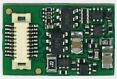
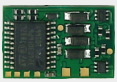
Locomotive decoder LD-G-41

Manual





Locomotive Decoder
with Next18 interface

Item no. 41-04414

MM | DCC | DCC-A | RailCom | SUSI

tams elektronik

Version: 1.0 | Status: 11/2023

Printing the manual

The formatting is optimised for double-sided printing. The standard page size is DIN A5. If you prefer a larger display, printing on DIN A4 is recommended.

Notes on standards

The following RailCommunity standards are mentioned in this manual:

- RCN-118 "Next18 / Next18-S decoder interfaces"
- RCN-217 "DCC feedback protocol – RailCom"
- RCN-218 "DCC-A - Automatic registration"
- RCN-227 "DCC Extended Function Assignment"
- RCN-600 "SUSI-Bus Module Extension Interface"

The standards are published at: www.railcommunity.org

Notes on RailCom®

RailCom® is a German trademark registered in the name of Lenz Elektronik for class 9 "Electronic Controls" under number 301 16 303 and a trademark registered for classes 21, 23, 26, 36 and 38 "Electronic Controls for Model Railways" in U.S.A. under Reg.No. 2,746,080. To enhance the readability of the text, we have refrained from referring to the term each time it is used.

****Products of other manufacturers**

This manual mentions the following companies:

Gebr. MÄRKLIN & Cie. GmbH
Stuttgarter Str. 55-57 | DE-73033 Göppingen

Contents

1. Getting started

This manual will help you step by step to mount and commission the decoder safely and correctly. Before you connect the decoder and put it into operation, please read this manual completely, particularly the chapter on safety instructions and the checklist for trouble shooting. You will then know where to take care and how to prevent mistakes which take a lot of effort to correct.

Keep this manual safely so that you can solve problems in the future. If you pass the decoder on to another person, please pass on the manual with it.

1.1. Contents of the package

- one locomotive decoder with Next18 interface. N.B. For technical reasons it is possible that the PCB is not completely inserted. This is not a fault.

1.2. Required accessories

Tools and consumables

For mounting and connecting decoders without interface you need:

- a soldering iron with temperature control and a thin tip and a deposit stand or a controlled soldering station
- a scraper, rag or sponge
- a heat-resistant pad
- a small pair of side cutters and wire strippers
- tweezers and flat-nose pliers if necessary
- electronic solder (preferably 0.5 to 0.8 mm diameter)
- stranded wires ($\geq$ 0,05 mm² for the connections to the backup capacitor)

Bridging power interruptions

To bridge short current interruptions you need:

- an electrolytic capacitor:
  capacity: 100 to 220 µF | proof voltage: $\geq$ 25 V
- or a buffer circuit that does not necessarily have to be connected to the special control output for buffer circuits of vehicle decoders, e.g.
  USV-mini 0.47 (capacity 0.47 F, item no. 70-02215 or 70-02216)
  USV mini 1.0 (capacity 1.0 F, item no. 70-02225 or 70-02226)
  USV mini 1.5 (capacity 1.5 F, item no 70-02235 or 70-02236).

ABC braking section or ABC-shuttle section

To be able to use the ABC braking method, you need

- per braking distance: one ABC brake module (e.g. ABC-1 art. no. 49-03106-01)
- per shuttle section: two ABC brake modules (e.g. ABC-1 art. no. 49-03106-01)

1.3. Intended use

The locomotive decoder LD-G-41 is designed to be operated according to the instructions in this manual in model building, especially in digital model railroad layouts. Any other use is inappropriate and invalidates any guarantees.

The locomotive decoder should not be mounted by children under the age of 14.

Reading, understanding and following the instructions in this manual are mandatory for the user.

1.4. Safety instructions

The LD-G-41 locomotive decoder is equipped with integrated circuits (ICs). These are sensitive to electrostatic charge. Therefore, do not touch the decoder until you have "discharged" yourself. For this purpose, e.g. a grip on a radiator is sufficient.

Improper use and non-observance of the instructions can lead to incalculable hazards. Prevent these dangers by carrying out the following measures:

- Only carry out installation work when the decoder is de-energised.
- Only carry out installation work in closed, clean and dry rooms. Avoid moisture, wetness and splashing water in your working environment.
- Supply the decoder only with extra-low voltage as specified in the technical data. Only use tested and approved transformers for this purpose.
- Only plug the mains plugs of transformers and soldering irons / soldering stations into professionally installed and fused earthed sockets.
- Do not expose the decoder to high ambient temperatures or direct sunlight. Observe the information on the maximum operating temperature in the technical data.
- If you notice damage or malfunctions, switch off the supply voltage immediately. Send the decoder in for inspection.

2. Operation overview

2.1. Digital operation

The locomotive decoder LD-G-41 is a multiple protocol decoder, that can operate with and automatically recognise both DCC or Motorola formats.

	DCC according to NMRA and RCN-standard	Motorola II (MM II)
Number of addresses	127 basic addresses or 10.239 extended addresses	255
Speed level modes	14, 28 or 128 in 28/128 speed level mode: SDF*	MM II: 14 or 27b
Programming	Configuration variables: Direct programming on the programming track (DCC conform) or PoM (Programming on Main = main track programming)	Registers

* **Background info: SDF** (**S**peed – **D**irection – **F**unction)

This procedure is used to reduce the time required to transmit speed, direction and function commands to vehicle decoders in DCC format. Instead of transmitting the various commands individually, all commands are summarised and transmitted in a single command.

The reduction in transmission time has a particularly positive effect on systems where a large number of decoders with many functions are used.

The prerequisites for using this method are:

- the use of a digital control unit that supports SDF
- the installation of vehicle decoders that support SDF
- setting the speed step mode 28 / 128 on the decoder.

2.2. Analogue mode

The locomotive decoder LD-G-41 can also be used in analogue model railway layouts run with a **DC** speed control.

Automatic analogue recognition

When putting the vehicle on the rails the decoder recognizes automatically if it is run in analogue or digital mode and sets the corresponding operation mode. The automatic analogue recognition can be switched off, e.g.

- if the decoder suddenly switches to analogue mode in digital operation (e.g. as a result of interference voltages whose cause is difficult to localise);
- if a value for the Packet Time Out is programmed to perform a forced stop in case of track voltage failure or shutdown;
- if the procedure "braking with DC voltage" (Märklin** braking distance) is used.

Switching the function outputs in analogue mode

Switching the function outputs on or off is not possible in analogue mode. The outputs can be programmed with the digital central unit so that they are either switched on or off in analogue mode. The effects set for the outputs are active in analogue mode as well.

Outputs that are switched depending on the direction are switched on or off in analogue mode according to the direction of travel. When operated in analogue d.c. layouts this applies only to lamps or accessories where the return conductor is connected to the decoder´s common return conductor for all function outputs.

Other functions active in analogue mode

The settings made in the CVs / registers for

- the maximum speed
- the acceleration and brake delay
- and the load control

are also taken over in analogue mode.

2.3. Overload protection

The locomotive decoder LD-G-41 has an overload protection which protects it from damage in case of exceeding the permissible total current or a short circuit at the motor output (the maximum form of an overload). If an overload is detected, the motor is switched off and lights that are switched with F0f or F0r flash. Resumption of operation is only possible after the decoder has been de-energised (track voltage off).

The response threshold of the overload protection can be adjusted by change in sensitivity, i.e. the magnitude of the overload at which the overload is detected ("short-circuit sensitivity").

Overload at an output

In case of a short-circuit at one output or if the maximum current at one of the outputs is exceeded, the overload protection of the decoder is ineffective as long as the total current of the decoder is not also exceeded. The output in question will be damaged.

Attention:

By lowering the overload response threshold, the influence of short-term interference voltages from the motor or connected consumers is to be reduced. This prevents the motor from being switched off although the permissible total current has not been exceeded. Before lowering the response threshold, the motor current must always be measured and the proper functioning of the motor and the gear unit checked.

Attention:

When a short circuit occurs that bypasses components on the decoder either to each other or to track voltage, the overload protection is not effective.

Examples:

- contact between the decoder and the rails or metal parts of the vehicle;
- contact between not-isolated decoder connecting wires and the rails or metal parts of the vehicle;
- contact between accessories connected to the common return conductor of the decoder and the rails or metal parts of the vehicle.

Attention:

Malfunctions of the locomotive motor (e.g. the so-called "sparking of the brushes") can cause extreme interference current, possibly damaging components on the decoder. The decoder´s overload protection is without effect with this extremely high current.

2.4. Motor control

Pulse width modulation

The LD-G-41 is designed to optimally control DC motors. With a PWM of 25 kHz, it is also suitable for coreless motors.

Load control

The LD-G-41 has a load control. The load control influences the motor voltage to keep the locomotive with a set speed level at constant velocity, independent of additional loads (e.g. running up a gradient, coupled carriages).

It is possible to switch on and off the load control by varying a CV-variable of the decoder. The parameters of the load control may be altered, in order to adapt the decoder to the motor ´s individual characteristics.

Parameters of the load control

The load control is determined by three parameters (KP, KI and KD) which have to be coordinated in order to achieve optimal driving characteristics. Each of the load control parameters is assigned to a configuration variable.

KP: The proportional component of the load control ensures the difference between the set and the present value being as small as possible. It cannot have the value "0" at any time. This component affects the basic speed. In case the set value is too small the locomotive runs too slowly. In case the set value is too high the locomotive stutters while moving.

KI: The integral component of the load control ensures the remaining difference between the set and the present value is reduced to 0 and so for the correction of very small divergences. If the set value is too high the locomotive stutters massively while moving.

KD: The differential component of the load control ensures that the control is not converted too quickly. If the set value is too low, the locomotive stutters. If it is too high, the locomotive rocks while moving.

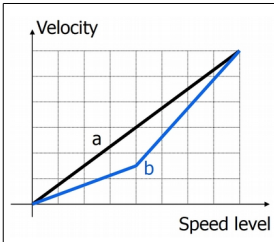
Gain factor

The basis for the influence of the load control on the motor voltage is the voltage returned by the motor during the measuring period. Depending on the individual characteristics, these values may be too high or too low. The effects are that the vehicle reaches its maximum speed already at a speed level below the highest speed level or does not reach it at all at the highest speed level. To compensate for these effects, the values sent by the engine can be increased or decreased by adjusting the amplification factor.

Velocity characteristic

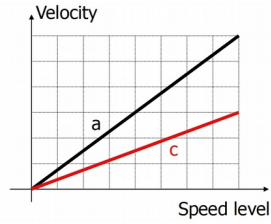
By adjusting the starting, middle and maximum speed, the decoder can be adapted to the driving characteristics of the motor and the characteristic driving speeds of the locomotive type. From these 3 points the decoder generates a speed characteristic curve which is linear between the starting and middle speed and between middle and maximum speed.

When the speed level mode is set to 28 speed levels, it is possible to assign any motor voltage to all of the 28 speed levels as an alternative to the linear velocity characteristic. This allows the programming of a velocity characteristic which adjusts the individual driving characteristics of the motor. The set values are saved in the alternative velocity characteristic.



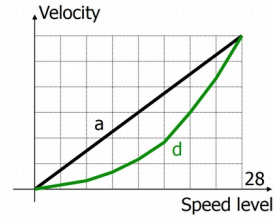
a: Linear characteristic from start and maximum voltage

b: Linear characteristic from start, medium and maximum voltage



a: Linear characteristic from start and maximum voltage

c: Shunting gear = 50 % of the voltage defined in the standard characteristic curve



a: Linear characteristic from start and maximum voltage

d: alternative characteristic with individual assignment of voltage to the 28 speed levels

Starting kick

If programmed accordingly, the starting kick causes a brief increase in motor voltage during start-up in order to overcome the breakaway torque. The motor voltage is regulated immediately after start-up at the set braking rate to the actually selected speed level.

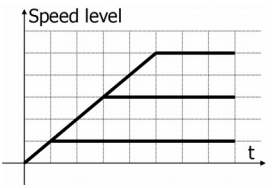
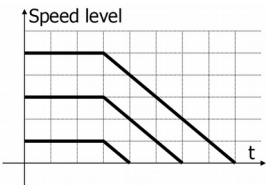
Shunting gear

With the function mapping, the special function "Shunting Gear" (SG) can be assigned to one or more functions with which it is activated and deactivated. On delivery, the function F3 is assigned to the special function "SG". In the shunting gear mode, the velocity of all speed levels is reduced to approx. 50 % compared to the set velocity.

Acceleration and brake delay

A well adjusted acceleration and brake delay (acceleration and brake rate) achieves a prototypical, jerk-free acceleration and braking of the locomotive. For this purpose, in the CVs is set separately for starting and braking, how much time should pass before the decoder changes to the next higher or lower speed level. The decoder then changes the speed level successively until the set speed level is reached. The higher the target speed or the speed level when the braking process is triggered, the longer the starting and braking distance.

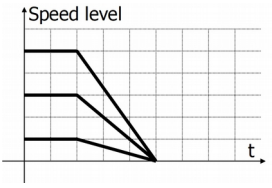
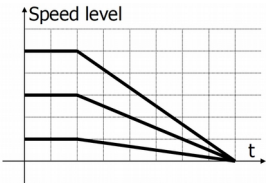
With the function mapping, the special function "Acceleration and Brake Delay" (ABD) can be assigned to one or more functions with which it is activated and deactivated. On delivery, the function F4 is assigned to the special function "ABD".

 Starting delay	 Braking delay	Starting and braking are time-controlled: The length of the starting and braking distance depends on the speed level to be reached or the speed level when the braking process is triggered.

Constant braking distance

When the brake delay is active, the length of the braking distance depends on the delay set in the CV and on the speed level when the braking process is triggered. An exact stop at stopping points is not possible.

For the LD-G-41 a constant braking distance can be defined, which the locomotive should cover when changing from any speed level to speed level 0. The braking distance corresponds to the distance that the locomotive covers with the set brake delay at the highest possible speed level until it comes to a stop. If the braking process is triggered at a lower speed level, the time until the change to the next lower speed level is automatically extended. This ensures that the braking distance is always the same regardless of the speed level when the braking process is started.

 Short braking distance: low value in CV4	 Long braking distance: high value in CV4	The length of the braking distance is always the same, regardless of the speed level when the braking process is triggered. The higher the value set in CV 4 for the braking rate, the longer the braking distance.

2.5. Automated processes

The control software in the locomotive decoder enables the automation of processes and the combination of complex processes in one function. The processes can thus be activated with a function / a function key.

2.5.1. ABC braking procedure

The LD-G-41 locomotive decoder, with the appropriate CV setting, detects when entering an ABC braking section that an asymmetrical track voltage is present and then automatically reduces the driving speed with the set brake delay or braking distance. It can be set to respond to a reduced negative voltage (lower voltage on the right rail as seen in the direction of travel) instead of a reduced positive voltage (lower voltage on the left rail as seen in the direction of travel).

While the locomotive is in the braking section

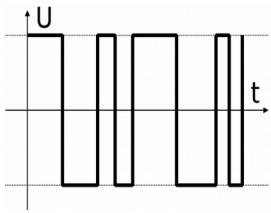
- the functions can be switched,
- the CVs of the decoder can be changed by means of main track programming (PoM),
- the direction of travel of the locomotive can be changed and thus the locomotive can be shunted or driven out of the braking section in the opposite direction.

As soon as the braking section is released or the locomotive moves out of the braking section, it accelerates with the set acceleration delay up to the set speed level.

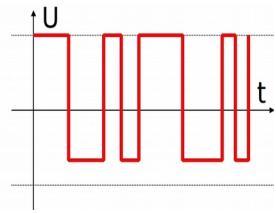
Background information: ABC braking method (**A**utomatic **B**reak **C**ontrol)

The ABC method is based on the fact that in the braking section, an asymmetrical voltage is applied to the track instead of a symmetrical one. In order to be able to use the ABC braking method, the booster must provide as symmetrical an output voltage as possible at the track output. A special ABC-braking module reduces either the positive or the negative part of the digital voltage for the braking section and thus generates an asymmetrical track voltage.

In principle, the braking section is only effective for one direction of travel at a time. While the locomotive is in the braking section, all digital functions are maintained (switching of outputs, PoM, change of direction). No short circuits occur when the locomotive crosses the separation point between the normal section and the ABC braking section.



Symmetrical track voltage in the normal section



Asymmetrical track voltage in the ABC braking section

The normally symmetrical digital voltage is reduced on one side in the braking section by a special ABC braking module, as standard on the right rail as seen in the direction of travel.

For technical reasons, the track voltage applied to the output of some boosters is not 100 % symmetrical. Some types of additional circuits that are connected to the track (e.g. track occupancy detectors) also influence the track voltage on a rail. To prevent the locomotive decoder from interpreting even a slightly unbalanced track voltage as an ABC braking section, the sensitivity can be reduced.

Automatic shuttle train operation based on the ABC method

With the appropriate CV setting, the ABC braking procedure is used to automate shuttle train operation between two terminal stations. When entering an ABC braking section, the locomotive decoder automatically reduces the driving speed as usual with the set brake delay or braking distance. After the stop, however, it changes the direction of travel and travels back in the opposite direction with the set acceleration delay. When entering the ABC braking section for the opposite direction, it automatically reduces the driving speed again.

2.5.2. Braking at DC voltage

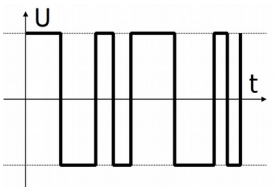
The locomotive decoder LD-G-41 reacts to the application of a pure DC voltage (e.g. Märklin** braking section) with the corresponding CV setting and then automatically reduces the driving speed with the set brake delay or the set braking distance. In the braking section, the status of the switched functions is retained. In contrast to the ABC braking method

- the functions cannot be switched,
- the CVs of the decoder cannot be changed,
- the direction of travel of the locomotive cannot be changed.

As soon as the braking section is released or the locomotive moves out of the braking section, it accelerates with the set acceleration delay up to the set speed level.

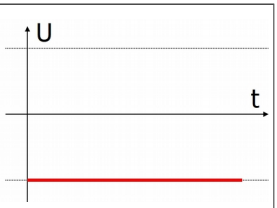
Background information: Braking with DC voltage

The braking method used e.g. by Märklin ("Märklin braking section") is based on the fact that in the braking section, instead of an alternating positive and negative voltage, only a purely positive or negative voltage is applied to the track. In order to prevent short circuits when entering the braking section, an additional transition section must be inserted between the "normal section" and the braking section, which must be a complete train length when used in DC systems..



Symmetrical track voltage in the normal section

Asymmetrical track voltage in the transition section to the braking section



Pure DC voltage in the braking section

2.5.3. Shunting function

Shunting gear and shunting light can be assigned to the same function. Then, when switching to the shunting gear (and the associated reduction of speed), the shunting light (white front and rear light) is switched on automatically. At the same time, the function that switches on the shunting gear can be used to deactivate the acceleration and brake delay function.

Example of programming for shunting operation → section 5.4.

2.5.4. Speed-dependent switching on and off

All function outputs for which the function is activated are automatically switched when a voltage defined in the associated CV is reached. It is possible

- to switch the output **off** when the voltage is exceeded and to switch it **on** when the voltage falls below the voltage or
- to switch the output switch **on** when the voltage exceeds the limit and switch **off** when the voltage falls below it.

The voltage is set for all outputs together.

2.5.5. Stop/Start with a function

With the function mapping, one or more functions can be assigned to the special function "STOP/START with a function". When the assigned function is switched on, the locomotive stops with the set braking delay; when it is switched off, it continues with the set acceleration delay.

On delivery, no function is assigned to the special function "STOP".

2.6. Outputs and interfaces

Function outputs and SUSI interface

In accordance with the RailCommunity standard RCN-118, which describes the Next18 interface, the LD-G-41 has six outputs:

- 4 amplified function outputs (F0f, F0f, AUX1 and AUX2) for switching loads with a maximum load capacity of 100 mA each
- 2 unamplified outputs (AUX5 and AUX6)

In addition, the LD-G-41 has two further connections which, depending on the CV settings, can be used as

- 2 further unamplified outputs (AUX3 and AUX4) or
- connections to a train bus, e.g. "Data (DATA)" and "Clock (CLOCK)" of the SUSI interface

When used for the SUSI interface, the locomotive decoder transmits the status of the functions and the speed level set on the control unit. This allows, for example, speed-dependent functions of the SUSI module to be influenced.

Function mapping according to RCN-227

Assigning the functions to the outputs follows RailCommunity standard RCN-227. It is possible to assign one or several outputs to each function (F0 to F28, seperately for forward and backward motion for each function). In addition, it is possible to assign another function as an "OFF"-switch to the functions.

This mode of function mapping allows to implement special features, e.g.:

- Switching on and off depending on the direction of travel.
- Shunting light: When switching to shunting operation the signals for shunting operation are switched on and those for standard operation switched off.
- Switching off the locomotive´s rear lights when connecting wagons.

Effects of the function outputs	
Direction-dependent switching: Assignment separately for each output.	Function Mapping
Shunting light: Assignment separately for each output.	Function Mapping
Dimming (only F0f, F0r, AUX1 and AUX2): The voltage at the output is reduced. Assignment separately for each output. Application example: By reducing the voltage, the lamps of older vehicles intended for analogue operation can continue to be used in digital operation and therefore do not have to be replaced after the decoder has been installed.	CV programming CV 47...50
Inverted switching: When set to "on" the assigned output is switched off, when set to "off" it is switched on. Assignment separately for each output.	CV programming CV 55...62
Flashing: The voltage at the output is switched on and off alternately. Assignment separately for each output. Setting the flashing frequency together for two outputs. By assigning the flashing function to two outputs and the function "Inverted switching" to one of the two outputs, an alternating flashing is generated.	CV programming CV 55...62 CV 101...104
Successive dimming up and down (only F0f, F0r, AUX1 and AUX2): The voltage at the output is gradually increased when switched on or gradually reduced when switched off. Assignment separately for each output. Setting the time duration for dimming up and down together for all outputs to which the function is assigned. Application example: Simulation of old oil or incandescent lamps.	CV programming CV 55...58 CV 100

Effects of the function outputs	
MARs-Light (only F0f, F0r, AUX1 and AUX2): To generate the additional warning light typical of American locomotives (fading in and out at short intervals), the following settings must be made for the output: ▪ flashing and successive dimming up and down active ▪ short flashing frequency ▪ short time for dimming up and down Assignment separately for each output. Setting the flashing frequency together for two outputs. Setting the time duration for dimming up and down together for all outputs to which the function is assigned.	CV programming CV 55...58 CV 100 CV 101...102
Fire simulation (only F0f, F0r, AUX1 and AUX2): The voltage at the output is reduced / increased in short, irregular intervals, connected LEDs or lamps produce the flickering light typical for an open fire. Assignment separately for each output. Application example: Simulation of the fire in the firebox of steam locomotives.	CV programming CV 55...58
On/Off at a defined voltage (speed): By default, the output is switched off when the voltage is exceeded and switched on again when it falls below. The function can be reversed by inverting the function. Assignment separately for each output. Setting the voltage together for all outputs to which the function is assigned. Application example: automatic switching on and off of the driver's cab lighting at a certain voltage.	CV programming CV 55...62 CV 63

Connection for backup capacitor or buffer circuit

The LD-G-41 has an additional connection for an external backup capacitor or a buffer circuit, but no special control output for buffer circuits. Suitable for bridging short-term current interruptions:

- Electrolytic capacitors with a capacity of 100 to 220 µF and a dielectric strength of at least 25 V or
- Buffer circuits that do not necessarily have to be connected to the special control output for buffer circuits of a vehicle decoder (e.g. UPS mini)

2.7. Triggering the actions

The switching on and off of the function outputs as well as the (de)activation of the special functions is carried out by the assigned function(s).

Assignment of actions to functions (function mapping)

The assignment of the actions controlled by the decoder to the functions is freely selectable, separately for forward and reverse motion.

Actions	DCC format	MM format
Outputs F0f, F0r, AUX1 … AUX6 on/off	F0 to F28	F0 to F4 F5 to F8 with 2. Adresse
Stop/start (STOP) with a function active/inactive		
Shunting gear (SG) active/inactive		
Acceleration and brake delay (ABD) active/inactive		

2.8. Feedback with RailCom

RailCom transmitter

The locomotive decoder LD-G-41 is a RailCom transmitter and fulfils the requirements of the RailCommunity standard RCN-217 "RailCom DCC feedback protocol" for mobile decoders (vehicle decoders).

Sending RailCom messages is possible in layouts with a DCC signal on the rails only. It is not possible to use the RailCom-function in a pure Motorola environment.

Background information: RailCom-messages of vehicle decoders

In channel 1, the vehicle decoders transmit their DCC address after each DCC command directed to any vehicle decoder. Channel 1 can be set "dynamically", i.e. the decoder will only transmit its address in channel 1 until a DCC command is directed to it. This frees the channel for the messages of other decoders to which no command has yet been sent or which are not yet known to the system.

In channel 2, vehicle decoders send their feedback as soon as a DCC command is sent to their address.

Background information: Dynamic RailCom information

"Dynamic information" mean contents of CVs (RailComCVs 64 - 127) which change during operation (e.g. real speed, reception statistics, tank content). If needed, they are sent by the decoder spontaneously.

The reception statistics are kept by the vehicle decoder, and reported as number of faulty data packages in relation to the total number of data packages. These statistics allow conclusions on the transmission quality between vehicle and rails.

Dynamic RailCom information of the locomotive decoder

The locomotive decoder LD-G-41 can send the following dynamic RailCom information:

reception statistics

2.9. Automatic registration according to RCN-218 (DCC-A)

DCC-A is an automatic registration procedure for DCC, with which the essential characteristics of a decoder are transmitted to the digital central unit immediately after the vehicle has been rerouted and are directly available there. The assignment of addresses and the allocation of functions is thus considerably simplified.

Notes for the use of DCC-A

Prerequisite for the use is the use of a digital central unit that also supports the procedure.

The automatic registration can be deactivated in CV 28. However, for trouble-free operation with digital central units that do not support DCC-A, it is irrelevant whether the registration procedure is activated or not.

Transfer of decoder parameters in the DCC-A registration procedure

The registration of the decoder with the central unit takes place automatically as soon as the vehicle is placed on the track. Some of the parameters can be adjusted individually with the help of the central unit.

	Value	Adjustments
Principle symbol and symbol	e.g.: 	The decoder can be assigned a principle symbol and a symbol from the file stored in the central unit.
Desired address	3	Address according to the settings in CVs 1 or 17/18
Address	e.g. 1000	The address is assigned to the decoder by the control unit and cannot be changed. If no vehicle decoder with the same address is available, the desired address set in the CVs is adopted.
Name and short name	LD-G-41	The decoder can be assigned its own name and/or short name (max. 8 characters).
Product name	LD-G-41	no change possible
Description	---	no change possible
Manufacturer	Tams Elektronik	no change possible
UID	e.g. 12345678	no change possible
Protocol	e.g. DCC/28	Protocol according to the assignment in the locomotive database / locomotive list of the control unit
Version SW	e.g. V2.00	no change possible
Version HW	e.g. V1.0	no change possible
registered	DCC-A	Method by which the decoder was registered with the control unit
Functions and function icons		Specific icons can be assigned to the functions, from which it is clear what they switch (e.g. front lighting, interior lighting, shunting gear).

3. Connections

3.1. Safety instructions

Caution:

Integrated circuits (ICs) are inserted on the decoder. They are sensitive to static electricity. Do not touch components without first discharging yourself. Touching a radiator or other grounded metal part will discharge you.

Mechanical hazards

Cut wires can have sharp ends and can cause serious injuries. Watch out for sharp edges when you pick up the PCB.

Visibly damaged parts can cause unpredictable danger. Do not use damaged parts: recycle and replace them with new ones.

Electrical hazards

- Touching powered, live components,
- touching conducting components which are live due to malfunction,
- short circuits and connecting the circuit to another voltage than specified,
- impermissibly high humidity and condensation build up

can cause serious injury due to electrical shock. Take the following precautions to prevent this danger:

- Never perform wiring on a powered module.
- Only install the decoder in closed, clean, dry rooms. Beware of humidity.
- Supply the decoder only with extra-low voltage as specified in the technical data. Use only tested and approved transformers.
- Connect transformers and soldering irons only in approved mains sockets installed by an authorised electrician.
- Observe cable diameter requirements.
- After condensation has formed, wait up to 2 hours for acclimatisation before working.

Fire risk

Touching flammable material with a hot soldering iron can cause fire, which can result in injury or death through burns or suffocation. Connect your soldering iron or soldering station only when actually needed. Always keep the soldering iron away from inflammable materials. Use a suitable soldering iron stand. Never leave a hot soldering iron or station unattended.

Thermal danger

A hot soldering iron or liquid solder accidentally touching your skin can cause skin burns. As a precaution:

- use a heat-resistant mat during soldering,
- always put the hot soldering iron in the soldering iron stand,
- point the soldering iron tip carefully when soldering, and
- remove liquid solder with a thick wet rag or wet sponge from the soldering tip.

Dangerous environments

A working area that is too small or cramped is unsuitable and can cause accidents, fires and injury. Prevent this by working in a clean, dry room with enough freedom of movement.

Other dangers

Children can cause any of the accidents mentioned above because they are inattentive and not responsible enough. Children under the age of 14 should not be allowed to mount vehicle decoders.

Caution:
Little children can swallow small components with sharp edges, with fatal results! Do not allow components to reach small children.

In schools, training facilities, hobby and self-help workshops, the assembly, installation and operation of electronic modules must be supervised by trained personnel.

In commercial facilities, the relevant accident prevention regulations must be observed.

3.2. Safe and correct soldering

Caution:
Incorrect soldering can cause dangers through fires and heat. Avoid these dangers by reading and following the directions given in the chapter **Safety instructions**.

- Use a soldering iron with temperature control, which you set to approx. 300 °C.
- Only use electronic solder with a flux.
- Never use soldering fluid or soldering grease when soldering electronic circuits. These contain an acid that destroys components and conductor paths.
- Solder quickly: Soldering for too long can detach solder pads or tracks or even destroy components.
- Hold the soldering tip on the soldering point so that it touches the wire and the pad at the same time. Add (not too much) solder simultaneously. As soon as the solder begins to flow, remove it from the soldering point. Then wait a moment for the solder to flow well before removing the soldering iron from the soldering joint.
- Do not move the created solder joint for about 5 seconds.
- A clean, non-oxidized soldering tip is essential for a perfect soldering joint and good soldering. Therefore, before each soldering, wipe off excess solder and dirt with a damp sponge, a thick damp cloth or a silicone wiper.

- After soldering, check (preferably with a magnifying glass) whether connections or tracks have been bridged with solder by mistake. This can lead to malfunction or destruction of components or, in the worst case, the complete circuit. You can re-liquefy excess solder with the clean hot soldering tip. The solder then flows from the board onto the soldering tip.

3.3. Avoiding irreparable damage to the decoder!

Caution:

To avoid (in the worst case) irreparable damage to the decoder , observe the following instructions:

1. No conductive connections to metal parts or rails!

Avoid all conductive connections between the decoder or consumers connected to the return conductor for all functions on the one hand, and metal parts of the vehicle or the rails on the other hand. Connections are caused e.g. by insufficiently insulated connecting cables (even at the stripped ends of unused connecting cables!) or insufficient fastening and insulation of the decoder or consumers. Danger of short circuit! In this case the overload protection of the decoder is ineffective!

2. No connection of the return conductor to vehicle ground!

You should under no circumstances connect the decoder´s common return conductor for all function outputs to vehicle ground. Risk of short circuit!

3. Exclude overload!

Before connecting the motor, lights and additional accessories, check that the current is below the maximum permissible values and that the total current is not exceeded. If the permissible current is exceeded, the decoder may be damaged during commissioning.

4. Do not use AC driving transformers!

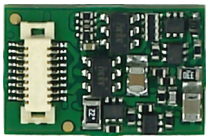
The decoder can be used in analogue systems that are supplied with direct current. If the decoder is supplied with alternating current in analogue operation, components on the decoder may be irreparably damaged!

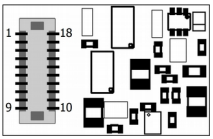
3.4. Pin assignment LD-G-41 | Front side

The LD-G-41 locomotive decoder has a Next18 interface corresponding to RCN-118 for connection to vehicles that are equipped with a corresponding interface at the factory.

Please note:
In principle, it is possible to use the LD-G-41 in vehicles that are not equipped with a Next18 interface at the factory. In this case, take the electrical properties of the connections into account and ensure that the permissible values are not exceeded. Otherwise the decoder may be damaged (possibly irreparably).

LD-G-41
Front side

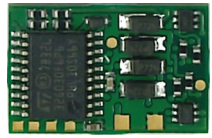


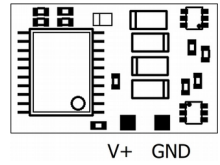


Next18 interface Assignment according to RCN-118	**Connection**		**Next18 interface** Assignment according to RCN-118
Right current collector	1	18	Right current collector
Motor connection 1 (plus)	2	17	F0r = Lighting backward motion (function F0)
AUX1 (function F1)	3	16	AUX5 (function F7)
AUX3 (function F5) or SUSI CLOCK	4	15	U+
GND	5	14	GND
U+	6	13	AUX4 (function F6) or SUSI DATA
AUX6 (function F8)	7	12	AUX2 (function F2)
F0f = Lighting forward motion (function F0)	8	11	Motor connection 2 (minus)
Left current collector	9	10	Left current collector

3.5. Pin assignment LD-G-41 | Rear side

LD-G-41
Rear side





V+	Positive pole (+) for backup capacitor or buffer circuit (UPS)
GND	Minus pole (-) for backup capacitor or buffer circuit (UPS)

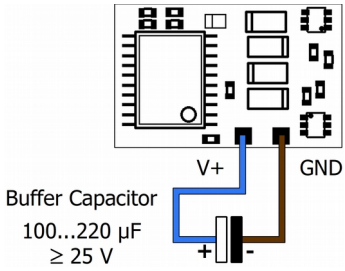
3.6. Connecting a backup capacitor or buffer circuit

In sections with bad contact to the rails (e.g. when running over turnouts) or with a (e.g. construction-related) bad current consumption of the locomotive, the power supply of the decoder can be interrupted briefly. In analogue mode the effects are usually small, but in digital mode massive disturbances can be the result: e.g. flickering of the lights and stuttering of the motor up to automatic switching to analogue mode. This can be remedied by connecting a backup capacitor or a special buffer circuit.

Connection of a backup capacitor

The electrolytic capacitor must have a capacity of at least 100 µF and a maximum of 220 µF. The minimum proof voltage is 25 V.

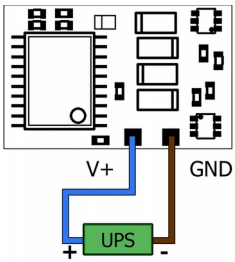
Pay attention to the correct polarity when connecting!



Connection of a backup capacitor

Connection of a buffer circuit

The capacity of buffer circuits is considerably larger than that of backup capacitors (e.g. UPS-mini with 0.47 F, 1.0 F or 1.5 F). Use a buffer circuit that does not necessarily have to be connected to the special control output for buffer circuits of a vehicle decoder, e.g. UPS-mini (item numbers 70-0221x, 70-0222x, 70-0223x).



Connection of a buffer circuit that can be used without connecting a control line (e.g. UPS-mini)

4. Programming

4.1. Programming with DCC central units

From the control unit you can program the configuration variables (CVs) of the decoder, main track programming is also possible. Please refer to the relevant section in the instructions of your control unit, which describes the byte-by-byte programming of the CV variables (Direct Programming) or the main track programming (PoM).

Register programming is not supported by the LD-G-41. You cannot program the decoder with DCC control units that only allow register programming.

4.2. Programming with Motorola central units

In Motorola format the settings are saved in registers. The registers have the same numbers as the configuration variables (CVs) for the DCC format.

Please note: If you use a central unit for both DCC and Motorola format it is recommended to program the decoder in the DCC format. After having finished programming the decoder it is possible to control it in Motorola format as well.

Please note: You should connect a lamp or a LED to at least F0f or F0r before starting to program the decoder with a Motorola central unit, as the decoder shows the status of the programming by flashing the lighting connected to these outputs. The flashing frequency shows, which input the decoder expects:

Slow flashing	**Fast flashing**
Number of the register to be programmed	**Value** of the register to be programmed

Put the vehicle on a track oval or a track section connected to the central unit's track output (not to the connection for the programming track). Make sure no other vehicle than the one you intend to program is set on the track as the decoder inside this vehicle might be programmed as well.

Starting the programming mode	**Programming the decoder**
1. Switch on the central unit or perform a reset at the central unit (pushing "stop" and "go") simultaneously. 2. Set the current decoder address (default value: 3) or the address "80". 3. Set all functions to "off". 4. Push button "stop" → switch off the track voltage. 5. Operate the direction switch and hold it in that position. Push the button "go" at once. 6. As soon as the lighting flashes, release the direction switch.	1. Enter the number of the register as a Motorola-address. If necessary: with a leading "0". 2. Operate the direction switch. → Lighting flashes faster. 3. Enter the value you want to set into the register (as Motorola-address). 4. Operate the direction switch. → Lighting flashes more slowly. If necessary: repeat steps 1 to 4 for all registers to be programmed. Push button "STOP".
→ Start of programming mode	**→ End of programming mode**

Programming with the Central Station I and the Mobile Station

With the Central Station I and the Mobile Station from Märklin** you can program the registers by calling up the item no. 29750 from the locomotive database. Then program the decoder as described for this item no. in the instructions for the digital controls.

5. Configuration variables and registers

The following lists shows all configuration variables (for the DCC format) and registers (for the Motorola format), that can be set for the locomotive decoder.

Registers and configuration variables (CVs) have identical numbers, they are shown in the tables in the column "No.". The defaults are those values set in the state of delivery and after a reset.

Please note: With variables destined to set several parameters, the input value has to be calculated by adding the numerical values assigned to the desired parameters.

5.1. Overview configuration variables LD-G-41

CV-Nr.	Name	Anleitung Abschnitt
1	Basic address	5.3. Setting the address
2	Starting voltage (starting velocity	5.4. Setting the motor control
3	Acceleration rate (start-up deceleration)	5.4. Setting the motor control
4	Braking rate (braking deceleration)	5.4. Setting the motor control
5	Maximum voltage (maximum velocity)	5.4. Setting the motor control
6	Medium voltage (center speed)	5.4. Setting the motor control
7	Version	5.12. Information
8	Reset | Manufacturer	5.11. Auxiliary functions 5.12. Information
10	Dynamic RailCom information	5.7. RailCom and DCC-A settings
11	Packet Time Out	5.8. Settings for driving operation
12	Permitted modes of operation	5.12. Information
13	Functions active in analogue mode (F1 to F8)	5.9. Settings for analogue mode
14	Functions active in analogue mode (F0, F9 to F12)	5.9. Settings for analogue mode
15 and 16	Decoder lock	5.11. Auxiliary functions
17 and 18	Extended address	5.3. Setting the address
19	Consist address	5.3. Setting the address
20	2nd Motorola address	5.3. Setting the address
21	Functions active in consist operation (F1 to F8)	5.8. Settings for driving operation
22	Functions active in consist operation (F0, F9 to F12)	5.8. Settings for driving operation

CV-Nr.	Name	Anleitung Abschnitt
27	Braking behaviour with DC voltage	5.8. Settings for driving operation
28	RailCom channels	5.7. RailCom and DCC-A settings
29	Configuration data 1	5.2. Basic settings
31 and 32	Index for higher CV-Pages	5.5. Function mapping
47...50	Dimming of the outputs	5.6. Effects of the outputs
55...62	Assignment of the effects to the outputs	5.6. Effects of the outputs
63	Voltage for switching outputs on/off	5.6. Effects of the outputs
65	Starting kick	5.4. Setting the motor control
67...94	Alternative characteristic curve (only for mode 28 speed steps)	5.4. Setting the motor control
96	Method for function assignment	5.12. Information
100	Dimming up and down the outputs	5.6. Effects of the outputs
101...104	Flashing frequency	5.6. Effects of the outputs
109	Overload sensitivity ("Short-circuit sensitivity")	5.10. Sensivity of the overload protection
112	Gain factor for load control	5.4. Setting the motor control
113	Parameter of load control KP	5.4. Setting the motor control
114	Parameter of load control KI	5.4. Setting the motor control
115	Parameter of load control KD	5.4. Setting the motor control
116	Load control	5.4. Setting the motor control
121	Configuration data 2	5.2. Basic settings
122	ABC sensitivity	5.8. Settings for driving operation
257...485	Assignment of outputs and special functions to the functions	5.5. Function mapping

5.2. Basic settings

Name	No.	Input values (Default)	Remarks and tips	
Configuration data 1	29	0 ... 255 (14)	Direction "Standard" Direction inverted	0 1
			14 speed levels 28 or 128 speed levels (in DCC format) Note: If you want to use the SDF method, you must set the 28/128 speed level mode. (→ section 2.1) Note: If the decoder is run in Motorola format, the setting of the speed step mode has no effect.	0 2
			Automatic analogue recognition off Automatic analogue recognition on	0 4
			RailCom off RailCom on	0 8
			Linear velocity characteristic Alternative velocity haracteristic	0 16
			Basic addresses Extended addresses (for DCC format only) Tip: If the use of extended addresses is activated in CV 29, the decoder does **not** react to signals in Motorola format!	0 32
Example: CV 29 = 0 | Meaning: Direction = "Standard". 14 speed levels . Automatic analogue recognition = "off". RailCom ="off". Linear velocity characteristic. Basic addresses. Example: CV 29 = 14 | Meaning: Direction = "Standard". 28 or 128 speed levels in DCC mode. Automatic analogue recognition = "on". RailCom ="on". Linear velocity characteristic. Basic addresses.				

Name	No.	Input values (Default)	Remarks and tips
Configuration data 2	121	0, 1, 4, 5, 8, 9, … 61 (4)	Use of contacts 4 and 13: unamplified outputs AUX3 and AUX4 0 Train bus / SUSI CLOCK and SUSI DATA 1 1
			Reaction to ABC braking method: ABC braking method active 0 ABC braking method inactive 4 Inverted ABC detection 8
			Constant braking distance inactive 0 Constant braking distance active 16
			Shuttle train operation inactive 0 Shuttle train operation active 32
Notes: The constant braking distance can be set independently of the use of the ABC braking method. The length of the braking distance is defined by the brake delay (CV 4). A prerequisite for shuttle operation is that an ABC brake module is connected for both directions of travel of the shuttle section.			

5.3. Setting the address

Name	No.	Input values (Default)	Remarks and tips
Basic address	1	1 ... 255 (3)	Range of values: in DCC format: 1 ... 127 in MM format: 1 … 255
Tip: If a value higher than 127 is set for the basic address and the use of extended addresses in CV 29 is set to off, the decoder does not react to signals in DCC format!			
Extended address Only for DCC format.	17	192 ... 255 (195)	Most central units permit entering extended addresses directly. The CVs 17, 18 and 29 are set automatically to the proper values.
	18	0 ... 255 (232)	
Consist address Only for DCC format.	19	1 ... 127 (0)	Address for consist operation (multi-traction)
2nd Motorola address	20	0 … 255 (4)	= Address needed to switch additional functions in Motorola format. The function keys F5 to F8 are reached via the function keys F1 to F4, the function key F9 via the function key F0.

5.4. Setting the motor control

Optimisation of the driving characteristics

By adjusting the load control and the motor characteristics curve the decoder is adapted to the individual characteristics of the locomotive motor.

Please note: The installation of a decoder generally increases the effects of vehicle defects on driving characteristics. Locomotive motor, brushes and collector, gearbox, moving parts and current collectors must therefore be in perfect condition. Electrical interference signals (e.g. "brush fire") can massively affect the transmission of digital signals.

Set the CVs in the following order to optimize the driving characteristics:

1. CV 112 "Gain factor"
2. CV 113 to 115 "Load control parameters"
3. CV 2, CV 5 and CV 6 "Start, maximum and medium voltage"

Setting the load control

Name	No.	Input values (Default)	Remarks and tips
Load control	116	0, 1 (1)	Load control off 0 Load control on 1
Gain factor	112	1...15 (5)	Adaptation of the load control to the individual motor voltage
Note: The adaptation of CV 112 is only necessary if - the maximum speed of the locomotive is already reached at a low speed level or - is not reached at the highest speed level. Change the value only gradually until the desired maximum speed is reached at the highest speed level.			

Setting the parameters of the load control

Parameter of load control	No.	Input values (Default)	Remarks and tips
KP	113	0 ... 255 (32)	= Proportional component
The parameter KP defines the basic speed. A too small value → locomotive too slow. A too high value → heavy shuttering of the locomotive.			
KI	114	0 ... 255 (5)	= Integral component
The parameter KI provides the fine tuning of the load control. The value has to be adjusted in very small steps. A too high value → heavy shuttering of the locomotive.			
KD	115	0 ... 255 (4)	= Differential component
The parameter KP defines the basic speed. A too small value → locomotive too slow. A too high value → heavy shuttering of the locomotive.			

Proceed as follows to set the load control parameters:

If the locomotive is shuttering: Increase the value for CV 115 (KD) in steps of 2. If this does not lead to an improvement of the driving characteristics, set the value of CV 115 back to factory setting (default value). Then decrease the value for CV 113 (KP) in steps of 2 and for CV 114 (KI) in steps of 1.

If the locomotive does not have enough power and e.g. gets very slow on the way uphill: Increase the value for CV 114 (KI) in steps of 1, until the locomotive starts to shutter. Then increase the value for CV 115 (KD) in steps of 2. If this does not lead to an improvement or the locomotive starts to shutter immediately after increasing CV 114, set the values for CV 114 and CV 115 back to factory setting (default value) and increase the value for CV 113 (KP) in steps of 5.

If the locomotive is rocking: Decrease the value for CV 115 in steps of 2.

Setting the motor characteristic curve

<table>
<tr><th>Name</th><th>No.</th><th>Input values (Default)</th><th>Remarks and tips</th></tr>
<tr><td>Starting voltage (starting velocity)</td><td>2</td><td>0 … 255 (4)</td><td>= Voltage to be output to the motor at speed level 1.
0 = 0 Volt
255 = max. voltage</td></tr>
<tr><td>Acceleration rate (start-up deceleration)</td><td>3</td><td>0 … 255 (10)</td><td rowspan="2">= Length of the delay before the switching to the next higher / lower speed level when the locomotive is accelerating / braking.The delay is calculated as follows:
(value of the CV) x 0,9 sec.
number of speed levels</td></tr>
<tr><td>Braking rate (braking deceleration)</td><td>4</td><td>0 … 255 (5)</td></tr>
<tr><td colspan="4">If constant braking distance (→ CV 121) is active, the setting only applies to the highest speed step (14, 28 or 128). If the braking process is triggered at a lower speed level, the waiting time until switching to the next lower speed level is automatically extended. This ensures that the braking distance is always the same regardless of the speed level when the braking process is started.</td></tr>
<tr><td>Maximum voltage (maximum velocity)</td><td>5</td><td>0 … 255 (255)</td><td>= Voltage to be output to the motor at the highest speed level.
2 = 0,8 % of the max. voltage
255 = maximum voltage</td></tr>
<tr><td>Medium voltage (center speed)</td><td>6</td><td>0 … 255 (100)</td><td>= Voltage at speed level
7 (14-speed mode) or
14 (28-speed mode)</td></tr>
</table>

Setting the motor characteristic curve (continuation)

Name	No.	Input values (Default)	Remarks and tips
Alternative characteristic curve (only for mode 28 speed steps)	67 68 69 ... 94	0 … 255	= Speed table for alternative speed characteristic. A specific motor voltage is assigned to each of the 28 speed steps. 0 = voltage of "0 255 = maximum voltage
Note: An example of an alternative characteristic curve is set in the default values of CVs 67 – 94.			

Setting the starting kick

Name	No.	Input values (Default)	Remarks and tips
Starting kick	65	0 … 255 (0)	= brief increase in the motor voltage during start-up to overcome the breakaway torque
Example: CV 65 = 6 → The motor voltage on start-up corresponds to the voltage present at internal speed level 6 (of 255). It is immediately regulated with the braking rate set in CV 4 (CV 4) to the actually selected speed level. After changing CV 4, it may therefore be necessary to change CV 65.			

5.5. Function mapping

The assignment of the actions controlled by the decoder

- switching the function outputs on and off
- (de)activation of the special functions
  - Uninterruptible power supply (UPS)
  - Start/Stop with a function (Stop with F)
  - Shunting gear (SG)
  - Acceleration and brake delay (ABD)

to the functions is carried out according to RailCommunity standard RCN-227. Note: The use of the function mapping is not possible with pure Motorola control units.

Basic settings for using the function mapping

To get access to the corresponding memory area (the so-called "page"), the values for "Function mapping" must be set in CV 31 **and** 32 (= default values).

Name	No.	Input values (Default)	Remarks and tips
Index for higher pages	31	0 ... 255 (0)	Function mapping active 0
	32	0 ... 255 (42)	Function mapping active 42

Configuration variables for function mapping

According to RCN-227, eight configuration variables (CVs) are assigned to each function (F0 to F28): four each for forward ("f") and reverse ("r"). Six of these are used for the LD-G-41 locomotive decoder (3 for forward and 3 for reverse):

- 2 CVs for the outputs (F0f, F0r, AUX1 ... AUX6): Here you set which outputs are switched with the function.
- 4 CVs for the special functions: Here you set separately for each driving direction with which function the special functions are activated / deactivated.
- Switch-off function: Here you can define a function with which you can switch **off** the actions assigned to the function when switching **on**. The value "255" determines that the actions are switched off with **no** function.

Use of contacts 4 and 13

Depending on the setting in CV 121 (configuration variable 2), contacts 4 and 13 are used

- either as (unamplified) outputs AUX3 and AUX4
- or as connections for the train bus (e.g. SUSI CLOCK and SUSI DATA).

The settings for AUX3 and AUX4 are only effective if use as outputs is set for the two contacts in CV 121. If the contacts are set to be used for the train bus (e.g. SUSI), the CV settings for the AUX3 and AUX4 outputs are ineffective. They have no influence on the data transmission in the train bus.

	Outputs								not in use	Special functions			off/on with function
	F0f	F0r	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6		Stop with F	SG	ABD	
Values	1	2	4	8	16	32	64	128	0	2 (on)	4 (on)	8 (off)	F0, F1, F2, ..., F28, ---
Input values	0, 1, 2, 3, 4,..., 255								0	0, 2, 4,..., 14			0, 1, 2, ... 28, 255

	Outputs		not in use	Special functions		off/on with function	
CV name	CV-No.	Default value	CV-No.	CV-No.	Default value	CV-No.	Default value
F0 f	257	(1) F0f during forward travel	258	259	(0)	260	(255)
F0 r	261	(2) F0r during backward travel	262	263	(0)	264	(255)
F1 f	265	(4) AUX1 during forward travel	266	267	(0)	268	(255)
F1 r	269	(4) AUX1 during backward travel	270	271	(0)	272	(255)
F2 f	273	(8) AUX2 during forward travel	274	275	(0)	276	(255)
F2 r	277	(8) AUX2 during backward travel	278	279	(0)	280	(255)
F3 f	281	(0)	282	283	(4) SG	284	(255)
F3 r	285	(0)	286	287	(4) SG	288	(255)
F4 f	289	(0)	290	291	(8) ABD	292	(255)
F4 r	293	(0)	294	295	(8) ABD	296	(255)
F5 f	297	(16) AUX3 during forward travel	298	299	(0)	300	(255)
F5 r	301	(16) AUX3 during backward travel	302	303	(0)	304	(255)
F6 f	305	(32) AUX4 during forward travel	306	307	(0)	308	(255)
F6 r	309	(32) AUX4 during backward travel	310	311	(0)	312	(255)
F7 f	313	(64) AUX5 during forward travel	314	315	(0)	316	(255)
F7 r	317	(64) AUX5 during backward travel	318	319	(0)	320	(255)
F8 f	321	(128) AUX6 during forward travel	322	323	(0)	324	(255)
F8 r	325	(128) AUX6 during backward travel	326	327	(0)	328	(255)
F9 f	329	(0)	330	331	(0)	332	(255)
F9 r	333	(0)	334	335	(0)	336	(255)

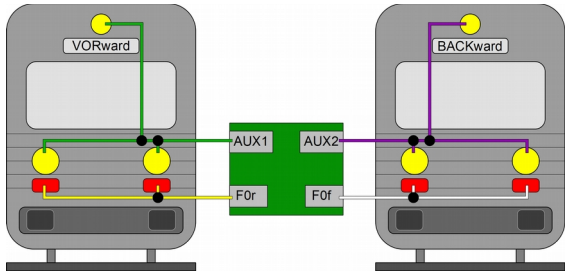
	Outputs								not in use	Special functions			off/on with function
	F0f	F0r	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6		Stop with F	SG	ABD	
Values	1	2	4	8	16	32	64	128	0	2 (on)	4 (on)	8 (off)	F0, F1, F2, ..., F28, ---
Input values	0, 1, 2, 3, 4,..., 255								0	0, 2, 4,..., 14			0, 1, 2, ... 28, 255

	Outputs		not in use	Special functions		off/on with function	
CV name	CV-No.	Default value	CV-No.	CV-No.	Default value	CV-No.	Default value
F10 f	337	(0)	338	339	(0)	340	(255)
F10 r	341	(0)	342	343	(0)	344	(255)
F11 f	345	(0)	346	347	(0)	348	(255)
F11 r	349	(0)	350	351	(0)	352	(255)
F12f	353	(0)	354	355	(0)	356	(255)
F12 r	357	(0)	358	359	(0)	360	(255)
F13 f	361	(0)	362	363	(0)	364	(255)
F13 r	365	(0)	366	367	(0)	368	(255)
F14 f	369	(0)	370	371	(0)	372	(255)
F14 r	373	(0)	374	375	(0)	376	(255)
F15 f	377	(0)	378	379	(0)	380	(255)
F15 r	381	(0)	382	383	(0)	384	(255)
F16 f	385	(0)	386	387	(0)	388	(255)
F16 r	389	(0)	390	391	(0)	392	(255)
F17 f	393	(0)	394	395	(0)	396	(255)
F17 r	397	(0)	398	399	(0)	400	(255)
F18 f	401	(0)	402	403	(0)	404	(255)
F18 r	405	(0)	406	407	(0)	408	(255)
F19 f	409	(0)	410	411	(0)	412	(255)
F19 r	413	(0)	414	415	(0)	416	(255)

	Outputs								not in use	Special functions			off/on with function
	F0f	F0r	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6		Stop with F	SG	ABD	
Values	1	2	4	8	16	32	64	128	0	2 (on)	4 (on)	8 (off)	F0, F1, F2, ..., F28, ---
Input values	0, 1, 2, 3, 4,..., 255								0	0, 2, 4,..., 14			0, 1, 2, ... 28, 255

	Outputs		not in use	Special functions		off/on with function	
CV name	CV-No.	Default value	CV-No.	CV-No.	Default value	CV-No.	Default value
F20 f	417	(0)	418	419	(0)	420	(255)
F20 r	421	(0)	422	423	(0)	424	(255)
F21 f	425	(0)	426	427	(0)	428	(255)
F21 r	429	(0)	430	431	(0)	432	(255)
F22f	433	(0)	434	435	(0)	436	(255)
F22 r	437	(0)	438	439	(0)	440	(255)
F23 f	441	(0)	442	443	(0)	444	(255)
F23 r	445	(0)	446	447	(0)	448	(255)
F24 f	449	(0)	450	451	(0)	452	(255)
F24 r	453	(0)	454	455	(0)	456	(255)
F25 f	457	(0)	458	459	(0)	460	(255)
F25 r	461	(0)	462	463	(0)	464	(255)
F26 f	465	(0)	466	467	(0)	468	(255)
F26 r	469	(0)	470	471	(0)	472	(255)
F27 f	473	(0)	474	475	(0)	476	(255)
F27 r	477	(0)	478	479	(0)	480	(255)
F28 f	481	(0)	482	483	(0)	484	(255)
F28 r	485	(0)	486	487	(0)	488	(255)

Example: Programming for shunting operation



Hint: The connection of the return conductor is not shown.

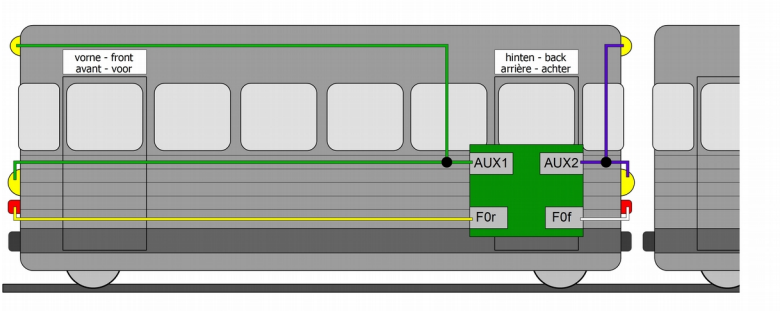
	Outputs				off/on with function							
	F0f	F0r	AUX1	AUX2	F0	F1	F2	F3	F4	...	F28	---
Values	1	2	4	8	0	1	2	3	4	...	28	255

CV name	CV-No.	Set value	CV-No.	Set value
F0 f	257	5 (outputs F0f and AUX1)	260	3 (= F3 / shunting operation)
F0 r	261	10 (outputs F0r and AUX2)	264	3 (= F3 / shunting operation)
F3 f	281	12 (outputs AUX1 and AUX2)	284	255 (= no F assigned)
F3 r	285	12 (outputs AUX1 and AUX2)	288	255 (= no F assigned)

With this programming you achieve the following effects when switching on the shunting mode (here with function F3):

- The three-light head signals (AUX1 and AUX2), which in normal operation are switched with F0 depending on the direction of travel, are switched off.
- The end-of-train signals (F0f and F0r), which in normal operation are switched with F0 depending on the direction of travel, are switched off.
- The three-light head signals (AUX1 and AUX2) on both sides are switched on (shunting lighting).

Example: Programming for rear end signal "off" with coupled carriages



Hint: The connection of the return conductor is not shown.

	Outputs				off/on with function							
	F0f	F0r	AUX1	AUX2	F0	F1	F2	F3	F4	...	F28	---
Values	1	2	4	8	0	1	2	3	4	...	28	255

CV name	CV-No.	Set value	CV-No.	Set value
F0 f	257	5 (outputs F0f and AUX1)	260	5 (= F5 / operation with attached wagons)
F0 r	261	10 (outputs F0r and AUX2)	264	5 (= F5 / operation with attached wagons)
F3 f	281	4 (output AUX1)	284	255 (= no F assigned)
F3 r	285	2 (output F0r)	288	255 (= no F assigned)

With this programming you achieve the following effects when switching on the operation with attached wagons (here with function F5):

- The three-light head signals (AUX1 and AUX2), which in normal operation are switched with F0 depending on the direction of travel, are switched off.
- The end-of-train signals (F0f and F0r), which in normal operation are switched with F0 depending on the direction of travel, are switched off.
- The three-light head signal (AUX1) is switched on when the direction of travel is "forward".
- The end-of-train signal (F0r) is switched on when the direction of travel is "backwards".

5.6. Effects of the outputs

Dimming of the outputs (only F0f, F0r, AUX1 and AUX2)

Output	No.	Input values (Default)	Remarks and tips
F0f	47	1...64 (64)	= Reduction of the voltage applied to the output 1 = lowest voltage 255 = maximum voltage
F0r	48	1...64 (64)	
AUX1	49	1...64 (64)	
AUX2	50	1...64 (64)	

Assignment of the effects to the outputs

Output	No.	Input values (Default)	Remarks and tips	
F0f	55	0 ... 255 (0)	no effects	0
F0r	56	0 ... 255 (0)	Invert function	1
AUX1	57	0 ... 255 (0)	Flashing **on**	2
AUX2	58	0 ... 255 (0)	Successive dimming up and down **off** (only F0f, F0r, AUX1 and AUX2)	8
AUX3	59	0 ... 255 (0)		
AUX4	60	0 ... 255 (0)	Fire simulation **on** (only F0f, F0r, AUX1 and AUX2)	16
AUX5	61	0 ... 255 (0)		
AUX6	62	0 ... 255 (0)	Output on/off at the voltage defined in CV 63	32
Example: Alternating flashing with AUX1 and AUX2: → Input value for AUX1: CV 59 = 2 | Input value for AUX2: CV 60 = 3 (1 + 2)				

Flashing frequency

Output	No.	Input values (Default)	Remarks and tips
F0f / F0r	101	1 ... 255 (20)	1 = highest flashing frequency 255 = lowest flashing frequency Setting common for 2 outputs
AUX1 / AUX 2	102	1 ... 255 (20)	
AUX3 / AUX4	103	1 ... 255 (20)	
AUX5 / AUX6	104	1 ... 255 (20)	
Note: The flashing function must be switched on for the output. (CV 55 - 62)			

Dimming up and down the outputs

Name	No.	Input values (Default)	Remarks and tips
Time for dimming up and down Setting common for all outputs	100	1...255 (10)	= Time until the maximum voltage is reached or the voltage is reduced to "0". 1 = shortest possible time 255 = longest possible time Note: For the output, dimming up and down must be switched on. → CV 55 - 58

Settings for MARs-Light (only F0f, F0r, AUX1 and AUX2)

The warning light typical for American locomotives is generated when the CV values are set as follows:

Output	No.	Input values (Default)	Remarks and tips	
F0f	55	0 ... 255 (0)	Flashing **on**	22
F0r	56	0 ... 255 (0)		
AUX1	57	0 ... 255 (0)		
AUX2	58	0 ... 255 (0)		
F0f / F0r	101	1 ... 255 (20)	Flashing frequency Setting common for 2 outputs	6
AUX1 / AUX2	102	1 ... 255 (20)		
F0f / F0r AUX1 / AUX"	100	1...255 (10)	Time for dimming up and down Note: For the output, dimming up and down must be switched on. → CV 55 - 62	2

Voltage for switching outputs on/off

Name	No.	Input values (Default)	Remarks and tips
Voltage for "output on/off" Setting common for all outputs	63	0 ... 255 (16)	0 = lowest voltage 255 = highest voltage The setting only applies to the outputs for which switching on/off has been activated when the voltage set here is reached. → CV 55 ... 62
By default, the output is switched off when the voltage is exceeded and switched on again when the voltage falls below it. The function can be reversed by inverting the function. (→ CV 55...62)			

5.7. RailCom and DCC-A settings

Name	No.	Input values (Default)	Remarks and tips	
Dynamic RailCom information	10	0,1 (0)	off	0
			Reception statistics: The decoder keeps statistics on all DCC packets and reports the number of faulty packets / total number of packets in %.	1
In order to read out RailCom information, you have to make the following additional settings: ■ CV 29 "Configuration data 1": RailCom on ■ CV 28 "RailCom channels": at least channel 2 on				
RailCom channels Automatic registration according to RCN-218 (DCC-A)	28	0 … 135 (131)	no feedback with RailCom and no automatic registration	0
			Channel 1 on	1
			Channel 2 on Recommendation: Always switch on channel 2 when you have switched on channel 1.	2
			Use of Dynamic channel 1 The setting only has an effect if channel 1 is switched on.	4
			Automatic registration according to RCN-218 (DCC-A)	128
Notes on automatic registration according to RCN-218 (DCC-A): The use of the DCC-A procedure is only possible with digital control units that support this registration procedure. To be able to use the automatic login via the DCC-A procedure, the following settings must be made: ■ CV 29 "Configuration data 1": RailCom on ■ CV 28 "RailCom channels": channel 1 and 2 on ■ CV 28 "DCC-A": on The activation of the Dynamic Channel 1 is optional. Notes on the use of Dynamic Channel 1: Some RailCom detectors can only receive address messages on channel 1. If these detectors are used, the application of Dynamic Channel 1 must not be activated. Further information on RailCom and automatic registration according to RCN-218 (DCC-A) → section 2.9.				

5.8. Settings for driving operation

Setting the Packet Time Out

Name	No.	Input values (Default)	Remarks and tips
Packet Time Out	11	2 … 255 (16)	Time period between the failure of the digital signal and the change to the alternative operation (analogue operation). Increasing the input value by "1" extends the time period by 10 ms.
Notes: If automatic analogue recognition is active, the decoder will automatically switch to analogue mode if it does not receive a digital signal during the set time. If the decoder is supplied via a buffer circuit, - the automatic analogue recognition in CV 29 should be deactivated and - a low value for the Packet Time Out should be set (approx. 16). This prevents the locomotive from continuing to run unplanned after the track voltage has been switched off (e.g. during an emergency stop or a signal stop).			

Consist operation

As a standard, in multiple units (consist operation) you can only control velocity and direction. In CV 21 and 22 you can define additional functions to be switched when using the address for multiple units defined in CV 19. If the value "0" is set, the function will continue to be addressed only via the address set for the vehicle concerned in CV 1 or CV 17 and 18.

Name	No.	Input values (Default)	Remarks and tips	
Functions active in consist operation (F1 to F8)	21	0 ... 255 (0)	F1 on	1
			F2 on	2
			F3 on	4
			F4 on	8
			F5 on	16
			F6 on	32
			F7 on	64
			F8 on	128
Functions active in consist operation (F0, F9 to F12)	22	0 ... 63 (0)	F0f on	1
			F0r on	2
			F9 on	4
			F10 on	8
			F11 on	16
			F12 on	32

Braking behaviour with DC voltage

Name	No.	Input values (Default)	Remarks and tips	
Braking behaviour with DC voltage	27	0, 16, 32, 48 (48)	No braking with d.c. voltage	0
			Braking with negative d.c. voltage	1
			Braking with positive d.c. voltage	2
Tip: It is standard to switch over into analogue mode when applying a d.c. voltage at the rails. In case that the decoder is run in a layout with a braking route based on applying a d.c. voltage (e.g. Märklin**-braking route), the analogue recognition has to be disactivated (in CV 29) to ensure that the locomotive reacts as expected on the braking route. The setting of the negative or positive d.c. voltage is related to the right rail, as seen in the locomotive´s direction of motion.				

Use of the ABC braking method

Name	No.	Input values (Default)	Remarks and tips
ABC sensitivity	122	0 … 255 (10)	= Level of asymmetry of the track voltage, which the decoder interprets as entering an ABC braking section. 0 = highest sensitivity 255 = lowest sensitivity
Notes: Boosters that do not have a 100 % symmetrical voltage or additional circuits on the track (e.g. track occupancy detectors) can unintentionally generate an asymmetrical track voltage. To prevent the LD-G-41 from interpreting this asymmetrical voltage on the normal track as entry into an ABC braking section, the ABC sensitivity can be reduced. For the decoder to react to the ABC braking section, the ABC braking procedure must be activated in CV 121.			

5.9. Settings for analogue mode

Name	No.	Input values (Default)	Remarks and tips	
Functions active in analogue mode (F1 to F8)	13	0 ... 255 (0)	F1 on	1
			F2 on	2
			F3 on	4
			F4 on	8
			F5 on	16
			F6 on	32
			F7 on	64
			F8 on	128
Functions active in analogue mode (F0, F9 to F12)	14	0 ... 31 (0)	F0 on	1
			F9 on	2
			F10 on	4
			F11 on	8
			F12 on	16

5.10. Sensivity of the overload protection

Name	No.	Input values (Default)	Remarks and tips
Overload sensitivity ("Short-circuit sensitivity")	109	0 ... 255 (0)	= Level of overload at which the overload is detected and the overload protection responds. 50 = 1,500 mA The higher the value, the higher the current at which the overload protection trips. The value of 50 should only be changed in exceptions!

Info: The overload protection switches off the motor (not the function outputs) if the permissible total current is exceeded or if there is a short circuit at the motor output (the maximum form of an overload). Short-term interference voltages of the motor or connected loads can cause the motor to switch off, although the permissible total current has not been exceeded and there is no short-circuit at the motor output. In this case the sensitivity of the overload protection can be slightly adjusted in CV 109.

Always check the motor current and the correct functioning of the motor and transmission before lowering the short-circuit sensitivity.

5.11. Auxiliary functions

Name	No.	Input values (Default)	Remarks and tips
Reset	8	0 ... 255	Any input value restores the settings in state of delivery.
Decoder lock	15	0 ... 255 (3)	Changing the CV values of the decoder is only possible if the values in CV 15 and 16 are identical.
	16	0 ... 255 (3)	
By assigning specific values in CV 16 the CVs of decoders with the same address can be changed separately. Application e.g. for vehicles or train formations with several decoders with the same address (e.g. locomotive, sound, function decoders). Note: In case of a reset, the setting in CV 16 is retained and is **not** reset to the factory settings.			
Index for higher CV-Pages	31	0 (0)	Adjustable in DCC format only! Function mapping 0
	32	0 (42)	Adjustable in DCC format only! Function mapping 42
Note: If different values are entered in CV 31 and/or 32, it is not possible to use the function mapping. The settings for the function outputs and the special functions cannot be changed then.			

5.12. Information

Name	No.	Input values (Default)	Remarks and tips
Version	7	---	Readable in DCC format only!
Manufacturer	8	--- (62)	Readable in DCC format only!
Permitted modes of operation Readable in DCC format only!	12	--- (53)	Defines the permitted modes of operation for the decoder 53 = 1 + 4 + 16 + 32 1 = DC | 4 = DCC | 16 = AC | 32 = MM
Method for function assignment Readable in DCC format only!	96	--- (2)	Defines the method for assigning the functions: 2 = Function assignment via CVs 257 to 512 in the bank selected by CV 31 = 0 and CV 32 = 42 with CVs per function according to RailCommunity standard RCN-227 section 2

6. Checklist for troubleshooting and error correction

Warning:
If you notice a strong heat development or if the decoder starts to smoke, disconnect the connection to the supply voltage immediately. **Fire hazard!**

Possible causes:

- Possible cause: one or more connections are soldered incorrectly. → Check the connections.
- Possible cause: Short circuit between the decoder or accessories connected to the retrun conductor for all functions and metal parts of the locomotive or the rails. → Check the connections. A short circuit can result in irreparable damage.

6.1. Problems with programming the decoder

The CV values cannot be changed.

Possible cause:

- Different values are entered in CV 15 and CV 16 (decoder lock). → Enter the same value in CV 15 as in CV 16.

6.2. Problems in driving mode

After installation of the decoder the loco runs badly or not at all.

Possible cause:

- The current consumption of the loco (and thus the transmission of the digital signals to the decoder) is insufficient. → Check the current collectors / the slider and if necessary ensure a better current consumption.

The locomotive stops and the lights that are switched with F0 flash.

Cause: The overload protection has been activated because the current consumption is higher than the maximum total current of the decoder or there is a short circuit at the motor output. → Eliminate the cause of the overload. Check the following points in particular:

- Current consumption of the motor and the additional consumers. If the current consumption is higher than the permissible current, the decoder is not suitable for this locomotive.
- Smooth running of all moving parts (e.g. wheels, rods).
- Condition of the brushes

Note: The decoder must first be de-energised before it will respond to run commands again.

In digital mode, the locomotive suddenly runs at high speed.

Possible cause:

- Interference signals from the layout have switched the decoder to analogue operation. → As it is often not possible to localise the cause of the interference signals, it is advisable to switch off the automatic analogue detection during digital operation.

After the decoder has been installed, the locomotive only runs in one direction.

Possible cause:

- The output voltage of the booster is not symmetrical. The decoder interprets the unbalanced track voltage as ABC braking distance. → Reduce the ABC sensitivity in CV 122 (by increasing the value in CV 122) or deactivate the ABC braking procedure in CV 121.

After programming the decoder the loco runs badly or not at all.

Possible causes:

- In CV 1 a base address > 127 is on and in CV 29 the use of extended addresses is off. In this case the decoder does not react to DCC commands. → Enter a base address < 127 in CV 1 or activate the use of extended addresses in CV 29.
- In CV 29 the use of extended addresses is set. In this case the decoder does not react to Motorola commands. → Deactivate the use of extended addresses in CV 29.
- The entered values for the CV variables are inconsistent. → Perform a decoder reset and set the values for the motor control again. Follow the instructions in section 5.3.
- The load control is switched off. → Check the settings in CV 116.
- The load control is poorly set. In this case the locomotive jerks or rocks when driving. → Set the default values again and follow the instructions in section 5.3 when setting the load control parameters again.

6.3. Problems with the feedback of the decoder

The CV values cannot be read out via RailCom.

Possible cause:

- RailCom is switched off. → Change the value for CV 29 (add "8" to the input value).

The decoder does not register with the control unit via DCC-A.

Possible causes:

- RailCom is switched off. → Change the input value in CV 29 (add "8" to the input value).
- DCC-A is switched off. → Change the input value for CV 28.
- There are one or more decoders on the layout which (wrongly) react to the DCC-A command for registration. → In this case carry out the registration from a separate track (e.g. from the programming track).

6.4. Problems when switching functions

An additional device / lighting does not react to switching commands.

Possible cause:

- The assignment of the functions to the output to which the device / lighting is connected is different than intended. → Check the settings in the Function Mapping.
- The accessory is defective or incorrectly connected. → Check the accessory and the connection.
- The output is defective (e.g. due to overload or a short circuit). → Send in the decoder for checking / (chargeable) repair.

The light goes on and off when switching up the speed levels or the light cannot be switched on or off.

Possible cause:

- The DCC speed mode of the decoder and the digital control unit do not match. Example: The control unit is in 28 speed level mode, but the decoder is in 14 speed level mode. → Change the speed mode on the control unit and / or on the decoder.

Additional devices on AUX3 and AUX4 do not respond to switching commands. Lights connected to AUX3 and AUX4 flicker constantly.

Possible cause:

- In CV 121, the use for the data bus (e.g. SUSI) is set for contacts 4 and 13. → Change the setting for CV 121.

The SUSI module in the locomotive does not react to switching commands.

Possible cause:

- In CV 121, the use as outputs is set for contacts 4 and 13. → Change the setting for CV 121.

6.5. Problems in analogue mode

The locomotive does not run in analogue mode, the decoder does not react.

Possible cause:

- Analogue mode is switched off. → Change the value for CV 29.

The decoder does not switch to analogue mode
(or switches over although it is still controlled digitally).

Possible cause:

- In CV 11 the value for the Packet Time-Out is set too high or too low.. → Change the value and check the setting during operation.

6.6. Technical Hotline

If you have any questions about the use of the decoder, our technical hotline will help you (telephone number and e-mail address on the last page).

6.7. Repairs

You can send us a decoder for inspection / repair (address on the last page). Please do not send us your return freight collect. In the event of a warranty or guarantee claim, we will reimburse you for the regular shipping costs.

Please enclose the following with your shipment

- proof of purchase as evidence of any warranty or guarantee claim
- a brief description of the defect
- the address to which we should return the product(s)
- your email address and/or a telephone number where we can reach you in case of queries.

Costs

The inspection of returned products is free of charge for you. In the event of a warranty or guarantee claim, the repair and return are also free of charge for you.

If there is no warranty or guarantee case, we will charge you the costs of the repair and the costs of the return. We charge a maximum of 50% of the new price for the repair according to our valid price list.

Carrying out the repair(s)

By sending in the product(s), you give us the order to inspect and repair it. We reserve the right to refuse the repair if it is technically impossible or uneconomical. In the event of a warranty or guarantee claim, you will then receive a replacement free of charge.

Cost estimates

Repairs for which we charge less than € 25.00 per item plus shipping costs will be carried out without further consultation with you. If the repair costs are higher, we will contact you and carry out the repair only after you have confirmed the repair order.

7. Technical data

Digital protocols

Data formats	Motorola II DCC (according to NMRA and RCN-standard)
Formats for the automatic registration of vehicle decoders	DCC-A according to RCN-218 (can be switched off)
Feedback format	RailCom according to RCN-211 (can be switched off)

Interfaces, outputs and inputs

Decoder interface	Next18 according to RCN-118
Number of switching inputs	---
Number of switching outputs	according to RCN-118: 4 amplified function outputs (F0f, F0f, AUX1 and AUX2) 2 unamplified outputs (AUX5 and AUX6) depending on the configuration: 2 unamplified outputs (AUX3 and AUX4) or 2 connections for the train bus, e.g. "DATA" and "CLOCK" of the SUSI interface
Connection for backup capacitor or buffer circuit	1
Connection for control line of buffer circuit	---

Electrical properties

Power supply	12-20 volts digital voltage or analogue driving transformer (direct voltage)
Current consumption (without consumers)	maximum 20 mA
Maximum total current	1,000 mA
Maximum motor current	500 mA
Maximum current per output	amplified function outputs (F0f, F0f, AUX1 and AUX2): 100 mA unamplified function outputs (AUX3, AUX4, AUX5, AUX6): 0.5 mA

Protection

Protection class	IP 00 Meaning: No protection against solid foreign bodies. No protection against water.
Overload	Automatic switch-off when the permissible total current is exceeded or a short circuit at the motor output ("short-circuit shutdown")

Environment

	For use in closed rooms
Ambient temperature during operation	0 ~ + 60 °C
Permissible relative humidity during operation	10 ~ 85% (non-condensing)
Ambient temperature during storage	- 10 ~ + 80 °C
Permissible relative humidity during storage	10 ~ 85% (non-condensing)

Other features

Dimensions	0-series: 15 x 9.5 x 3.3 mm (thickness differs from RCN-118) Series: 15 x 9.5 x 2.9 mm according to RCN-118
Weights	approx. 0.6 g

8. Warranty, EU conformity & WEEE

8.1. Guarantee bond

For this product we issue voluntarily a guarantee of 2 years from the date of purchase by the first customer, but in maximum 3 years after the end of series production. The first customer is the consumer first purchasing the product from us, a dealer or another natural or juristic person reselling or mounting the product on the basis of self-employment. The guarantee exists supplementary to the legal warranty of merchantability due to the consumer by the seller.

The warranty includes the free correction of faults which can be proved to be due to material failure or factory flaw. With kits we guarantee the completeness and quality of the components as well as the function of the parts according to the parameters in not mounted state. We guarantee the adherence to the technical specifications when the kit has been assembled and the ready-built circuit connected according to the manual and when start and mode of operation follow the instructions.

We retain the right to repair, make improvements, to deliver spares or to return the purchase price. Other claims are excluded. Claims for secondary damages or product liability consist only according to legal requirements.

Condition for this guarantee to be valid, is the adherence to the manual. In addition, the guarantee claim is excluded in the following cases:

- if arbitrary changes in the circuit are made,
- if repair attempts have failed with a ready-made module or device,
- if damaged by other persons,
- if damaged by faulty operation or by careless use or abuse.

8.2. EU Declaration of Conformity

CE This product fulfils the requirements of the following EU directives and therefore bears the CE marking.

2001/95/EU Product Safety Directive

2015/863/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

2014/30/EU on electromagnetic compatibility (EMC Directive). Underlying standards:

DIN-EN 55014-1 and 55014-2: Electromagnetic compatibility - Requirements for household appliances, electric tools and similar electrical appliances. Part 1: Emitted interference, Part 2: Immunity to interference

To maintain electromagnetic compatibility during operation, observe the following measures:

Only connect the supply transformer to a professionally installed and fused earthed socket.

Do not make any changes to the original components and follow the instructions, connection and assembly diagrams in this manual exactly.

Only use original spare parts for repair work.

8.3. Declarations on the WEEE Directive

This product is subject to the requirements of the EU Directive 2012/19/EC on Waste Electrical and Electronic Equipment (WEEE), i.e. the manufacturer, distributor or seller of the product must contribute to the proper disposal and treatment of waste equipment in accordance with EU and national law. This obligation includes

- registration with the registering authorities ("registers") in the country where WEEE is distributed or sold
- the regular reporting of the amount of EEE sold
- the organisation or financing of collection, treatment, recycling and recovery of the products
- for distributors, the establishment of a take-back service where customers can return WEEE free of charge
- for producers, compliance with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive.

The "crossed-out wheeled bin" symbol means that you are legally obliged to recycle the marked equipment at the end of its life. The appliances must not be disposed of with (unsorted) household waste or packaging waste. Dispose of the appliances at special collection and return points, e.g. at recycling centres or at dealers who offer a corresponding take-back service.

Further Information and Tips:

http://www.tams-online.de

Warranty and Service:

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CE