LD-G-24

Lastgeregelter Lokdecoder
für Gleichstrommotoren
DCC-Format

Locomotive Decoder
with load control for
DC engines - DCC format

Décodeur avec compensation de
charge pour locomotive avec
moteur continu - Format DCC

Lastgeregelde Locdecoder
voor gelijkstroommotoren
DCC-format

■ **Anleitung**

■ **Manual**

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Art.-Nr. 22-01-086
Art.-Nr. 22-01-087

■ $\mathsf{C}\mathsf{E}$

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How to use this manual

Even if you have no specialist technical training, this manual gives step-by-step instructions for safe and correct fitting of the module, and operation. Before you start, we advise you to read the whole manual, particularly the chapter on safety instructions and the FAQ chapter. 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 module on to another person, please pass on the manual with it.

Intended use

The locomotive decoder is designed for mounting in a model train with DC motor. It evaluates the DCC format data sent by the digital central unit to its address and controls the locomotive´s motor and additional functions.

The module should not be mounted or operated by children under the age of 14.

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

Any other use is inappropriate and invalidates any guarantees.

⚠ Caution:

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

Safety instructions

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,
- connecting the circuit to another voltage than specified,
- impermissibly high humidity,
- 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.
- Mounting the module should only be done in closed, clean, dry rooms. Beware of humidity.
- Only use low power for this module as described in this manual and only use certified transformers.
- Connect transformers and soldering irons only in approved mains sockets installed by an authorised electrician.
- Observe cable diameter requirements.
- After condensation build up, allow a minimum of 2 hours for dispersion.
- Use only original spare parts if you have to repair the module.

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 work with this module.

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

In schools, training centres, clubs and workshops, assembly, mounting and operation must be supervised by qualified personnel.

In industrial institutions, health and safety regulations applying to electronic work must be adhered to.

EMC declaration

This product is developed in accordance with the European standards EN 55014 and EN 50082-1, tested corresponding to the EC - directive 89/336/EWG (EMVG of 09/11/1992, electromagnetic tolerance) and meets legal requirements.

To guarantee the electromagnetic tolerance you must take the following precautions:

- Connect the transformer only to an approved mains socket installed by an authorised electrician.
- Make no changes to the original parts and accurately follow the instructions, print layout and circuit diagram included with this manual.
- Use only original spare parts if you have to repair the module.

Operation overview

The decoder LD-G-24 is designed for operation in DCC format and can be adjusted to one of 127 basic addresses or to one of 10.239 extended addresses. It is designed to be controlled from digital control units that are set on the 14-, 28- or the 128-speed mode.

The decoder can be programmed individually by setting the configuration variables. It is possible to set all configuration variables with central units which support the CV-programming. With central units which only support the so-called register-programming the number of the configuration variables that can be set is restricted.

Automatic recognition of the analogue mode

The decoder can also be used in analogue model railway layouts run with a D.C. speed control. When putting the locomotive on the rails the decoder recognizes automatically if it is run in analogue or digital mode and sets the corresponding operation mode. The automatic recognition of the analogue mode can be switched off by programming the decoder accordingly.

The decoder is not suitable for analogue model railway layouts run with an A.C. speed control.

The lighting is always switched on according to the direction of travel. Switching on or off the lighting and the additional functions is not possible.

The configuration variables of the LD-G-24

The following configuration variables (CVs) can be set from the digital control unit:

- Basic address (CV#1)
- Starting voltage (CV#2)
- Acceleration rate (CV#3)
- Braking rate (CV#4)

- Maximum voltage (CV#5) [1]
- Version (CV#7) – read only
- Manufacturer identification (CV#8) - read only
- Extended address (CV#17 and CV#18) [1]
- Configuration data 1 (CV#29)
- Assignment of the outputs X4 to X7 to the function keys F5 to F8 (CV#39 to 42) [1]
- Configuration data 2 (CV#49) [1]
- Dimming of the outputs X4 to X7 (CV#50 to C53) [1]
- Proportional component of the load control "KP" (CV#54) [1]
- Assignment of the outputs X4 to X7 to the function keys F0 to F4 (CV#55 to 58) [1]
- Integral component of the load "KI" (CV#59) [1]
- Effects for the outputs X4 to X7 (CV#60 to 63) [1]
- Differential component of the load control "KD" (CV#64) [1]
- Alternative velocity characteristic for mode 28 speed levels (CV#67 to 94) [1]

[1] Not possible with central units with register programming!

Driving of the motor

The motor is driven with a PWM of 16 kHz. This guarantees a soft and constant run of the motor. The decoder may also be used with coreless (Faulhaber) motors as well.

Load control

At constant motor voltage, additional loads (e.g. running up a gradient, coupled carriages) cause the locomotive to slow down or even come to a standstill. If the load control is active the motor voltage varies to keep the locomotive operating at constant velocity at a given speed level, independent of additional loads.

It is possible to switch on and off the load control by varying a CV-variable of the deocder. The parameters of the load control may be altered as well.

⚠ **Attention:**

For most locomotives you will achieve good driving characteristics with the factory settings. Incorrect of the load control parameter settings deteriorate the driving characteristics of the motor considerably. Therefore you should first check the locomotive with the preset values and modify the parameters of the load control only step-by-step.

Parameters of the load control: The load control is determined by three parameters which have to be coordinated in order to achieve optimal driving characteristics. Each of the load control parameters is assigned to a configuration variable. The parameters are:

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.

KI: The integral component of the load control ensures the remaining difference between the set and the present value being reduced to 0.

KD: The differential component of the load control ensures that the control is not converted too quickly. Shaking and vibrating would be the consequence.

Velocity characteristic

The decoder can be adjusted to the driving characteristics of the motor and the characteristic speed of the locomotive type, by setting the starting velocity and the maximum velocity. From the starting velocity and the maximum velocity the decoder generates a linear velocity characteristic.

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 table.

Shunting gear

In the speed modes 14 and 28, it is possible to switch into the shunting gear mode via a function key, when so programmed. 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

It is possible to program the acceleration and brake delay individually via the central unit.

Emergency stop

By setting a CV-variable it is possible to adjust how an emergency stop is carried out. There are the following possibilities:

- no emergency stop possible,
- emergency stop at change of direction and / or
- emergency stop by operating of F1.

Function outputs

The decoder has four function outputs which can be switched on and off via the function keys F0 to F8. They are available to connect optional accessories with a current of max. 1.000 mA.

You can assign the function keys to the function outputs freely. It is possible to assign several function keys to one function output.

Effects of the function outputs

It is possible to set the following effects for all function outputs individually:

- Irregular flickering. Example of use: Flickering of the boiler fire by steam engines.
- Strobe (flashing). Example of use: American locomotives with that kind of lighting.
- MARS light (swelling of the brightness). Example of use: American locomotives with that kind of lighting.

- Switching on and off depending on the direction of travel.
- Flashing with a frequency of 2 Hz with two phases which are out-of-phase by 180 degrees. Example of use: individual flash lights or alternating flash lights.
- Flashing with a frequency of 1 Hz.

Technical specifications

Data format	DCC
Supply voltage	12-24 Volt digital voltage
Current consumption	
(without connected loads)	approx. 10 mA
Max. current for motor	3.000 mA
Max. current per function output	1.000 mA
Max. total current	3.000 mA
Protected to	IP 00
Ambient temperature in use	0 - + 60° C
Ambient temperature in storage	-10 - + 80° C
Comparative humidity allowed	max. 85 %
Dimensions	approx. 26 x 19 x 7,5 mm
Weight	approx. 3,5 g

Checking the package contents

Check the contents of the package for completeness immediately after unpacking:

- one decoder, with or without soldered connecting wires resp. soldered NEM 652 interface connector, depending on the version.
- one manual.

N.B. For technical reasons it is possible that the PCB is not completely inserted. This is not a fault.

Required tools and materials

Make sure you have the following tools, equipment and materials ready for use:

- an electronic soldering iron (max. 30 Watt) with a fine tip,
- a soldering iron stand,
- a tip-cleaning sponge,
- a heat-resistant mat,
- a small side cutter and wire stripper,
- a pair of tweezers,
- tin solder (0,5 mm. diameter),
- wire, diameter: $\geq$ 0,05 mm² up to a current of 1 A resp. $\geq$ 0,14 mm² (from a current of more than 1 A).
- When the total current consumption is more than 1,5 A: a heat sink, e.g. a SMD heat sink with a base of 7 x 19 mm.

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 small soldering iron with max. 30 Watt. Keep the soldering tip clean so the heat of the soldering iron is applied to the solder point effectively.
- Only use electronic tin solder with flux.
- When soldering electronic circuits never use soldering-water or soldering grease. They contain acids that can corrode components and copper tracks.
- Solder quickly: holding the iron on the joints longer than necessary can destroy components and can damage copper tracks or soldering eyes.

- Apply the soldering tip to the soldering spot in such a way that the wire and the soldering eye are heated at the same time. Simultaneously add solder (not too much). As soon as the solder becomes liquid take it away. Hold the soldering tip at the spot for a few seconds so that the solder flows into the joint, then remove the soldering iron.
- The joint should be held still for about 5 seconds after soldering.
- To make a good soldering joint you should use a clean and unoxidised soldering tip. Clean the soldering tip with a damp piece of cloth, a damp sponge or a piece of silicon cloth.
- After soldering check (preferably with a magnifying glass) tracks for accidental solder bridges and short circuits. This would cause faulty operation or, in the worst case, permanent damage. You can remove excess solder by putting a clean soldering tip on the spot. The solder will become liquid again and flow from the soldering spot to the soldering tip.

Mounting the locomotive decoder

Before mounting the decoder check if the locomotive motor´s current is below the maximum permissible value of 3.000 mA. If it is above 3.000 mA the decoder is not suitable for mounting in this locomotive. It would be damaged when put into operation.

Follow the connection diagrams fig. 1, 2 and 3.

Connecting the motor

Open the locomotive housing. Locate the position for the decoder. Disconnect the motor from the rail current collector.

⚠ Caution:

The interference suppression devices mounted to the motor or the connecting wire must not be removed! Motor and interference suppression devices are one unit. If even one part is removed, it can cause extreme interference!

Solder the connections from the rail current collectors at the points X1 and X2. Next solder the connections from the motor at the points X11 and X12. In case the locomotive´s direction of motion in analogue mode does not match the direction of motion set at the speed control you have to swap the connections to the points X11 and X12.

Connecting the lighting and other accessories

Before connecting the accessories check if the current is below the maximum permissible value of 1.000 mA. If lightings or other accessories with a current of more than 1.000 mA are connected the decoder will be damaged when put into operation. Please note that the maximum total current for motor and accessories should not exceed 3.000 mA.

Disconnect any existing diodes in the leads to the lamps. Connect the lamps and the other accessories to the function outputs X4 to X7. The assignment of the function outputs to the function keys will be made when programming the decoder. If the lamp or the accessory is already connected with one side to locomotive ground, the connection is complete. If not, connect the second side of the lamp or the accessory to the return conductor of the decoder (point X3).

If you want to use the decoder factory settings, you have to connect the lighting and the accessories as follows:

Front lighting: X4
Back lighting: X5
Accessory to be switched via F1: X7
Accessory to be switched via F2: X6

⚠ **Caution:**

If you connect the loads to the return conductor for all functions (point X3), the loads must be insulated. The loads should not make contact with metal parts of the locomotive. Possible short circuit! The locomotive decoder will be damaged in operation.

⚠ **Caution:**

The return conductor for all functions (point X3) must under no circumstances be connected to locomotive ground. Possible short circuit! The locomotive decoder will be damaged in operation.

Tip: Before starting to program the locomotive decoder you should connect the motor to the decoder. Otherwise there is no confirmation signal from the central unit.

Connecting the LEDs

The function outputs of the locomotive decoder switch against decoder ground. For that reason you must connect the cathode (-) of the LED to the output of the relevant function.

⚠ **Caution:**

If you use light-emitting diodes (LEDs) you must always operate them via a series resistor. LEDs are available in many different models. The series resistor limits the current flow of the LED and will need to be calculated for each model. Ask for the max current rating when buying your LEDs.

You can connect several LEDs in parallel to each output. In this case every LED must have a series resistor of its own. If you connect several LEDs to one output in series, only one series resistor is needed.

Fixing the locomotive decoder

After completing all connections fix the locomotive decoder with double-sided adhesive tape, for example.

⚠ **Caution:**

The locomotive decoder can get warm during operation. For that reason it should not be covered with shrinking hose or hot adhesive.

⚠ **Caution:**

When the total current consumption is more than 1,5 A you should cool the decoder. As a heat sink you could use a SMD heat sink with a base

of 7 x 19 mm. Fix the heat sink on the diodes D1 to D4, using an appropriate glue (e.g. super glue). Take care that the heat sink does not contact the adjoining IC1. Risk of short circuit!

Using a NEM 652 interface connector

Some locomotives already have an NEM 652 interface connector mounted. Using a convenient connecting plug you save disconnecting the connections and you do not need to solder at the locomotive.

The list below shows how to connect the contacts of the interface connector to the connecting points of the locomotive decoder.

Contact	Connection	Colour of cable	Connecting points
1	Motor connection 1	orange	X11
2	Lighting back (-)	yellow	X5
3	Not used or F1	green	X7
4	Power supply left	black	X2
5	Motor connection 2	grey	X12
6	Lighting front (-)	white	X4
7	Common conductor for all functions (+)	blue	X3
8	Power supply right	red	X1

Programming the locomotive decoder

The locomotive decoder is programmed from the digtial central. See the chapter in the manual of your digital control unit where the programming of configuration variables (CVs) is explained.

You can programm resp. read out the following locomotive decoder variables:

NB. With central units with register-programming it is only possible to program the variables CV#1 to CV#4 (= register 1 to 4) and CV#29 (= register 5).

CV-name	CV-no.	Input value / (State of delivery)	Remarks
Basic address	1	1 ... 127 (3)	
Starting voltage	2	0 ... 255 (5)	= The voltage to be output to the motor at speed level 1. The value "0" corresponds to 0 Volt, the value "255" to the max. voltage.
Acceleration rate	3	0 ... 255 (8)	= Length of the delay before the switching to the next higher speed level when the locomotive is accelerating. The delay is calculated as follows: (value of CV#3) x 0,9 sec. / number of speed levels
Braking rate	4	0 ... 255 (5)	= Length of the delay before the switching to the next lower speed level when the locomotive is braking. The delay is calculated as described in CV#3.

CV-name	CV-no.	Input value / (State of delivery)	Remarks	
Maximum voltage	5	0 … 255 (0)	= The voltage to be output to the motor at the highest speed level. The value "2" corresponds to 0,8 %, the value "255" to 100 % of the max. voltage.	
Version	7	---	Read only!	
Manufacturer	8	--- (62)	Read only!	
Reset	8	0 … 255	Any value restores the settings in state of delivery.	
Extended adress	17 18	1 … 10239 (-)		
Configuration data 1	29	(6)	Numerical value $*^2$	
			Direction "standard"	0
			Reverse direction	1
			14 speed levels	0
			28 or 128 speed levels	2
			Analoge recognition off	0
			Analoge recognition on	4
			Linear velocity characteristic	0
			Alternative velocity characteristic	16
			Basic adress	0
			Extended adress	32

CV-name	CV-no.	Input value / (State of delivery)	Remarks	
Assignment F5 – F8 to the outputs:		0 ... 15 (0)	Numerical value **²**	
			Operation with:	
			---	0
X4	39		function key F5	1
X5	40		function key F6	2
X6	41		function key F7	4
X7	42		function key F8	8
Configuration data 2	49	0 ... 127 (1)	Numerical value **²**	
			Load control active	1
			Emergency stop at change of direction	2
			Emergency stop at F1	4
			Shunting gear mode at F1	8
			Shunting gear mode at F2	16
			Shunting gear mode at F3	32
			Shunting gear mode at F4	64
Dimming of the outputs::		0 ... 63 (63)	= The voltage that is applied to the output. The value "1" corresponds to the minimum, „63" to the maximum voltage.	
X4	50			
X5	51			
X6	52			
X7	53			
Parameter of load control KP	54	0 ... 255 (96)	= Proportional component of the load control.	

² Tip: You program the configuration variables CV#29, CV#39 to 42, CV# 49, CV#55 to 58 and CV#60 to 63 by entering the sum of the numerical values which are assigned to the desired parameters.

CV-name	CV-no.	Input value / (State of delivery)	Remarks
Assignment F0 – F4 to the outputs:		0 ... 31	Numerical value *²
			Operation with:
			--- 0
X4	55	(16)	function key F1 1
X5	56	(16)	function key F2 2
X6	57	(1)	function key F3 4
X7	58	(2)	function key F4 8
			function key F0 16
Parameter of load control KI	59	0 ... 255 (5)	= Integral component of the load control.
Effects for the outputs:		0 ... 255	Numerical value *²
			Flickering active 1
			Strobe active 2
X4	60	(16)	MARS light active 4
X5	61	(8)	at backward motion inactive 8
X6	62	(0)	at forward motion inactive 16
X7	63	(0)	Flashing 2 Hz phase A 32
			Flashing 2 Hz phase B 64
			Flashing 1 Hz 128
Parameter of load control KD	64	0 ... 255 (16)	= Differential component of the load control
Alternative velocity characteristic (only with mode 28 speed levels)	67 94	0 ... 255	= The velocity table for the alternative velocity characteristic. Any motor voltage can be assigned to all of the 28 speed levels. The value "0" corresponds to a voltage of „0", „255" to the maximum voltage.

Improvement of the driving characteristics

Locomotives with especially high current consumption or track sections with bad contacts (e.g. some types of points) may give an unsatisfactory performance. You can improve the locomotive performance by soldering a capacitor 100 µF / 35 V between X8 and X15 (see fig. 1 and 3).

FAQ

- Parts are getting very hot and/or start to smoke.

  Tip: The deocder may warm up to 45 °C in operation. This does not affect the functioning of the decoder.

  ⚠ **Disconnect the system from the mains immediately!**

  Possible cause: one or more connections are soldered incorrectly. → Check the connections.

  Possible cause: The connection of the motor is connected to locomotive ground. → Disconnect the connection from locomotive ground.

- The lighting goes on and off when the speed levels are turned up or the lighting cannot be switched on or off.

  Possible cause: The speed mode of the decoder and the digital control unit do not correspond. Example: The central is set to the mode 28 speed levels, but the decoder to the mode 14 speed levels. → Change the speed mode at the central and / or at the decoder.

- The locomotive does not run in analogue mode.

  Possible cause: The analogue mode is switched off. → Alter the value for CV #29.

  Possible cause: The analogue model railway layout is run with a A.C. speed control, the analogue mode however is only possible with D.C. speed controls.

- After programming the decoder the locomotive does not run or runs badly.

  Possible cause: The set values for the CV are inconsistent.
  → Perform a decoder reset and program the decoder anew.

- In digital mode the locomotive suddenly runs very fast.

  Possible cause: Interfering signals from the layout have switched the decoder to analogue mode. → As the origin of the interfering signals´ often cannot be found, it is advisable to switch off the automatic recognition of the analogue mode during digital operation.

  Possible cause: The changing direction impulse for a Motorola decoder has switched the decoder to analogue mode. → If you simulaneously control DCC and Motorola decoders, it is advisable to switch off the automatic recognition of the analogue mode during digital operation.

If you cannot find the problem, please return the decoder for repair (address on the cover page).

Manufacturer's note

According to DIN VDE 0869, the person who brings the circuit into operation by extension resp. mounting into a housing is the manufacturer of the product. If he sells the product to another person he is responsible for passing on all the relevant papers and to give his name and address.

Certification

This product conforms with the EC- directive 89/336/EWG on electromagnetic radiation and is therefore CE certified.

Conditions of warranty

This product is guaranteed for two years. The warranty includes the correction of faults which can be proved to be due to material failure or factory flaw. We guarantee the adherence to the technical specifications of the circuit when assembled and connected according to the manual.

Other claims are excluded. By law, we are not responsible for damages or secondary damages in connection with this product. We retain the right to repair, make improvements, supply spare parts or return the purchase price.

The following invalidate the warranty:

- using an unsuitable soldering iron, solder containing liquid acids or similar,
- if damage is caused by not following the instructions in this manual,
- if the module has been altered and repair attempts have failed,
- if arbitrary changes in the circuit are made,
- if additional components are added which are not described in the manual,
- if the copper tracks or soldering eyes are damaged,
- if damage occurs due to an overload of the module,
- if connected to a incorrect voltage or current,
- if damaged by other persons,
- if damaged by faulty operation or if damaged by careless use or abuse,
- if damaged by touching components before electrostatic discharging of the hands.

Fig. 1:

Anschluß LD-G-24 / Connections LD-G-24

Connexion LD-G-24 / Aansluiten LD-G-24

100 µF/35 V

Fig. 2:

Anschluß LD-G-24 / Connections LD-G-24

Connexion LD-G-24 / Aansluiten LD-G-24
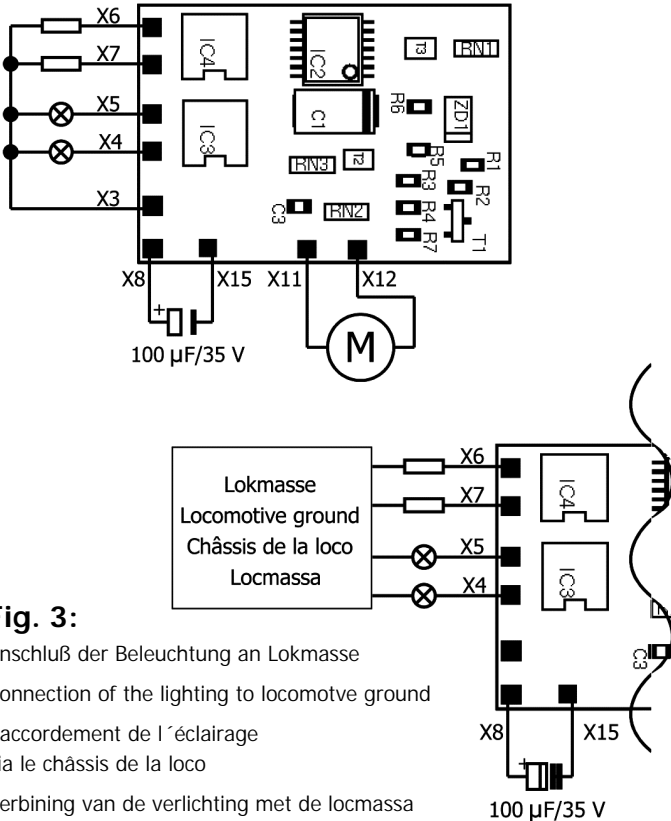
Fig. 3:

Anschluß der Beleuchtung an Lokmasse
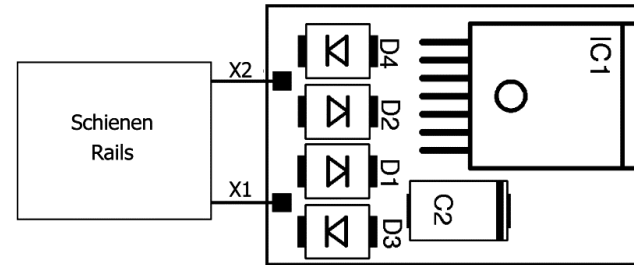
Connection of the lighting to locomotve ground

Raccordement de l´éclairage
via le châssis de la loco

Verbining van de verlichting met de locmassa

100 µF/35 V

X1	Schienenabnehmer links / Rail current collectors left
	Prises de courant de la voie gauches / Railstroomafnemers links
X2	Schienenabnehmer rechts / Rail current collectors right
	Prises de courant de la voie droites / Railstroomafnemers rechts
X3	Rückleiter für alle Funktionen / Return conductor for all functions
	Pole commun des fonctions / Retourleiding voor alle functie
X4	Beleuchtung Vorwärtsfahrt / Lighting forward direction
	Feux marche avant / Verlichting vooruitrijden
X5	Beleuchtung Rückwärtsfahrt / Lighting reverse direction
	Feux marche arrière / Verlichting achteruitrijden
X6	F2
X7	F1
X8 / 15	falls erforderlich / if necessary
	si necessaire / indien noodzakelijk
X11/X12	Motor / Moteur

Fig. 4: Schaltplan - Circuit diagram - Schéma de principe - Schakelschema
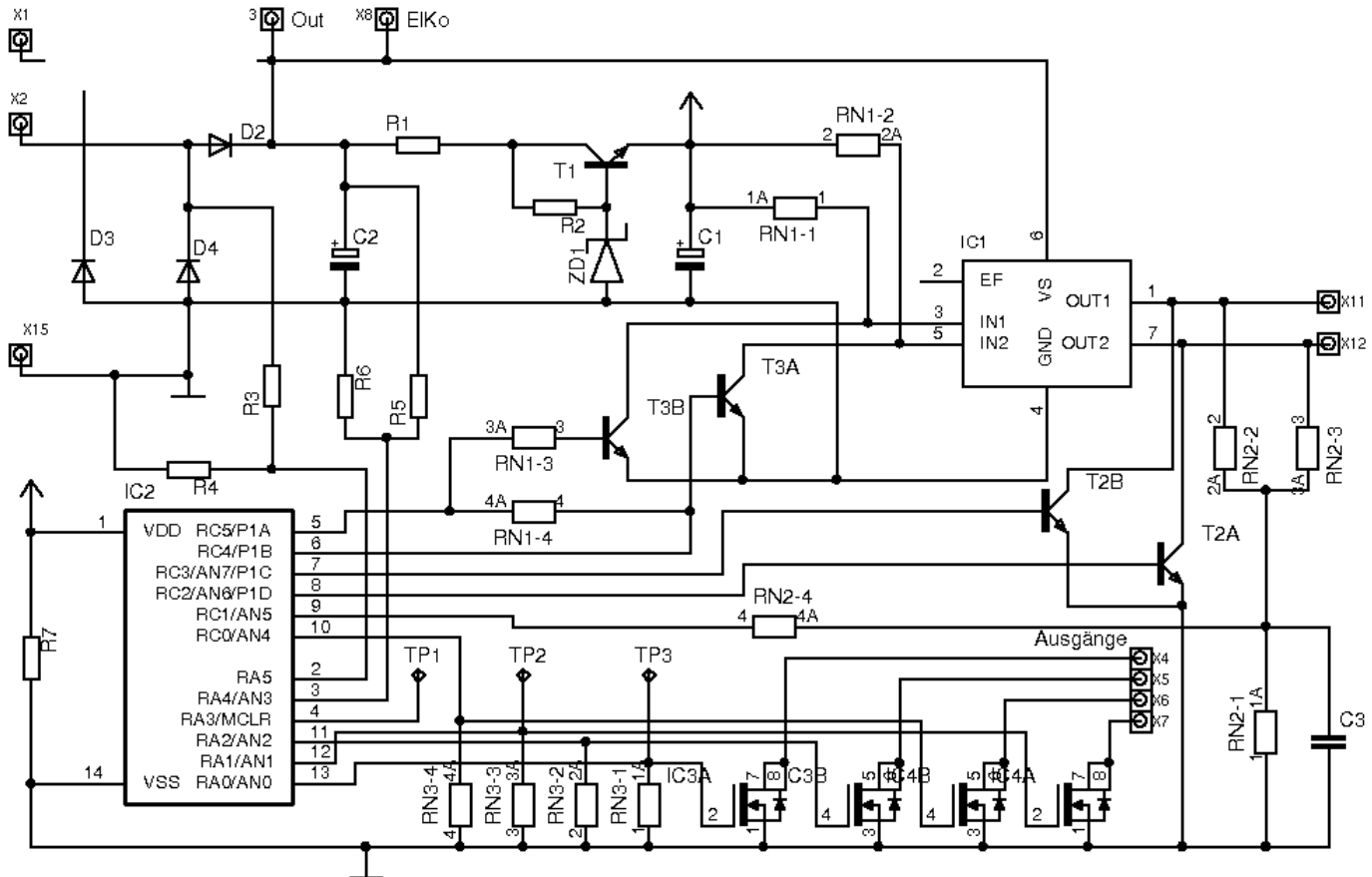
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Information and tips:
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Warranty and service:
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