

The DIGITAL plus locomotive decoder LE4024 is suitable for all DC motors in S, O and Large Scale locomotives with continuous current draw of up to 4.0 Amps maximum continuous operating current. The characteristics of the decoder are:

- * Super smooth 12 bit resolution back-emf motor control. The LE4024 automatically adjusts the motor voltage to keep the motor's rotation speed nearly constant, which provides extremely smooth slow movement. This creates the illusion that there is actually 100 tons moving.
- * Selectable for operation with 14/27, 28/55 or 128/256 speed steps.
- * Operation on conventional DC layouts is possible or can be disabled.
- * Provides 4A continuous motor current.
- * Four on/off function outputs with a current rating of 150 mA each.
- * Special lighting effects including directional, independent, dimming, Mars light, Gyro light, single Strobe, double Strobe, adjustable blinking and ditchlights.
- * Support for Advanced Consist Control and Extended Addressing.
- * Support for programming on the mainline.
- * Support for all forms of programming as described in NMRA RP-9.2.3.
- * Programmable locomotive address, acceleration and brake momentum, speed curve and much more.
- * Size: L 2.8" x W 1.2"x H 0.41" L 70 mm x W 30 mm x H 10.5 mm

LE4024S High Amperage Back EMF DCC Decoder

Art. No. 10240
Version 5.4
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Digital

plus
by Lenz TM



Submitted for C&I testing

The features of the LE4024 Decoder

The LE4024 has been revised and is packed with features you expect in a high end decoder. Advanced consist control, extended addressing, outstanding 128 step motor control, and 4 function outputs (two for directional headlight control) are but a few examples. The LE4024 supports all forms of programming described in NMRA Recommended Practice 9.2.3, including the user friendly direct CV programming mode. Also, standard is a built in self-test procedure. The advantages of this standardization are obvious: Every locomotive decoder responds in the same way to changes in their properties. All new DIGITAL plus locomotive decoders are produced according to these NMRA DCC standards. This standardization will greatly improve interoperability of locomotive decoders for all manufacturers.

DIGITAL plus decoders built to the NMRA standards and recommended practices are labeled:



This prestigious label means that the NMRA has tested this product and found that it fully complies with all NMRA DCC Standards, Recommended Practices and industry norms. The LE4024 decoder has been submitted to the NMRA for testing.

Many characteristics of the LE4024 decoder can be programmed to customize the decoder to its locomotive. For example, you can operate the decoder with the factory pre-set speed table or generate your own. You can set which end of the locomotive is the forward end. You can even decide whether or not you want to be able to operate on conventional DC layouts.

Please read “Programming the LE4024 locomotive decoder” found later in this booklet for details on the configuration variables supported by the LE4024. There you will find much more information regarding the features and their respective settings.

Back EMF Control

The LE4024 uses a form of motor control called "back emf" control. All DC motors produce a small amount of current when they are rotating. The amount of current produced is a function of the load that the motor is controlling. The LE4024 measures this current and is able to adjust the current to the motor based upon the motor load. The result is exceptionally fine motor control that is extremely smooth and quiet.

The LE4024 employs the finest motor control possible. It is suitable for all forms of motors including coreless motors.

Preparing to Install the LE4024

A locomotive that runs well under DC will run exceptionally well under DCC. Replace worn out motor brushes and burned out light bulbs. Clean any dirt or oxidation from the wheels and pickups, and make sure that electrical contact is good. Now is also a good time to lubricate your locomotive.

An internal rectifier supplies the current for all the decoder outputs with a maximum current rating of 4.0 Amps. The sum of the current to the motor and the function outputs cannot exceed this limit. Each individual output can only draw up to its limit.

Example:

Suppose the motor may require as much as 3.5 A. Then the function outputs combined must not exceed 0.5 A. If the headlights require 150 mA each, then the load on outputs C and D combined must not exceed 200 mA.

Some advice on installing the decoder:

Although the LE4024 has many internal safeguards to prevent damage, you must not allow any metal part of the locomotive to touch the surface components of the decoder. This could cause a direct internal short circuit and the decoder will be destroyed. **The motor brushes MUST also be completely isolated from the rail pickup.** Achieving isolation may require some different approaches on different locomotives, perhaps unsoldering wires, placing a thin piece of insulating plastic between brush terminal and contact spring. If you have a VOM, check for infinite

resistance between the motor and all the wheels. Take special note that metal contact might occur only when the loco body is reinstalled.

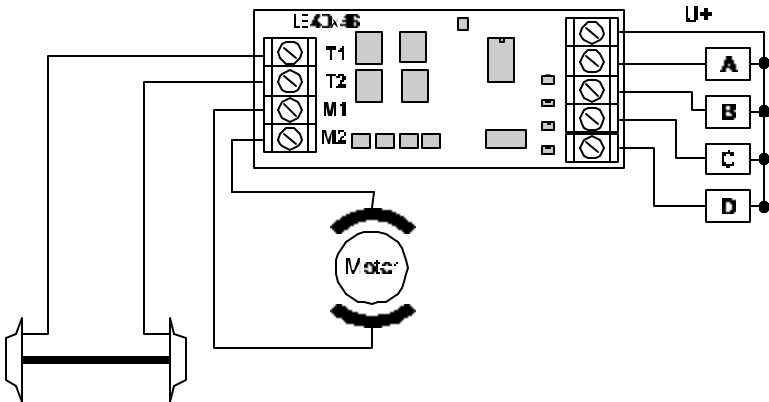
DO NOT WRAP decoder with electrical tape or shrink wrap!

Doing so will impede air circulation and degrade the performance of the decoder. Instead, put electrician tape over any part of the locomotive frame or body that might touch the decoder and use double sided foam mounting tape to mount the decoder. This will prevent short circuits without 'suffocating' the decoder.

The LE4024 can not be set up for simultaneous use for 2-rail pickup and overhead cantenary or trolley operation. If the locomotive is turned the wrong way, the decoder could get twice the track voltage, which would destroy it!

Wiring Options

There are two wiring options for installing the LE4024, depending on how the locomotive is constructed. The functions could be connected with their common to the decoders floating common (blue wire) as shown below or one rail can be used as a common. A mixture of both options is also possible.



If the bulbs for the directional headlights are floating (isolated against wheel pick up and chassis) and connected according to above figure, they will shine brighter compared to using the rail as a common and the directional headlights will function while operating on conventional DC layouts.

Step by Step Installation

The LE4024S has 9 screw terminals. The 4 terminal connector is for the track and motor connections, the 5 screw terminal connector is for the functions. The following instructions assume the decoder is oriented with 4 terminal connector on the left and the label on the top as in the figure above. Be careful to orient the decoder properly during installation to avoid improper installation

Two wires connect the decoder to the track. (T1 and T2 above)

- T1 terminal connects to Right rail pickup.
- T2 terminal connects to Left rail pickup.

Two wires connect the decoder to the motor. (M1 and M2 above)

- M1 terminal connects to the motor terminal that was previously connected to the right rail.
- M2 Terminal connects to the motor terminal that was previously connected to the left rail.

Make sure that the motor is electrically isolated from both track pickups:

Five wires connect the headlights and functions to the decoder. These are connected to the 5 terminal block on the right side of the decoder.

- The U+ terminal is the function common
- Function Terminal A connects to the forward headlight or the function controlled by Output A. If the bulb is isolated, connect the U+ terminal to the other terminal.
- Function Terminal B connects to the rear headlight or the function controlled by Output B. If the bulb or function is isolated, then connect U+ terminal to the other terminal.
- Function Terminal C connects to the function controlled by Output C. If the bulb is isolated, connect the U+ terminal to the other terminal.
- Function Terminal D connects to the function controlled by Output D. If the bulb is isolated, connect U+ terminal to the other terminal.

Place the locomotive (without its shell) on the programming track and read back the locomotive's address from the decoder. If the decoder is properly installed, you will be able to read back the factory pre-set address 03. Remove the locomotive from the track, and if necessary correct any wiring errors.

Programming the locomotive decoder LE4024

The LE4024 supports all NMRA DCC programming modes and can be programmed by any NMRA DCC programmer. With some entry level systems only a few CVs (such as CV #1, the locomotive address) can be set unless you use a separate programmer. Specific details for reading and writing the decoder's configuration variables can be found in the manuals of the appropriate equipment used for programming.

The configuration variables and their meaning

The following table lists the various CVs supported in the LE4024 decoder. Both the NMRA DCC CV numbers and the older Register numbers are provided for cross reference.

Please note: Some CVs (such as CV29) have specific meanings for each bit. The bit assignments in this table use a bit numbering scheme of 0-7 to correspond the NMRA convention for universal bit numbering. Many handhelds (such as the DIGITAL plus LH100 handheld) use a scheme of 1-8 to refer to the individual bits rather than 0-7. (Bit 0 in this table is displayed as a "1" on LH100 handheld, Bit 1 is identified as "2".) The bit numbers in () within these tables contain the LH100 bit numbers.

Table 1: LE4024 Configuration Variables

CV	Re g	Description	Range	Factory setting
1	1	Locomotive address: This is the number with which you select a locomotive in the DIGITAL plus system. Setting the address from #1 to #3 using register mode will reset the decoder to utilize 14 speed step operation.	1-127	3
2	2	Start voltage: This is the voltage applied to the motor in speed step 1. Set this value so that the locomotive just starts moving in speed step 1.	1-15	0
3	3	Acceleration Momentum: Determines the rate of change of speed upon acceleration. A higher value leads to a slower acceleration.	1-31	1

**Note: in the factory setting field the numbers in the [] are decimal.

CV	R	Description	Range	Setting
4	4	Brake Momentum: Determines the rate of change of speed upon braking. A higher value leads to longer brake distance.	1-31	1
5	-	Maximum speed (only valid if Back EMF is on) Determines the maximum speed that the locomotive will move. This allows you to operate your locomotives in a prototypical speed range.	1-10	10
-	5	Contains CV29 (see CV29 below)	0-55	6
-	6	Page/Pointer Register: Normally this CV is not modified directly by a user. For correct operation, this CV should be set to have a value of 1 after any use.	0-127	1
7	7	Version Number: This location stores the version number of the decoder. This location is read only.	-	54
8	8	Manufacturers Identification: Contains the manufacturer ID of the decoder, (Lenz =99). Writing a value of 33 using Register mode resets all CVs to their factory condition	-	99
9	-	EMF Frequency Adjusts the pulse rate frequency for finer motor control. This value also effects the minimum speed.	0-15	10
17	-	Extended Address High Byte	192-231	0
18	-	Extended Address Low Byte The two byte address if used is contained in CV17+18	0-255	0
19	-	Consist Address The advanced consist address if used is stored in CV19	0-255	0
29	5	Decoder Configuration, Byte 1: Several decoder properties are set with this byte. Changes are best done in binary mode (see the information for the Hand Held LH100). The detailed properties are:	0-63	6
	bit 0 (1)	Locomotive direction: Locomotive's relative direction: This bit sets the direction the locomotive will move when told to move forward in digital mode. 0 = locomotive's direction is normal 1 = locomotive's direction is reversed	0,1	0 [1]

CV	Description	Range	Setting
bit 1 (2)	Headlight mode: 0 = Operation with 14 or 27 speed step systems. This setting is selected when the locomotive decoder is used with any Digital system that does not support 28 speed step mode. If the headlights turn on and off as the speed is increased, the command station is configured for 28 speed step mode, and the decoder is in 14 speed step mode. 1 = Operation with 28, 55 or 128 speed steps. If you use this setting, the Command Station must also be configured to use 28 speed step mode or 128 speed step mode for the decoder's address, otherwise the headlights can not be controlled.	0,1	1 [2]
bit 2 (3)	Usage on conventional DC layouts: 0 = locomotive operates in digital mode only 1 = locomotive can operate on either conventional DC and on DCC	0,1	1 [4]
bit 3 (4)	Enable RailCom	0,1	0 [8]
bit 4 (5)	Speed Curve Selection: 0 = factory pre-set speed curve is used 1 = user defined speed curve is used using the values in CV 67 to CV 94	0,1	0 [16]
bit 5 (6)	Extended Addressing 0= Normal addressing 1= Four digit extended addressing	0-1	0 [32]
bit 6 bit 7	always 0	0	0
50	Decoder Configuration, byte 2: Similar to CV 29, but other properties are set with this byte:	0-7	1
bit 0 (1)	Back EMF Control If set back emf control is active	0,1	1 [1]
bit 1	not used		
bit 2 (3)	Brake momentum on DC operation. Used to achieve prototypical braking at red signal indications if conventional DC control CV29.2 is disabled. (CV 29 bit 2 = 0) 0 = locomotive proceeds with track voltage dependent speed inside the conventional DC section. 1 = locomotive brakes in the conventional DC section with pre set brake momentum.	0,1	0 [4]
bits 3-7	not used		

CV	Description	Range	Setting
51	Lighting Special Effects for Outputs A	0-255	0
	bit 0 (1)	0 = the headlights (A&B) are directional. 1 = the lights (A&B) are independent per Rule 17. F0 controls the front headlight and F1 the rear headlight or a separate function.	0,1 [1]
	bit 1 (2)	Only active if dimming (bit 2 (3)) is set to a value of 1. The value in CV52 is used for dimming. 0 = function A output is always dimmed 1 = If directional F1 is used for dimming, if independent F4 is used for dimming	0,1 [2]
	bit 2 (3)	Output A can be dimmed	0,1 0 [4]
Bits 3-7 are only active for independent lighting. If more than one bit is set, only the higher bit is active. If a bit is set dimming is inactive.			
	bit 3(4)	Not used	0,1 0 [8]
	bit 4 (5)	Output A is a Gyrolight	0 [16]
	bit 5 (6)	Output A is a Mars light	0 [32]
	bit 6 (7)	Output A is a Single Strobe	0 [64]
	bit 7 (8)	Output A is a Double Strobe	0 [128]
52	Dimming CV for Output A - contains the value used for dimming. 0 is dark 255 is max brightness	0-255	64
53	Lighting Special Effects for Outputs C and D	0-7	0
	bit 0 (1)	1 = Output C blinks with the frequency set in CV56	0,1 0 [1]
	bit 1 (2)	1 = Output D blinks with the frequency set in CV56	0,1 0 [2]
	bit 2 (3)	1= Outputs C and D act as Ditch Lights. CV55 controls which function turns on both ditch lights and CV54 controls which function activates the alternating blinking.	0,1 [4]
54	Function assignment for Output C	0-255	1
	bit 0 (1)	1 = Output C is controlled By F1	0,1 1 [1]
	bit 1 (2)	1 = Output C is controlled By F2	0,1 0 [2]
	bit 2 (3)	1 = Output C is controlled By F3	0,1 0 [4]
	bit 3 (4)	1 = Output C is controlled By F4	0,1 0 [8]
	bit 4 (5)	1 = Output C is controlled By F5	0,1 0 [16]
	bit 5 (6)	1 = Output C is controlled By F6	0,1 0 [32]
	bit 6 (7)	1 = Output C is controlled By F7	0,1 0 [64]
	bit 7 (8)	1 = Output C is controlled By F8	0,1 0 [128]
55	Function assignment for Output D	0-255	2
	bit 0 (1)	1 = Output D is controlled By F1	0,1 1 [1]
	bit 1 (2)	1 = Output D is controlled By F2	0,1 0 [2]
	bit 2 (3)	1 = Output D is controlled By F3	0,1 0 [4]
	bit 3 (4)	1 = Output D is controlled By F4	0,1 0 [8]

CV	Description	Range	Setting
55	Function assignment for Output D (Cont)		
	bit 4 (5) 1 = Output D is controlled By F5	0,1	0 [16]
	bit 5 (6) 1 = Output D is controlled By F6	0,1	0 [32]
	bit 6 (7) 1 = Output D is controlled By F7	0,1	0 [64]
	bit 7 (8) 1 = Output D is controlled By F8	0,1	0 [128]
56	Blinking Rate for Outputs C and D. Frequency in Hz = $1/0.016*(1+CV56)$	0-255	15
57	Lighting Special Effects for Outputs B	0	0
	bit 0 (1) Not Used: CV51 Bit 0 (1) applies to both output A and output B	0,1	0 [1]
	bit 1 (2) Only active if dimming (bit 2 (3)) is set to a value of 1. The value in CV58 is used for dimming. 0 = function B output is always dimmed 1 = If directional F1 is used for dimming, if independent F4 is used for dimming	0,1	0 [2]
	bit 2 (3) Output B can be dimmed	0,1	0 [4]
Bits 3-7 are only active for independent lighting. If more than one bit is set, only the higher bit is active. If a bit is set dimming is inactive.			
	bit 3(4) Not used	0,1	0 [8]
	bit 4 (5) Output B is a Gyrolight		0 [16]
	bit 5 (6) Output B is a Mars light		0 [32]
	bit 6 (7) Output B is a Single Strobe		0 [64]
	bit 7 (8) Output B is a Double Strobe		0 [128]
58	Dimming CV for Output B - contains the value used for dimming. 0 is dark 255 is max brightness	0-255	64
67 to 94	Values for user defined speed curve: These registers are used for a user defined speed curve. The factory setting for these registers is shown in the following speed curve table. The value in each CV determines the velocity of the locomotive for each assigned speed step: For the 14 speed step mode the odd CVs are used If you are using 128 speed step mode and you have activated the user defined speed table, the intermediate speed steps are calculated by the decoder.	0-255	Factory Default Speed Curve
105	User Identification #1	0-255	255
106	User Identification #2	0-255	255
128	Decoder Software Version – read only		03

Creating a Speed Curve

One common feature is to set a specific operating speed curve for your locomotives. This is usually done to have dissimilar locomotives have the same performance characteristics or to have the locomotives perform more prototypically. Start by writing down how you want to assign the internal speed settings to the speed steps, for example by making up a table as shown below.

Note: CV2 (Start Voltage) is still used as part of the calculation even when the decoder is in User Defined Speed Curve mode.

Speed step in 14/27 mode	Speed step in 28 mode	Default speed setting	CV / register
1	1	2	67
	2	12	68
2	3	24	69
	4	36	70
3	5	48	71
	6	60	72
4	7	70	73
	8	80	74
5	9	90	75
	10	100	76
6	11	110	77
	12	120	78
7	13	130	79
	14	140	80
8	15	150	81
	16	160	82
9	17	170	83
	18	180	84
10	19	188	85
	20	196	86
11	21	204	87
	22	212	88
12	23	216	89
	24	224	90
13	25	232	91
	26	240	92
14	27	248	93
-	28	254	94

In 128 speed step mode the decoder internally averages the speed table to obtain the correct speed step value.

North American Warranty

Lenz GmbH does everything it can do to ensure that its products are free from defects and will operate for the life of your model railroad equipment. From time to time even the best-engineered products fail either due to a faulty part or from accidental mistakes in installation. To protect your investment in Digital Plus products, Lenz GmbH offers a very aggressive 10 year Limited Warranty.

This warranty is not valid if the user has altered, intentionally misused the Digital Plus product, or removed the product's protection, for example the heat shrink from decoders and other devices. In this case a service charge will be applied for all repairs or replacements. Should the user desire to alter a Digital Plus Product, they should contact Lenz GmbH for prior authorization.

Year One: A full repair or replacement will be provided to the original purchaser for any item that that has failed due to manufacturer defects or failures caused by accidental user installation problems. Should the item no longer be produced and the item is not repairable, a similar item will be substituted at the manufacturers discretion. The user must pay for shipping to an authorized Lenz GmbH warranty center.

Year 2 and 3: A full replacement for any item will be provided that has failed due to manufacturer defects. A minimal service charge for shipping and handling costs will be imposed. Should the item no longer be produced and the item is not repairable, a similar item will be substituted at the manufacturer's discretion.

Year 4-10: A service charge to include repair, shipping and handling will be placed on each item that has failed due to manufacturer defects and/or accidental user installation problems. Should the item no longer be produced and the item is not repairable, a similar item will be substituted at the manufacturers discretion.

A return authorization number is necessary for warranty service. Please contact a Lenz Service Center to receive this number and give the required information.

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This equipment complies with Part 15 of FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.



Please save this manual for future reference!

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