

The DIGITAL plus locomotive decoder LE230 is suitable for all DC motors in S Scale or larger locomotives with continuous current draw of 2.5 Amps or less. The characteristics of the decoder are:

- * Control of the motor's rotational speed (load compensation). Regardless of the load, the motor's rotation speed is kept nearly constant. During extremely slow movement (for instance through sharp curves and over a series of turnouts), LE230 always provides the motor with enough voltage. This creates the impression that there is actually 100 tons moving.
- * Selectable for operation with 14/27, or 28/55 speed steps.
- * Optional operation on conventional DC layouts is possible.
- * Provides 2.5A continuous motor current.
- * 8 switchable function outputs (includes 2 for directional lighting) that can be connected directly or through Function Module LF200 (depending on the current draw) + 2 additional function outputs controllable through the LP200 auxiliary motor module.
- * Support for Advanced Consist Control and Extended Addressing
- * Support for short form programming on the main for acceleration and deceleration trim
- * Support for all form of programming as described in NMRA RP-9.2.3
- * Programmable locomotive address, acceleration and brake momentum, speed curve and much more.
- * Size: L 2.75" x W 1,18" x H 0.50"
L 70.0 x W 30.0 x H 12.0 mm

Information

LE230

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The features of the LE230 Decoder

The LE230 has been revised and is packed with features you expect in a high end decoder. Advanced consist control, extended addressing, outstanding 28 step motor control, and 10 function outputs (includes two for directional headlight control) are but a few examples. The LE230 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.

Many characteristics of the LE230 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 “The Configuration Variables and Their Meanings” section later in this booklet for details on the configuration variables supported by the LE230. There you will find much more information regarding the features and their respective settings.

Back EMF Control

The LE230 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 LE230 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 LE230 employs the finest motor control possible. It is suitable for all forms of motors.

Important considerations for LE230 use

The LE230 is designed for a maximum voltage of 26V for safety reasons. It must not be operated with higher voltages as higher voltages can result in destroying the decoder.

The LE230 can be safely used without any restrictions with any NMRA DCC command station/power station that displays the NMRA conformance seal. Before using the LE230 with other DCC systems please verify the maximum voltage output from the operation manuals or from the manufacturer.

Conventional operation, i.e. operation using a model railroad transformer/power pack:

Several Large Scale transformers put out voltages that exceed the 26 volt maximum. Before operating the LE230 in analog mode determine that the output voltage of the transformer/power pack does not exceed 26V. On model railroad transformers, the effective output voltage is often indicated. This is not the maximum voltage!

You can find the maximum voltage by multiplying the stated effective voltage with a factor of 1.4:

Example:

The transformer lists the voltage (effective voltage) as: 16V. The maximum voltage: $16V \times 1.4 = 22.4V$. This means that the LE230

can be safely operated with this transformer. Normally 18V is the highest allowed effective transformer voltage:

$$26V / 1.4 = 18V$$

Operation with an electronic controller:

For electronic controllers, you cannot determine the maximum output voltage through a simple formula. It is simply not enough to use the maximum output voltage of the transformer that supplies the electronic train controller! Contact the manufacturer if you do not find any indications in the operation manual.

Preparing to Install the LE230

The locomotive must be tested for excellent operation on normal DC power before installing the decoder. 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 smooth. Now is also a good time to lubricate your locomotive. Only a locomotive in great mechanical condition can take maximum advantage of the LE230 decoder.

Make note of which motor lead goes to the right rail wiper and which goes to the left. During installation of the Locomotive Decoder, this will save you trial and errors to find which screw terminal on the decoder needs to connect to which motor lead, in order to set the correct direction of travel.

Notes on current load of the Decoder outputs:

The outputs of LE230 may be subjected to the following loads:

- Motor: 2.5A
- Light front/rear 0.3A
- F1: 0.5A
- F2-F6: 0.1A
- F7-F8 (refer to the LP200 manual)

All outputs of the Decoder are supplied by an internal rectifier circuit that allows a maximum total current flow of 2.5A.

Accordingly the sum total of all current flowing to motor and function outputs must never be greater than this maximum allowable total current. Each individual output must only be subjected to its own allowable maximum current.

Mathematically the sum of all the maximum currents is greater than the allowable total current of 2.5A – this in order to allow customized use of the decoder –, but even so this value must never be surpassed in continued operation.

An example:

You need a motor output current of 1.5A for the operation of the motor. You now calculate the current left available for the function outputs by deducting the motor current from the total current. In this case, there will only be 1.0A left for the functions. If you now connect a lamp drawing 100mA to each of the two outputs of the directional light function, then you have another 0.9A available for the other functions. If this is not enough for the intended use, then you can use one or more Function Module LF200. This module then provides you with isolated relay contacts for switching the functions.

Installation Considerations

LE230 is equipped with numerous safety circuits, however no part of the decoder may touch any metal part of the frame or locomotive shell at any time. If they do, there will be a short circuit inside the Locomotive Decoder and it will be destroyed.

Do not however wrap the Decoder in insulating tape, since this will hinder the needed air circulation around the decoder. Instead stick insulating tape, or similar, onto the metal parts of the locomotive. This way you can prevent undesired short circuits, without ‘choking’ the Decoder.

The motor connections must be isolated after removing the previous wires. That means that there must be no connection to the frame or wheels (wheel wipers) any longer. **Also note that such connections occasionally can happen when replacing the shell onto the frame!**

Locomotives equipped with LE230 must not be operated via overhead wire (catenary) on 2 rail layouts, since the locomotive can get twice the applied voltage if put on the track in the wrong direction.

Plug-in terminal row S2 is intended exclusively for connection of Power Module LP200. Power Module LP200 is used to control additional motors whose total current needs exceed the current

limits of the LE230. There must not be any other connections created to the motor, track, or other terminals on Locomotive Decoder LE230.

The different installation options

For connecting Locomotive Decoder LE230 there are several options, all depending on if you intend to connect the functions in the locomotive (as shown in illustration 1) with their common lead connected to a rail wiper, or (as in illustration 2) isolated (isolated from contact with wheel wipers and frame/shell). A mixture of both connection methods is also possible, for instance: the light bulbs of the front lighting can be connected to a wheel wiper, and other functions can be set up to be isolated.

When using LF200, please consult the information included with it for installation details.

If the light bulbs of the headlights are isolated and connected according to illustration 2, they will light up a little brighter than when connected according to illustration 1. In addition, the directional lights will then also work in conventional DC operation

Which of the methods you use, largely part depends on how the locomotive is constructed.

Step by step: Installation and Testing

- * First connect the Locomotive Decoder to the wheel wipers:
- * Terminal G1 to the right wheel wiper (in direction of travel).
- * Terminal G2 to the left wheel wiper (in direction of travel).

Then connect the decoder with the motor leads:

- * Terminal M1 to the motor lead that earlier was connected to the right wheel wipers.
- * Terminal M2 to the motor lead that earlier was connected to the left wheel wipers.

Now you connect the lights:

- * Terminal L1 to the front lights (in direction of travel). If the lamp is isolated, then connect terminal U+ with the other lamp lead.

- * Terminal L2 to the rear lights (in direction of travel). If the lamp is isolated, then connect terminal U+ with the other lamp lead.

Now put the locomotive (without putting on the shell) on the programming track, and read out the address. From the factory the decoder is programmed to address 03. If you have connected the decoder properly so far, you should now be able to read out the address. If that is not the case, then you may have made a mistake in wiring. The decoder will help you in tracking it down.

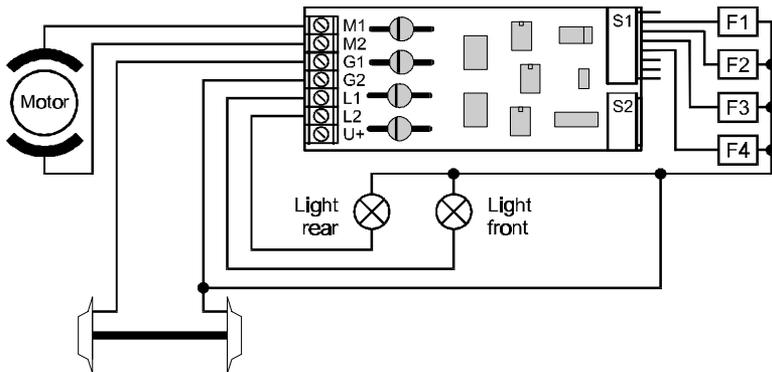


Figure 1: Wiring the LE230 using track voltage common

With the self-test turned on (factory default, bit 2 in CV60 is '1'), the decoder is able to determine the following wiring problems on the programming track:

- * Prohibited connection of a motor lead with the track.
- * Short circuit of the directionally switched light output to the track.

If a problem of this kind is present, then the decoder cannot be read out. On the Hand Held Controller you get the display "ERR02".

In that case, proceed as follows:

First turn off the decoder self-test by clearing bit 2 in CV60 (see the section "Programming the Locomotive Decoder").

Read out CV30. In this CV (when the self-test is on) the type of problem is stored as the corresponding bits. From the table "Determining the settings of the Locomotive Decoders in CVs" you can read which bit shows which problem.

Now again remove the locomotive from the track, correct the problem as needed and test it again. First clear the bits in CV30 that showed you the problem, and then turn on the self-test in CV60 again.

Connecting additional functions:

You connect additional functions using wires to the 8-pin terminal strip S1. The correct plug, with attached wires, is included. You can connect the additional functions either directly to the wires, or if the maximum current load of the outputs is exceeded, via Function Module LF200.

- * To the yellow wire you connect the function that you want to turn on and off with key '1' on Hand Held Controller LH100 or key '1' on Arnold/Märklin control 80.
- * To the white wire, connect the function that you want to turn on and off with key '2' on the Hand Held Controller.
- * To the black wire, connect the function that you want to turn on and off with key '3' on the Hand Held Controller.
- * To the red wire, connect the function that you want to turn on and off with key '4' on the Hand Held Controller.
- * To the gray wire, connect the function that you want to turn on and off with key '5' on the Hand Held Controller.
- * To the orange wire, connect the function that you want to turn on and off with key '6' on the Hand Held Controller.
- * The green wire is a power ground. This wire should be used with extreme caution and is only intended for use with devices that require it..

If the functions and/or lamps are isolated in the locomotive, then you can connect the blue wire to the common connection for the functions. After this wiring, you can program the locomotive to the desired address and start your trial run.

Connecting Slave Motor Driver LP200

The plug-in terminal row S2 is intended for this. The wire colors are assigned as follows:

blue	U+
red	T
yellow	S
green	R

Two additional wires are provided for controlling F7 and F8. For detailed information on installation and wiring, please refer to the operation manual for the LP200.

Programming the locomotive decoder LE230

Locomotive address, acceleration and brake momentum and all other properties of the decoder can be changed as often as desired. This process is called *programming*.

The properties will be saved in non-volatile memory locations on the locomotive decoder. The values will be permanently saved, even after disconnecting the operating voltage. These memory locations are called "Configuration Variables, or CVs" by the NMRA. The LE230 has a total of 128 CVs. Not all of them are used at this time as many are reserved for future use.

The reading and writing of these values is done electronically, the locomotive does not need to be opened after initial installation of the decoder to read or later modify any CV value.

Any NMRA DCC Command Station, such as the DIGITAL plus LZ100 and a Hand Held LH100 or an Interface LI100, can be used to program the locomotive decoder LE230. With older command stations (including Arnold or Märklin) the decoder supports index mode, a special form of register mode which allows you to easily address all the CVs. Using the Arnold Commander 6, or the ROCO 'DIGITAL is cool' command station, only register 1 (locomotive address) can be set. Many other DCC command stations support paged programming. The LE230 supports this mode as well. Details for reading and writing the decoder's configuration variables can be found in the manuals of the appropriate equipment.

The configuration variables and their meaning

The new line of Lenz advanced decoders, version 5.1, support a full range of features which are set up using a variety of configuration variables. All the configuration variables are numbered. These numbers are used during programming and are identical for all decoders that conform to the NMRA standards independent of the manufacturer. The following table lists the various CVs supported in the LE230 decoder. Both the New 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 1-8 to correspond to the 1-8 display on DIGITAL plus systems. Many other systems use a scheme of 0-7 to refer to the individual bits. If you are using such a system you should subtract one from all bit numbers described in these CVs.

Table 1: LE230 Configuration Variables

CV	Register	Description	Range	Factory setting
1	1	Locomotive address: This is the number with which you select a locomotive in the DIGITAL plus system.	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	1
3	3	Acceleration Momentum: Determines the rate of change of speed upon acceleration. A higher value leads to a slower acceleration.	1-31	1
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 Determines the maximum speed that the locomotive will move. This allows you to operate your locomotives in a prototypical speed range.	1-10	10

CV	Reg	Description	Range	Factory setting
-	5	CV29 when the page/pointer register has a value of 1 or value of CV pointed to by Register 6 when register 6 is being used as a pointer register	0-63	4
-	6	Page/Pointer Register: Used during programming for paging or indexing	0-127	1
7	7	Version Number: This location stores the version number of the decoder. This location is read only.	-	51
8	8	Manufacturers Identification: This value is the manufacturer ID of the decoder, (Lenz =99). This location is read only.	-	99
9	-	EMF Frequency Allows you to adjust the pulse rate frequency for finer motor control	0-15	4
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	4
		bit 1 locomotive direction: 0 normal: locomotive moves forward when the arrow on the Hand Held points up. 1 inverted: locomotive moves forward when the arrow on the Hand Held points down.	0,1	0

CV	Reg	Description	Range	Factory setting
		bit 2 speed step mode: 0 Operation with 14 or 27 speed steps. This setting is selected when the locomotive decoder is used with a software below version 2.0, ROCO-Digital, LGB-Digital, Arnold Digital and with all other Digital systems that do not support the 28 speed step mode. 1 Operation with 28 speed steps. This setting is selected when the locomotive decoder is used with a Command Station with software version 2.0 or higher. The Command Station has to be set to 28 speed step mode for the decoder address, if you are using this setting! Other Digital systems supporting the 28 speed step mode can use the decoder in this setting.	0,1	0
		bit 3 Usage on conventional DC layouts: 0 locomotive operates in digital mode only 1 locomotive can operate in both conventional DC and digital mode.	0,1	1
		bit 4 always 0	0	0
		bit 5 speed curve: 0 factory pre-set speed curve is used 1 user defined speed curve is used. Please enter the appropriate values into CV 67 to 80 before setting this bit.	0,1	0
		bit 6 Extended Addressing 0= Normal addressing 1=Two Byte extended addressing	0-1	0
		bit 7 bit 8 always 0	0	0
30	-	Decoder Error Information		
		bit 1 Motor Short If set short between motor and track	0,1	0
		bit 2 Front Headlight Short If set the front headlight is shorted	0,1	0
		bit 3 Rear Headlight Short If set the rear headlight is shorted	0,1	0

CV	Reg	Description	Range	Factory setting
60	-	Decoder Configuration, byte 2: Similar to CV 29, but other properties are set with this byte:		
		bit 1 Back EMF Control If set back emf control is active	0,1	1
		bit 2 Decoder Control Active If set CV30 contains decoder error	0,1	1
		bit 3 Brake momentum on DC operation. This setting is only active with conventional DC operation disabled. (CV 29, bit 3 = 0) This setting can be used to achieve prototypical braking at red signal indications. 0 locomotive proceeds with track voltage dependent speed inside the conventional section. 1 locomotive brakes in the conventional section with pre set brake momentum.	0,1	0
		bit 4-8 not used		
67 to 81	-	Values for user defined speed curve: These registers are used for a user defined speed curve. The factory setting for these registers is 0. If you are trying to use this speed curve unmodified, your locomotive will not move! The value in each register determines the velocity of the locomotive for each assigned speed step: For the 14 speed step mode, speed step 1 is using the value in CV 67, speed step 2 the value in CV 68, speed step 3 the value in CV 69, etc. For the 28 speed step mode, speed step 1 is using the value in CV67, speed step 3 the value in CV 68, speed step 5 the value in CV 69, etc. The intermediate speed steps are calculated by the decoder.	0-63	0

Creating a Speed Curve

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. The table shown is just an example and gives the factory pre-set speed curve for a starting speed of 1.

In the following description, we will assume that the decoder is properly installed and tested, and the locomotive is on the programming track with the power on. We assume you are familiar with the general process of programming using your command station.

Speed step in 14/27 mode	Speed step in 28 mode	Internal speed setting	CV / register
1	1	1	67
2	3	3	68
3	5	5	69
4	7	7	70
5	9	9	71
6	11	12	72
7	13	15	73
8	15	19	74
9	17	23	75
10	19	28	76
11	21	34	77
12	23	42	78
13	25	52	79
14	27	60	80
-	28	63	81

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 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. If the failure was caused by accidental user installation or use, a minimal service charge may be imposed. 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 shipping to and from the authorized Lenz GmbH warranty center during this portion of the warranty period.

Year 4-10: A minimal service charge 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. The user must pay shipping to and from the authorized Lenz GmbH warranty center during this portion of the warranty period.

Please contact your dealer or authorized Lenz GmbH warranty center for specific instructions and current service charges prior to returning any equipment for repair.



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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.