Complete
Train
Control

Mobile & Sound Decoder Manual
Second Edition

Includes:
Digitrax Series 3, 4, 5 & 6
Mobile, Sound & Function Decoders

Digitrax, Inc.
2443 Transmitter Road
Panama City, Florida 32404
www.digitrax.com

Digitrax Mobile & Sound Decoder Manual Second Edition

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1.0 Introduction

Congratulations on your purchase of a Digitrax Digital Command Control Decoder for your locomotive. It is engineered to give you both exciting DCC and Digitrax Complete Train Control features at a reasonable price. Digitrax mobile decoders work with DCC compatible systems. Many Digitrax decoders also go beyond DCC compatibility to offer additional Complete Train Control features like sound, realistic FX^3 effects, analog mode conversion, speed stabilization, transponding and more.

Digitrax offers many decoders that are simple to install however, in some cases decoder installations are more challenging. Most model railroaders have the common sense, judgment and skills needed to successfully install decoders. It is important to carefully follow the directions included in this manual and in the decoder specific instruction sheets you receive with each decoder. If you choose to have someone else install decoders in your locomotives, your local Digitrax Authorized Dealer can handle the installation or can refer you to someone who can do the job for you.

Thank you for choosing Digitrax! Please feel free to contact us or your Digitrax Authorized Dealer with any questions or concerns you might have about our products. We are always looking for ways to make our products better so, let us know what you think!

2.0 Digitrax Mobile and Sound Decoder Overview

Digitrax mobile decoders are just one part of your Complete Train Control system. When properly installed in your locomotives, they will receive the commands sent from your command station through the rails, decode the commands and control the motor, function and, in some cases, sound operation of your locomotives.

Digitrax makes a wide variety of decoders with many different features. This lets you choose which decoder is best for each individual locomotive. All Digitrax decoders are robust, reliable and quiet running.

Digitrax builds economy decoders with fewer features, mid range decoders with more features and premium decoders with even more advanced features.

Visit our online Decoder Selector at www.digitrax.com/decoderselector for help selecting the decoder that will work best in your locomotive.

The Decoder Instruction Sheet included with your decoder lists the features of the decoder and includes specific information about how to install the decoder and any special uses of CVs in conjunction with the decoder. This Manual explains the features available in current production Series 3, 4,

5 and 6 Digitrax decoders. This Mobile Decoder Manual and all Decoder Instruction Sheets are available at www.digitrax.com. In addition, the first edition of the Digitrax Mobile Decoder Manual is available at www.digitrax. com for pre-Series 4 decoders that are no longer in production.

Specification sheets and Instruction Sheets for all Digitrax decoders past and present are available at www.digitrax.com

2.1 Digitrax Decoder Part Numbering System

Current production Digitrax mobile decoders use the following numbering/naming system:

All motor + function decoders begin with a "D" for digital decoder.

All sound + motor + function decoders begin with either SD or SDX:
SD is a standard sound decoder with 8-bit sound.
SDX is a premium sound decoder with 16-bit sound.

The next character indicates physical size.
This is based on the smallest "scale" the decoder is designed to fit. This will be a Z, N, H, O, or G.

The next character is the current rating.
This is 1, 2, 3, 4 or 5. We designate 1.25 & 1.5 amp decoders as 1 and 3.5 amp decoders as 3 for simplicity and as a conservative rating.

The next character is the number of function outputs, including directional lights.
This is not necessarily the number of function leads. In some cases, function output pads are provided so leads can be added to operate additional functions. Consult your decoder instruction sheet for the location and function output numbers associated with these output pads.

The next character is a Digitrax series designator.
Series 3, 4, 5 & 6 decoders are current production decoders. These have FX^3 function outputs, torque compensation, supersonic (silent operation), scaleable speed stabilization (Back EMF) and transponding.

Series 3 decoders with less than 6 functions have a modified set of features. See decoder descriptions for actual features available in each decoder.

Series 4 & 5 decoders have all the features of Series 3 plus support for sound on board or the ability to add sound using a SoundBug sound only decoder. Series 4 sound decoders are 3 voice, 8-bit sound/motor/function decoders.

Series 5 decoders are capable of hosting Sound Bug add-on sound decoders.

Series 6 decoders have optimized LED and lamp lighting algorithms, have improved scaleable speed stabilization (Back EMF), work with Digitrax Power Xtenders to improve performance in the presence of power interruptions and have configurable FX^3 pulse function on all function outputs. Sound equipped Series 6 decoders are available with 8 or 16 bit sound.

Additional letters and numbers at the end of the decoder number indicate the decoder's installation interface.
Manufacturer designations are followed by a design number, 0-9, and sub-design letter, a-z, when there is more than one version of a particular design. If the decoder number ends after the series number, then it is a wired decoder.

TABLE I: Digitrax Decoder Part Numbers For Installation Interfaces

Designation	Installation Interfaces
Blank or W	Wired or Digitrax 9 pin to wires
D	Digitrax 9 pin to wires
IP	Integrated DCC Medium Plug
IN	Integrated DCC 6 pin N-Scale Plug
P	DCC Medium Plug Long 3.25" wire harness
PS	DCC Medium Plug Short 1.25" (HO) or 2" (N) wire harness
S	Screw terminals provided for installation
T	Smaller version of regular scale size decoder-tiny
AT	Athearn No Solder Harness for Blue Box Installation (Discontinued Interface)

Designation	Manufacturer Specific Interfaces: Followed by additional designators for specific board types
K	Kato board replacement
A	Atlas board replacement
L	LifeLike/Walthers board replacement
I	InterMountain board replacement
M	MicroTrains
MK	Marklin board replacement
Q	QSI board replacement
Z	AZL board replacement
AR	Aristocraft G Scale Plug

Digitrax Decoder Numbering Examples:

DH163 is a series 3 wired decoder that fits HO scale, is rated for at least 1 amp & has 6 function outputs. This decoder is actually rated at 1.5 amps.

DH165A0 is a series 5 board replacement decoder that fits HO scale Atlas locomotives that use the version "0" board, is rated for at least 1 amp, has 6 function outputs and can host a sound only decoder.

SDXH166D is a Series 6 wired premium sound decoder that fits HO scale, is rated for at least 1 amp, and has 6 FX^3 function outputs.

Visit our online Decoder Selector at www.digitrax.com/decoderselector for help selecting the best decoder for your locomotive.

3.0 Decoder Installation

Each Digitrax decoder comes with an instruction sheet that shows you the specifics of how to install it in a locomotive. There are also additional installation application notes and installation videos available at www.digitrax.com/support. The following sections explain decoder installation in general.

3.1 Decoder Installation Basic Steps

1. Choose a locomotive that runs well on regular DC because adding a decoder will NOT improve mechanical operation.
2. Choose the appropriate decoder for your installation.
3. **READ** the instructions.
4. **PLAN** the installation.
5. Have the proper tools on hand.
6. Test the decoder before installation.
7. Carefully disassemble the loco without losing any parts.
8. **Isolate the motor!** Current to the motor from the pick ups should flow only through the decoder and NOT through the frame.
9. Follow the decoder's wiring diagram or installation instructions for installing motor, sound and function components.
10. Test the installation first on DC then on DCC.

3.2 Choosing a Locomotive

Choose a locomotive that runs well on conventional DC power. Digital decoders don't compensate for faulty motor operation, poor track pickup, or other problems with a locomotive's mechanical operation. If you are not happy with the way your locomotive runs on DC power, installing a decoder will not make it run any better.

If there are mechanical issues with your locomotive, fix them before you install the decoder. Since you have to open up the loco anyway, do a tune up before you install the decoder. Digitrax recommends using a conductive brush lubricant like Aero Car Technology's "Conducta" brush lubricant (aerocarlubricants.com) to minimize brush noise in all locos. Be sure the brushes are making reliable contact and that the commutator is clean.

Decide where the decoder will fit inside the loco. Is there space to put the decoder or will you need to "make room?" Is there a decoder made specifically for the loco? Digitrax offers a variety of decoder sizes, form factors and current ratings to accommodate almost any locomotive. Check the Decoder Selector at www.digitrax.com for a list of recommendations. If there is just nowhere in the locomotive to install a decoder, it can be installed in a piece of rolling stock that is wired to the loco for controlling the motor or you can run it on your Digitrax system as an analog locomotive on address "00."

3.3 Choosing The "Right" Decoder

3.3.1 The Digitrax On-Line Decoder Selector

The Digitrax On-line Decoder Selector is an on-line list of decoder recommendations for specific locomotives. Visit www.digitrax.com/decoderselector to use the Decoder Selector. The Decoder Selector is also part of the Digitrax Toolbox App for mobile devices. Most Digitrax Authorized Dealers can also help you determine which decoder will work best in your locomotive.

4 Steps To Choosing the Right Decoder for Your Loco
1. Is there a decoder made for your specific loco? Check the Decoder Selector at www.digitrax.com/decoderselector for specific decoder recommendations for specific locomotives. If so, you can skip steps 2 & 3.
2. What is the stall current of the motor in the locomotive?
3. How much room do you have available inside the loco?
4. Do you want a decoder that does motor and function control and would you like to add sound? If you are planning a sound installation, remember you'll need to have room for the speaker and sound hold up capacitor.

3.3.2 What Is Your Loco's Stall Current?

For HO locomotives, most modern high efficiency can motors draw less than 1/2 amp when running and less than 1 amp when stalled at 12V DC. These motors will use 1 amp & 1.5 amp decoders. Some older HO motor designs (older Athearn open frame motors, Pittman motors, etc.) may exceed these limits and will need a higher current decoder for better long term reliability. Most current production Digitrax decoders are rated for at least 1 amp, even if they

are designated as N or Z sized decoders. That means that our N & Z decoders are suitable for use in HO locomotives where space is tight.

For N & Z scale locomotives most modern high efficiency can motors draw less than 1/2 amp when running and less than 1 amp when stalled at 12V DC. However, we have found that many high performance N-scale locos actually draw more than this and are comparable to HO locos. To ensure long-term reliability, all current production Digitrax decoders are rated at 1 amp or more.

For large scale locomotives, it is particularly important to test the specific loco you will use to determine the appropriate decoder to use. In many cases for O, S, O-27 & G scale Digitrax 3, 4, or 5 amp decoders will the best choice. If your installation has 2 or more motors, you will need to consider the stall currents for both motors to determine the best decoder to use. In large scale, there are often variations in the way locomotives are built so, it is important to assess each individual locomotive before proceeding with decoder installation.

How to Determine The Stall Current Of A Locomotive

1. Place the loco (without the shell) on a track powered with regular DC at 12V for HO & N Scales (Use 16V for G Scale).
2. Attach a DC current meter (ammeter) in series with one of the track feeds. A power pack with an ammeter is good for this test.
3. Apply DC power to the track (12V for HO/N, 16V for larger scales).
4. Stop the motor from rotating by holding the fly wheel or drive shafts for a couple of seconds and measure the current that the unit is drawing from the power pack while the motor is stalled.
5. Be sure that the power pack voltage remains at 12V (16V for G Scale) during this test to be sure you get an accurate stall current measurement.
6. Choose a decoder with at least the current rating determined with this test. Digitrax recommends using the decoder with the highest current rating that will fit in your locomotive for long term reliability.

3.3.3 Which Decoder Will Fit?

The space available inside the locomotive is a major factor in choosing which decoder to use for your installation. Many sizes & form factors are available.

Visit www.digitrax.com/decoderselector to see our recommendations for many locomotives. Complete information, including size measurements, for each decoder is available in the product section of the website. Instruction Sheets

for specific decoders which include installation examples are also available on our web site. Our website has decoder installation videos to guide you and your local dealer can show you examples of decoders and help you determine the best one to use for your installation.

For installations in small spaces, Z and N scale decoders are rated at 1 amp or more and will work fine in HO scale locomotives.

The Digitrax Tech Support Depot at www.digitrax.com/support, has links to application notes and videos for installations in many different locomotives.

3.3.4 Decoder Interfaces for Installation

Each locomotive has its own set of issues surrounding installation. Current production locomotives often have easy installation interfaces that allow you to simply plug in a decoder or replace a circuit board inside the loco. Other locomotives, particularly really small ones, may require a soldered installation. Sound decoders are a challenge because of speaker & hold up capacitor installation requirements in addition to the decoder itself.

3.3.4.1 Plug 'N Play and Board Replacement Interfaces

Many locomotives come from the factory with provisions for decoder installation. Some locomotives come with the decoder pre-installed. Manufacturers use several terms for these locos. Be sure to read the box and examine the loco so you know what you are getting. Some "plug 'n play/board replacement" decoders require special installation steps. Be sure to read the instructions.

DCC Ready Locomotives: These locomotives are usually equipped with a DCC medium socket, though you may find some locos where this terminology means that there is room for a decoder. Be sure to check this before purchasing the locomotive

DCC Medium Socket: This diagram shows the DCC medium plug that is widely used with HO locomotives that come from the manufacturer with the DCC medium socket. The color code refers to the wire colors on a DCC wire harness. To install a decoder in a loco with a DCC medium socket, remove the dummy plug that comes with the locomotive and insert a decoder with a DCC medium plug in the socket.
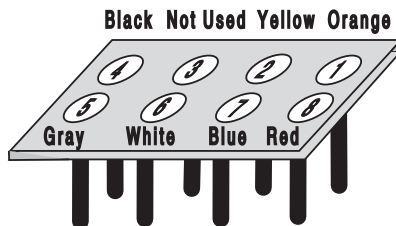
Digitrax offers the DCC medium plug in three variations:

IP - Integrated Plug where the DCC medium plug is built in to the decoder itself with no wires.

P - DCC Medium Plug on a long harness with 3.2" wires for installation where the decoder body will be located away from the socket site.

PS - DCC Medium Plug on a short harness with 1.2" wires for installation in HO Scale and 2" wires for installation in N Scale where the decoder body will be near the socket.

Digitrax 9 Pin HO: The Digitrax 9 pin socket & plug is another commonly used DCC plug 'n play interface that is available in some HO locos.

Integral 6 Pin N Scale Socket: The 6 pin integral socket is used in N scale locomotives where 8 pins won't fit. The 6 pin "IN" type decoders have 6 fine pins integrated into the edge of the decoder to fit the socket. Also called NEM651 plug.

Board Replacement Decoders: In this case decoders are designed for specific locomotives. Board replacement installations require you to remove an existing circuit board and replace it with a board replacement decoder. This may involve adding insulating tape inside the loco and/or building up solder pads to insure good electrical contact. While not always completely "plug 'n play," board replacements are usually much more convenient that wired installations.

Decoder Equipped Locomotives: These locomotives are equipped with decoders at the factory. These pre-installed decoders may have minimal features. If you want additional features, you may wish to replace the decoder that came with a loco with one that has more features. In some cases you have the option to purchase a loco with or without a decoder. Evaluate the features offered before deciding which one best fits your needs. DCC compatible decoders shipped with locomotives should work with your Digitrax system but will not have the same feature set as you Digitrax decoders.

3.3.4.2 Digitrax 9 Pin HO & 8 Pin N Decoder Interfaces

Some Digitrax HO & N scale decoders come with a plug and socket on the decoder so that the wire harness can be unplugged from the decoder. This interface lets you share one or more decoders among multiple locomotives wired with the corresponding harnesses and lets you use dummy plugs for operation on DC.

Wire Harnesses: DHWH (9 pin for HO) and DNWH (8 pin for N) have a plug that attaches to your decoder and wires that are soldered to the motor, brushes and functions on your locomotive during installation. The HO wire harnesses also come in both short and long versions with a plug on one end and DCC medium plug on the other end. The N scale version comes in the short version only with the DCC medium plug.

Dummy Plugs: DHDP (HO) and DNDP (N) are available for DC operation of harnessed locomotives (without decoders). When you install a wire harness in your locomotive and plug a dummy plug into it, your loco will operate on any analog control system and will run on DCC as an analog loco. When you remove the dummy plug and plug in a decoder, the loco will run on DCC.

To separate a Digitrax decoder from the Wire Harness:
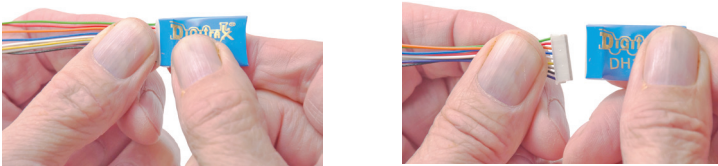
Firmly hold all harness wires between thumb and forefinger approximately 5/8" back from the plug. Grasp the decoder body on the sides right next to the socket to ensure no stresses are placed on components under the protective sleeve. Pull gently and evenly on all wires simultaneously. Distribute the force needed to separate the plug and socket EVENLY over all the wires to prevent damage to the plug.

3.3.4.3 Installing Decoders with Wires

In some cases, especially in older locomotives, brass locomotives and really tiny locomotives, there is no special harness arrangement, plug 'n play installation or board replacement option available. In these cases, the decoder wires are soldered into the locomotive.

Refer to **TABLE II** for Digitrax Mobile Decoder Standard for Wire Colors and *Figure 1 Digitrax Decoder Wiring Diagram* for general instructions and the specific Decoder Instruction Sheet that came with your decoder for specific instructions for the decoder you are installing. See *Figure 2* for lamp installation information.

TABLE II: Digitrax Mobile Decoder Wire Colors	
What the wires are for	**Wire Color**
Power Pick-up Right (Engineer's Side)	Red
Power Pick-up Left (Fireman's Side)	Black
Motor + Right Brush	Orange
Motor - Left Brush	Grey
F0(FWD)-Forward Light	White
F0(REV)-Reverse Light	Yellow
Lamp Common	Blue
F1-Function 1	Green
F2-Function 2	Violet
F3-Function 3	Brown
F4-Function 4	White w/ Yellow Stripe
F5-Function 5	White w/ Green Stripe
F6-Function 6	White w/ Blue Stripe

Figure 1: Digitrax Decoder Wiring Diagram
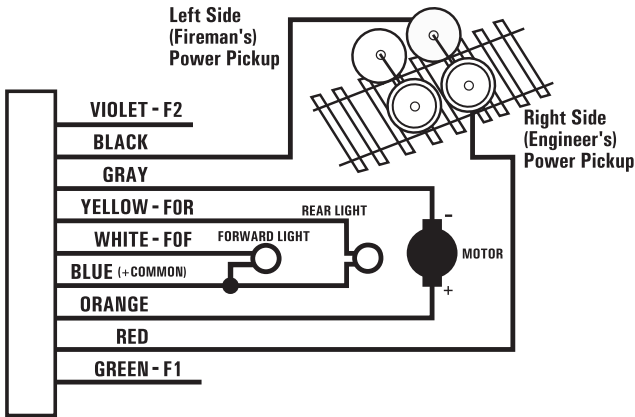
Figure 1 Notes:
Do not exceed the decoder's total function output current rating. Blue (+ common) must be hooked up to enable transponding. If Blue (+ common) is not used, connect function power to either track power pick up. The directional light function "Lamp Return Line" can be hooked to Blue (+ common) as shown or to either track pick-up.

3.3.5 Decoder Features-LocoMotion

Features control the movement of the locomotive and other operating characteristics. Digitrax LocoMotion® System lets you customize your locomotive so it runs like the real thing. These LocoMotion features are set up using CVs to customize the locomotive's operation.

LocoMotion includes normal direction of travel, use of 3 step or 128 step s to customize throttle response, acceleration and deceleration rates, start-mid-max voltage settings, torque compensation, switching speed, consisting (basic, advanced or universal) and more.

3.3.6 Decoder Functions-Lights, Sound, Etc.

Once you have determined the current rating and decoder size needed for your loco, consider what lighting and other on/off items installed in the locomotive you want to control from your throttle.

Functions are generally used for lamps, LEDs, uncoupling devices, controlling sound and other low current draw features you want to be able to control from your throttle. All Digitrax decoders are equipped with two or more function outputs that are used to turn functions on and off and set up special lighting effects called FX^3. You can have reversing headlights or independently controlled headlights. You can map functions to operate on specific throttle keys. Series 6 decoders have lighting algorithms that are selectable for either lamps or LEDs. If you are using smoke generators or other high current devices, make sure you do not exceed the specified function current.

Function outputs can be in the form of :
1. Leads (wires) soldered to the decoder at the factory that are used to hook up functions.
2. Pre-wired function outputs that work when the decoder is installed. The forward and reverse lights on board replacement decoders are an example of pre-wired functions.
3. Solder pads on the decoder where function wires can be soldered by the end user.

Some decoders have more than one form of function output. For example, the DN163K0A has two function outputs pre-wired to the white LEDs on the decoder and 4 additional solder pads available for adding wires to hook up more functions.

Check the decoder's specifications to determine how many function outputs a particular decoder has available. Function only decoders, like the TL1 & TF4, can be used in addition to mobile decoders to add more standard on/off functions. TL1 & TF4 do not have FX^3 capabilities.

Digitrax FX^3 **functions** incorporate up to 8 FX generators that can be customized. These FX^3 function outputs can be mapped so they are controlled by any function key on your throttle. A master light switch can be set up to turn off all lights on a locomotive. Functions associated with advanced consists can be controlled, too.

Function outputs on Digitrax decoders are available in several current ratings depending on the decoder. These ratings are the total current available for activating and running the devices attached to ALL the function outputs on the decoder. Check your specific decoder's specifications for the function current rating for your decoder.

3.3.7 SoundFX Decoders

Sound inside your locomotive is another factor to consider in decoder selection. Because sound installation requires additional space inside the locomotive for installing a hold up capacitor and a speaker with baffle, this must be considered during decoder selection.

3.4 Read the Instructions

Digitrax decoders are shipped with individual instruction sheets. These have specific instructions for each particular decoder. These are also available online along with installations that demonstrate how to do many different decoder installations.

3.5 Plan the Installation

Planning ahead will make decoder installation easier to do.

3.6 Have the Proper Tools At Hand

You'll need a few simple tools when you begin installing decoders:

1. A temperature controlled low wattage soldering iron. Though many installations do not require soldering, you may need to use a soldering iron to install LEDs and lamps for special lighting effects.
2. 0.015"-.032" rosin core solder for electronics
3. Small screwdrivers and small shims for disassembling your loco.
4. Small diagonal cutters for cutting & stripping small wire.
5. Tweezers to pick up small loco parts.
6. Heat shrink tubing for protecting wire connections, electrical tape is NOT recommended.
7. Tape for securing wires and the decoder inside the locomotive. Digitrax provides Kapton tape with many decoders for electrically insulating the locomotive frame.
8. Decoder installation should be done in a static free environment on a non-metallic surface.

3.7 Testing Decoders Before Installation

Digitrax tests each decoder prior to shipping. That said, we strongly recommend testing by the installer before installation. The test procedure shows you how the decoder works and how to hook up the wires. Testing verifies that the decoder is working before you install it in a loco. Use the LT1 that came with your Digitrax Starter Set to perform the test as follows:

LT1 Diagram

TWIST BLACK & GREEN WIRES TOGETHER

BLUE WIRE NOT USED

Wire order in RJ12 plug
Blue
Yellow
Green
Red
Black
White

RJ12 SOCKET

RAIL - (LED)
LOCO 2 (LED)
LOCO 1 (LED)
RAIL + (LED)

WHITE WIRE NOT USED

RJ12 PLUG
(Top view-clip on top)

TWIST RED & YELLOW WIRES TOGETHER
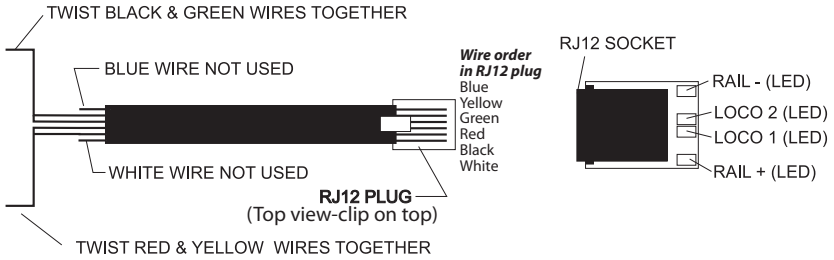
HARNESS   LT1 TESTER

Decoder Testing Diagram

Protection Resistor 100 Ohm/2Watt

LT1

Test Kit Contents

Red/Yellow
(twisted together)

Black/Green
(twisted together)

DIGITRAX COMMAND STATION

Gray
Orange

Motor -
Motor +

Right Rail (Engineer's Side)
Left Rail (Fireman's Side)

Red
Black

White
Yellow
Blue
Green
Violet
Brown

Forward Light (F0 FWD)
Reverse Light (F0 REV)
Light Common (+RAW)
Function 1 (F1)
Function 2 (F2)
Function 3 (F3), etc.

Digitrax Decoder

Digitrax Throttle must be plugged in during LT1 testing

Secure other leads individually

Protected Wiring Side

Note: Recommended decoder input voltage is 12V DC peak

LT1 Decoder Testing Instructions

1. Strip the insulation from the red and yellow wires and twist them together.
2. Strip the insulation from the green and black wires and twist them together.
3. The blue and white wires are not used. They can be left on the harness.
4. Hook up decoder as shown here. If your decoder does not have wires, use alligator clips to make the appropriate connections to the pads or pins on your decoder.
5. Use your throttle to select the decoder and run it in the forward direction.
6. One of the two center LEDs will light as the motor voltage increases. Change direction and the other LED will light.
7. Test the decoder function outputs by connecting the LT1 to the blue lamp common and one of the function outputs.
8. Use your throttle to turn the function on and off . One of the two center LEDs will go on and off with the function. Do this test for all function outputs separately.

Note: The LT1 can also be used to test LocoNet Cables by plugging in one end of the cable being tested into the LT1 and the other end into your command station or booster. At least one Digitrax throttle or Zephyr all-in-one unit must be plugged in to LocoNet. If all four LEDs light, the cable is good. Note that the LEDs may not all be the same brightness, this is normal. If any of the LEDs fail to light, remove the plug from on end of the cable and re crimp another one prior to re-testing the cable. Digitrax LocoNet Cable Maker Kit has everything you need to make repairs to LocoNet Cables.

3.8 Locomotive Disassembly

Before you begin, read the instruction sheet that came with your decoder. It is not possible for this manual to cover the specifics of each decoder individually, these are provided with the individual decoder and are also available online at www.digitrax.com.

1. Read the locomotive manufacturer's disassembly instructions. Many of these are available online. Making photos of the loco as you take it apart can be a big help later if you need to go back.
2. Disassemble your loco carefully. You'll need all the little parts later.
3. Note how + and - motor connections & the left & right power pick up connections are set up.
4. Look carefully at the loco's wiring & determine where all the wires go and what they do before changing or disconnecting any of them.

The physical location of the decoder in the loco is important and may involve sculpting plastic and or metal parts to allow enough room for installation.

Install the decoder in the coolest part of the loco body. Recommended operating temperatures should be between 70 & 120 degrees Fahrenheit (20-50 degrees Celsius).

When making wire connections inside the loco, use the shortest length of wire that will do the job. After the wires are attached and insulated with heat shrink sleeving, secure them so that repeated removal and replacement of the locomotive shell won't pull the wires loose. The biggest cause of decoder failure after initial installation is wires being pulled loose and shorted to the frame when the shell is removed or replaced.

3.9 Electrically Isolating the Motor

Failure to isolate the motor will damage your decoder. For DC permanent magnet powered locomotives, the decoder must be electrically inserted between the track power pickups and the 2 motor brushes.

The most important part of any successful locomotive conversion is proper electrical isolation of the 2 motor brush connections, so that they are driven only by the decoder.

Once the motor is isolated, visually inspect the brushes again, just to be sure. Use a continuity checker (beeper box) to be sure there is an OPEN circuit (very high resistance) from both brushes to any other part of the locomotive chassis, power pickups and wheels. Check both motor brushes. If the circuit is not open, your beeper box will beep.

Only when you are satisfied that the motor is isolated, should you proceed with the decoder installation.

Some motor brush power connections may be tricky, like a spring to or interference fit with part of the chassis. Some locos pick up brush power from the chassis through a spring. In this case, after removing the spring connection to the brush, wire the corresponding decoder power input to the chassis. Examine the loco carefully to determine how power moves from the track pickups to the motor.

Decoders with FX^3 functions have motor isolation protection. If the decoder senses that the motor is not isolated, it will not run the motor. In this case, you will be able to control the loco's functions but the motor will not work.

For board replacement decoders, it is important to follow the Decoder Instruction Sheet for the particular decoder when installing insulating tape inside the loco to prevent shorts during operation caused by the decoder board shifting inside the engine.

Figure 2: Lamp & LED Wiring Diagrams

Operation With Blue Lamp Common Connected	Operation Without Blue Lamp Common Connected
Preferred method.	Use to save space in installation.
Lamp brightness won't vary when analog locos are operated on the layout.	Lamp brightness varies depending on the direction of the analog locomotive.
Transponding can be enabled.	Transponding can't be enabled.

LEDs

Lamp Common Blue

+ +

LED Cathode End   LED Cathode End

* *

Forward Lamp White

Reverse Lamp Yellow

Right Rail Pickup

Left Rail Pickup

+ +

LED Cathode End   LED Cathode End

* *

Forward Lamp White

Reverse Lamp Yellow

*Note: LEDs are sensitive to polarity when hooked up. Typical resistor values range from 680 ohm to 1.5 kohm 1/4 watt.

12V to 16V Lamps

Lamp Common

Forward Lamp White

Reverse Lamp Yellow

Right Rail Pickup

Left Rail Pickup

Forward Lamp White

Reverse Lamp Yellow

1.5V Lamps

Lamp Common

* *

Forward Lamp White

Reverse Lamp Yellow

Right Rail Pickup

Left Rail Pickup

* *

Forward Lamp White

Reverse Lamp Yellow

*Note: Current setting resistor. Typically 560 ohm 1/4 watt for grain of rice and 250 ohm 1/4 watt for grain of wheat. Lower resistance values to increase lamp brightness, min value is 100 ohms. Values vary depending on track voltage in use.

3.10 Installing Lighting Effects

Adding lights to your locomotives can bring an added degree of realism but there are a few things to consider.

Headlight and Rear Light Operation

Automatic headlight reversing: All Digitrax decoders are shipped with automatic reversing headlight operation as the default.

Non-directional (independent) headlight operation: If you do not want automatic reversing headlight operation use CV33 & CV34 to map F0Fwd and F0Rev to operate on two different throttle function keys.

FX^3 light operation: Refer to the FX^3 Section 9.0 which details how to program the many different FX^3 effects.

Additional Lamp and Function Wiring Considerations

Lamps with current draw over 50mA: For regular 12 to 16 volt lamps that draw more than 50mA when lit, we recommend using a 22 to 33 ohm 1/4 watt resistor in series with the lamp leads to avoid the lamp "start-up currents" overloading the outputs. These start-up currents can be up to 10 times the normal current draw.

Loco with only one lamp: If the locomotive has only one lamp, connect the F0Fwd (white) and F0Rev (yellow) outputs together. In this case the single light will be on if F0, the light function, is turned ON.

Connecting additional function outputs: Connect F1-F6 to the lamps or other items you want to control. Be sure not to exceed the total output current rating of the function outputs for the decoder you are using.

Transponder equipped decoders: All Digitrax Series 3, 4, 5, & 6 decoders have built in resistors for transponding. Earlier versions of Digitrax decoders may need to have a load resistor installed for transponding to work. Please consult instructions for those specific decoders. You may see a slight glow even when the forward light is turned off, this is normal.

3.11 Installing Power Xtenders

Digitrax Power Xtenders are available for most Series 6 decoders. They are designed to keep locomotives running and sound from dropping out in situations where power to the locomotive is interrupted due to dirty, dead or bad track. Hold up time varies based on actual decoder load and track conditions.

Most Series 6 mobile decoders include either solder pads, a 2 pin socket or a sound harness replacement for adding a PX module to the decoder. Some very small Series 6 decoders cannot accommodate power xtenders because there is no room available on the board. No CV configuration is required to add a power xtender module and most are plug 'n play installs. See www.digitrax.com for more information about Digitrax Power Xtenders

Note: Pre-series 6 decoders do not support the addition of power xtenders.

3.12 Final Decoder Test

Once the decoder is installed, you are ready for the test track. For decoders with FX3 functions, if you are able to control the loco's lights but the motor will not run, this is also an indication of a motor short circuit that must be corrected.

1. Place your Digitrax decoder equipped locomotive on the programming track and try to read or write to the decoder. If you get a programming error, check your wiring. This allows you to test the decoder in a low current environment to avoid damage due to incorrect wiring or installation.

2. Run your Digitrax decoder equipped locomotive on a regular DC track with the positive polarity connected to the right side wheels. The Digitrax decoder in the locomotive will recognize that it is not receiving DCC commands and automatically convert to analog mode, this is called analog mode conversion.

3. Using a DC power pack, move the loco in the forward direction. If the loco moves in reverse, the input power feeds to the decoder are reversed. Power down, swap the decoder power input connections (red & black leads) and try again.

4. Next, run the decoder equipped loco with your Digitrax system. Follow the instructions in your Digitrax Starter Set manual to select and run the locomotive on address 03. Operate any functions installed to be sure they can be turned on and off. Since you have not programmed the decoder yet, the decoder will use the factory default settings.

5. If any problems are observed, make corrections to your wiring and re-test.

3.13 Avoiding Heat Problems with Installations

Most HO & N Scale locomotive motors, LEDs, and lamps are designed to operate on 12 volts DC on the track. Z Scale equipment is designed to run at 9 volts. Digitrax recommends running your command station and boosters at the lowest track voltage possible that provides acceptable operation.

The "N" (12V) setting on Digitrax command stations and boosters works well for most HO & N scale layouts. The "HO" setting should be used only for HO and larger scales. We recommend using a UP6Z Voltage Reducer for Z scale layouts to avoid applying too much track voltage to Z scale equipment.

If the track voltage applied exceeds the operating parameters of the locomotive and it's LEDs/lamps, damage to the locomotive or decoder may occur.

4.0 General Decoder Troubleshooting

4.1 The decoder won't respond

Make sure track power is ON
If the throttle is indicating that track power is off, turn track power on.

Can you control the functions but not the motor?
If so, remove the loco from the track and check your installation for motor isolation or short circuit problems.

Can't select the loco address on your throttle
1. If you see STEAL=Y? or stL? on your throttle display, the loco is in use by another throttle. Release the loco from the other throttle before proceeding.
2. If you see consist or cn, the loco is part of a consist and can't be selected individually. Remove the loco from the consist before continuing

Check the value programmed into CV29
If your decoder is a 14 step decoder running on a system that is sending 28/128 speed step commands, status editing is necessary to make the commands sent by the system match what the decoder can handle.

Have you reset any CVs since the last time you ran the loco?
If so, go back and change them to their default values and then try to run the loco. It is possible to set acceleration so high that it will take 10 minutes for the loco to start moving.

Does your throttle say slot=max or FuLL?
This means that the system's capacity to handle operating locos is full. If you have the slot=max or FuLL message, be sure that all locos that are not running are released from throttles. Check your command station manual to determine how many locos your system can handle at a time.

During decoder programming, slot=max or FuLL message will be displayed if the loco you are trying to program has too many current loads attached. If this is the case, you need to remove some of the extra loads to program the decoder. This happens with locos that have many lamps installed or where the lamps are wired directly to the track pickups.

If all else fails, reprogram the decoder's address and reset CVs to default values by setting CV08 to 08 to reset everything or to 09 to reset everything except loadable speed table and sound project selection entries.

4.2 The decoder runs for a while & then just stops

If a decoder is hot to the touch, it may be overheating
It is normal for decoders to warm up while in use but they should not be hot to the touch. Be sure the decoder is installed so that it can shed heat. Don't put decoders near the motor or lights.

Check for localized track problems
Be sure you are not on a section of track that is not powered or does not have enough power. Use the Quarter trick described below to diagnose this condition.

4.3 Loco operation is jerky & erratic
Is the track clean and are the power feeds reliable?
Are the locomotive wheel pickups and internal electrical connections reliable? The majority of intermittent operation faults can be traced to bad connections and poor or noisy wheel pickups on locomotives. Series 6 decoders can use a Power Xtender module to improve operation of both motor and sound in the presence of power interruptions.

4.4 "Strange" locomotive light operation
If you can't control the operation of the lights in your locomotive with your throttle (in default 128, or 28 speed step mode), be sure that the decoder is programmed for advanced 28 speed step mode. Your Digitrax decoder was shipped programmed to 128 speed step mode. You may have changed your decoder's programming when performing the decoder test procedure. In any case, if you are not able to turn the locomotives lights on and off, you will need to change CV29 to 006 or another appropriate value that sets the decoder to advanced 28/128 speed step mode.

If you can't turn the lights on and off or the lights blink when you run the loco, make sure you are not running a standard (14 speed step operation) decoder trying to process 28 speed step Advanced packets. Be sure that the decoder and command station are using the same mode by programming CV29 to an appropriate value or by changing the command station's operating mode to match the decoder.

4.5 The locomotive won't move at all
Does the locomotive have any mechanical binding problems? Is there anything inside the loco that is preventing the motor from turning? Are any wires shorting or touching moving parts?

When you are operating a Digitrax Command Station set up to run in 128 speed step mode, there are some decoders that only understand 14 speed step

mode. If you are using one of these non-Digitrax decoders, you will need to status edit the decoder so that it will run.

4.6 Locomotive "buzzes"

Most noisy locomotive issues are caused by vibrations inside the loco's mechanism. For DCC equipped locos, try lubricating the locomotive's brushes and tuning up the loco's mechanism.

Analog locos (without DCC decoders) make a "singing" sound when sitting still on DCC layouts. This noise, which is caused by the DCC track signal, decreases as the analog loco is accelerated. You can significantly reduce this noise by using conductive brush lubricants and by assuring that there is no vibration inside the loco that will add to the noise generated.

When operating analog locos on DCC layouts, DO NOT leave analog locos sitting still. It is best to park them off the live track unless they are running. This will prevent heat build up that can damage the loco, minimize the humming noise and lessen stress on the motors.

4.7 The Quarter Trick

If your track does not have adequate power supply to the locomotives, then the DCC signal won't get through either. Use a coin or screwdriver blade and go around your layout creating electrical shorts every 10 feet. Your boosters should indicate a short by beeping (or in the display for Zephyr units) and shut down track power when the short is present. When the short is removed, the booster will return to normal operation. If this does not happen, then you need to add more feeders to make sure the track has enough power supply to operate.

4.8 Are your LocoNet Cables built correctly?

Check your LocoNet cables with the LT1 tester to be sure the cables are good. If your LocoNet cables are not working correctly, the signal won't get through.

4.9 Getting Help

Don't suffer in silence! There is no such thing as a "dumb question!" Our website, www.digitrax.com, and Tech Support Depot have the answers to many commonly asked questions. These are always available. If you can't get it to work the way you think it should, let us know! Often your local Digitrax dealer will be able to help you work out any problems you may encounter. If not, please contact Digitrax directly. Our support staff is available Monday through Friday 8AM to 5PM CDT to help you. E-mail techsupport@digitrax.com. We have found that e-mail is the most efficient way to handle tech support questions. Often, we can send you written instructions to solve your issue. If that does not work, we will call you for further assistance.

5.0 Decoder Programming

5.1 What are Configuration Variables (CVs)?

Each Configuration Variable, CV, controls one or more operating characteristics of the decoder based on the CV value that you program. All Digitrax decoders come with default settings from the factory that will run "out of the box." Before you start programming your decoders, it's a good idea to run your decoders with the default values that come pre-programmed from the factory. This will let you get used to using DCC before you begin customizing. In many cases, you will find that you only need to change the address of the locomotive to have great operation.

Once you are ready to customize, you can pick and choose from among the CVs and program each one independently. Once these CV values are programmed, they are "remembered" in the decoder until you reprogram it with a new value. If you decide to use deceleration, in particular, keep the programmed CV values small so that you have time to adapt to the delays in deceleration you have set up without crashing your valuable locomotives! See the Configuration Variables section below for complete information on how CVs are used by Digitrax decoders.

5.2 Service Mode and Ops Mode Programming Methods

Digitrax supports two programming methods:

Service Mode Programming is done on an electrically isolated programming track. In service mode, the command station broadcasts programming information to all decoders on the programming track. Direct, paged and physical register modes are used for service mode programming.

Operations Mode Programming, also called Ops Mode or programming on the main, is done on the layout by sending programming commands to a specific locomotive address. To use this mode, you must have decoders that are capable of operations mode programming.

5.3 Programming Modes

Digitrax Command Stations support direct, operations mode, paged, or physical register programming methods. This gives you maximum flexibility to program DCC decoders made by different manufacturers at different times in history.

Direct mode is the most commonly used programming method. Digitrax recommends using direct mode for programming on the programming track.

Paged mode also gives access to all CVs for programming. Direct and paged programming appear very similar to the user.

Operations mode programming allows programming of decoders while the locomotive is on the mainline without having to use the programming track. The decoder address can be programmed with Ops mode programming with Digitrax DT300 & DT4xx series throttles. Some DCC systems allow operation mode programming only for CVs other than address.

Physical register mode is a very basic mode for programming decoders. With "register mode" you can program CVs 01, 02, 03, 04 & 29 only. This is only used with older decoders that require this method.

All of these programming modes may or may not be supported by your non-Digitrax command station or programmer. For the specifics and mechanics of programming with your system, please check your command station or programmer manual.

5.4 DCC Outputs: Programming & Layout Operation

The DB150 Command Station/Booster, has one DCC output that is used both to run the trains and to program decoders. For this kind of command station, you will have to shutdown layout operations to program in service mode. The DCS100/DCS200 Command Station/Boosters and the DCS50/DCS51 Command Station/Booster/Throttle Combos have two DCC outputs. This means that you can program in service mode and read back decoders without having to shut down the layout. Both single and dual DCC output systems require a service mode programming track unless you are using operations mode programming on the main.

5.5 Reading & Writing CVs

The DB150 Command Station/Booster has a "write only programmer," it will program CVs to the values you choose. DB150 will not read back CVs and their values programmed into your decoders.

The DCS100/DCS200 & DCS50/DCS51 Command Stations are "read/write programmers," they can program decoders and read back their CVs and values. Another programming option is to use a PR3 Xtra programmer and your computer to program and read back decoders. Other DCC compatible programmers are able to program Digitrax decoders as well. Consult the manual for the system you are using for complete programming instructions.

Digitrax FX^3 decoders have operations mode read back capabilities when used on layouts instrumented for this feature.

Note: Some DCC systems use a low power setting for all decoder programming. Digitrax recommends that you use low power programming for initial decoder tests prior to installation in the locomotive. We do not feel that it is

necessary to use a low power setting for decoder programming once you have successfully installed the decoder in the locomotive. If you are reprogramming an installed decoder, feel free to follow the steps presented here. If you wish to use a low power setting for decoder programming, please see the decoder initial test procedures in Section 3.7 which detail the use of a protection resistor to provide a low power programming option.

6.0 CVs-Configuration Variables

Configuration Variables or CVs are special storage locations or "pigeonholes" in the decoders. By programming CV values into CVs you can customize each decoder's performance characteristics. These characteristics are permanently "remembered" by the decoder even when the power is off. CV values can be changed as often as you like. The meaning of most CVs is set by industry standard. There are also some manufacturer specific CVs that are defined by each manufacturer to accommodate their own special features. Some legacy decoders do not use the same CVs that are currently in standard use.

At first glance, you will see that there are many different CVs. This may seem confusing but, don't worry, Digitrax decoders are shipped with a set of pre-programmed factory default values that let you get up and running right away. As you begin to explore the possibilities with DCC, you will probably reprogram CV01, the decoder's 2 digit address. This lets you run more than one locomotive at a time. You may need to make changes to CV29, the "configuration" CV to make your lights operate correctly. Next you may decide to set up acceleration (CV03) and deceleration (CV04) or you may wish to set up your FX^3 options using CVs 49 through 63 As you explore more of the capabilities of your decoder and system refer to **TABLE III** as a guide.

Digitrax decoders use many different configuration variables (CVs) to control the operating characteristics of the decoder. CV usage is fairly standardized from decoder to decoder but there may be differences in how CVs are used by different manufacturers.

To be absolutely sure about which CVs a particular decoder uses for a particular feature, the range of values available and the factory default value please consult the specification sheet available on each decoder's product page on www.digitrax.com. This will give you a complete list of CV uses for each individual decoder.

Sound projects are totally customizable and CVs may not be used consistently from project so project. Information on CVs used in sound decoders is included with each sound project.

Visit our online CV Calculator at www.digitrax.com/support/cv/ for help with determining the best CV Value to program into a CV.

Table III: CVs used in Digitrax Decoders

CV#	CV Usage/Notes	Default Value	Value Range
Basic Decoder Set Up CVs			
Locomotive Address CVs			
01	2 Digit Decoder Address	03	001-127
17 18	4 Digit Address (High Byte & Low Byte CV17 & 18 are used together to program the 4 digit address. Current production Digitrax throttles handle this automatically. See online calculator if your system needs separate values to program the 4 digit address CVs separately.	00	0128-9983
29	Configuration Register Controls Multiple Features-must be set to a value that allows either 2 digit or 4 digit address.	06	See below
Configuration Register CV			
29	Configuration Register	06	
	Address Selection 2 or 4 digit	2 Digit	TABLE IV
	Normal direction of travel (NDOT)	Fwd	TABLE IV
	Speed Step Control	28/128	TABLE IV
	Use loadable 28 step speed table? Leave Off for three step speed table with V-start, V-mid, V-max.	Off	TABLE IV
	Analog mode conversion-change to DC operation when on DCC present	On	TABLE IV

CV#	CV Usage/Notes	Default Value	Value Range
LocoMotion CVs-Control locomotive motion characteristics			
Acceleration and Deceleration			
03	Acceleration Rate-128 steps	00	00-31
04	Deceleration Rate-128 steps	00	00-31
Three Step Simple Speed Table & Start Voltage (Simple Throttle Response Curve)			
02	Start Voltage-128 Steps	00	00-255
05	Maximum Voltage-128 Steps 00, 01 & 255=voltage at step 28	00	00-255
06	Mid Point Voltage-128 steps 00 & 01=Straight line curve	00	00-255
Loadable 28 Step Speed Tables with 256 Step Resolution (High Resolution Throttle Response Curve-128 speed step interpolated)			
65	Kick Start Value	00	
66	Forward Trim	00	
67	First Speed Table Entry	00	
68-93	28 Step Speed Table Entries	00	
94	Maximum Speed Table Step	00	
95	Reverse Trim	00	
29	Configuration Register-Must be set to a value that enables speed tables. Speed Tables Are Disabled in the default settings	06	See CV29 above
Torque Compensation and Switching Speed			

54					00	00, 01, 16, 17, 64, 65, 80, 81
	Value	Switching Speed	Torque Compensation	Decoder Lock		
	00	Off	On	Enabled		
	01	On	On	Enabled		
	16	Off	Off	Enabled		
	17	On	Off	Enabled		
	64	Off	On	Disabled		
	65	On	On	Disabled		
	80	Off	Off	Disabled		
	81	On	Off	Disabled		

CV#	CV Usage/Notes	Default Value	Value Range
Scaleable Speed Stabilization (Back EMF)			
55	Static compensation	128	00-255
56	Dynamic compensation	080	00-255
57	Amount of Back EMF (Intensity) See Scaleable Speed Stabilization Section for Range	06	See CV57 section
Advanced Consist Address			
19	Advanced consist address-default is off	00	00-255
Transponding and LED/Lamp Selector			
61	<table><tr><td>CV Value</td><td>Transponding</td><td>LED or Lamp</td></tr><tr><td>00</td><td>Off</td><td>LED</td></tr><tr><td>01</td><td>Off</td><td>Lamp</td></tr><tr><td>02</td><td>On</td><td>LED</td></tr><tr><td>03</td><td>On</td><td>Lamp</td></tr></table>	00	00-03
SuperSonic (Quiet Operation)			
09	Motor Frequency-Default is Max	00	00-255
Function CVs for controlling lights, etc.			
49	F0F, Forward light effect (white)	00	TABLE
50	F0R, Reverse light effect (yellow)	00	TABLE
51	F1, Function 1 (green)	00	TABLE
52	F2, Function 2 (violet)	00	TABLE
113	F3, Function 3 (brown)	00	TABLE
114	F4, Function 4 (white w/yellow stripe)	00	TABLE
115	F5, Function 5 (white w/green stripe)	00	TABLE
116	F6, Function 6 (white w/blue stripe)	00	TABLE
62	FX Rate and Keep Alive Adjustment	00	00-255
63	Ditch Light Blink Hold Time	00	00-255
Function Mapping CVs set up throttle key for each function output			
33-46	Function mapping CVs	00	TABLE XVIII
Advanced Consist Function Control			
21	Advanced consist function control override for F1-F8	00	

CV#	CV Usage/Notes	Default Value	Value Range
22	Advanced Consist function control override for F0 & F9-F12	00	
Decoder Utility CVs			
Decoder Reset			
08	Reset decoder to factory default CVs	129	

Value	Action
08	Reset all to factory default
09	Reset to factory default except speed tables and selected sound scheme.

CV#	CV Usage/Notes	Default Value	Value Range
Decoder Lock			
15	Selects the target decoder for programming commands 0=Decoder Lock Off 1-7=Unique decoder IDs	0	0-7
16	Sets the ID number of each decoder installed in a locomotive 0=Decoder Lock Off 1-7=Unique decoder IDs	0	0-7
Decoder IDs			
105	User private ID #1	00	
106	User private ID #2	00	
07	Version ID-Read Only	64	
08	Manufacturer ID-Digitrax	129	

7.0 Basic Decoder Setup CVs

The decoder's address and the configuration register CVs are the basic CVs needed to operate a decoder.

7.1 Decoder Addresses

The decoder's address is the unique identification number that lets that decoder recognize commands sent to it by the command station. Once you program the decoder's address, it is remembered by the decoder until it is changed.

Decoders can be programmed with both 2 digit and 4 digit addresses but only one or the other will be in use at any time. Whether the 2 or 4 digit address is used is determined by CV29, the configuration register.

You can change the decoder address by reprogramming it at any time so, you can set up any numbering scheme you choose for your locos. Many people assign the last two numbers of the loco's road number as the 2 digit decoder or 4 digits of the road number as the 4 digit address.

More than one loco can be programmed to the same address. This is useful if you want to set up a basic consist and run more than one loco on a single address.

Digital Address Ranges for Mobile Decoders

Address "00" is used for analog operation of a locomotive without a decoder on the same track as DCC equipped locos.

Addresses from 001 to 127 are the two digit address range. Two digit decoder addresses are set up by programming CV01 & CV29.

Addresses from 0128 to 9983 are the four digit address range. Four digit decoder addresses are set up by programming CV17, CV18 & CV29.

There is no "three digit address." If your loco only has a three digit road number, you can use 0-127 as a 2 digit address or use a 4 digit address with a leading 0.

7.1.1 Decoder 2 Digit Address: CV01

```
Ad2=???
CVNo P6 dAt
```
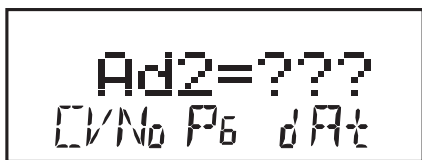
On your DT300 & DT4xx throttles, the display will show Ad2 for two digit addresses and Ad4 for four digit addresses. All other CVs are displayed as numbers on Digitrax throttles. Be sure that CV29 is programmed to a value that enables 2 digit operation. See CV29 below for more information.

7.1.2 Decoder 4 Digit Address: CV17 & CV18

The 4 digit address is sometimes called the long address. It is programmed in CV17 & CV18. Simply programming CV17 & CV18 will not enable 4 digit addressing. The DCS50, DCS51, DB150, DCS100 & DCS200 Command Stations that come with Zephyr Series, Super Empire Builder Series and Super Chief Series Sets provide automated programming that makes this process simple. See the starter set manuals for step by step instructions for setting up and enabling 4 digit addresses in your decoders.

7.2 Configuration Register: CV29

7.2.1 Characteristics Controlled by CV29

Configuration Variable 29 (CV29 for short) is a very special CV. The value entered for this CV controls several things:
1. 2 digit addressing or 4 digit addressing (as described above)
2. Normal Direction of Travel (NDOT)
3. Speed step control: Advanced Mode (28/128 speed steps) or Standard Mode (14 speed steps)
4. Analog mode conversion On or Off
5. Speed table On or Off

The **Normal Direction of Travel, or NDOT** for short, lets you set up your locos to run either long hood forward or short hood forward. The decoder determines which way the loco will move independent of track polarity, you can set up either direction as forward depending on the prototype.

There are two modes for speed step control: **Standard or 14 speed step mode** and **Advanced or 28/128 speed step control**.

Because of differences in the capabilities of DCC compatible command stations and decoders, you may have to set CV29 in your decoders to different values to match the mode of the command station you are using. If your command station sends standard 14 speed step mode commands, your decoders must be programmed for standard mode. If your command station sends advanced 28/128 speed step commands, your decoders must be programmed for advanced mode. All Digitrax decoders are 128 speed step capable and we recommend that for best performance you run them in 128 speed step mode. If you are using non-Digitrax decoders that do not support advanced mode and you want to run your command station in advanced mode, you can "status edit" the standard decoders so that they can be run with your command station. See your starter set manual for the specifics of status editing.

Loadable speed tables can be enabled or disabled with CV29. Speed tables are used to customize the throttle response curve of each decoder equipped locomotive. The speed table values can be stored in the decoder and then the table can be turned on or off with CV29. See the section on CVs 65-93 below for a complete description of how speed tables work.

The **analog mode conversion** feature is very convenient if you plan to run your Digitrax decoded locomotive on regular DC layouts. With analog mode conversion enabled, the decoder will automatically begin operating as a DC locomotive when no DCC signal is detected by the decoder. This means that if you place your Digitrax decoder equipped loco, with analog mode conversion enabled, on a regular DC layout, it will run on the DC layout. Disabling analog mode conversion can be useful too as the following example illustrates:

Brake Generator Example:

If you disable the analog mode conversion feature in a decoder, when DC power is present the locomotive will stop. This gives you a very inexpensive way of generating a "brake section" for stopping DCC locomotives in front of red signals.

By disabling analog mode conversion in the decoder, a relay can supply DC voltage to a track section in front of a red signal to slow and stop a locomotive in the brake section. When the signal turns green, the relay can restore the DCC track signal, and the locomotive will restart. The decoder will slow to a stop and restart at its programmed deceleration and acceleration values. In addition, if you are using a decoder with FX^3 functions, the locomotive's lights and functions will remain active when stopped on the DC brake section as long as DC power is supplied to the track while the loco is stopped.

You can use your DCS100's second DCC output to set up a braking section. See our website www.digitrax.com Tech Support Depot for instructions for setting up a braking section with DCS100.

7.2.2 Determining CV Value To Program Into CV29
The value you program into CV29 will affect many important decoder characteristics. Each of these characteristics is controlled by a "software switch." This switch is either on or off depending on the CV value programmed. There are three ways to determine the value to program into CV29.
The easiest way to determine this value is to use our on-line CV calculator at www.digitrax.com/support/cv/. TABLE IV details the CV value for each combination of features.

Our on-line CV Calculator and the Digitrax Tool Box App for mobile devices make this calculation easy, too.

TABLE IV: CV29 Value Table

CV Values	2 or 4 Digit Address	Normal Direction of Travel	Speed Steps/Loadable Speed Table	Analog Mode Conversion
000	2	Forward	14	OFF
001	2	Reverse	14	OFF
002	2	Forward	28/128	OFF
003	2	Reverse	28/128	OFF
004	2	Forward	14	ON
005	2	Reverse	14	ON
*006	2	Forward	28/128	ON
*007	2	Reverse	28/128	ON
016	2	Forward	14 Speed Tables	OFF
017	2	Reverse	14 Speed Tables	OFF
018	2	Forward	28/128 Speed Table	OFF
019	2	Reverse	28/128 Speed Table	OFF
020	2	Forward	14 Speed Tables	ON
021	2	Reverse	14 Speed Tables	ON
022	2	Forward	28/128 Speed Table	ON
023	2	Reverse	28/128 Speed Table	ON
032	4	Forward	14	OFF
033	4	Reverse	14	OFF
034	4	Forward	28/128	OFF
035	4	Reverse	28/128	OFF
036	4	Forward	14	ON
037	4	Reverse	14	ON
*038	4	Forward	28/128	ON
*039	4	Reverse	28/128	ON
048	4	Forward	14 Speed Tables	OFF
049	4	Reverse	14 Speed Tables	OFF
050	4	Forward	28/128 Speed Table	OFF
051	4	Reverse	28/128 Speed Table	OFF
052	4	Forward	14 Speed Tables	ON
053	4	Reverse	14 Speed Tables	ON
054	4	Forward	28/128 Speed Table	ON
055	4	Reverse	28/128 Speed Table	ON

*The most often used values for CV29 are 06 (the default), 07, 38 & 39.

Most common values for CV29:

All Digitrax decoders are shipped with a factory default value of **006 in CV29**. This gives the following characteristics to the decoder: 2 digit address, normal direction of travel is forward, 28/128 speed step operation, analog mode conversion ON, loadable speed table OFF.

Programming **007 in CV29** gives the following characteristics to the decoder: 2 digit address, normal direction of travel is reverse, 28/128 speed step operation, analog mode conversion ON, loadable speed table OFF.

Another commonly used value is **038 in CV29**. This sets the decoder to use a 4 digit address, normal direction of travel is forward, 28/128 speed step operation, analog mode conversion ON, loadable speed table OFF.

A value of **039 programmed into CV29** will set the decoder to use a 4 digit address, has a normal direction of travel in reverse, operates in advanced 28/128 speed step mode, has analog mode conversion enabled, does not use a speed table.

8.0 LocoMotion CVs

8.1 Acceleration and Deceleration Rates
Acceleration and Deceleration rates are used to simulate operating a real train with your throttle.

8.1.1 Acceleration Rate: CV03
Acceleration is the rate at which the decoder increases from one speed step to the next in response to a new command to increase speed. CV03, acceleration, lets you simulate train weight or inertia. The range of values for acceleration is 000 to 031. Setting CV03 to a value of 00 generates an immediate response to a new command to increase speed. As you increase the CV value programmed into CV03, the rate of speed step change is approximately 1/10 second per increment in acceleration value.

For example, a value of 01 programmed to CV03 will cause the decoder to change at 1/10 second per speed step (using the 28 speed step range). This means that it would take approximately 2.8 seconds for the loco to go from stopped to full speed if you command the loco to go immediately to full speed.

8.1.2 Deceleration Rate: CV04
Deceleration is the rate at which the decoder decreases from one speed step to the next in response to a new command to decrease speed. CV04, deceleration, lets you simulate locomotive braking action. The range of values for CV04, deceleration, is 000 to 031. A value of 00 causes an immediate response to a new command to decrease speed. As you increase the CV value programmed into CV04, the rate of speed step change is approximately 1/10 second per increment in deceleration value.

For example a value of 01 programmed to CV04 causes the decoder to change at 1/10 second per speed step (using the 28 speed step range). This means that it would take 2.8 seconds to decelerate from full speed to stop if you commanded the loco to go immediately to stop when it was moving at full speed.

8.2 Throttle Response Curves & Loadable Speed Tables

THROTTLE RESPONSE CURVE
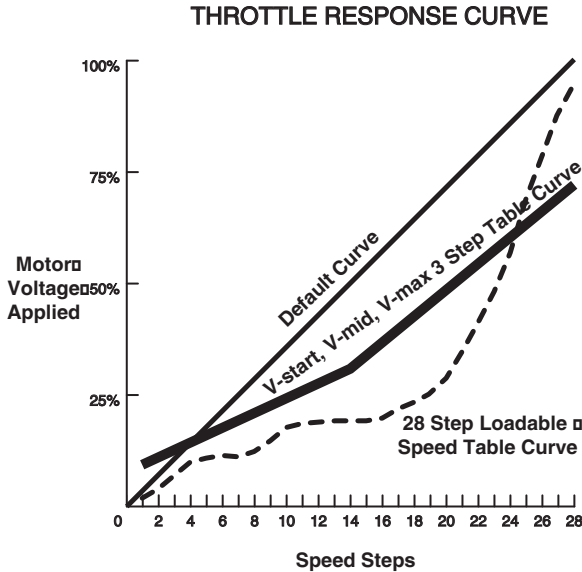
When using a throttle to control a locomotive, you will notice that as you increase and decrease the speed, the loco responds to the change in throttle settings according to the relationship between motor voltage applied and the throttle setting. This is called the throttle response curve. Decoders are shipped from the factory with a linear throttle response curve. This means that as you increase the throttle setting from 0 to full speed, the loco will look like the default curve in this diagram.

If you want to create a more realistic throttle response curve, you can set up either a simple three step speed table or a loadable speed table.

The simple speed table involves setting three CV values. The loadable speed table is a bit more involved with more precise results. Loadable speed tables define the percentage of motor voltage applied at each of 28 digital speed steps. By programming a value for each of the 28 steps, you can set up a customized throttle response curve for each individual decoder equipped locomotive. The shape of this curve defines the "feel" of the decoder's throttle response.

With Digitrax FX^3 decoders, when the loadable speed table is active and 128 speed step information is received from the command station, the table is interpolated to generate 4 in-between steps to give full 128 step resolution.

You can use the 3 step method for some locos and the 28 step method for other locos on your layout, you **do not** have to choose only one method or the other.

8.2.1 Simple 3 Step Speed Table

Start voltage, Max Voltage and Mid-point voltage can be used to set up a simple three step speed table. In most cases, a simple 3 step speed table is the easiest way to set up the throttle response curve you want. For higher resolution in your throttle response curve, you can use a loadable speed table.

You can set up a simple 3 step throttle response curve by setting V-start (CV02), V-mid (CV06) and V-max (CV05). This method requires programming just 3 CVs. Once these three CVs are set, you are ready to run the loco, no programming of CV29 is needed for this type of speed table.

8.2.2 V-Start: CV02

Start voltage, V-start, is the extra voltage added to the motor drive voltage at the first speed step. This adjustment allows you to compensate for the locomotive motor's efficiency. The range you can program for this CV value is from 000 to 255. Each value increment represents an increase of approximately 1/2% of the total motor drive voltage, when a "straight-line" throttle response curve is used. The value of 255 represents 100% motor voltage. Digitrax Series 3, 4, 5 & 6 decoders use V-start in 128 speed step mode and run loadable speed tables in 128 speed step mode. Most earlier version Digitrax decoders disregard V-start in 128 speed step mode and run loadable speed tables in 14 or 28 speed step mode.

8.2.3 V-Max: CV05

Setting CV05, V-max or maximum voltage, specifies an exact voltage that is applied to the motor at the highest speed step Setting V-max to a lower value than 255 allows you to limit the top speed of a locomotive. The range of available V-max CV values is 000 to 255. A value of 128 applies 50% of total voltage to the motor at the highest speed step. A value of 255 applies 100% voltage at the highest speed step.

For backward compatibility, CV05 values of 000, 001 & 255 all mean 100% voltage at step 28. If V-Max is accidentally set below V-mid, the decoder will use the V-mid setting as V-max.

V-max is not available when loadable speed tables are in use. In this case, set the maximum voltage by programming speed step 28 as the max voltage.

8.2.4 V-Mid: CV06

Setting CV06, V-mid or mid point voltage specifies an exact voltage that is applied to the motor at speed step 15 (or speed step 7 in a 14 step system). The range of available V-mid CV values is from 000 to 255. A value of 128 applies 50% of the total voltage to the motor at step 15 (28 step system). A value of 255 applies 100% voltage at the middle speed step.

If V-start (CV02) is accidentally programmed to a CV value greater than that programmed for V-mid (CV06), the decoder will force the output voltage for all steps below the V-mid value to be fixed at the V-mid value. This is done to prevent undesirable operational effects.

If a value of 00 or 01 is programmed into CV06 (V-mid), the decoder assumes a "straight-line" throttle response curve. In this case, the decoder will run as though V-mid were set at a value of 50% of total motor voltage.

V-mid is not available when loadable speed tables are in use.

8.2.5 Simple 3 Step Speed Table Examples

The following are examples of 3 step speed tables you might want to try. Keep in mind that these are average examples for average locos that are not using torque compensation or scaleable speed stabilization (Back EMF). Depending on your particular locomotive, you may need to adjust the values to achieve the results you want.

TABLE V: 3 Step Throttle Response Curve Examples

Throttle Response Curve Type	V-start CV02	V-mid CV06	V-max CV05
Switcher Concentrated low speed control. Limited top speed.	026	038	064
Road Switcher Prototypical top speed with evenly distributed speed control over range of throttle operation.	026	048	098
Mainline Locomotive Quick increase to cruising speed then levels off to prototypical top speed.	026	128	154

8.3 High Res 28 Step Loadable Speed Tables CV65-95

For a more precise throttle response curve, Digitrax decoders also have available a 28 step loadable speed table option. With this method, you must program values for up to 32 different CVs as detailed below. This can be time consuming but you only have to do it once, since the settings will be remembered by the decoder until you change them. If you have programmed a loadable speed table into a decoder, you can preserve that speed table when performing a decoder reset with CV08 by programming CV08 to a value of 09. If you do a full reset by programming CV08 to 08, the loadable speed table will be reset to the factory default with no values programmed.

When speed table is enabled and 128 speed step information is received from the command station, the table is interpolated to generate 4 in-between steps to give full 128 step resolution.

28 Step Speed Table Programming Example
1. Program CVs 65 through 95 and CV29 with CV values from **TABLE VI**.
2. After programming the table values, program CV29 to the value of 16 to enable the loadable speed table. If you want to disable the loadable speed table later, just program CV29 to 06 and you will return to 128 speed step operation (the speed table is still remembered and can be re activated by programming CV29 to 16 again later). Setting CV29 to the value of 16 will enable the 28/128 step speed table, enable analog mode conversion, set the normal direction of travel of the loco and enable 2 digit addressing. This CV value is just one of many choices to enable the loadable speed table and control the other variables handled by CV29 at the same time. Consult CV29 TABLE IV above for complete information about what value to program into CV29 to get the features you want.
3. Once the speed table is programmed, you can scale the entire speed curve by using the forward trim value (CV66) and reverse trim value (CV95). These CVs act like a "volume control." When you use these trim values, you don't have to reload the entire 28 step table if you want to change, for example, the maximum forward speed from 45 scale mph to 80 scale mph. Changing the forward or reverse trim values will scale all the values used in the table, in the corresponding direction, by the value programmed into the CV. Using different forward and reverse trim values allows for many different combinations. The trim values can increase the table values from 100% up to 200% or decrease them from 100% down to 2%.

When speed matching locos, get the first loco running the way you like and then match subsequent locos to it. We strongly recommend that you keep a running list of the CVs and CV values you have programmed for each decoder.

When CV29 is set to enable a loadable speed table, any V-max(CV05) or V-mid(CV06) values programmed are not used by the decoder when it determines how much motor voltage to apply. Non FX decoders don't use V-start (CV02) when a loadable speed table is enabled. Non-FX decoders don't run loadable speed tables in 128 speed step mode. To run non-FX decoders with a loadable speed table, you must run them in 14 or 28 speed step mode. Set their CV29 value to 016, 017, 020, 021, 048, 049, 052 or 053 and status edit these decoders to a value of 10, 20, 12, or 22. FX decoders have start voltage and 128 speed step table operation available.

TABLE VI: Example Loadable Speed Table

Used For	CV#	CV Value
Kick Start	CV65	001
Forward Trim	CV66	128
Step 4 Value	CV67	010
Step 5 Value	CV68	014
Step 6 Value	CV69	018
Step 7 Value	CV70	022
Step 8 Value	CV71	024
Step 8 Value	CV72	028
Step 9 Value	CV73	032
Step 10 Value	CV74	036
Step 11 Value	CV75	040
Step 12 Value	CV76	044
Step 13 Value	CV77	050
Step 14 Value	CV78	054
Step 15 Value	CV79	060
Step 16 Value	CV80	064
Step 18 Value	CV81	070
Step 19 Value	CV82	076
Step 20 Value	CV83	082
Step 21 Value	CV84	090
Step 22 Value	CV85	096
Step 23 Value	CV86	106
Step 24 Value	CV87	114
Step 25 Value	CV88	126
Step 26 Value	CV89	136
Step 27 Value	CV90	148
Step 28 Value	CV91	162
Step 29 Value	CV92	178
Step 30 Value	CV93	198
Step 31 Value	CV94	218
Reverse Trim	CV95	128
Configuration Register	CV29	022

Notes for **TABLE VI:**
1. The Kick Start CV provides for a short voltage "kick" when you start the locomotive decoder from 0 speed. A value of 00 turns this option OFF.
2. If you program Forward Trim (CV66) & Reverse Trim (CV95) to CV values of 128, 000, or 001 you will get no scaling effect. A trim value of 255 will give 200% scaling of the table entry value.
3. A final scaled table value of 255 represents 100% applied motor voltage or Full speed. A value of 128 represents 50% applied motor voltage, i.e., the actual table step entry is multiplied by the appropriate Trim value to yield the final scaled table value that defines the voltage to apply to the motor.
4. The steps defined in the table are for the 28 speed step mode. Step 4 is the first motion step in the 28 speed step system. Step 31 is the "full throttle" speed step. When setting up the decoder to run 14 step mode, only every second entry in the table is used. When 14 speed steps are used by the command station, the decoder will automatically use the correct CVs and their CV values from the speed table.
5. The suggested CV values given in the example speed table will give a throttle response curve that most US users will find useful. Once you have loaded the example table, feel free to modify the CV values to suit your own preferences.

8.4 CV54 Torque Compensation, Switching Speed & Decoder Lock Disable

Torque Compensation can improve loco performance by adjusting for the loss of torque due to high frequency pulse width modulation, PWM, associated with SuperSonic (silent) operation.

In FX^3 decoders, CV54 is used to control the decoder's torque compensation, switching speed and decoder lock enabled features.

Switching speed gives you fast access to lower speeds used in switching operations. This feature effectively reduces the throttle's target speed by approximately 50% and reduces the effects of accel and decel programmed into the decoder by 1/4 when the user activates this mode by turning on F6.

The decoder lock feature allows you to program CV values in individual decoders when there is more than one decoder installed in a locomotive. This is useful when sound only decoders have been added to a regular mobile decoder installation.

TABLE VII: CV54 Values

CV54 Values	Switching Speed	Torque Compensation	Decoder Lock
00	Off	On	Enabled
01	On	On	Enabled
16	Off	Off	Enabled
17	On	Off	Enabled
64	Off	On	Disabled
65	On	On	Disabled
80	Off	Off	Disabled
81	On	Off	Disabled

8.5 Scaleable Speed Stabilization (Back EMF)

Digitrax decoders are equipped with scaleable speed stabilization (adjustable Back EMF). This LocoMotion feature can help smooth out operation in the low end speed range. It allows you to run locomotives at the same speed no matter the track grade. It can also help improve operation of steam locomotives. Digitrax decoders offer the ability to adjust the amount of speed stabilization used by a decoder. Digitrax FX^3 decoders are shipped with default speed stabilization values that improve the operation of most locomotives.

TABLE VIII: Scaleable Speed Stabilization-Adjustable Back EMF CVs

Scaleable Speed Stabilization (Back EMF)			
CV#	Purpose	Default Value	Range
55	Static compensation	128	00-255
56	Dynamic compensation	80	00-255
57	Amount of speed stabilization (Intensity)	06	00-15

CV55 controls the static compensation or how much the decoder considers the difference between the current motor and locomotive speed and the target speed set on the throttle when determining the next speed command to send to the motor. This is like the stiffness of a spring. The stiffer the spring, the more compensation you will get. CV55 values can range from 000-255. Higher values give a more intense reaction and lower values give less intense reactions. The factory default setting for CV55 is 128. It will have no effect on decoder operation until you program CV57 as described below.

CV56 controls the dynamic compensation or how much the decoder considers the historical difference between the current speed and the target speed when determining the next speed command to send to the motor. This setting is like a damper or shock absorber on the spring that helps to restore the spring to its new position. CV values can range from 000 to 255. Higher values cause more rapid adaptation to the target speed and lower values cause slower adaptation to the target speed. The factory default setting for CV56 is 048. It will have no effect on decoder operation until you program CV57 as described below. Excessively high CV values programmed to CV56 will tend to let the locomotive "hunt" around a new desired speed when a change of speed is commanded. We recommend that you use the lowest CV value in CV56 that gives the desired performance.

CV57 controls the amount of back EMF (intensity) or speed loss as load is increased, by limiting the amount of change or compensation that the decoder is allowed to implement. CV57 controls the back EMF separately for regular addresses and advanced consist addresses.

Table VIIIa: CV57 Values To control the amount of Back EMF

Amount of Back EMF (approximate)	Value to add single unit	Value to add for advanced consists
Off	00	00
7%	1	16
14%	2	32
20%	3	48
27%	4	64
33%	5	80
40%	6	96
47%	7	112
53%	8	128
60%	9	144
67%	10	160
73%	11	176
80%	12	192
87%	13	208
93%	14	224
100%	15	240

If either digit is 00, speed stabilization is OFF. A value of 015 is speed stabili-

zation FULL ON. If the amount of back EMF intensity CV value is too high, you may see locos jump from one speed to the next if they encounter an obstacle or problem with track work. If the value is too low, there will be very little speed stabilization effect at all. A higher value makes the intensity or speed fall-off less. A typical value for most locomotives not part of an advanced consist is CV57=005, but the actual value that is best for a locomotive and train length must be determined by observation and experimentation. Note that this value of 005 for this example means that no speed compensation is used when this decoder is in an Advanced Consist.

When you are using Scaleable Speed Stabilization (Back EMF), you don't need to program a large CV value for V-start (CV02) to compensate for sluggish motors. This is because when scaleable speed stabilization is used, the decoder will automatically adjust the motor power up to at least the V-start setting, to achieve the actual speed commanded. This means that low speeds like 3% or 4% of full speed will perform best when CV02 is programmed to 000.

How to set up a loco with Scaleable Speed Stabilization (Back EMF)
1. Install the decoder.
2. Program CV57 (Amount of Back EMF) to a CV value of 005 This will turn on speed stabilization.
3. Put the loco on level track and run it at approximately 20% of full speed. Beginning with the default value of 128 in CV55 (Static), reprogram the CV value to increasingly higher values until you observe the loco jumping as speed steps increase when you run the locomotive. Finish this step by reprogramming CV55 to the CV value just before the jumping started. Ops Mode programming on the main line works very well here.
4. Follow the same procedure with CV56, beginning with the default value of 048 and increasing it until you notice the loco oscillating, as speed is increased. Finish this step by programming CV56 to the CV value just before the oscillation started.
5. Follow the same procedure with CV57, beginning with the value 05 as programmed in step 1. Increase the CV value in this CV until the speed when going up hill is roughly equivalent to the speed on level track. This will yield a best Back EMF intensity consistent with the locomotive's characteristics.
6. Keep notes about the CV values you program for these 3 scaleable speed stabilization control CVs so that you can use them as a starting point for setting up scaleable speed stabilization in similar locomotives.

8.6 Advanced Consist Address CV19

CV19 is the advanced consist address. When this CV is in use for an advanced consist, the functions within the advanced consist are individually controlled at their individual locomotive addresses. CV21 & 22 are used to control functions in advanced consists, see Section 9.10.

8.7 CV61 Transponding & LED/Lamp Algorithm Selector

Digitrax FX^3 Decoders use CV61 (one of the manufacturer specific configuration variables) for enabling or disabling transponding and for selecting whether the decoder will use the LED or incandescent lamp lighting algorithm.

8.7.1 Transponding Feed Back From Decoders

Transponding feeds back the transponding zone location of any specific locomotive or other rolling stock equipped with a transponder. Location and identification information are updated constantly on LocoNet and can be displayed on a track diagram, throttle, or computer. Transponding decoders and transponders work in conjunction with transponding receivers installed on the layout.

Digitrax transponding does not require any additional modifications or inductors to be added to your locos, rolling stock or system boosters.

All current production Digitrax decoders incorporate patented transponding technology. Decoders are shipped with transponding disabled because layout hardware must be installed to use this feature.

If your decoder does not have an integrated transponder, you can add a TL1 or TF4 to your installation to add transponding. Transponders can also be added to rolling stock that does not have a decoder. Transponding devices can be added to DCC equipped locos as well as non-DCC equipped locos and rolling stock. You can install transponding devices in locos with decoders made by other companies to get the benefits of transponding. If you are using "silent-running" decoders made by other DCC companies on your layout be sure that they are Digitrax transponding compatible. If they are not, simply disable this feature in those decoders to prevent interference with transponding.

Digitrax transponder current pulse generation uses the F0 decoder function output that is also used for the forward light function. Transponding will not affect the operation of the forward light but you may see a slight glow when the light is turned off.

To set up your layout for transponding:
  1. Install transponding layout hardware on the layout according to instructions.
  2. All Digitrax Series 3, 4, 5, & 6 decoders have built in resistors for

transponding. Earlier versions of Digitrax decoders may need to have a load resistor installed for transponding to work. Please consult instructions for those specific decoders.

3. In some situations it may be beneficial to add a resistor between the blue and white leads to improve transponding effectiveness. If you are running zones where the average current draw is more than 3 amps, you may need to connect an additional 100 ohm 1/8 watt resistor in series with a 0.1uF ceramic capacitor across the white and blue decoder outputs.

4. Enable transponding by programming CV61 to a value of 02 or 03.

5. Place the loco on the track set up for transponding, select it and run it back & forth. Verify that transponding is working. If transponding is not working, be certain that the resistor described above is installed properly between the white and blue outputs of the decoder.

6. Pick up the loco and turn it around on the track, select it and run it back and forth again. Verify that transponding is working in that orientation as well. If transponding is not working, be certain that the resistor described above is installed properly between the white and blue outputs of the decoder.

NOTE: Locos must be selected in the system for transponding to work.

8.7.2 LED/Lamp Algorithm Selector

Beginning with Series 6 decoders, Digitrax FX effects are optimized for either LEDs or incandescent lamps. Since these two types of lighting devices have different characteristics, Digitrax has set up two selectable algorithms for operating the devices. Some users like lamps better than LEDs and vice versa. Many new production locomotives have been produced with LEDs. You have the option to use either.

8.7.3 CV61 Values: Transponding & Lighting Algorithm

You can set up whether transponding is enabled or disabled and which lighting algorithm you use in CV61 as shown in the following table. The factory default is 00, transponding off and LED algorithm selected.

TABLE IX: CV61 Values Transponding and Lighting Algorithm

CV 61 Value	Transponding	LED or Lamp
00	Off	LED
01	Off	Lamp
02	On	LED
03	On	Lamp

8.8 CV09 SuperSonic (Quiet Operation)

SuperSonic motor drive sets up transponding compatible silent operation by adjusting the motor frequency. In this case, 00 is max (16KHz) and 225 is minimum.   Note: If you are using decoders made by other manufacturers on a transponding equipped layout, you may need to turn off this feature in those decoders for transponding to work properly.

9.0 Function CVs

Function CVs control how the function leads on your decoder work.

9.1 Digitrax Light Effects: CV49-CV52 & CV113-CV116

Decoders with FX^3 features have 8 user configurable, independent special effects generators. These are set up by programming CV values as described below. If you do not program the FX^3 CVs to set up the features, your function outputs will run as standard on/off function outputs.

Standard functions turn functions on and off.

FX^3 **functions** incorporate up to 8 independently controllable FX^3 generators. FX^3 function outputs can be mapped to be controlled by any function key on your throttle. A master light switch can be set up to turn off all lights on a locomotive. Functions associated with locomotives in advanced consists can also be controlled independently.

9.2 Setting Up FX^3 Effects On Function Outputs

1. Each function output has an FX^3 control CV associated with it. Using **TABLE X** below, determine which CV you need to program to set up an FX^3 feature for the function output you are working with. For example, if you want to set up an FX^3 feature on your forward headlight, you will use CV49 to control the FX^3 feature for the LED/lamp attached to the F0F decoder output.

TABLE X: FX^3 Generator CVs		
FX^3 CV#	Function #	Output Color
CV49	F0/Light Forward (F0F)	White
CV50	F0/Light Reverse (F0R)	Yellow
CV51	F1 Function 1	Green
CV52	F2 Function 2	Violet
CV113	F3 Function 3	Brown
CV114	F4 Function 4	White/Yellow
CV115	F5 Function 5	White/Green
CV116	F6 Function 6	White/Blue

Note: Some decoders do not have function output wires attached. See the specific decoder instructions to determine which function output "pad" on the decoder controls each function. Use thin wire to solder function output wires to the pads associated with the function you want to use.

2. Each FX^3 effect has a CV value that generates the effect you want on a particular output. That CV Value also controls the FX^3 effect's operating characteristics with respect to locomotive direction and the head light (F0) function. Because of all the built in flexibility offered by FX^3, it may seem confusing at first. So, wiring and CV programming combinations for the most commonly used FX^3 effects are included in the next section. We recommend that you try these first.

Then if you want to do more customization to your specific installation you can use our online CV calculator at www.digitrax.com/support/cv to compute the CV values for your specific situation.

Or, use TABLE XI & XII to determine the CV value to program for each individual output lead. Choose a value from the FX^3 Effect Table and a value from the FX^3 Operational Characteristics Table. Add these two numbers together to determine the CV value to program into the CV associated with the output you are using to achieve the effect and operational characteristics you want.

3. Program the FX^3 CV value you have selected to the FX^3 CV that corresponds with the function output you are using.

4. For FX^3 decoders, you can repeat steps 1, 2 and 3 to set up as many as 8 FX^3 effects on any function outputs available on the decoder you are using. For example 6 function FX^3 decoders support only 6 FX^3 generators.

9.3 Commonly Used FX^3 Effects On Function Outputs

To help you get up and running quickly with FX^3 we have included examples of the most often used combinations in this section. Each of these examples shows how to use these effects on specific function outputs. Note that if you are using the effects on different function outputs, you will need to use the appropriate CV# to control the function output in use.

If you want to go further and do additional customization, please read on to the following sections to dig deeper and learn more.

9.3.1 Simple On/Off Function

All FX^3 decoders are set up as simple ON/OFF functions at the factory. That means that each FX^3 Generator CV (49-52 & 113-116) is programmed to a value of 00. If you have changed the CV values, you can always reprogram them back to 00. If you do a decoder reset by programming CV08 to 08 or 09, the FX^3 Generator CVs will return to their factory defaults of 00.
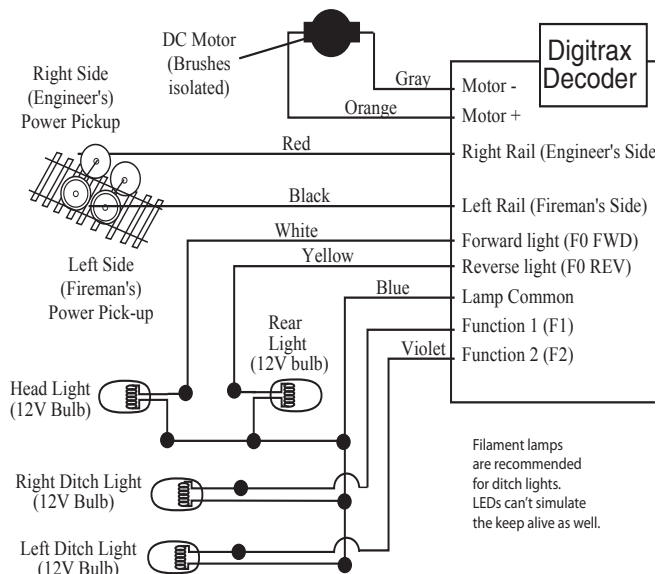
9.3.2 Forward Ditch Lights Operating on F2

To set up forward ditch lights to flash alternately when F0 is ON & F2 is pressed:

1. Wire left (conductor's side) lamp or LED to F1 and Blue Common
2. Wire right (engineer's side) lamp or LED to F2 and Blue Common
3. Program CVs as shown below:

FX^3 CV#	CV Value
CV51	106
CV52	107
CV62	196
CV63	64

Setting Up Ditch Lights
with ~~Digitrax~~ FX³ Decoders

Right Side (Engineer's) Power Pickup

DC Motor (Brushes isolated)

Digitrax Decoder

Gray — Motor -
Orange — Motor +
Red — Right Rail (Engineer's Side
Black — Left Rail (Fireman's Side)
White — Forward light (F0 FWD)
Yellow — Reverse light (F0 REV)
Blue — Lamp Common
Function 1 (F1)
Violet — Function 2 (F2)

Left Side (Fireman's) Power Pick-up

Rear Light (12V bulb)

Head Light (12V Bulb)

Right Ditch Light (12V Bulb)

Left Ditch Light (12V Bulb)

Filament lamps are recommended for ditch lights. LEDs can't simulate the keep alive as well.

9.3.3 Rear Ditch Lights Operating on F3 & F4

To set up rear ditch lights:
1. Wire left (conductor's side) lamp or LED to F3 and Blue Common
2. Wire right (engineer's side) lamp or LED to F4 and Blue Common
3. Program CVs as shown below:

FX³ CV#	CV Value
CV113	122
CV114	123
CV62	196
CV63	64

The ditch lights will flash alternately when F4 is pressed and loco is operating in reverse.

9.3.4 Mars Lights On F1

To set up a Mars lights:
1. Wire lamp or LED to F1 and Blue Common
2. Program CV51 to 34
3. Mars light will be on when F1 is turned ON. This will make it non-directional and ON whenever F1 is ON no matter which direction the loco is running.

9.3.5 Rotary Beacon on F1

To set up a rotary beacon:
1. Wire lamp or LED to F1 and Blue Common
2. Program CV51 to 038
3. Rotary beacon will be on when F1 is turned ON. This will make it non-directional and ON whenever F1 is ON no matter which direction the loco is running.

9.3.6 Rule 17 Dimming on F0Fwd and F0Rev

To set up a rule 17 dimming:
1. Wire lamp or LED to F0F and Blue Common
2. Wire lamp or LED to F0R and Blue Common
3. Program CV49 to 104
4. Program CV50 to 120
5. When loco is reversed lights will dim on opposite end of locomotive.

9.3.7 Rule 17 AND Forward Ditch Lights

To set up a rule 17 dimming & forward ditch lights on F0F, F0R & F2:
1. Wire lamp or LED to F0F and Blue Common
2. Wire lamp or LED to F0R and Blue Common
3. Wire lamp or LED to F1 and Blue Common
4. Wire lamp or LED to F2 and Blue Common
5. Program CVs to the values in the table below.

CVs for Rule 17 dimming and Forward Ditch Lights Example

CV#	CV Value	Effect
49	104	Rule 17 on head light & no ditch lights in reverse
50	120	Rule 17 on rear light & no ditch lights in reverse
51	106	Right forward ditch light, directional F0 & F2 must be ON for this to operate
52	107	Left forward ditch light, directional F0 & F2 must be on for this to operate
62	196	High keep-alive for lamps, rate 4 gives approx. 1 second FX effect rate
63	064	5 second ditch light hold over after F2 is turned OFF
This will cause ditch lights to be ON while moving along the track and flash when F2 is pressed at the crossing. If you want the ditch lights to be OFF while moving and come ON & flash when you press F2, program CV51 to 234 and CV52 to 235.		

9.3.8 Alternating Double Pulse Strobes on F1 & F2

To set up alternating double pulse strobes:
1. Wire lamp or LED to F1 and Blue Common
2. Wire lamp or LED to F2 and Blue Common
3. Program CV51 to 037
4. Program CV52 to 053

This is an example of using the alternate effects of phases A & B with two different function outputs wired to two different LED/lamps..

9.4 Tables for Determining FX^3 CV Values

Choose a value from TABLE XI:FX^3 Effect Table and a value from TABLE XII: FX^3 Operational Characteristics Table. Add these two numbers together to determine the CV value to program into the CV associated with the output you are using to achieve the effect and operational characteristics you want to use.

TABLE XI: FX^3 Effect Table

Decimal Value to Add for CV Value Computation for FX^3	FX^3 Effect Generated
0	No effect, normal function control of output lead
1	Random flicker
2	Mars light
3	Flashing headlight
4	Single pulse strobe
5	Double pulse strobe
6	Rotary beacon simulation
7	Gyralite
8	Rule 17 dimmable headlight, dim with F4 is active or locomotive direction is opposite normal direction of travel (NDOT)
9	FRED or "end of train" light
10	Right ditch light, On when loco is running forward and F0 is on. When F2 (Horn) is on, the right ditch light flashes alternately with the left ditch light to simulate ditch light operation at a grade crossing.
11	Left ditch light. On when loco is running forward and F0 is on. When F2 (Horn) is on, the left ditch light flashes alternately with the right ditch light to simulate ditch light operation at a grade crossing.
12	Series 6 decoder pulse function
13-16	Digitrax reserved for effects expansion.

TABLE XII: FX^3 Operational Characteristics Table

Value to Add for CV Value Computation for FX^3	How the FX^3 Effect Generated Will Operate
0	Forward direction, ON with function ON, effect phase A*
16	Reverse direction, ON with function ON, effect phase B*
32	Non directional effect, ON with function ON, effect phase A*
48*	Non directional effect, ON with function ON, effect phase B*
64*	Forward direction, ON with F0 ON **&** function ON, effect phase A*
80*	Forward direction, ON with F0 ON **&** function ON, effect phase B*
96*	Special logic for Forward Ditch Light or Rule 17 dimming, standard Ditch Light Operation
112	Special logic or Reverse Ditch Light or Rule 17 dimming , standard Ditch Light Operation
160	Speed=0, non directional effect, phase A and function qualifier
176	Speed>0, non directional effect, phase B and function qualifier
192*	Ditch light off phase A Alternate Ditch light operation- OFF when running flash on with F2
208*	Ditch light off phase B Alternate Ditch light operation- OFF when running flash on with F2
*Master Light Switch	To use F0 as the Master Light Switch, you must use 48, 64, 80, 96, 192, or 208

*Each FX^3 function can be set up to have two phases. This allows you to set up ditch lights and other effects where you use two function leads that alternate. Each of two function outputs is wired to a different LED/Lamp and Phase A & B are set up to have them alternate being on.

9.5 FX^3 Rate & Keep Alive Brightness CV62

CV62 controls the keep alive/baseline off voltage for incandescent lamps. This lets you set a lamp so that it does not go completely off for a realistic simulation of ditch lights. LEDs behave differently than lamps so this adjustment should be set to 0.

CV62 also controls how fast/slow the programmed effect operates. This lets you adjust the flashing rate of the lights.

The settings in CV62 affect all function outputs on the decoder.

The default value for CV62 is 00 for no keep alive brightness and fastest function operation rate.

Use our online CV calculator at www.digitrax.com/support/cv to compute the CV values for your specific situation. Or use the following table to determine the appropriate CV value for CV62. Simply choose a value for each characteristic and add them together to get the CV value to program into CV62.

NOTE: Lamps produce better effects. LEDs cannot be set to go completely off and are not able to simulate lighting effects as well as incandescent lamps.

TABLE XIII: CV62 Rate and Keep Alive

Characteristic	Value to add
Keep Alive Brightness/Baseline Off Voltage for incandescent lamps	0-15 0=Lamp goes completely off 15=maximum keep alive brightness For LEDs this should be 0
Rate of effect programmed	0, 16, 32, 48, 64, 80, 96, 112, 160, 176, 192, 208, 224, 240 0=fast rate 240=slowest rate Start with 64 and adjust from there

9.6 Ditch Light Hold Over Time CV63

If you are using the ditch light effect in conjunction with F2, CV63 lets you set up a hold over time to control how long the ditch lights continue to blink after F2 turned off by releasing the key on the throttle. Remember that F2 is a momentary key on most Digitrax throttles that will keep Function 2 on as long as you hold the key down and then turn Function 2 off when you release the key. This allows the ditch lights to be on steady during regular operation and to begin alternate flashing when F2 (usually the horn) is activated and to continue flashing alternately for a predetermined length of time after F2 is released; just like the prototype. A value of 00 yields no hold over time, a value of 40 yields a realistic time of approximately 3 seconds. A value of 255 yields approximately 20 seconds hold over time. Use our online CV calculator at www.digitrax.com/support/cv to compute the CV values for your specific situation.

Note: The settings in CV63 affect all function outputs on the decoder.

9.7 Troubleshooting FX effects

Common problems with FX set up are:

Trying to program a decoder for FX when the decoder does not support FX. Be sure the decoder you are installing has FX features. Digitrax introduced FX in the summer of 1995 so if your decoder was made before then it does not have FX capability. Since 1995 all Digitrax premium decoders have included FX. Digitrax standard and economy decoders do not have FX features.

FX effects don't work as expected. Review the qualifiers you set up for the effect. For example, if the effect is set up to come on only when F1 and F0 are active and the loco is headed in the forward direction, be sure you have met those conditions.

9.8 Setting Up A Master Light Switch with FX³ Decoders

For FX^3 decoders F0 can be used as a master light switch to turn off all lights in the locomotive when F0 if OFF. To do this, set up all functions so they are ON when F0 is ON and OFF when F0 is OFF. See TABLE XII for master light switch set up.

9.9 Lamp Selection For Prototypical Lighting Results

At the heart of realistic FX lighting effects is the selection of lamps that can give realistic looking results. Adjusting the brightness and locating the lamps in the model also have an effect on how realistic your installation will look.

Most modern locomotives use LEDs for lighting and over time the LEDs in current use have gotten more realistic looking. Digitrax recommends using incandescent lamps to achieve the most realistic lighting effects. Digitrax Series 6 decoders give you the option to select whether to use the FX algorithm that is best for LEDs or the one that is best for incandescent bulbs, this is set in CV61 and is set to the LED setting at the factory since most current production locos use LEDs.

For 1.5V lamps, a current setting resistor MUST be used in series with the + voltage supply to the lamp. This is usually installed in series with the "white or yellow" wire. For example operating on the DB150 "N scale" setting with 12V DCC signal on the track, we have found a resistor of approximately 500 ohms 1/4 watt gives 1.2mm lamps a good brightness level without shortening their lives too much. With 1.5V lamps, the brightness level is very sensitive to the resistor value. As you change the value of the resistor you will see that the related change in lamp brightness is "non linear." Running a few volts higher will create too bright a light and degrade lamp life and lower voltages may result in very dim lights.

A 12 or 14 volt lamp run directly without resistors will be less sensitive to voltage fluctuations. ***For regular 12 to 16 volt lamps that draw more than 50 mA when lit, we recommend that you put a 22 to 33 ohm 1/4 watt resistor in series with the lamp leads. This will ensure that the lamp "start-up currents" (up to 10 times normal current draw) do not overload the outputs.***

To achieve the best results, select an appropriate incandescent lamp and experiment with different resistors and FX settings to get just the right prototypical lighting effects for your model. To get the best looking "pulse" and "Mars" type light effects, place the lamp so that it is viewed directly. Lamp end lenses can intensify and focus the filament image when viewed end-on. Lenses can be used to create a more intense bright period without having excessive, voltages on the lamp which can reduce lamp life.

LEDs and incandescent bulbs have inherently different lighting characteristics. You may find that you prefer one or the other. Since plastic light pipes diffuse lamp outputs, installations with light pipes will look different from those where lamps that are directly viewed.

9.10 Setting Up Non-FX Functions

When an FX^3 decoder output is set up for no FX effect, you can use static qualifiers to customize the operation of the on/off function of that output. See the table below to determine the CV value to program for this type of operation.

TABLE XV: Static FX function set up

Static CV Value	How the Static Function Output Will Work
000	On/Off Output controlled by function map
016	On/Off Output controlled by function map
032	Forward qualified On/Off Output
048	Reverse qualified On/Off Output
064	F0 qualified On/Off Output (Master Light Switch F0)
080	F0 qualified On/Off Output (Master Light Switch F0)
096	F0 On in reverse direction qualified On/Off Output
112	F0 On in forward direction qualified On/Off Output
160	Speed=0, non-directional qualified On/Off Output
176	Speed>0, non-directional qualified On/Off Output

9.11 Advanced Consist Function Controls CV21 & CV22

CV19 is the advanced consist address. When it is active, the functions within the advanced consist are individually controlled at their individual locomotive addresses.

CV21 & CV22 allow you to place specific functions under the control of the advanced consist address instead of the individual locomotive addresses. To determine the value to program into these CVs, add up the values of the functions you want to control in the advanced consist and program those values into the CVs. To make all CVs be controlled by the advanced consist address, program a value of 255 to both CV21 & CV22. Visit www.digitrax.com/support/cv/ for our automated CV value calculator.

TABLE XVI: CV21 Values

Function Controlled	Value to add
F1	1
F2	2
F3	4
F4	8
F5	22
F6	50
F7	100
F8	200

TABLE XVII: CV22 Values

Function Controlled	Value to add
F0	1
F9	22
F10	50
F11	100
F12	200

For example: If you want to have F0, F1 and F5 controlled by the advanced consist address, program CV21 to a value of 023 and CV22 to a value of 001. All other functions will still be controlled by the decoder's regular address.

9.12 Function Mapping

Function mapping lets you set up which key on your throttle controls a given function output. More than one function output can be mapped to one function key. Use the table below to determine the CV values to program to the function mapping CVs to make the function controls on your throttle work the way you want them to work. For an automated function mapping calculator see www.digitrax.com/functionmapping/.

Each row is a throttle function control key and its associated control CV. The columns show the function outputs on your decoder can be mapped to the throttle function control keys. Function outputs are called out as the wire colors related to each one. In the case of decoders without function wires attached, check the wiring diagram to determine what color the wire would be if there

were one attached to the decoder. On the following table, a ● in any column indicates the default throttle function control key that controls the decoder function output. More than one function output can be mapped to be controlled by a single throttle function control key. All mapping combinations are not available, only the ones shown on the TABLE XVIII below.

TABLE XVIII: Function Mapping

Throttle Function	Map CV	Decoder Output Colors								Default Value
		Wht F0F	Yel F0R	Grn F1	Vio F2	Brn F3	Wht Yel F4	Wht Grn F5	Wht Blue F6	
Add Value to Include		001	002	004	008	016	032	064	128	
F0F	CV33	●								001
F0R	CV34		●							002
F1	CV35			●						004
F2	CV36				●					008
F3	CV37					●				016

Throttle Function	Map CV	Decoder Output Colors					Default Value
		Vio F2	Brn F3	Wht Yel F4	Wht Grn F5	Wht Blue F6	
Add Value to Include		001	002	004	008	016	
F4	CV38			●			004
F5	CV39				●		008
F6	CV40					●	016
F7	CV41						032
F8	CV42						064

Throttle Function	Map CV	Decoder Output Colors		Default Value
		Wht Grn F5	Wht Blue F6	
Add Value to Include		001	012	
F9	CV43			016
F10	CV44			032
F11	CV45			064
F12	CV46			0128

To map functions, place ●s in the appropriate columns, add up the numbers and program the decoder with the values derived.

9.12.1 Function Mapping Example

The following example shows how to map functions as follows:

F0 non-directional controlling both White & Yellow Outputs
F1 controls Green
F2 and F8 control Violet. Turns Violet ON when either F2 or F8 is ON.
F3 controls Yellow
F5 controls White with Yellow Stripe and White with Green Stripe
F6 controls nothing and F7 controls Brown

Throttle Function	Map CV	Decoder Output Colors								Default Value
		Wht F0F	Yel F0R	Grn F1	Vio F2	Brn F3	Wht Yel F4	Wht Grn F5	Wht Blue F6	
Add Value to Include		**001**	**002**	**004**	**008**	**016**	**032**	**064**	**128**	
F0F	CV33	•								001
F0R	CV34	•								002
F1	CV35			•						004
F2	CV36				•					008
F3	CV37		•							016

Throttle Function	Map CV	Decoder Output Colors					Default Value
		Vio F2	Brn F3	Wht Yel F4	Wht Grn F5	Wht Blue F6	
Add Value to Include		**001**	**002**	**004**	**008**	**016**	
F4	CV38			•			004
F5	CV39				•	•	008
F6	CV40						016
F7	CV41		•				032
F8	CV42	•					064

Throttle Function	Map CV	Decoder Output Colors		Default Value
		Wht Grn F5	Wht Blue F6	
Add Value to Include		**001**	**012**	
F9	CV43			016
F10	CV44			032
F11	CV45			064
F12	CV46			0128

10.0 Decoder Utility CVs

The decoder utility CV group handles decoder reset to factory default CV values, decoder lock for programming when multiple decoders are present in a locomotive and decoder ID information.

10.1 Factory Reset CV: 08

CV08 is the factory reset CV for all FX^3 decoders.

For Series 3, 4, 5, & 6 decoders, reset all CV values to their factory default, program CV08 to a value of 008. This will also cause sound projects to revert to the factory installed project.

For Series 3, 4, & 5 decoders, reset all CV values except for 28 step speed tables to their factory values set CV08 to a value of 009. For Series 6 sound decoders, programming CV08 to 009 will also preserve the current sound project selected by CV60.

Note: Performing a factory reset will not affect the manufacturer ID and will reset the decoder's address to the factory default of 03, a 2 digit address.

10.2 Decoder Lock CV15, CV16 & CV54

Decoder Lock lets you use more than one decoder in a locomotive and be able to program their CVs separately. Since all decoders with the same address will accept programming commands directed to that address, decoder lock avoids the inconvenience of uninstalling one or more of the decoders in order to program CVs in just one of the decoders installed in the loco. For example, if you use a mobile decoder and a sound decoder together in your locomotive, you can use the same mobile decoder address during operation and when programming you can unlock only the one you want to program.

Note: If you are installing only one decoder in a locomotive, there is no need to modify the default values of zero in CV15 and CV16.

Decoder Lock is a manufacturer specific CV. The instructions provided here are for Digitrax decoders. If you are using decoders from another manufacturer, please consult your decoder's instructions for how this feature works with the decoder you have installed.

CV16 sets the ID number of each decoder installed in the locomotive.

CV16 can be programmed to a value from 0 to 7 inclusive. This value identifies a single decoder. A unique value must be assigned to each decoder installed in a particular locomotive so that it can be selectively unlocked for programming later.

Digitrax recommends using the following values for CV16 for consistency:

0: Factory Default Value-Decoder is not locked
1: Motor decoder
2: Sound decoder
3: Function-only decoder (e.g. for additional lights)
4-7: Additional Decoders installed in the locomotive.

CV15 selects the target decoder that will accept programming commands.

When the values in CV15 and CV16 are **equal**, all CVs in the target decoder can be programmed.

When the values in CV15 and CV16 are **not equal**, only CV15 can be programmed.

CV54 allows decoder lock to be disabled. Digitrax decoders are shipped with decoder lock enabled by default.

The Factory Default Reset CV (CV08=08) will not work on decoders that are locked unless the CV15 and CV16 values are equal. This prevents the user from accidentally resetting multiple decoders at the same time, and losing the ability to separately address them for programming purposes.

Implementation Specifics:
Each decoder is shipped from the factory with decoder lock enabled but are unlocked with both CV15 & CV16 programmed to a value of 0.

Before installing each unlocked decoder in the locomotive:
1. Connect the target decoder to the programming track all by itself
2. Write a value of 08 to CV08 to ensure CV15 and CV16 are both zero
3. Read CV15 to confirm that the CV Value is 0 meaning that the decoder is unlocked.
4. Program CV values desired into any CVs in the target decoder. Program the address to the one you will use for all of the decoders that will be locked together.
5. When you are finished programming the CVs, lock the decoder by writing CV16 to the desired ID number, for example 02 for a sound decoder. This step locks the target decoder to ID 02.
6. Disconnect the target decoder from the programming track and install it in the locomotive
7. Repeat in turn for each decoder to be installed in the locomotive. Note that this decoder lock method can be performed even when only a write-only programming method is available. Also, it is possible to use a "legacy" non-lock version decoder along with new lock

capable decoder(s). In this case, program the decoders with the lock feature first, locking each one when programming is complete, and leave the non-lockable decoder to be programmed last.

To access a decoder after installation:
1. When you want to program CVs in the target decoder with ID XX again, unlock it by programming CV15 to match the ID XX programmed in CV16. In the case of the example decoder, program CV15 to 02.
2. Once the decoder is unlocked, program CVs as desired.
3. When programming is finished, lock the decoder by programming CV15 to 0.

To identify the decoder(s) present in a locomotive:
1. Write a 0 to CV15
2. Attempt to read a 0 from CV16.
3. If no acknowledge is received, there is no decoder with ID 0. If an acknowledge is received, a decoder with ID 0 exists.

Repeat this process for ID 1 through 7 to check for those IDs. Because the ID values are low, a successful read is usually quick. An unsuccessful read, i.e. when the decoder is not present, will take some time on many existing command stations, but eventually give an answer.

10.3 Decoder ID CVs 105, 106, 07, 08
CVs 105 & 106 are user private ID CVs. These can be programmed to any value you choose.

CV07 is the version ID. This is a read only CV that can't be changed.

CV08 is the decoder reset CV which also contains the manufacturer ID. The manufacturer ID is read only and can't be changed.

11.0 Digitrax SoundFX System
Digitrax SoundFX® decoders come "ready to run" with a pre-loaded sound project appropriate for the locomotive each decoder was designed to fit. Decoders not built for specific locos come preloaded with a multiple scheme sound project that gives the choice of a either generic diesel or generic steam sound project or, in the case of the multi-scheme project, several different choices including both steam and diesel. Some sound projects include additional sounds such as horns, whistles and bells that can be used to customize schemes within the project.

Using Digitrax SoundLoader and your PR3 Xtra, you can change the sound projects your decoder plays. SoundLoader runs on your PC and connects to your sound decoder using the Digitrax PR3 Xtra programmer. With SoundLoader you can easily manage the sound project files your decoders uses. If you simply want to browse inside sound projects, you can use SoundLoader without a PR3.

11.1 Sound Decoder Installation

Sound decoder installation takes more space than standard decoder installation because of the speakers, baffles and sound hold up capacitors that are needed to successfully produce consistent sound in a real world layout environment. Wired sound decoders have sound harnesses in addition to the regular decoder installation harnesses:

10 Pin Sound Harness
for 6 Series HO Decoders

Pin 1 – Brown – F3
Pin 2 – Red – Not used
Pin 3 – Red – speaker (+ polarity)
Pin 4 –Yellow – F4
Pin 5 – Green – not used
Pin 6 – Blue – to sound cap +
Pin 7 – Violet – not used
Pin 8 – Black – speaker (– polarity)
Pin 9 – White – cam input (steam)
Pin 10 – Black – to sound cap -
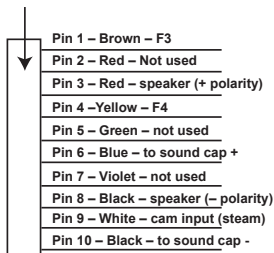
6 Pin Sound Harness
for 6 Series N Scale Decoders

Pin 1 – Grey-Cam Input (Steam)
Pin 2 – Red – speaker (+ polarity)
Pin 3 – Black-speaker (- polarity)

Pin 5 – Red-Capacitor (+ polarity)
Pin 6 – Black-Capacitor (- polarity
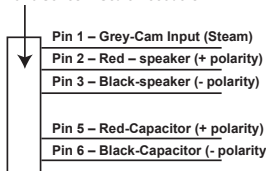
11.1.1 Speaker and Baffle Installation

The sound performance of any sound decoder depends on the speaker(s), how it is installed and the baffle or rear enclosure. Your Digitrax SoundFX decoder was equipped with speaker at the factory. You may choose to use a different speaker as long as it does not exceed the decoder's specifications. Some speakers come with baffles and others do not. Check the installation instructions for the particular decoder you are using. If your decoder has a box speaker, it is already mounted in a baffle however, additional baffles or other mounting systems may be used to improve sound performance.

Baffles isolate the speaker diaphragm's front sound waves from the rear sound

waves that are "out of phase". This minimizes sound cancellation, particularly at lower frequencies. For best sound generation, the cubic volume of the baffle should be as large as possible and the baffle walls should be acoustically rigid to prevent acoustic interference.

Practical baffle materials are plastic, cardboard and sheet metal. Common items such as cardboard tubes, soda caps, or 35mm film canisters can be modified to create reasonable baffles in the available space inside your locomotive. Most N and HO scale locomotives have limited internal volume inside the shell, requiring ingenuity to get best sound performance out of the limited space available.

11.1.2 Sound Hold Up Capacitor or Power Xtender?

All series Digitrax SoundFX decoders have an electrolytic capacitor either wired to the harness or provided separately in the package. Installation of this cap is necessary for reliable operation. However, it will keep the sound alive in the presence of short power interruptions.

If you are using a series 6 sound decoder and you have problems with power interruptions that interfere with the operation of your locomotives and the sound, you may want to consider using a PX power extender module. Power Xtenders are engineered to provide additional power storage capacity to allow locos to continue running and producing sound even when electrical signal is lost for a short amount of time.

11.2 Programming SoundFX Decoders

Your Digitrax SoundFX decoder is ready to run and will operate and generate sound using address 03 with no additional programming. See the instruction sheet that came with your decoder for information about the default sound scheme and other sound schemes that may be available in the decoder.

On your Digitrax system, simply select the locomotive's address and the sound will start. On some other DCC systems, it may be necessary to select the locomotive address AND send a command to start the sounds.

For a more prototypical railroading experience, your decoder can be customized for your specific locomotive by programming various Configuration Variables. Digitrax sound decoders use the same CVs as non-sound decoders for controlling everything except sound. Digitrax sound decoders can be programmed using either a programming track or with the operations mode using the main line.

Before changing any CVs, it is useful to run it on the factory default address 03 to check the installation. The following sections detail CVs commonly used in Digitrax Sound Decoders.

Consult the instruction sheet provided with your decoder or the project description area of the sound project (.spj) file you have loaded into the decoder to determine how CVs are used in the specific decoder and in the specific sound project file.

For more information on general decoder installation and programming techniques and examples visit www.digitrax.com.

CAUTION: Programming track voltage must not exceed 16V when programming SoundFX decoders.

11.3 Change Sound Scheme: CV60

The factory supplied sound project in your decoder may more than one sound scheme. 8-bit decoders have dual schemes with generic steam and diesel and 16-bit decoders have multiple schemes. Downloaded sound projects may also have more than one sound scheme included. The sound scheme that the decoder will play is selectable by programming the appropriate value into CV60. Consult the Instruction Sheet that came with your decoder or the project description in the .spj file for available CV values for the particular sound project downloaded in your locomotive.

11.4 Customizing Sound Schemes CV132-CV256

SoundFX sound CVs in the range of CV132 to CV256 let you customize your decoder without having to reprogram or change the installed sound scheme.

11.5 Diesel Notching CV132 & 155

Sound CV155 customizes diesel engine notching and CV132 controls notching rate.

TABLE XIX: Diesel Notching CVs

CV#	CV Value	Effect
CV155	00 default	Automatic notching Changes diesel RPM settings at 8 distinct throttle speeds controlled by CV132
CV155	01	Semi-automatic notching. F6 ON increases current notch setting. F7 ON decreases current notch setting towards the lowest current throttle notch setting
CV155	02	Manual notching F6 ON increases current notch F7 ON decreases current notch without regard for current throttle setting which controls just motor speed
CV132	127 default	Notch Rate 0-255

11.6 Steam Chuff/Cam & Gear Rotation Trim CV133 & 134

The cam input is available for steam installations to synchronize chuffing.

CV133 controls the Steam Chuff/Cam configuration in the decoder. The range of values for this CV is 01-128.

Enable an external cam by setting CV133 to the value of 128. Install a cam on the cam lead to provide feedback that will match chuffing to the actual movement of the locomotive.

To get synchronized chuffing without installing a cam, Set CV 133 to a value between 01 and 127. The factory default is 63. This lets you approximate the diameter of the driver from 1-127 inches to synchronize the chuffing. You may need to experiment with this setting to get the best result.

CV134 controls the gear rotation trim where a value of 32 equals a 100% ratio.

11.7 Bell and Air Effect Rates CV146-149

CV146 controls the bell rate or time between ring of the bell, it has a range from 1-100 with each increment adding 24ms of delay.

CV147 controls the air drier rate, it has a range from 1-64 with each increment adding approximately 2 seconds. CV148 controls the Compressor/ Air pump start rate.

CV148 controls the Compressor run rate.

CV149 controls how long the Compressor/Air Pump runs.

11.8 Auto Coupler Sequence Threshold Value CV151

CV151 controls the threshold at which coupler and brake sounds are automatically played when locomotive direction is changed and function 3 is enabled. CV151 has a range of 0-60.

11.9 Example: Changing a Sound Scheme on SDXH166D

Each sound project whether it is pre loaded into your decoder or you have downloaded it from Sound Depot may have multiple sound schemes and other sounds available for use in your locomotive. This information is specific to each individual sound project. **Please consult the instruction sheet for your decoder if you are using preloaded sounds or the project description included in the .spj files if you are using sounds downloaded from Sound Depot to determine the CV values to program.**

The following is an example of the sound project that is pre-loaded in the SDXH166D. It has 8 different sound schemes, 6 diesel and 2 steam. One of these schemes can be selected to be played by the locomotive by programming CV60 to the appropriate value from the table below.

In addition, each diesel scheme can be configured with one of 8 different horns using CV150 and one of 4 different bells using CV157.

Each Steam scheme can be configured with one of 3 whistles using CV150 and one of 4 bells using CV157.

To enable playable whistle for your selected horn or whistle add 128 to the selected value (ex. Playable volume on horn 2 is enabled with a value of 130, 02+128=130).

TABLE XX: SDXH166D Sound Scheme Selection with CV60 Example

CV60 set to	Sound Scheme	CV150 set to	CV157 set to
0	GP38 Diesel	0= default 1-7= alt horns 128-135 = Playable horns	0=default 1-3 = alt bells
1	GE Evolution Diesel	1= default 0-7= alt horns 128-135 = Playable horns	0=default 1-3 = alt bells
2	SD70 Diesel	2= default 0-7= alt horns 128-135 = Playable horns	0=default 1-3 = alt bells
3	GP10 Diesel	3= default 0-7= alt horns 128-135 = Playable horns	0=default 1-3 = alt bells
4	RS1 Diesel	4= default 0-7= alt horns 128-135 = Playable horns	0=default 1-3 = alt bells
5	C420 Diesel	5= default 0-7= alt horns 128-135 = Playable horns	0=default 1-3 = alt bells
6	Steam type 1 (based on 3985)	0= default 0-2= alt whistles 128-130 = Playable whistles	0=default 1-3 = alt bells
7	Steam type 2 (based on K27)	1= default 0-2= alt whistles 128-130 = Playable whistles	0=default 1-3 = alt bells

11.10 Loading Sound Projects into your SoundFX Decoder

Your sound decoder's sound project can be changed using a Digitrax PR3 programmer and your computer with SoundLoader 2.0 software. Both the software and a number of alternate sound project files are available from the Digitrax Sound Depot web site at no charge. SoundLoader can be used to view sound project descriptions, CV uses and function information.

It takes only a few minutes to download the new sound to your decoder. The following tables show the CVs used in SDXH166D and how it is set up at the factory to operate various sounds using your throttle. (Table on next page.)

CV60 selects a sound scheme from the sound project (.spj) that is loaded in the decoder. Once you have downloaded a project into the decoder, the sound scheme is selected by programming a CV and no PR3 or computer is needed for selecting a scheme.

Note that each sound project can use CVs in a different way. Please consult the documentation for the specific sound project you are running in your decoder to determine how the CVs are used.

CV#	Used For	Range	Default Value
01	2 Digit Address		03
11	Sound Time Out, 06 = Sound ends when loco address is de-selected, 00=Sound stays on after loco is de-selected		06
29	Configuration Register - Advanced or Standard speed steps, 2 or 4 digit addressing, Analog Mode, Normal direction of travel, speed tables		06
49	Forward Light (F0F) - Headlight		00
50	Reverse Light (F0R) - Reverse Light		00
51	Function 1		00
52	Function 2		00
58	Master Volume (F8 used for Mute) 1=min 00=max	00-15	09
60	Sound Scheme Select	00-07	00
132	Notch Rate	00-255	127
133	Steam Chuff/CAM config, 128=>EXT cam, 1-127=>DRIVER diameter in inches	01-128	63
134	Steam Gear Ration Trim, 32 = 100% Ratio	00-255	32
135	Mute Volume	00-64	00
140	Prime Mover / Chuff Volume	00-64	60
141	Bell Volume	00-64	25
142	Horn/Whistle Volume	00-64	60
143	Time-Scattered Air Effects Volume	00-64	30
145	Misc Volume Levels	00-64	40
146	Bell Ring Rate (1=24 milliseconds)	01-100	07
147	Air Drier Rate (1= approx. 2 seconds)	01-64	02
148	Compressor Run Rate	00-255	30
149	Air Compress On Time	00-255	20
150	Horn/Whistle Setup (Default=0, Playable Horn=1, Alternate Horn=2 +128 for playable volume.)	00-07 or 128-135	00
151	Auto Coupler Sequence Threshold Value-Peak speed to allow auto coupler/brake when direction change occurs and F3 is ON	00-64	48
152	Project Author ID, Digitrax=221		221
153	Project ID		168
154	Steam Blow down / Safety Volume	0-64	60
155	Notching/Slip Mode: 00=Automatic,		00
157	Bell Selector	00-03	00

Function	Used For	Notes
F0	Lights	
F1	Bell	
F2	Horn/Whistle	CV150 sets mode
F3	Coupler crash	Auto coupler/brake set by CV151 max speed
F4	Air feature disable	F4 off enables pop-off, drier and starts compressor/ air pump
F5	Diesel = Dynamic brake Fans Steam = Water Pump turbine	
F6	Diesel = Notch Up Steam = Blow down	Notch UP if CV155=01 or 02
F7	Crossing Gate Air horn OR Diesel = Notch DOWN Steam = Wheel slip	Notch DOWN, if CV155 = 01 OR 02 (Crossing Gate active if in Diesel mode and CV155=0)
F8	Mute Control	F8 ON is mute
F9	Brake squeal	
F10	Crossing Gate Air horn Sequence	
F11	Steam = Greaser	
F12	Steam = Safety Blow off	

11.11 SoundFX DC Operation Mode

Digitrax SoundFX decoders will operate on smooth DC power. The sound will not start until approximately 7 volts is applied to the track and there will be no "start up sound."

11.12 Downloading & Installing Sound Projects

1. Find the sound project your want to download on SoundDepot.
2. Connect your PR3 programmer to the programming track on your layout.
3. Place your SoundFX decoder equipped locomotive on the programming track.
4. Open the SoundLoader application.
5. In the Sound Loader application, open the .spj file with the sound project you want to load into the decoder.
6. Click on "Program" and wait for the programming process to complete (usually 60-90 seconds for an 8 bit project and up to 10 minutes for a 16-bit sound project).
7. That's it. You've just customized your locomotive.

11.13 Modifying Sound Project Files

You can customize any sound project using your own recordings. You can replace any locomotive sound segment (a chuff, or a brake squeal, etc.) with an

actual sound recording you've made. You do this with the SoundLoader utility in conjunction with a Digitrax PR3 programmer. Once you've customized the project, you can save the sound project (.spj) file with a new name. This will let you use your custom project over and over again.

We encourage you to share your customized sound projects with other modelers by submitting them to the Sound Depot at www.digitrax.com/sound-depot/submit/. We are happy to post customer projects on the Sound Depot! Please limit file sizes for upload to less than 20mb.

See www.digitrax.com/sound-depot/ for more information on how to create new sound project files from your own recordings.

11.14 SoundFX Decoder Troubleshooting

If the sound does not start in the decoder
1. Make sure you have selected the locomotive address on a throttle. The sound will not run unless the locomotive is addressed in the system.
2. Make sure F8 is not set to mute the sound.
3. Check your installation to make sure the decoder is installed properly.

If the sound output sounds distorted
1. Check the speaker cone for magnetic debris that may have collected there. Debris on the speaker will cause a loss of sound quality and must be removed.
2. Be sure that the CV58 volume is not set at a level that is too high for the speaker being used.

If the sound in your decoder shuts down after you stop it and you are not using a Digitrax system for control. On some DCC systems decoders are not addressed by DCC packets after the locomotive is set to 0 speed. In this case after the CV11 timeout elapses (6 second default), sound will "shutdown.". To defeat this feature, set CV11=00 to remove the timeout and shutdown. *To make sounds, the decoder must have a command addressed to it at least once.*

If you have trouble reading back CVs on the programming track, this may be due to insufficient current draw. Of course you can always just re-program the CV value into a CV to get the desired results, even if reading CVs does not work. OPS mode is recommended for writing to (programming) all CVs except CV01, CV17 & CV18 (2 digit and 4 digit addresses). If a second DCC decoder is present that is not SoundFX compatible then correct read back of CV data is not possible, since the NMRA CV read back was not designed for multiple decoder read back.

I have loaded a new scheme but the CVs and Functions are not what I expected. Load the sound project you programmed and then select the

view>project description" menu and then read the text file on the screen that defines how that project in particular uses CVs and functions for sound generation and configuration.

12.0 Operation With Digitrax Command Stations

Digitrax decoders support direct and paged programming. Digitrax decoders are designed to operate with command stations that are compatible with DCC industry standards. If your command station and/or programmer are designed to interoperate with other DCC products, you will be able to operate with few problems. If you experience problems when running Digitrax decoders with other manufacturers' command stations please refer to the command station manual first to determine if any special programming or set up is required to run Digitrax decoders with the system you are using. If there is still a problem, please check the Tech Support Depot on our website for articles related to the non-Digitrax equipment you are using.

Some Digitrax default CV values are loaded as "0s" which may not be read back correctly by some programmers. This does not affect operation, only read back. You can always program values that are within a particular system's operating range with that system's programmer. Some systems may require a value of 1 instead of 0 in some CVs.

13.0 Operating Digitrax Decoders On DC Track

Analog operation is when Digitrax decoders are operated on DC or conventionally controlled layouts. Analog mode conversion is a feature of all Digitrax decoders, that allows a decoder equipped loco run on a DC layout without having to remove or re-program the decoder. There are a few things you need to know about analog operation:

· Digitrax decoder equipped locomotives will not move until the voltage is above 5 to 6 volts DC. When operating decoder equipped locos on DC power, increase the voltage quickly from zero to five volts for best operation.

· Decoder equipped locos may not operate smoothly on "pulse power." The decoders should be driven from a quality smooth DC power supply when on a conventional layout. Some DC throttles/power supplies with proprietary control systems, such as "tracking control," exhibit pulse power characteristics and may give unpredictable operation with DCC equipped locos.

· Decoders that use the Digitrax 9 (HO) or 8 (N) Pin Decoder Interface can be easily unplugged from the harness installed in the loco and replaced with a Dummy Plug (sold separately). Using the dummy

plug converts the locomotive to DC operation only. Locomotives with the dummy plug will run on conventional layouts without sacrificing low speed performance and can run using pulse power. To run the loco on DCC again, remove the dummy plug & re-install the decoder.

14.0 Decimal & Hex Numbers

Digitrax produced our first throttles in 1992. Many of these throttles are still in use on layouts today. Over the years as technology has improved, different Digitrax throttles have used a combination of decimal, modified hexadecimal and hexadecimal numbers for entering CV#s and CV values. All current production Digitrax products use decimal notation. Information is provided on www.digitrax.com in the Products and Support Sections for retired products that use hexadecimal notation.

15.0 Warranty & Repair Information

Digitrax gives a one year "No Worries" Warranty against manufacturing defects and accidental customer damage on all Digitrax command stations, boosters, throttles, decoders, power supplies and layout control devices.

Digitrax gives a 90 day warranty against manufacturing defects on accessory products.

That's it! A simple, straightforward warranty with no tricky language!

Please return all items covered under warranty and other repair items directly to Digitrax, Inc. DO NOT return warranty or repair items to the place of purchase.

For complete warranty and repair details see www.digitrax.com. Please contact Digitrax tech support by e-mail at techsupport@digitrax.com before sending anything to us for repair so that we can try and resolve the problem. Except as expressly stated in the full warranty statement, there are no warranties, express or implied, including but not limited to any warranties of merchantability or fitness for a particular purpose.

In the event that you need a repair for a decoder or other Digitrax product that is out of warranty we will make every effort repair or replace it for a small charge. For full details of repairs available, go to www.digitrax.com, click on Support, then click on Warranty and Returns to begin the repair process. Please

complete the online form, print it out and send it in with your items for repair. Proof of date of purchase is required for all warranty repairs.

In some cases with Digitrax lower cost decoders, the cost to purchase a new decoder may be less than the repair charge. Also some older models are no longer repairable or replaceable due to unavailability of components needed for these repairs.

FCC Information
Radio or TV Interference: (this information is MANDATED by the FCC)
This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.
-Increase the separation between the equipment and the receiver.
-Connect the equipment into an outlet on a circuit different form that to which the receiver is connected.
-Consult the dealer or an experienced radio/TV technician for help.

Note that any modifications to the equipment not expressly approved by Digitrax voids the users authority to operate under and be in compliance with CFR 47 rules, as administered by the Federal Communication Commission. Digitrax believes any conscientiously installed equipment following guidelines in this manual would be unlikely to experience RFI problems.
For Canadian Users:
"This digital apparatus does not exceed the Class B limits for Radio noise emission from digital apparatus set out in the Radio Interference Regulation of the Canadian Department of Communications."
Le present appariel numerique n emet pas de bruits radio-electriques depassant les limites applicables aux appareils numeriques de la classe B prescrites dans le Reglement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada.

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Need Help?

Digitrax Tech Support Team

Need Help?: helpdesk.digitrax.com

Digitrax Tech Support Depot 24/7/365
www.digitrax.com/support
Contains links to all instructions sheets and manuals, application notes,
videos and tons of helpful information.

Digitrax Decoder Selector
www.digitrax.com/decoderselector
Helps you find which decoder will fit in a particular locomotive.

Digitrax CV Calculators
www.digitrax.com/support/cv
Calculate a CV value to program your locomotive,

Digitrax Tool Box App
Download our Mobile App for on the go help at your fingertips. This
app contains links to all manuals and instruction sheets, videos, CV
calculator, decoder selector, news and events & dealer locater.
www.digitrax.com/toolbox

Warranty and Repairs
www.digitrax.com/support/returns
Fill out the online form, print it out and return it with your item for repair

**Your Local Digitrax Dealer Is Also Available to Assist
You.**