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DIGITAL COMMAND CONTROL | THE WAVE OF THE FUTURE

DH84
1 Amp Digital Command Control Decoder With Easy Connect Plug

Users Manual

DH84 USERS MANUAL

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1.0 Introduction:

Congratulations on your purchase of a Digitrax DH84 Digital Command Control Decoder. It is engineered to give you exciting Advanced DCC control features at a reasonable price. It operates using the *proposed* NMRA DCC standard baseline packet format Digitrax Decoders are American designed and manufactured to address the needs of the American Model Railroader.

Digitrax Inc., encourages and supports *owner* installation of decoders. We feel that most serious modelers have the common sense, judgment and skills needed to successfully install decoders. However, it is important that you follow the directions included in this manual and perform all tests and inspections carefully. To help make your first installation a pleasant experience, we recommend that you follow the Decoder Test Procedure. This simple test can be performed with a Digitrax Decoder Test Kit (included with Challenger systems or available from your dealer at a nominal charge or you can assemble your own kit from a few simple parts as outlined on page 4). The Test Procedure allows you, to check your new Digitrax decoder's functionality and familiarizes you with the decoder's features and hookup procedure. Please note that decoders that don't pass the Test Procedure should not be installed in your locomotive. See Section 9.0 Warranty & Repair on page 27 for details.

Please read this manual carefully before you install your DH84. We have included lots of hints and operating ideas based on our experience with the Digitrax system. Your dealer can give you suggestions too. If you have questions not covered by this manual please let us know. Feel free to call, write or fax your inquiry.

If you choose not to convert your own locomotives, your dealer can handle the installation or refer you to someone who can perform the job for you.

2.0 DH84 Features & Specifications:

- 1 amp (1.5 amps peak) Digital Command Control Decoder designed to fit easily in HO scale narrow-body Diesel prototypes, e.g., GP30 & GP35's
- Easy to connect decoder plug and wire harness. Allows you to share decoders between multiple locomotives wired with harnesses. DC shorting plug available for DC operation of harnessed locomotives (without decoders).
- Compatible with the proposed baseline NMRA Digital Command Control Standard
- User adjustable 28 step Speed Table lets you change the throttle response and match the speeds of locomotives with different drive trains. Easy to change forward and reverse speed trims.
- An "open" mobile address range that allows you to program up to 236 loco addresses.
- Programmable decoder addresses, acceleration, deceleration, start voltage and mid-point voltage are easily reprogrammable from DCC compatible programmers without opening the locomotive
- Programmable Acceleration (simulation of train weight or inertia).
- Programmable Deceleration (simulation of braking action).
- Programmable Start Voltage (allows trim for locomotive motor efficiency).
- Conversion to Analog operation for use with smooth DC power packs.
- Programmable Mid-Point Voltage setting for adjusting the motor speed curve & performance.
- Directional lighting outputs for Forward and Reverse lights rated at 200ma.
- Smooth deceleration to stop before changing direction, when locomotive is reversed while moving forward. No sudden, non prototypical stops unless you send an Emergency Stop command.
- Complies with FCC Part 15, class B RFI requirements.
- Programmable Configuration Register allows full control of decoder personality. Compatible with NMRA Advanced Programming Paging RP.
- Selectable 28 Forward & 28 Reverse speed step operation or 14 Forward & 14 Reverse speed step operation.
- Decoders accept Advanced Direct speed control for 128 Forward & 128 Reverse speeds.
- Control of 2 additional 200ma function outputs, "F1" and "F2".
- Automatic Thermal Overload shutdown protects components against temperature stresses. If the receiver gets overheated it shuts down and cools off before starting again.
- Bipolar DC motor drive of up to a conservative 1 amp rating, typically limited by heat buildup in locomotive body. (Transistors are actually rated for brief pulse of over 1.5 Amps.) This is more than adequate for most quality HO scale motors on the market today.

3.0 DCC Communication Strategy:

The Digital Packet based DCC communication strategy offers a very robust and reliable method for a Command Station to convey commands to decoders.

Digitrax decoders:

- Verify all packets for valid SYNC, START, FRAME & STOP bits & reject incorrectly formatted packets.
- Perform Error Control Byte checking as part of the DCC protocol & reject packets with data errors.
- Only decode commands that are allowed in operating context, ignoring false actions.
- Will accept 3, 4 or 5 byte data packets and process those that they are programmed to execute.
- Utilize nominal 56 micro-second "1" bit 1/2 cell timing.
- Implement an additional "1/2 Cell Parity check" to help reject bad data bursts.
- Will accept Zero-bit (Analog mode) stretching in excess of 15 milliseconds/zero bit.
- Have sophisticated Digital filtering algorithms to ensure smooth mode conversion, including: "bounce-back" prevention when converting from Digital to Analog power mode or vice- versa.

Digitrax DH84 Decoder Wire Colors & Electrical Specifications

	DH84	Notes
Power Right rail	Red	Engineer's side
Power Left rail	Black	Fireman's side
Motor +	Orange	1 amp rating, 1.5 amp peak
Motor -	Gray	1 amp rating, 1.5 amp peak
Forward Light	White	200ma rating
Reverse Light	Yellow	200ma rating
Light Common	Blue	+ve full-wave supply, max 300ma
Function 1	Green	200ma rating
Function 2	Violet	200ma rating

Table 1

4.0 DECODER TEST PROCEDURE & KIT:

In order to provide maximum support to our customers, Digitrax has developed this quick and easy Decoder Test Procedure. We recommend that you test ALL decoders upon receipt to ensure that **you** are confident of their hookup, programming and function. The units leave the factory fully tested and ready to go, but it is always *comforting* to see correct operation before installing a decoder in your locomotive. This is especially true for anxious first time installers!

Digitrax will gladly exchange or refund payment for any decoder that you are not convinced works correctly after performing this test procedure. If there is a problem, please call for technical assistance. **Do not install any decoder that does not pass this test**. Do not shorten any decoder wires until the unit has passed this test.

4.10 Test Kit:

To perform the decoder test you need either a Digitrax Decoder Test Kit (provided with Challenger Systems or available from your dealer at a nominal charge) or you can assemble your own test kit from a few simple parts as outlined below.

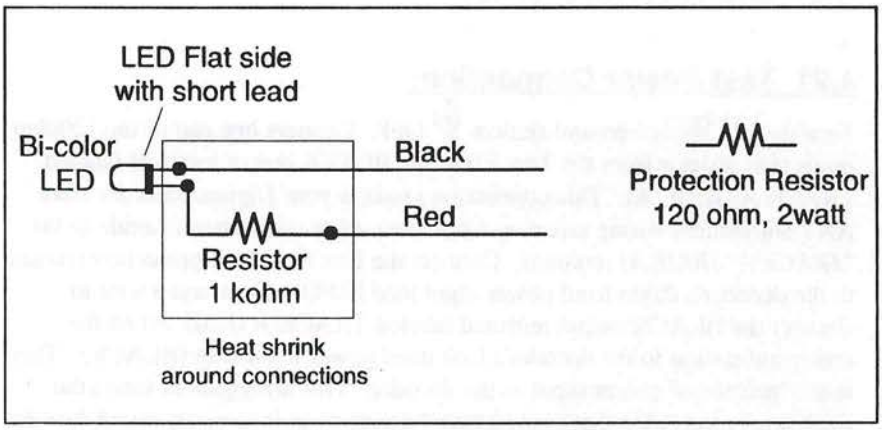
4.11 Build Your Own Test Kit:

Test Kit Parts List

#	Description	Radio Shack #
1	Resistor 120 ohm 2 watt (brown-red-brown bands) (Any resistor between 100 & 120ohms, minimum 2 watts, will do)	271-135
1	Resistor 1 kohm 1/4 watt (brown-black-red bands) (Any resistor between 750 & 1.5 kohms, minimum 1/4 watt, will do)	271-1321
1	Bi-Color LED, e.g., Radio Shack 276-012	276-012
1	Black wire	
1	Red wire	
	Shrink tubing	

Note: Do not substitute an Incandescent (regular) or non-resistor LED lamp for the bi-color test LED.

Test Kit Diagram



4.2 Decoder Test Procedure:

This procedure is detailed for a CHALLENGER™ Command Station but can be performed with other DCC compatible Command Stations. This test should be performed on a non-metallic surface. Please refer to Diagram 1 on page 7, along with the following instructions.

How to connect a DH84 harness plug:

For the DH84 to be tested, or used in a harnessed locomotive, the small 9 pin plug on the wiring harness (included with the decoder purchase) must be plugged into the mating socket on the end of the DH84 module. The harness plug is a "polarized" design to ensure it cannot be plugged in incorrectly. Note that the 9 little holes in the end of the harness plug are off-center, and match this orientation with the 9 small off-center pins in the DH84 socket. Press the plug fully home to a depth of about 1/8". The color codes given in Table 1 refer to the wire colors of the plug and harness.

How to remove a DH84 harness plug:

Firmly pinch between thumb and forefinger all 9 wires, about 5/8" back from the plug. Pull gently and evenly on all 9 wires simultaneously. **Note it is important to distribute the force needed to unmate the plug, EVENLY over all the wires.** *Failure to pull evenly can result in pulling a single wire out of the plug.* Removal is easier if you gently rock the plug from side-to-side to start the process. Grasp the DH84 decoder body on the sides right next to the socket to ensure no stresses are placed on components under the protective sleeve. After the first connection and removal of the DH84 plug, the forces

required will decrease and subsequent plug operations will be easier. Keep the plug and socket free of dirt and debris.

4.21 Test Power Connection:

Turn the DB 100 command station OFF. Connect one end of the 120ohm protection resistor from the Test Kit to the BLACK output terminal labeled TRACK A (RAIL A). This connection protects your Digitrax decoder from ANY subsequent wiring errors *as long as no other connection is made to the "TRACK A" (RAIL A) terminal.* Connect the free end of the protection resistor to the decoder's Right hand power input lead (RED). Next, use a wire to connect the BLACK output terminal labeled TRACK B (RAIL B) on the command station to the decoder's Left hand power input lead (BLACK). This is the "protected" power input to the decoder. This arrangement limits the track power available that could cause damage to an incorrectly wired decoder.

4.22 Test "Motor" Connection:

Connect the RED lead of the Test Kit's bicolor LED to your decoder's Motor + lead (ORANGE). Connect the BLACK lead of the Test Kit LED to the decoder's Motor - lead (GRAY). Make sure none of the decoder leads is shorted to ANY other lead. (It may be easiest to temporarily tape the other leads out of the way to the non-metallic bench or table top.)

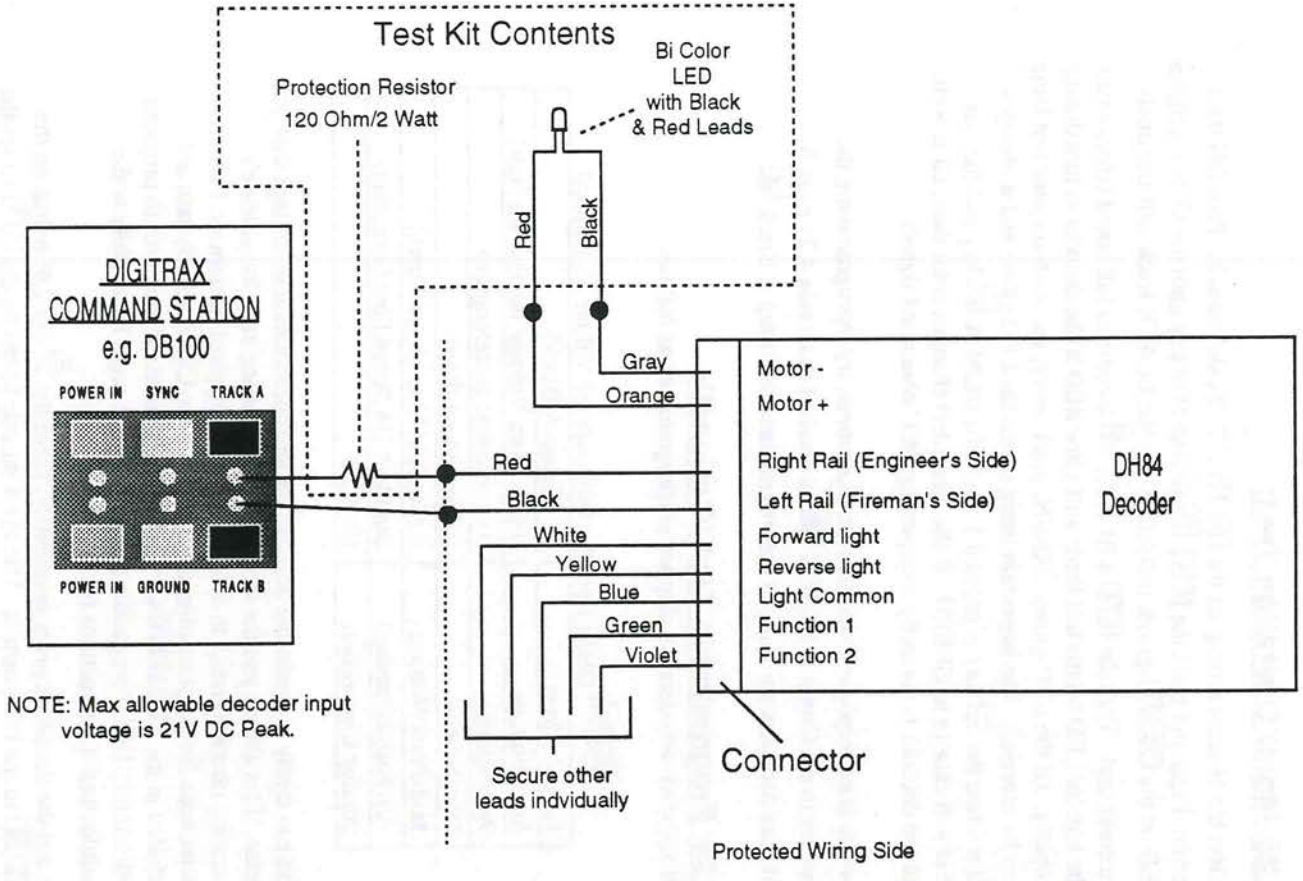


Diagram 1: DH84 Decoder Test Procedure Wiring Diagram

4.23 Motor Operation Test:

Select the N-scale setting on the DB 100 "Scale" switch. Turn ON track power. Press and Hold the CT4 RUN/STOP key until the O Track Status LED on the DB 100 glows, indicating that the BLACK track A/B terminals are energized. Turn the CT4's BLACK throttle to full speed (clockwise). The bicolor LED on the test leads will glow RED if the decoder is functioning properly. (If the LED glows GREEN, don't worry, the leads on your test lamp may be reversed. The important thing is that the LED glows and it changes color when the key is pressed.) Press the BLACK key and the test LED will change to GREEN. If the Test LED changes color then, all is well, and the decoder is correctly interpreting DCC command signals.

If there is no response to the throttle movement, try reprogramming the decoder to the Group A BLACK as detailed in section 4.24 page 8. Digitrax decoders are shipped preprogrammed to Group A Black.

4.24 Programming Test (Optional):

All Digitrax decoders are shipped preprogrammed as follows:

Digitrax DH84 Decoder Programmed Values As Shipped

Loco Address	03 (Group A Black)
Start Voltage	0 (No Extra Voltage Needed To Start)
Acceleration	0 (Immediate Acceleration)
Deceleration	0 (Immediate Stop)
Mid-Point Voltage	0 (Straight Line Motor Curve)
Advanced/Standard	Standard (14 Speed Step Operation)
Analog Conversion	Enabled

You can easily program the decoder for any combination of settings that you prefer. This allows you the flexibility to determine each locomotive's operating characteristics to achieve truly prototypical operations. Full instructions for programming decoders with the Challenger System are included in the CHALLENGER™ Operating Manual. If you wish to program with another DCC compatible programmer see page 17 and follow the manufacturer's instructions for that equipment.

To test the decoder's programmability, move the MODE switch on the DB 100 to the P/R position. Use the 4 throttle knobs on the CT4 to set the decoder's Acceleration, Deceleration, Start-voltage and Mid-point motor curve adjustment to characteristics that you want. *The text under*

each knob indicates the type of adjustment that knob affects when programming is underway. Press one of the BLUE, GREEN or BLACK ⇔ keys to send the programming information to the decoder, this will set the decoder's address to that *"color" locomotive channel.* If all the throttle knobs are turned completely counter-clockwise when you press the selected color ⇔ key the nominal value of "0" will be loaded into the decoder's control registers. You can check that programming is occurring by watching the test LED when you press the ⇔ key. The Test LED will briefly pulse several times, indicating that good program commands were received and stored by the decoder. The unit will remember all programmed settings in Non-volatile memory even when the power is turned OFF. Experiment with the program settings to gain an understanding of their effects on your locomotives. Digitrax One-Step programming makes it easy to change loco settings as often as you wish.

Note: The Group A RED address is reserved as the "ANALOG" operation channel to allow operation of one conventional locomotive on your Digitrax layout. Therefore, the Group A RED throttle is not programmable for digital locomotives. Note the DB100 defaults to Group A at power on.

4.25 Directional Lighting Test:

Turn OFF the [DB 100] track power by pressing and holding down the [CT4] [PWR STOP] RUN/STOP key until the unit beeps twice and the track status LED goes off. Disconnect the Test LED leads from the decoder. Attach the BLACK lead of the Test LED to the wire that is connected to the decoder Left power lead (BLACK). Connect the RED lead of the Test LED to the Forward light lead from the decoder (WHITE). Be sure that the Motor and all leads *not being used* are secured and not touching each other. Press [PWR STOP] to turn ON the track power. Press the [☼] LIGHT key followed by pressing the colored ⇔ key corresponding to the decoder's programmed address. The Test LED will glow when the Light has been turned on by the command station. (More than one [☼][⇔] command may be required because the DB100 simply sends a toggle command and if the decoder's Light function was OFF and the OFF command was sent then nothing will happen until the next [☼][⇔] command that sends the ON command.) Once the Test LED lights up, press the ⇔ key several times to simulate changing direction. The light should toggle between on and off as you "change direction." Press and hold [PWR STOP] to turn OFF track power (you'll hear 2 beeps). Change the Test LED RED lead to the Reverse Light function lead (YELLOW) and repeat the test. This completes the Directional Lighting tests.

4.26 Function Output Test (Optional):

To test the extra function outputs you will need a command station that is able to access these outputs. The CHALLENGER™ System does not access these functions but you can use Digitrax DCS200, DCS300 or DT200 command stations to do this. Some other DCC compatible Command Stations are also able to access these functions. The test setup is the same as for the lighting test but the RED Test LED lead is connected to the function lead. Verify that the Test LED glows for each function command given.

At this point you can **confidently** install your decoder in a locomotive, knowing it is working properly, is correctly configured and that you understand the connections. For installation instructions refer to section 5 that follows.

5.0 Decoder Installation Instructions:

Please refer to the wiring Diagram 2 on pages 12 & 13, along with these instructions. Before beginning ANY conversion it pays to carefully plan the whole installation strategy and review the options available.

A great benefit of the DH84 decoder is the ability of the unit to be simply plugged into a harnessed locomotive. This allows a DH84 to be shared between several harnessed locomotives. Since additional harnesses and DC shorting plugs are relatively inexpensive, it allows the modeller a cost-effective way of easily running a variable selection of DCC locomotives from the whole available fleet. Any harnessed locomotive without a matching DH84 decoder can simply be returned to original conventional operation with an available DC shorting plug.

To ensure easy DH84 access, the harness length should be maintained with about a 2 or 3 inch minimum "service loop". This will ensure that enough room is available to grasp all the harness wires for even strain on the plug during removal. This recommended practice should be considered when planning a DH84 installation.

5.1 Choosing a Locomotive:

Choose a locomotive that runs well on conventional DC power. Digital decoders cannot compensate for faulty motor operation, poor track pickup, etc. So, be sure to address any mechanical issues with your locomotive before you install the decoder.

Remove the shell and look inside. Is there a readily available space to put the decoder or will you need to "make room?" The answer to this question is as varied as the different locomotives available.

5.2 Decoder Placement:

The mechanical placement of the decoder is important, and may involve sculpting plastic and or metal parts to allow enough room for installation. Try to locate the decoder in the coolest part of the body. Digitrax decoders have built in thermal overload protection to protect them from long term overloads and high ambient temperatures. We recommend an operating temperature of between 20 and 50 degrees Celsius. The decoders will provide more power to your motors if they are installed away from heat sources inside the locomotive body, e.g., motors and lamps. Try to put them where they can shed as much heat as possible. If your decoder becomes overheated, it will briefly shut down until it cools down.

5.3 Choosing the Right Decoder For Your Locomotive:

Most modern high efficiency can motors draw less than 3/4 amp when running and less than 1 amp when stalled at 12V DC. These motors are suitable for use with the DH84 Decoder.

To determine whether a particular motor is suitable to run with the DH84 decoder, check the stalled motor current at 12V. To test the motor put the loco without shell on regular DC powered track at 12V for HO & N Scales (16V for G Scale). Attach a DC current meter (ammeter) in series with one of the track feeds. Apply DC power to the track. 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. If the stall current exceeds 1.25 amp, you should use a Decoder with a higher current rating.

TECHNICAL NOTES:
For use with motors other than normal 3 or 5 pole axial DC motors (Open-frame or sealed cans) you should test the motor's suitability to run with the DH84 Decoder at different voltages and loads, and be sure the motor's thermal ratings won't be exceeded in operation. Examples of these may be very low inductance and low inertia ironless rotor type designs and other new technologies as they are introduced to the scale model locomotive market.

5.4 Isolate the Motor

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 exclusively by the decoder circuitry. Failure to do this could damage your decoder. Damage caused by failure to isolate the motor is specifically excluded from our warranty. If you do damage your decoder, all is not lost, just call Digitrax and return the decoder to us along with the replacement fee and we will either repair the decoder or replace it.*

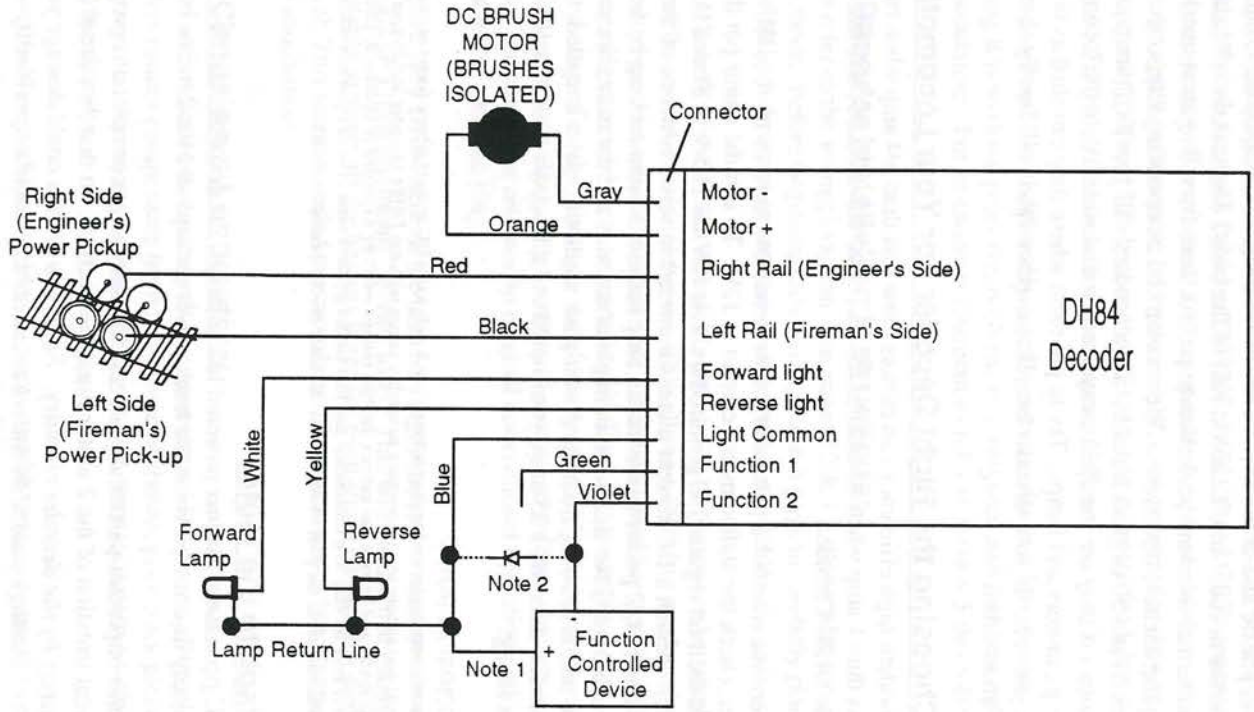


Diagram 2: DH84 Decoder Wiring Harness Installation Diagram

Diagram 2 Notes:

1) If Light Common is available this is the positive lead for "full wave" function power operation. Do not exceed the 200 ma rating of the function outputs. If Light Common is not used, connect function power to either track power pick-up for "half wave" operation. The directional light function "Lamp Return Line" can be hooked to Light Common as shown or to either track pick-up.

2) If you use an inductive (coil) type load, you should place an inductive kick-back suppression diode across the coil with the cathode (banded) end connected to the function power side, Not the function output connection. A small signal diode such as IN4148 or rectifier such as IN4001 should be satisfactory. An incorrectly connected diode may damage the function output, so be careful.

3) See Diagram 3: Directional Lighting Wiring Specifics on page 15 for details of wiring 12-16V lamps, 1.5V lamps and LED's for full and half wave operation. Lamps that draw more than 50 milliamps when running require an 22-33 ohm 1/4 watt resistor in series with the directional light function lead to protect the decoder.

Once you think the motor is isolated, visually inspect the brushes one more time to be sure. Then measure the resistance of both brushes to the power pickup and frame, with a reliable continuity checker. There must be an OPEN circuit (very high resistance) from both brushes to any other part of the locomotive chassis or power pickups and wheels. If this is not the case, determine what is causing the low resistance path. Some motor brush power connections may be tricky, such as a spring to or interference fit with part of the chassis. Some locos pick up brush power from the chassis through a spring. After removing the spring connection to the brush, wire the corresponding decoder power input to the chassis.
Only when you are satisfied that the motor is isolated, should you proceed with the decoder installation.

5.5 Motor & Power Connections:

Connect the wire that was previously connected to the motor from the Right power pickup to the decoder's Right power input (RED). Connect the Motor + lead (ORANGE) from the decoder directly to this motor brush. Remove the wire from the Left power pickup and connect it to the decoder's Left power input (BLACK). Hook the MOTOR - (GRAY) to the brush that was connected to the Left power pickup.

5.6 Directional Lighting & Function Outputs:

See Diagram 3 on page 15. Connect the Forward light function (WHITE) to the forward lamp or cathode lead of a resistor LED. Make sure that this lead does not connect directly to either track power feed via a lamp socket, other wire, etc. Hook up the Reverse light function (YELLOW) in the same manner. Hook both directional light outputs together if the locomotive has only one lamp. In this case the light will be on if the light function is turned ON. Hook up the extra function outputs (GREEN and VIOLET) the same way as directional lighting. Be sure not to exceed the 200 milliamp output current rating. Make sure all joints are heat shrink sleeved or **reliably** insulated.

For regular 12V to 16V lamps that draw more than 50ma when lit, it may be advisable to include a 22 to 33 ohm 1/4 watt resistor in series with the lamp leads to ensure the lamp "start-up currents" (up to 10 times normal current draw) do not overload the outputs.

Again make sure that BOTH motor brushes are completely isolated from any connection other than the decoder and that there are no short-circuits. Unfortunately, with a real motor load it is impossible to use a protection resistor to prevent decoder damage. So, be very careful and visually inspect the installation for any possible interferences or mechanical hazards that may cause problems. Examples of this may be wire routings that can touch moving surfaces and be chafed, or wires that could be pinched when the locomotive bogeys, etc., articulate on the track.

Diagram 3: Directional Lighting Wiring Specifics

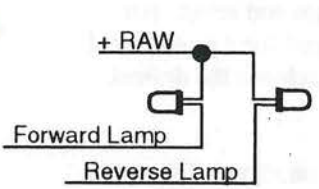
Full Wave Operation

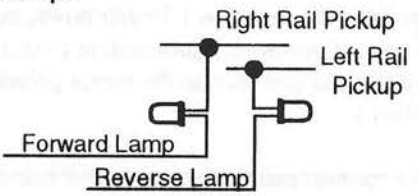
Lamp brightness will not be affected by analog stretching on the layout. This is the preferred wiring method but, in some locomotives (particularly in N-Scale and smaller HO units) it may not be convenient to wire the lights this way.

Half Wave Operation

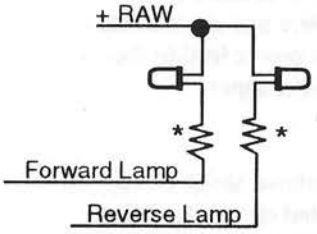
Lamp brightness will change depending on the direction of the analog locomotive being operated on the layout. If you don't run analog engines on your layout, you won't notice any difference between the two modes of operation.

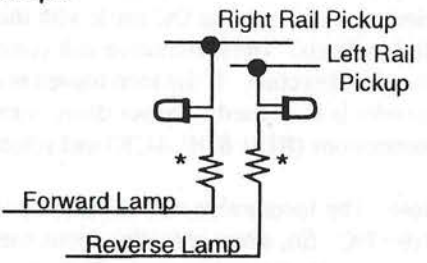
12-16V Lamps





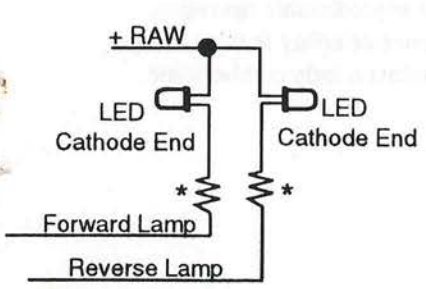
1.5V Lamps

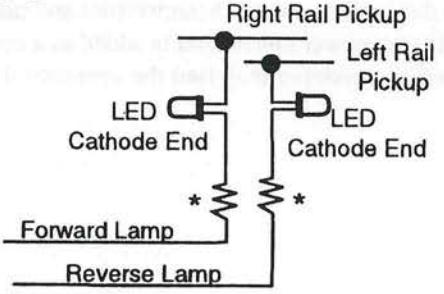




*Note: Current setting resistor to suit the lamp used. Typically 560 ohm 1/4 watt for grain of rice and 250 ohm 1/4 watt for grain of wheat. Lower resistance values will increase the lamp brightness, minimum value is 100 ohms.

LED's





*Note: LED's are sensitive to polarity when hooked up. Typical resistor 680 ohm 1/4 watt.

5.7 Final Test:

Finally, you are ready for the test track. If you followed the conversion steps carefully and correctly, you will be able to drive the locomotive and turn the lights and functions ON and OFF. Most problems are the result of some small detail in the conversion process.

If the unit does not travel in the proper direction you have reversed the polarity of the motor brush connection. (The DB100 powers up with all locomotives in the Forward direction.) Power down, swap the motor leads and retest. (Of course, if you want a locomotive to seem to "run in reverse" for a prototypical consist you can reverse the motor polarity on purpose to achieve the desired effect.)

We recommend that you test your converted locomotive on regular DC at this point because in DCC operation, the wrong pickup polarity will not reverse the motor direction. If the pickup polarity is reversed, it must be fixed for proper Analog operations. Test your locomotive for proper analog operations, by running it on a regular DC track with the positive polarity connected to the Right wheels. The locomotive will convert to Analog power and move in the Forward direction. If the loco moves in reverse, the input power feed to the decoder is backwards. Power down, swap the decoder power input connections (RED & BLACK) and retest.

Note: The locomotive will not move until the voltage is above about 5 or 6 Volts DC. So, when operating locos with decoders installed on regular DC layouts, raise the voltage quickly from zero to five volts for best operation. You may switch polarity instantly without a problem. The decoders may not operate smoothly on conventional "pulse power," which may be present on some Cab power units. *The decoders should be driven from a quality smooth DC Cab power unit when on a conventional layout.* Some Cab Power supplies with proprietary control systems, such as "tracking control" and the like, exhibit pulse power characteristics and may give unpredictable operation. Analog power conversion is added as a convenience or utility feature and the serious modeller may find the operational constraints a little cumbersome.

6.0 Operation With Other DCC Compatible Command Stations:

Digitrax decoders are designed to operate with Command Stations that are compatible with the proposed NMRA DCC standard. If your command station and/or Programmer is designed to interoperate with DCC products, you should be able to operate with few problems. Several of the Advanced features incorporated in Digitrax decoders are only accessible from Digitrax Command Stations and more advanced command stations that implement Advanced features of the proposed NMRA DCC standard. You **always** have the option of programming Digitrax decoders to operate on any DCC compatible system even though it does not access these advanced features.

Digitrax Decoders are shipped from the factory with the default programming settings outlined on page 8 and some values are loaded as "0"'s. Also, the Challenger System loads "0" values in some registers when the knobs are turned completely counterclockwise during programming. *This "0" value may not be read back correctly by some programmers although the decoder will operate properly.* You can always program values that are within a particular system's operating range with that system's programmer, e.g., store a value of 1 instead of zero.

The Decoder Test Procedure can be performed with any DCC compatible command station as long as the Protection resistor is correctly wired into the Track output, and you substitute the appropriate commands to select Locomotive addresses, directional light functions and extra Functions. Be sure the output peak voltage from the command station is appropriate for the decoder you are testing. The manufacturer of your command station should be able to easily assist you with these details.

7.0 Troubleshooting:

If the decoder has intermittent problems on the track, check the following possibilities:

7.1 Is the Decoder is Overheating? See Sections 5.2 & 5.3 on page 10.

7.2 Is the track clean, and are the power feeds reliable?

7.3 Are the locomotive wheel pickups and internal electrical connections reliable?

7.4 Strange Lights? Does the programmed operating mode of the decoder match the mode used by the command station? This is symptomatic of 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 reprogramming the receiver or by changing the command station's operating mode.

7.5 Does the locomotive have any mechanical binding problems, etc., are any wires shorting, etc., or touching moving parts?

7.6 Locomotive "buzzes" after decoder installation? Try lubricating the loco's brushes with an appropriate brush lubricant.

8.0 Technical Reference for Programming & Configuration:

The Locomotive address, start voltage, acceleration, deceleration, mid-point voltage value and configuration register are all "One Step" programmable using the "Challenger" TM Command Station. This allows the user to **avoid the confusion** inherent in the "nuts and bolts" details.

Other DCC compatible programmers are able to access and program Digitrax decoders as well. The following details are provided for the technically minded user who wants to decipher the appropriate programming sequences detailed in the technical support documentation provided with his or her programmer. Digitrax *intentionally* designed its advanced configurations, expanded features and future product enhancements to be generally usable from earlier generation programmer devices, and to allow upgrading to more powerful programming techniques planned in the proposed NMRA advanced packet formats.

Note that numbers following are decimal values (binary or hexadecimal representations will be noted if referred to).

Digitrax decoders are programmed using reserved "Service Mode" addresses that are not normally used for operating locomotives. To allow access to more configuration variables and proposed future NMRA features, one of the direct service mode addresses is always a "PAGE" address register. This register is write data address at 125 and performs a "read compare" match response at address 117. The value in this register is the page number for a "page" of four values written at 120 to 123 and "read compared" at 112 to 115. These four "offsets" are tabulated in Table 2 for the currently defined Digitrax usage. This is compatible with the

baseline usage of these addresses by other programmers that use the four baseline values (LOCO ADR through DECEL).

Note that the V-MID value is stored in page 2 at offset 2, or service mode address of 121/113. The Digitrax configuration register has been fixed at service mode address 124 for writing and 116 for read comparison.

The "read comparison" of the service mode is the way a programmer can determine what data a decoder has stored in its many registers. A packet sent to one of the 8 reserved read addresses causes the decoder to generate a motor current pulse response when the data in the packet matches the data in the register being interrogated. This is why locomotives "chirp" during programming and when they are read on a programming track.

Digitrax Configuration Register:

This is a full 8 bit flag register with 3 defined and 5 reserved flag bits. These are defined by data bit position and function. This section assumes that the reader is familiar with data formats and "bit positions."

Digitrax Flag Map:

Flag Data Bit	Decimal Equivalent	Flag Function
0(lsb)	1	Reserved
1	2	If Set, use Advanced 28 Speed Steps
2	4	If Set, allow ANALOG mode conversion
4	16	If set, select User LOADABLE Speed Table
3,5-7	x	Reserved, all reserved bits programmed 0 (or cleared by) Digitrax Command Stations

To decode the register setting, add up the decimal equivalents for any flags that are SET. This is the decimal data to write to the register. Factory settings for Digitrax decoders are: analog conversion SET and advanced speed steps NOT set (since Digitrax Command Station owners can so easily configure decoders) the data value is 4 in this register when shipped. This allows Digitrax decoders to operate properly on a system that does not support advanced modes. Decoder users using Digitrax Command Stations generally reconfigure new Digitrax decoders during the initial Decoder Test Procedure.

Locomotive Address:

The locomotive address has a valid decimal value between 1 and 253, excluding the numbers 112 to 127, which are service mode programming access addresses. Note that Digitrax decoders *do not limit* mobile decoder addresses to addresses below 99. If a user experiences conflicts with stationary decoder addresses in the range 128 to 253, as are used in some existing systems, it is a simple matter of reprogramming the locomotive to a different address outside the stationary address range used. This gives Digitrax customers maximum flexibility and the greatest available address range, since it is unlikely that the whole 128 to 253 address range will be used by stationary decoders.

Start Voltage:

The start voltage, V-START, is added to the motor drive voltage at the first code step (NMRA code 02 speed code). The value is defined as valid between 0 and 255. Each value increment represents an increase of approximately 0.25% of the motor drive voltage, when using a "straight-line" motor speed curve. The value of 255 represents 100% motor voltage. Note that this V-START value is interpolated from the first code step, 02, to the mid code step, code 15

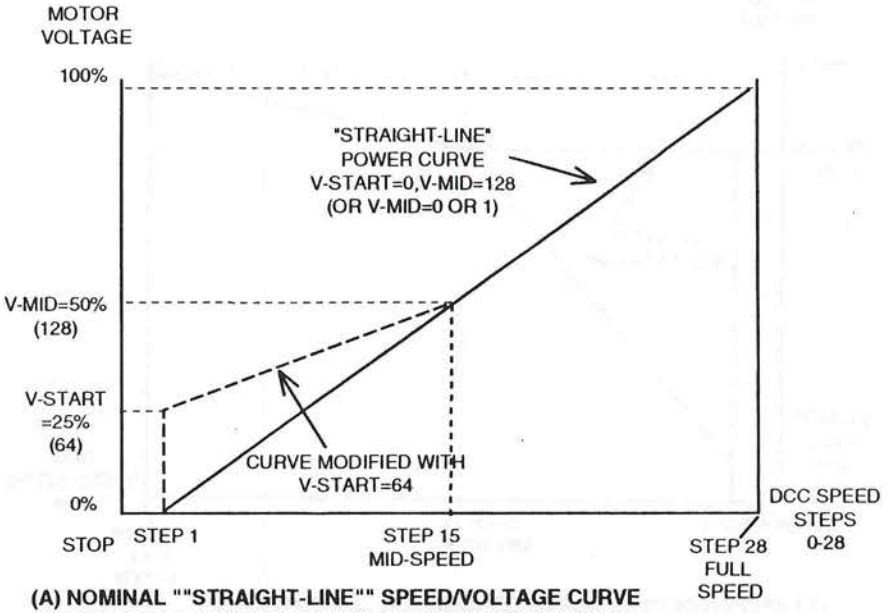
in the advanced 28 speed steps mode, which itself has a motor voltage of V-MID, see following section. If the V-START value loaded in the decoder is *greater* than the V-MID value, the decoder will clamp the motor voltage output for code values from code 02 to the mid-code 15 (28 step system) to the V-MID value. This avoids undesirable throttle effects.

Acceleration:
This register sets the rate at which the decoder can increase code steps in response to a new speed value. The valid range of values is 0 to 31. A value of zero sets an *immediate* response to any new speed. The rate of speed step change is approximately 0.1 second per increment in acceleration value. For example a value of 1 in this register sets the decoder to change at 0.1 second per code step (using the 28 speed step range), such that it takes 2.8 seconds to slew from stopped (code 0) 28 steps to full speed (code 31), assuming a full speed code is received when the locomotive is stopped. If the user is using the older 14 speed step command stations the decoder will process this data so that the acceleration rate appears the same in either mode.

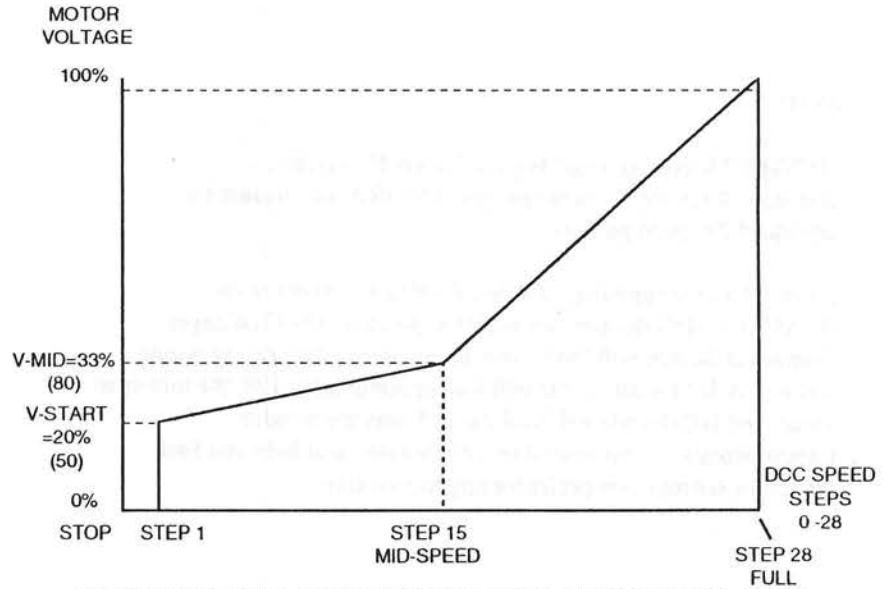
Deceleration:
This register sets the rate at which the decoder decreases code steps in response to a new speed value. The valid range of values is 0 to 31. A value of zero sets an *immediate* response to a new speed. The rate of speed step change is approximately 0.1 second per increment in Deceleration value. For example a value of 1 in this register sets the decoder to change at 0.1 second per code step (using the 28 speed step range), such that it takes 2.8 seconds to slew from full speed (code 31) 28 steps to stopped speed (code 0), assuming a Stop code is received when the locomotive is at full speed. If the user is using the older 14 speed step command stations the decoder will process this data so the deceleration rate appears the same in either mode.

Mid-Point Voltage:
The V-MID register is a subtle, yet powerful, motor speed performance adjustment. Refer to diagram 4 for a graphical representation of some V-MID adjustment examples. Valid values of V-MID are 0 to 255. The decoder uses the value of VMID as a representation of the exact voltage to apply to the motor for the mid-code step 15 (or 7 in a 14 step system). A value of 128 applies exactly 50% of the available voltage to the motor at step 15 (28 speed system). A value of 255 applies 100% voltage at the mid-code step.

For code values *below* the mid-step code 15, the decoder calculates a straight line interpolation proportional to the code step value and the V-START initial and V-MID endpoint values, respectively. In a similar manner, for the code value *above* mid-step code 15, the decoder calculates a straight line interpolation proportional to the code value and the V-MID initial and maximum voltage (100%) endpoint values, respectively. The code for the mid-point code for the 14 step system is 7, and the adjustment is transparent and appears to have the same result

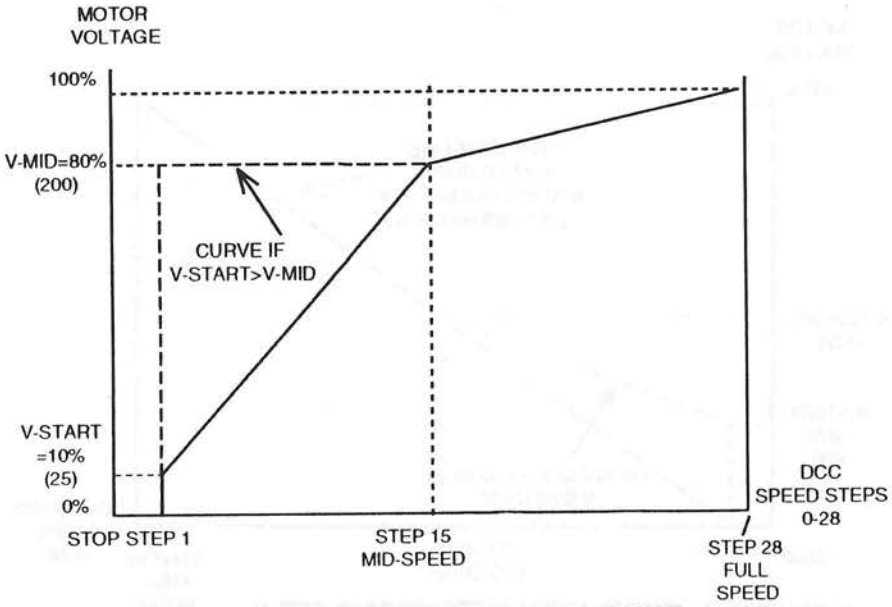


(A) NOMINAL ""STRAIGHT-LINE"" SPEED/VOLTAGE CURVE V-MID=128 OR 0 OR 1, V-START=0 (FACTORY SETTINGS)



(B) SPEED/VOLTAGE CURVE COMPRESSED IN LOWER RANGE V-MID=80, V-START=50

DIAGRAM 4: Digitrax Decoder V-MID Control Examples



(C) SPEED/VOLTAGE CURVE EXPANDED IN LOWER RANGE
V-MID=200, V-START=25

NOTES:

1)"STOP" is code 0, step1 is code 2, step 15 is code 15 and step 28 is code 31 in the proposed NMRA data format for advanced 28 speed packets.

2)For CT4 programming, if either the RED(V-Start) or the BLACK(V-Mid) throttles are at STOP position, the Challenger Command Station will load a zero data value to the corresponding setting. A 1/2 throttle value will load appoximately 128, the mid-span value, and full throttle will load the 255 maximum value. Experimentation with several throttle settings will help you find the motor settings you prefer for any locomotive.

DIAGRAM 4: Digitrax Decoder V-MID Control Examples

whether the decoder is configured for Advanced or Standard mode in the Configuration register.

Note that if V-START is accidentally programmed to be greater than the V-MID numeric register value, the decoder will force the output voltage for all codes below the mid-step value to be fixed at V-MID.

For operational convenience, if the values 0 or 1 are loaded into the V-MID register the decoder will assume that a "straight-line" power curve is desired, and load VMID operationally as 128, the mid point 50% value.

Owner Code 1 & 2:

Digitrax has predefined 2 private data registers of your OWN to load any ID data that you want. These are on page 27 at offsets 2 and 3 as shown in table 2. Digitrax present and future decoder products *will not use these two data registers*. An example of how you might use these codes is as a decoder ID code that is fixed to a particular decoder so you can identify it by, for example, purchase date, etc., without having to open the locomotive to verify the exact decoder model and serial number. **Do not store data you want to *keep* in any other accessible registers** as Digitrax has already defined more than 90 more active registers for future products and many of these will be automatically programmed by future Digitrax programmers.

Note that users of the Marklin 6032 programmer (or similar Arnold unit) will not be able to *read* the offset 1 (corresponding to loco address in page 1) data back properly in any page except Page 1, since this programmer will interpret the offset address 1 (a single LED bar in the 6032 display) as an address interrogation command, and it executes this in a different manner than a normal DCC compatible service mode read comparison at address 112. However write data to offset 1 will program properly as a DCC compatible write to address 120, only limited by the data range of 1 through 99 of the 6032.

Table 2: Program Data Map of Digitrax DH84 (Release A January 1994)

Usage	Address Write	Address Read	Valid Range	FactorySetting	6032 "Bars"
Configuration Register	124	116	See flag map	4	5
Page Register	125	117	1 to 30	1	6
Page 1:					
Loco Address	120	112	1 to 253	3	1
Start Voltage (V-START)	121	113	0 to 255	0	2
Acceleration (ACCEL)	122	114	0 to 31	0	3
Deceleration (DECEL)	123	115	0 to 31	0	4
Page 2					
Mid-Point Voltage (V-MID)	121	113	0 to 255	0	2
Page 27					
Owner Code 1		113	0 to 255	x	2
Owner Code 2	122	114	0 to 255	x	3

Notes & Observations:

1) "x" denotes that the value is not defined.

2) The 6032 "Bars" refer to the number of horizontal LED segments the Arnold/Marklin 6032 style programmers use to indicate which data value they are referencing, e.g., 2 bars lit corresponds to the service mode address of 121 to write and 113 for read compare, which for example, programs the start voltage in a Marklin 6082 2-Rail DC decoder.

3) For the 6032 programmer, "5 code bars" will always read the Digitrax configuration register irrespective of page number, which itself is always in the "6 code bar" register location.
4) The data in all the programming registers is non-volatile and will be remembered during any time the power is off. Thus, the page number will always be left at the last page address loaded.
5) 6032 style programmers read back data for the "1 code bar" in a different fashion from the DCC service mode protocol, since they consider this a locomotive address interrogation and not generic service mode data read comparison. This interrogation will also suppress proposed advanced flying programming data address 25 that is at present unused.

USER LOADABLE SPEED TABLES:

For the demanding user who wishes to fully customize the throttle response of individual decoders and locomotives, Digitrax has incorporated Loadable Speed Tables compatible with proposed NMRA Advanced Configuration Recommended Practices. The table has 28 speed step data entries that allow the User to "draw" an arbitrary "power curve" with a resolution of 1/2%, from the Stop to Full-speed codes. The shape of this curve defines the "feel" of the decoder throttle response. Once the curve is drawn, the user can scale the actual speed the curve sets by using a Forward and Reverse Trim value which acts like a "volume control." In this way, 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 80scale mph . Changing the Forward or Reverse Trim values will scale or multiply all the values used in the table, in the corresponding direction, by the amount desired. Using different Forward and Reverse Trim values allows different Forward and Reverse speeds. The Trim value can multiply up the table values from 100% to 200% with 1% resolution, or down from 100% to 2% with 1% resolution. All the table values are non-volatile and are remembered when the power is off.

Note that if the Configuration Register is set up with the User Loadable Speed Table flag SET to *enable* the Speed Table, the VSTART and VMID values are *not used* to by the decoder when calculating Loadable Speed Table values.

Table 3 is a MAP of the Loadable Speed Tables. These can be loaded from a Marklin 6032 programmer, but the 1-99 data value range will limit the maximum Forward and Reverse Trim values; such that only about half speed operation is possible. This may be acceptable for some slower locomotives.
The following is an example using the the Lenz Programming Register values using Rev 1.3 LH100 software, or later. This software has been upgraded to allow a greater data range. Consult your Lenz dealer for additional information. For Digitrax Advanced DCS200 Command stations and other programmers consult their technical manuals for programming instructions.

Programming Instructions: To set up User Loadable Speed Tables, using Lenz LH100.

1) Set up the decoded locomotive on the normal programming track
2) Select programming Mode, e.g. ,"F, 8, Enter, Enter," using the LH100
   Then: Select PAGE
3) Select Page Register, R6, e.g. ,"ESC, (Pos) 6," to access Page register
4) Load Page number 17, e.g. ,"17, Enter," to select Page 17
   Then: Load DATA for 4 registers in each PAGE
5) Load Transient Value, e.g., "ESC, (Pos) 1, 1, Enter," load 1 into Trans. (Reg 1)
6) Load Forward Trim, e.g., "ESC, (Pos) 2, 250, Enter," load 250 to Fwd Trim, (Reg 2)
7) Load Step 4 value, e.g., "ESC, (Pos) 3, 5, Enter" load 5 for Step 4 value,(Reg 3)
8) Load Step 5 value, e.g., "ESC, (Pos) 4, 7, Enter" load 7 for Step 5 value (Reg 4)
   Then load 7 more pages
9) Repeat Steps (3) through (8), loading the appropriate Page Number (18 to 24) followed by 4 data entry values per page as suggested in Table 3, for Steps 6 to 31, and Reverse Trim.
   Then: Enable Loadable Speed Tables
10) Select Configuration Register, e.g., "ESC, (Pos)5, to change to Config Reg
11) Load Table Enable flag, e.g. ,"22, Enter," for Speed Table ON, Adv 28 Speed mode and Analog Enabled

NOTES:

1) The example speed table is set up to work with the value 99 Register 1 limit (ADR) of the Rev 1.3 LH100 software. The table can be best set up using full 0-255 range with a Programmer that has the full data value capabilities.

2) With the LH100 display, Register 1 is synonymous with "ADR," Register 2 is "STV," Register 3 is "ACC" and Register 4 is "DEC."

Table 3: Program Data Map of Digitrax DH84 (Release A January 1994)
LOADABLE SPEED TABLE

Usage	Address Write	Address Read	Range	Suggested Setting	Lenz Register #
Configuration Register	124	116	See flag Map	22	5
Page Register	125	117	1 to 30	1	6
Page 17:					
Transient	120	112	0-255	**1**	1
Forward Trim	121	113	0-255	**250**	2
Step 4 value	122	114	0-255	**5**	3
Step 5 value	123	115	0-255	**7**	4
Page 18:					
Step 6 value	120	112	0-255	**9**	1
Step 7 value	121	113	0-255	**11**	2
Step 8 value	122	114	0-255	**12**	3
Step 9 value	123	115	0-255	**14**	4
Page 19:					
Step 10 value	120	112	0-255	**16**	1
Step 11 value	121	113	0-255	**18**	2
Step 12 value	122	114	0-255	**20**	3
Step 13 value	123	115	0-255	**22**	4
Page 20:					
Step 14 value	120	112	0-255	**25**	1
Step 15 value	121	113	0-255	**27**	2
Step 16 value, Mid value	122	114	0-255	**30**	3
Step 17 value	123	115	0-255	**32**	4
Page 21:					
Step 18 value	120	112	0-255	**35**	1
Step 19 value	121	113	0-255	**38**	2
Step 20 value	122	114	0-255	**41**	3
Step 21 value	123	115	0-255	**45**	4
Page 22:					
Step 22 value	120	112	0-255	**48**	1
Step 23 value	121	113	0-255	**53**	2
Step 24 value	122	114	0-255	**57**	3
Step 25 value	123	115	0-255	**63**	4
Page 23:					
Step 26 value	120	112	0-255	**68**	1
Step 27 value	121	113	0-255	**74**	2
Step 28 value	122	114	0-255	**81**	3
Step 29 value	123	115	0-255	**89**	4
Page 24:					
Step 30 value	120	112	0-255	**99**	1
Step 31 value, Max speed	121	113	0-255	**109**	2
Reverse Trim	122	114	0-255	**250**	3
Block ADR	123	115	1-8	**1**	4

Notes: for Table 3

1) Forward and Reverse Trim values of 128 will yield a scaling of 100%. The same effect will occur if the value 0 or 1 is loaded for Forward or Reverse Trim, i.e., Multiply by exactly 1. A Trim value of 255 will give 200% scaling of the table entry value.

2) 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.

3) The Steps defined in table 3 are for the NMRA 28 step mode. Step 4 is the First motion step in the 28 Speed step code system. Step 31 is the Full speed step. When configuring the Decoder to run 14 step mode, only every second entry is used, and the Decoder automatically uses the correct data value transparently to the user.

4) The suggested data values given in table 3 allow for a speed curve that most US users are comfortable with. The data values can be further modified to suit individual requirements.

Operational Considerations:

Initially, you should keep deceleration numeric values as small as practical. This allows you to adapt to the delays in deceleration you have programmed without crashing your valuable locomotives!

9.0 Warranty & Repair Information:

Digitrax excludes from warranty repair, damage caused to a DH84 plug harness due to imprudent handling that leads to the separation of harness wires from the plug. The user should exercise due care to ensure maximum life and reliability from plugs and sockets.

Digitrax fully tests every decoder we ship to be sure that you receive reliable products. Because we want you to be comfortable installing your own decoders, we outline a Decoder Test Procedure for performing an assurance test on your decoder so that you can be sure your decoder works before you begin installing in your locomotive. If, within 60 days of purchase, your decoder fails to pass the Decoder Test Procedure outlined on pages 4-10, we will replace it free of charge to you. Because we can't control the actual decoder installation we can't cover your decoder once you have tested it and started the installation. In the event that you somehow manage to "blow-up" one of these little guys, we will repair or replace it for a nominal fee (call for the current amount) if you return the decoder to us.

All warranties on Digitrax products are limited to refund of purchase price or repair or replacement of Digitrax products at the sole discretion of Digitrax. In the event that Digitrax products are not installed or used in accordance with the manufacturer's specifications, any and all warranties either expressed or implied are void. Except to the extent expressly stated in this section, there are no warranties, express or implied, including but not limited to any warranties of merchantability or fitness for a particular purpose.

10.0 Appendix: Other Digitrax Decoders & NMRA Addresses:

Digitrax Decoder Wire Colors For Selected Models

	DN83/F DN82/F	DH82/F	DH83/F	DG82/F	DH84
Power Right	Red	Orange	Red	Red	Red
Power Left	Black	Red	Black	Black	Black
Motor +	Orange	Violet	Orange	Orange	Orange
Motor -	Gray	Blue	Gray	Gray	Gray
Forward Light	White	Yellow	White	White	White
Reverse Light	Yellow	Brown	Yellow	Yellow	Yellow
Light Common		Green	Blue	Blue	Blue
Function 1	Green*	Black	Green	Green	Green
Function 2		White	Violet	Violet	Violet
Function 3			Brown	Brown	

*Blue on all A&B Series DN82F's

NMRA ADDRESSES AS THEY CORRESPOND TO CHALLENGER COLOR CODES

	RED	GREEN	BLUE	BLACK
GRP A	CONV	01	02	03
GRP B	04	05	06	07
GRP C	08	09	10	11
GRP D	12	13	14	15

NOTE: LOCOMOTIVE LIGHTS NOT WORKING CORRECTLY WITH DT200

If you can't control the operation of the lights in your locomotive with the DT200 (in default 128 or 28 speed step mote), be sure that the decoder is programmed in advanced 28 speed step mode.

Do this by programming Configuration Variable 29 with a value of "06."(the code for advanced mode per Table IV page 28 DT200 Manual). Refer to section 10.0 on page 25 in the DT200 manual for complete programming instructions.

Since all Digitrax decoders are shipped programmed to standard 14 speed step mode, you will need to change CV 29 to "06" to have proper light operation when using the DT200. The decoders are shipped programmed to standard mode to allow DCC command stations that are not capable of running advanced mode to run the decoders.

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