to run a double headed steam train or a multi-unit diesel lash-up for example. The consist CVs allow the decoder to recognize a new address assigned to the consist without changing its primary or extended addresses. Additionally, they allow each locomotive in the consist to be run as a single unit but with different function properties allowing for example, only the lead engine's headlight to turn on.

Consist Address

Each locomotive in the consist is assigned the same consist address by programming CV 19 with the consist address between 1 and 127. If a locomotive is facing backwards in the consist (common in diesel operations), it should be programmed with the same consist address plus 128. If the forward facing locomotives are set to consist address 60 for example, the backwards engine must be set to $60+128 = 188$. Failure to do this will turn the consist into an angry pushme-pullyou as all locomotives will try to move forward from the perspective of their own cab and a few pulled couplers might result!

To deactivate the consist address and restore normal operation, CV 19 must be reprogrammed to 0.

Note that when the consist address is set, the decoder will continue to respond to instructions sent to its primary or extended address except for speed and direction data.

The decoder will not respond to operations mode programming commands sent to its consist address. These commands must always be used with the primary or extended address.

Consist Function Enable

CV 21 and 22 allow you to define how each engine individually responds to function commands sent to the consist address. When the consist is enabled, CV 21 controls which of functions 1-8 are active and CV 22 controls the F0 function for forward (F0(f)) and reverse (F0(r)), as well as functions 9-12.



Basic Programming

CV 21 and 22 take effect only when the consist address is set. When function commands are used with the decoder's primary or extended address, all functions will continue to work regardless of the settings of CV 21 and 22.

Use Table D to calculate the correct value for CV 21, and Table E to calculate the correct value for CV 22. Begin by looking at Table D and determining which functions you want active in the consist and circle the number below it. When you are done, add up all the circled numbers in the row and program the total into CV 21.

Table D. Consist Function Control 1								
CV#	F1	F2	F3	F4	F5	F6	F7	F8
21	1	2	4	8	16	32	64	128

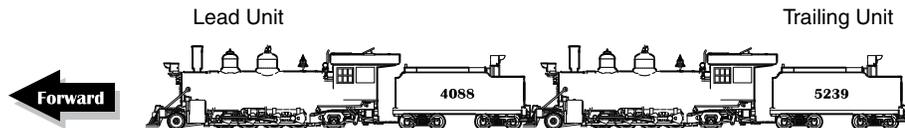
Now look at Table E and do the same: add up all the circled numbers in the row and program CV 22 with the sum.

Table E. Consist Function Control 2						
CV#	F0(f)	F0(r)	F9	F10	F11	F12
22	1	2	4	8	16	32

Note that each decoder in the consist will require a different set of values for CV 21 and 22 depending upon your requirements.

Consist Example:

Consider a double-header consisting of two engines, #4088 and #5239. Let's suppose we wish to operate these two engines as a single unit with consist address 40.



Engine Address	4088	5239
Direction	Normal	Normal
CV 19 (Consist Address)	40	40
CV 21	64	64
CV 22	17	18

You might want the braking effect (F11) and dimmer (F7) to work on both engines. However, you will likely want the headlight (F0(f)) to only work on the lead engine, #4088, and the backup light (F0 (r)) to work only on #5239.



Basic Programming

Engine 4088.

$$\text{CV 21} = 1 + 2 + 4 + 128 = 135$$

Then using Table E, determine the value for CV 22 by summing the values for F0(f) and F11:

$$\text{CV 22} = 1 + 16 = 17$$

Engine 5239.

$$\text{CV 21} = 128$$

Then using Table E, determine the value for CV 22 by summing the values for F0(r) and F11:

$$\text{CV 22} = 2 + 16 = 18$$

Consist Inertia Control

CVs 23 and 24 can be used to increase or decrease the locomotive's acceleration and braking response whenever it is part of a consist (i.e., CV 19 is programmed with a valid address).

CV 23 controls the consist acceleration rate and CV 24 controls the consist braking rate. When the consist address is active a new acceleration rate is calculated by adding the value in CV 23 to the baseline acceleration rate in CV 3. Similarly, a new braking rate is calculated by adding CV 24 to the baseline braking rate in CV 4. When the consist address is set to 0, CV 23 and 24 have no effect.

Both CV 23 and 24 may be set to any value between -127 and +127. A positive value will produce a slower throttle response while a negative value will result in a quicker throttle response.

If the sum of consist and baseline rate exceeds 255, then the final rate is set to the maximum value of 255. If the sum of consist and baseline rate is negative, then the final rate is set to the minimum value of 0.

To set a positive value, simply program the CV with the desired number between 0 and 127. To set a negative value, first change the sign of the value back to positive and then add 128. Thus, to set -5, program the CV with $5 + 128 = 133$. Note that a setting of 128 is the same as 0 and has no effect.



Basic Programming

Step 5: Function Mapping

Function Mapping Explained

Function mapping allows the decoder to be reconfigured so that function outputs can respond to a different function key input. This is especially useful for users who have throttles with less than six function keys as now they can pick and choose what effects they can control instead of being restricted to an arbitrary assignment.

There are 14 function mapping CVs - twelve CVs, 35-46 are used to assign output control to function keys 1 through 12 respectively.

The other two CVs, 33 and 34 are both for the F0 function. CV 33 controls which outputs are on when F0 is on and the locomotive is moving forward. CV 34 controls which outputs are on when F0 is on and the locomotive is moving in reverse. If the same output is selected in both CV 33 and CV 34, that function will turn on when the F0 function is on regardless of locomotive direction.

Not all keys can control all outputs or effects. The table below shows which functions can be mapped to which outputs. Note that a function key can be set up to control more than one output.

Function Mapping Table																		
Function Key	Control CV	Headlight	Backup Light	Xing Logic	RESERVED	Dimmer	RESERVED	RESERVED	Brakes	RESERVED								
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	64	128			
F8	42							1	2	4	8	16	32	64	128			
F9	43							1	2	4	8	16	32	64	128			
F10	44								1	2	4	8	16	32	64	128		
F11	45									1	2	4	8	16	32	64	128	
F12	46										1	2	4	8	16	32	64	128

Bold Numbers indicate default settings.



Basic Programming

An output can be also be controlled by more than one function key. In the second case, if an output is mapped to two function keys, either key will turn that output on, however, the output will not turn off until both function keys have been turned off.

To determine the correct CV value,

1. Find the column in the Function-Mapping Table corresponding to the function or sound effect output you wish to control.
2. Next locate the row corresponding to the function key you wish to use for controlling the selected output.
3. Note the number located in the box at the intersection of the row and column you have selected.
4. Program the CV listed in the row chosen in step 2 with the value found in step 3.



Basic Programming

Step 6: Configuring the Lighting Outputs

SoundTraxx Mobile decoders have up to four function outputs used for controlling the locomotive lights.

Each can be set for a variety of effects or as simple on/off lights. In addition, you can use the Grade Crossing Logic to automatically activate the selected lighting effect when you activate function 2.

There are six CVs for customizing the lighting effects:

- CV 49, Headlight Configuration
- CV 50, Backup Light Configuration
- CV 59, Lighting Effect Flash Rate
- CV 60, Grade Crossing Effect Hold Time.

Setting the Hyperlight Effects

Each lighting output has a corresponding CV that determines its operating characteristics:

Bit 7				Bit 0			
LED	R17	XING	PHSE	HYPERLIGHT SELECTION			

Hyperlight Select - Each output can be programmed to one of several Hyperlight™ Lighting Effects as listed in Table G. Most effects are self-descriptive and primarily warning beacons used for diesel locomotives. Some effects, such as the Mars Light, were used in some steam engines as well.

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 is on.

Mars Light - This effect simulates the sweeping figure-8 pattern of this popular warning beacon.

Pyle National Gyalite - The Gyalite is similar to the Mars Light, but generates a slow, wide, oval headlight sweep pattern.

Dual Oscillating Headlights - Similar in appearance to the common twin-sealed-beam headlight, the oscillating headlight uses a moving reflector to sweep the headlight beam in a tight circular motion.

Single and Dual Strobes - The Strobe effects simulate the white-hot burst of light associated with the Xenon Strobe.



Basic Programming

Western-Cullen D312 Rotary Beacon - This effect provides a spectacular rendition of the revolving reflector and bulb assembly of the prototype warning beacon found atop many diesels of the 60's and 70's.

Prime Stratolite - The Stratolite was a newer version of the rotary beacon, with the prototype consisting of a revolving reflector with four individual lamps arranged in a circular pattern which are electronically flashed in a clockwise sequence. The Stratolite flashes in a rather mechanical 'stepped' fashion, as opposed to the smooth motion of the Rotary Beacon.

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.

Exhaust Flicker - This effect produces a random flicker whose intensity increases with locomotive speed. This effect is best used by placing a red/orange LED in the firebox or in the smokestack. As the locomotive increases speed, it will glow brighter, imitating an increase in sparks and exhaust gases.

Firebox Flicker - This effect produces a random flicker whose intensity resembles a burning fire and can be used with a lamp placed in the firebox area. The effect is improved when two lights are used, one yellow and one red or orange and each connected to a separate function output.

Dyno-Light - This effect for steam locomotives synchronizes the lamp brightness to the "output" of the dynamo such that the lamp brightness gradually increases as the dynamo builds up speed.

Phase Select - 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.

Grade Crossing Logic - Causes the lighting effect to become active only when function 2 has been activated (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, Dyno-Light, FRED, exhaust flicker, and firebox flicker effects will not be affected. The other effects will either turn off (stobes and beacons) or revert to a steady on state (mars light, ditch lights, etc.) as appropriate to prototype practice.

Rule 17 Headlight Operation - Converts the headlight and backup light to independent, non-directional functions. When enabled, the headlight is controlled as if it were FX5, Function 5 and the backup light as FX6, Function 6.



Basic Programming

LED Compensation Mode - SoundTraxx Mobile Decoder's lighting effects can be used with either incandescent bulbs or LEDs. However, because of their differences in brightness characteristics, some lighting effects will appear less life-like when initially set up with an LED. To correct this, the LED compensation mode should be enabled which will improve the contrast of the lighting effect by automatically adjusting the function output level to correct for the different brightness characteristics of an LED.

To set the Hyperlight configuration CVs, proceed as follows:

1. First find the CV value in Table G on the next page for the desired lighting effect and operating mode.
2. If you wish to enable Rule 17 Mode, add 64 to the table value shown, otherwise, proceed to Step 3.
3. If you're using incandescent bulbs, skip to Step 4. If you are using LEDs, enable the LED Compensation Mode by adding 128 to the sum computed in Step 2.
4. Program the sum computed in Step 3 into the CV corresponding to the appropriate function output. Use CV 49 to set the headlight, CV 50 for the backup light.

Setting the Flash Rate and Hold Time

CV 59 is used to adjust the flash rate of the Hyperlight effect and has a range of 0-15 with 15 being the slowest flash rate. When the Grade Crossing Logic feature is enabled, CV 60 is used to adjust the length of time (in seconds) an effect will remain active after the whistle key is released. CV 60 can be programmed with any value between 0 and 15.

Example, Mars Light with Grade Crossing Logic

In this example, we will configure the headlight output for use with an incandescent bulb as a Mars Light with Grade Crossing Logic enabled. Following the steps outlined above, we proceed as follows:

1. We first look up the initial CV value in Table G for a Mars Light under the column labeled 'Crossing Logic On' and find it is 34 for Phase A and 50 for Phase B. Since we are only setting up one light, we do not care about the Phase and choose the value for Phase A, 34.
2. Since we are not using Rule 17, we skip to Step 3.
3. Since we are not using LEDs, we skip to Step 4.
4. CV 49 (Headlight Configuration) is programmed with the value found in Step 1 or 34.

Lastly, we need to set the grade crossing hold time to about six seconds by programming CV 60 to 6.



Basic Programming

Table G. Hyperlight Control Mode Settings				
Effect Type	CV Value			
	Crossing Logic Off		Crossing Logic On	
	Phase A	Phase B	Phase A	Phase B
On-off	0	16	32	48
Dimmable	1	17	33	49
Mars Light	2	18	34	50
Gyalite	3	19	35	51
Oscillating Headlight	4	20	36	52
Single Flash Strobe	5	21	37	53
Double Flash Strobe	6	22	38	54
D312 Rotary Beacon	7	23	39	55
Prime Stratolite	8	24	40	56
Type I Ditch Light	9	25	41	57
Type II Ditch Light	10	26	42	58
FRED	11	27	43	59
Exhaust Flicker	12	28	44	60
Firebox Flicker	13	29	45	61
Reserved				
Dyno-Light	15	31	47	63



Advanced Programming

Step 7: Setting Up the Hyperdrive

SoundTraxx Mobile Decoder's Hyperdrive system features high-frequency PWM drive for silent motor control along with load compensation (or back-emf) to improve low speed operation and maintain constant speed regardless of changes to the motor load.

The PWM frequency is fixed at 22.000Khz and there are no adjustments.

Tsunami uses back EMF and a PI control loop to sense and control motor speed. There are four CVs associated with the load compensation feature:

- CV 10, Back EMF Cutout
- CV 209, Kp Coefficient
- CV 210, Ki Coefficient
- CV 212, BEMF Feedback Intensity

Control Loop Coefficients

Your decoder compensates for load changes by comparing the locomotive's speed, as measured by the motor's back-emf voltage, with the current throttle setting. When a difference is detected, the motor voltage is adjusted up or down so that locomotive speed stays constant. This is done using a P-I (proportional-integral) control loop that is tuned using two CVs:

CV 209, Kp, controls the Proportional gain of the control loop and compensates for dynamic changes in the motor load by applying a correction based on the difference between the throttle setting and the current motor speed. This CV may be set between 1 and 255. Higher values produce an increasing level of compensation. However, setting this value too high can lead to irregular and rough performance.

CV 210, Ki, controls the Integral gain of the control loop and compensates for static motor load by applying a correction based on the historical (or integral) difference between the throttle setting and the current motor speed. This CV may be set between 0 and 255. Higher values produce an increasing level of compensation and set the 'snappiness' of the control loop. However, setting this CV value too high can lead to oscillations in locomotive speed and we suggest you use the lowest possible setting that still provides optimal performance.

Note: Setting both Kp and Ki to zero will cause the motor to stop.



Advanced Programming

Strategy for CV Optimization

Finding the right combination of CV settings requires a certain amount of experimentation and patience to get the best performance. Be aware that these settings will also vary from one locomotive to another. Take notes of your CV settings so you can use them as starting points when configuring other locomotives.

Overdoing a particular setting can actually degrade performance so changes should be made in small increments (+/- 10 or so) until the desired performance is attained. The default settings should provide satisfactory performance when used with most HO and N scale motors.

We suggest the following procedure to help fine tune the CV settings:

1. Begin with each CV set to its default value: CV 10 = 0, CV 209 = 25, CV 210 = 20, and CV 212 = 255. In addition, set CV 2 (Vstart) to 0.
2. With the locomotive on level track, set the throttle to around speed step 20.
3. Adjust the value in CV 209 (Kp) with increasingly higher values just until you begin to notice some jerkiness in the locomotive speed. Reduce the setting in CV 209 to the value just before the jerkiness started.
4. Adjust the value in CV 210 (Ki) with increasingly higher values until you begin to notice some oscillation in the locomotive speed whenever the throttle setting is changed. Reduce the setting in CV 210 to the value just before the oscillation started.

Note: When using load compensation, it is unnecessary to set large values into CV 2 (Start Voltage). This is because the load compensation algorithm will automatically adjust the motor power up to reach desired throttle setting. Therefore CV 2 can usually be set to 0 when load compensation is enabled.

Setting the Load Compensation Curve

Your decoder provides two degrees of freedom for controlling the amount of load compensation applied to the motor over the throttle range using CV 10, Back-Emf Cutout and CV 212, Back-Emf Feedback Intensity.

CV 212 sets the amount of load compensation that is initially applied to the motor and may be set anywhere between 0 and 255. A value of 0 disables load compensation altogether while a value of 255 corresponds to full (100%) compensation.

CV 10, Back-Emf Cutout, determines the degree by which the load compensation is reduced as the throttle speed is increased.

When CV 10 is set to 0, the amount of load compensation set by CV 212 is constant over the entire speed range. Setting CV 10 between 1 and 127 will determine the speed step at which the load compensation is reduced to zero as illustrated in the graph on the next page.

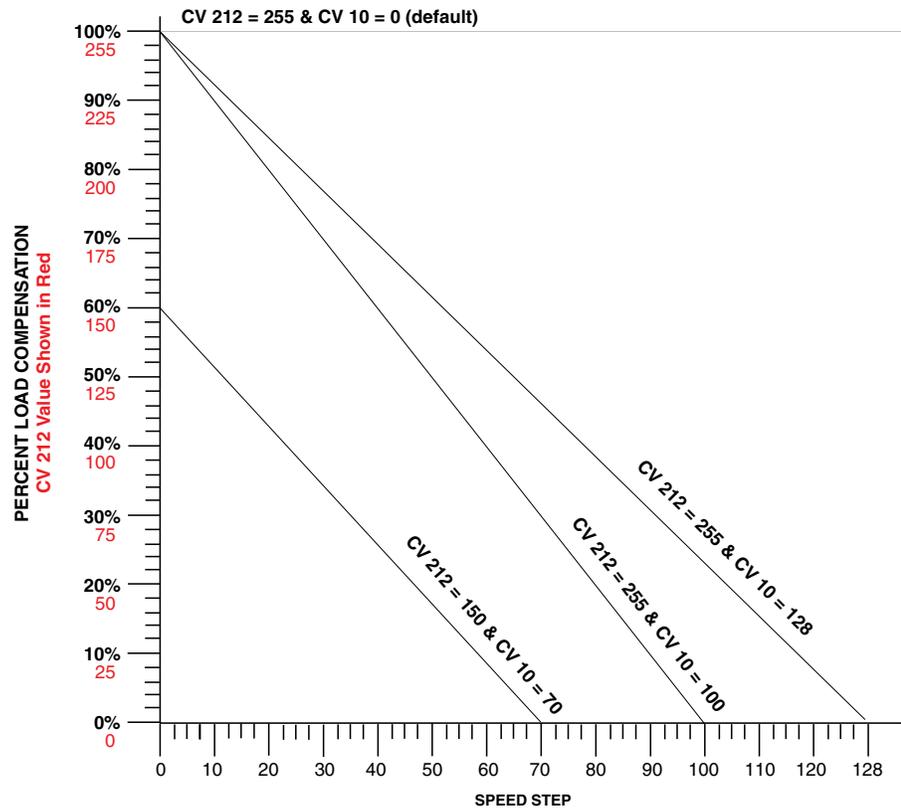
Setting CV 10 between 128 and 255 selects a partial reduction of load



Advanced Programming

compensation at full speed such that the minimum load compensation level at speed step 128 is:

$$\text{Full Speed Load Compensation} = \frac{\text{(CV 10 - 128)}}{128}$$

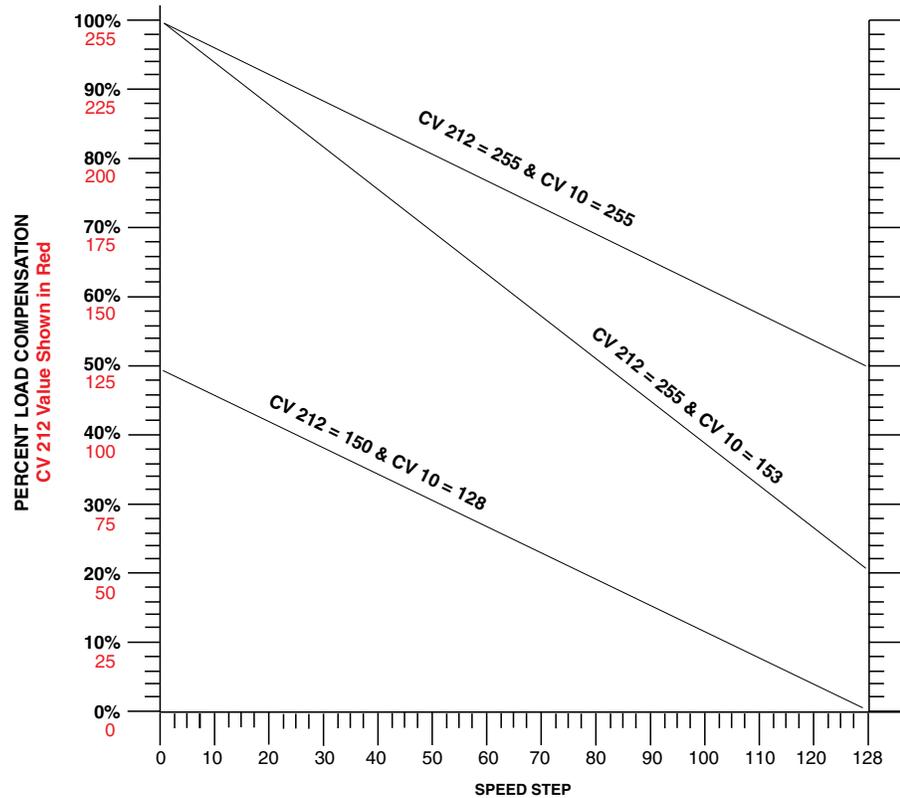


In general, you will want full load compensation at low speeds which gradually reduces to zero load compensation at full throttle and may be achieved by setting CV 10 to 126.

When operating in a consist, you may need to reduce the value in CV 212 which will reduce the low speed load compensation and avoid working the locomotives against each other due to slightly different running characteristics.



Advanced Programming



CV 216 Allows you to change the reference voltage for the back EMF to match the voltage that is found on your track. By matching the back EMF reference voltage of the decoder with your track voltage your locomotive will run smoother and more consistent. If you are planning on consisting the model with a SoundTraxx Tsunami decoder make sure this value is set to 160 (16 volts) so that the reference voltage is identical to your Tsunami decoder. To set this CV simply take the observed voltage on your track and multiply it by 10. For example 12.5 volts would be represented as 125.



Miscellaneous Features

Step 8: Floobydust - Configuring Mobile Decoder's Miscellaneous Features

F11 Train Brake

F11 can be used to slow your train down as if the brakes really are applied! To achieve this effect, you will need to first program some momentum into Tsunami using CV 3 and CV 4 to set the acceleration and braking rate respectively. The exact value is unimportant but should be large enough to produce a noticeable delay in the throttle response. A setting of 20 or so will do the trick. The reason for programming CV 3 (acceleration rate) is so the train does not immediately resume its old speed when the F11 function is released.

Next, program CV 61 (F11 Brake Rate) to adjust the rate at which the train will slow down when F11 is turned on. A value of 1 to 128 is added to the value programmed in CV 4 which has the effect of slowing the train more gradually than by simply turning the throttle down. Values of 129 thru 255 translate to -1 thru -127 which have the opposite effect as they subtracted from the setting in CV 4 and slow the train more aggressively than turning the throttle down (as a brake would be expected to do).

Be careful not to set F11 too high - if you do, the net braking rate will be zero and you will have effectively turned F11 into an emergency stop button!

Note that setting CV 61 to a value of 0 or 128 has no effect on the brake rate and basically disables this feature.



Troubleshooting

Troubleshooting

If you should have any difficulties with the operation of your SoundTraxx Mobile Decoder, first check this section for hints on trouble shooting. We have found that most problems are caused by an errant CV value and are easily corrected. When all else fails, try resetting the CV values back to their defaults (see the section 'Basic Programming') and try again.

Locomotive doesn't run but was working

Address has been accidentally changed.

Consist address (CV 19) was accidentally set.

CV 29 has been changed to select other address.

Acceleration and braking CVs set to very high values.

Broken motor wire or track pickup wire.

Tip: Check the decoder's Pilot Light to confirm presence of track power.

Locomotive never ran

See all the above.

Decoder wired incorrectly.

Locomotive runs in a consist but lights don't work

Consist functions are disabled. Set CV 21 and 22 to activate desired functions (see Step 4, 'Configuring for Consist Operation').

Lights flicker on and off

Decoder is in 14 speed step mode and command station is set to 28 speed steps.

Lights do not work

Decoder is in 28/128 speed step mode and command station is set to 14 speed steps.

Function mapping is improperly set.

Burned out light bulbs.

If using 1.5 volt micro-bulbs, resistor value is too large.

Broken lamp wires.

If you are still having difficulties, contact our customer service department for guidance.

SoundTraxx Service Department
210 Rock Point Drive
Durango, CO 81301
Telephone (970) 259-0690
Fax (970) 259-0691
Email: support@soundtraxx.com



Appendix A

Decimal-Hex-Binary Conversion Table

DECIMAL	HEX	BINARY (76543210)									
0	00	00000000	64	40	01000000	128	80	10000000	192	C0	11000000
1	01	00000001	65	41	01000001	129	81	10000001	193	C1	11000001
2	02	00000010	66	42	01000010	130	82	10000010	194	C2	11000010
3	03	00000011	67	43	01000011	131	83	10000011	195	C3	11000011
4	04	00000100	68	44	01000100	132	84	10000100	196	C4	11000100
5	05	00000101	69	45	01000101	133	85	10000101	197	C5	11000101
6	06	00000110	70	46	01000110	134	86	10000110	198	C6	11000110
7	07	00000111	71	47	01000111	135	87	10000111	199	C7	11000111
8	08	00001000	72	48	01001000	136	88	10001000	200	C8	11001000
9	09	00001001	73	49	01001001	137	89	10001001	201	C9	11001001
10	0A	00001010	74	4A	01001010	138	8A	10001010	202	CA	11001010
11	0B	00001011	75	4B	01001011	139	8B	10001011	203	CB	11001011
12	0C	00001100	76	4C	01001100	140	8C	10001100	204	CC	11001100
13	0D	00001101	77	4D	01001101	141	8D	10001101	205	CD	11001101
14	0E	00001110	78	4E	01001110	142	8E	10001110	206	CE	11001110
15	0F	00001111	79	4F	01001111	143	8F	10001111	207	CF	11001111
16	10	00010000	80	50	01010000	144	90	10010000	208	D0	11010000
17	11	00010001	81	51	01010001	145	91	10010001	209	D1	11010001
18	12	00010010	82	52	01010010	146	92	10010010	210	D2	11010010
19	13	00010011	83	53	01010011	147	93	10010011	211	D3	11010011
20	14	00010100	84	54	01010100	148	94	10010100	212	D4	11010100
21	15	00010101	85	55	01010101	149	95	10010101	213	D5	11010101
22	16	00010110	86	56	01010110	150	96	10010110	214	D6	11010110
23	17	00010111	87	57	01010111	151	97	10010111	215	D7	11010111
24	18	00011000	88	58	01011000	152	98	10011000	216	D8	11011000
25	19	00011001	89	59	01011001	153	99	10011001	217	D9	11011001
26	1A	00011010	90	5A	01011010	154	9A	10011010	218	DA	11011010
27	1B	00011011	91	5B	01011011	155	9B	10011011	219	DB	11011011
28	1C	00011100	92	5C	01011100	156	9C	10011100	220	DC	11011100
29	1D	00011101	93	5D	01011101	157	9D	10011101	221	DD	11011101
30	1E	00011110	94	5E	01011110	158	9E	10011110	222	DE	11011110
31	1F	00011111	95	5F	01011111	159	9F	10011111	223	DF	11011111
32	20	00100000	96	60	01100000	160	A0	10100000	224	E0	11100000
33	21	00100001	97	61	01100001	161	A1	10100001	225	E1	11100001
34	22	00100010	98	62	01100010	162	A2	10100010	226	E2	11100010
35	23	00100011	99	63	01100011	163	A3	10100011	227	E3	11100011
36	24	00100100	100	64	01100100	164	A4	10100100	228	E4	11100100
37	25	00100101	101	65	01100101	165	A5	10100101	229	E5	11100101
38	26	00100110	102	66	01100110	166	A6	10100110	230	E6	11100110
39	27	00100111	103	67	01100111	167	A7	10100111	231	E7	11100111
40	28	00101000	104	68	01101000	168	A8	10101000	232	E8	11101000
41	29	00101001	105	69	01101001	169	A9	10101001	233	E9	11101001
42	2A	00101010	106	6A	01101010	170	AA	10101010	234	EA	11101010
43	2B	00101011	107	6B	01101011	171	AB	10101011	235	EB	11101011
44	2C	00101100	108	6C	01101100	172	AC	10101100	236	EC	11101100
45	2D	00101101	109	6D	01101101	173	AD	10101101	237	ED	11101101
46	2E	00101110	110	6E	01101110	174	AE	10101110	238	EE	11101110
47	2F	00101111	111	6F	01101111	175	AF	10101111	239	EF	11101111
48	30	00110000	112	70	01110000	176	B0	10110000	240	F0	11110000
49	31	00110001	113	71	01110001	177	B1	10110001	241	F1	11110001
50	32	00110010	114	72	01110010	178	B2	10110010	242	F2	11110010
51	33	00110011	115	73	01110011	179	B3	10110011	243	F3	11110011
52	34	00110100	116	74	01110100	180	B4	10110100	244	F4	11110100
53	35	00110101	117	75	01110101	181	B5	10110101	245	F5	11110101
54	36	00110110	118	76	01110110	182	B6	10110110	246	F6	11110110
55	37	00110111	119	77	01110111	183	B7	10110111	247	F7	11110111
56	38	00111000	120	78	01111000	184	B8	10111000	248	F8	11111000
57	39	00111001	121	79	01111001	185	B9	10111001	249	F9	11111001
58	3A	00111010	122	7A	01111010	186	BA	10111010	250	FA	11111010
59	3B	00111011	123	7B	01111011	187	BB	10111011	251	FB	11111011
60	3C	00111100	124	7C	01111100	188	BC	10111100	252	FC	11111100
61	3D	00111101	125	7D	01111101	189	BD	10111101	253	FD	11111101
62	3E	00111110	126	7E	01111110	190	BE	10111110	254	FE	11111110
63	3F	00111111	127	7F	01111111	191	BF	10111111	255	FF	11111111



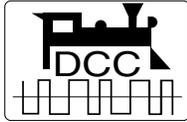
Appendix B

List of Configuration Variables (CVs)

The following is a quick reference list of CVs used by the mobile decoder. See the MC1 Technical Reference for detailed information about their uses.

CV 1	Primary Address Control
CV 2	Vstart
CV 3	Baseline Acceleration Rate
CV 4	Baseline Braking Rate
CV 7	Manufacturer Version ID (Read Only)
CV 8	Manufacturer ID
CV 10	BEMF Cutout
CV 11	Packet Time Out Value
CV 12	Power Source Conversion
CV 13	Analog Function Enable 1
CV 14	Analog Function Enable 2
CV 15	CV Unlock Register
CV 16	CV Lock ID Code
CV 17,18	Extended Address
CV 19	Consist Address
CV 21	Consist Function Group 1
CV 22	Consist Function Group 2
CV 23	Consist Acceleration Rate
CV 24	Consist Braking Rate
CV 25	Speed Table Select Register
CV 29	Configuration Register 1
CV 30	Error Information/Alternate Mode Selection
CV 33	FL(f) Output Location
CV 34	FL(r) Output Location
CV 35	F1 Output Location
CV 36	F2 Output Location
CV 37	F3 Output Location
CV 38	F4 Output Location
CV 39	F5 Output Location
CV 40	F6 Output Location
CV 41	F7 Output Location
CV 42	F8 Output Location
CV 43	F9 Output Location
CV 44	F10 Output Location
CV 45	F11 Output Location
CV 46	F12 Output Location
CV 47	Analog Whistle Control
CV 49-52	Hyperlight Effect Select (for FL(f), FL(r), Function 5, 6)
CV 59	Flash Rate
CV 60	Crossing Hold Time
CV 62	Transponding Control
CV 63	Analog Mode Motor Start Voltage
CV 64	Analog Mode Max Motor Voltage
CV 66	Forward Trim
CV 67-94	Loadable Speed Table
CV 95	Reverse Trim
CV 105	User Identifier #1
CV 106	User Identifier #2
CV 209	Kp Coefficient
CV 210	Ki Coefficient
CV 212	Motor Control Intensity
CV 213	Motor Control Sample Period
CV 214	Motor Control Sample Aperture Time
CV 216	Motor Voltage Reference

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