

# Operating instructions



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## 1. Introduction

Congratulations for the purchase of a TILLIG quality product. We are giving you all the information you need to install the interior lighting and customize all the features, as you wish.

This type of interior lightning is matching to follow coaches:

- Double-deck driving cab coach DO2003



- Double-deck coach DO2003



On each page of this manual, you will find the hardware-software index at the bottom left. This shows the development status of the PCBs and the software of the On-Board Decoder.

At the bottom right you will find the date of the last modification of the manual.

## 2. Installation

Depending on which coach you want to equip with the interior lighting kit, the installation may be different. Please follow the respective installation instructions.

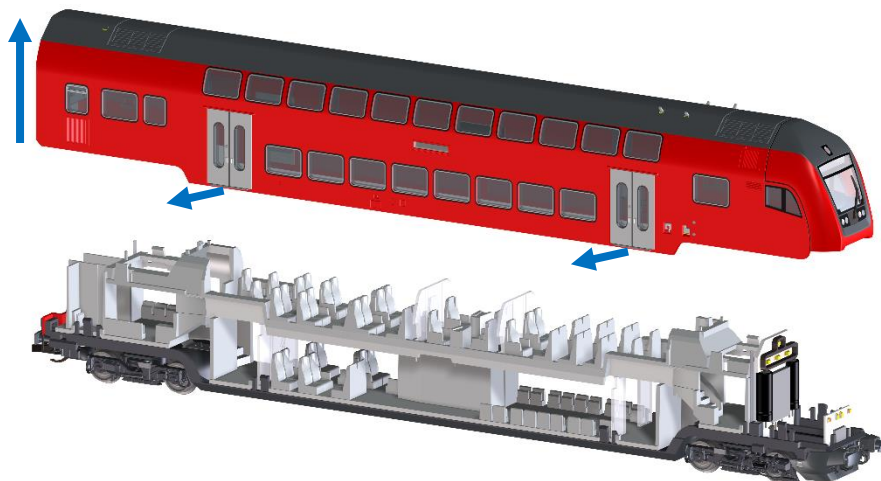
### 2.1 Double-deck driving cab coach

**NOTE FOR DCC USERS:** If you have a driving cab coach and intend to use it in DCC mode **make sure you program a secondary address (see 4.1.1) before installing it to the coach.** This is to prevent programming issues if other decoders are installed in the same coach. If not, both decoders will be programmed at the same time.

The interior lighting will be installed at the upstairs interior.

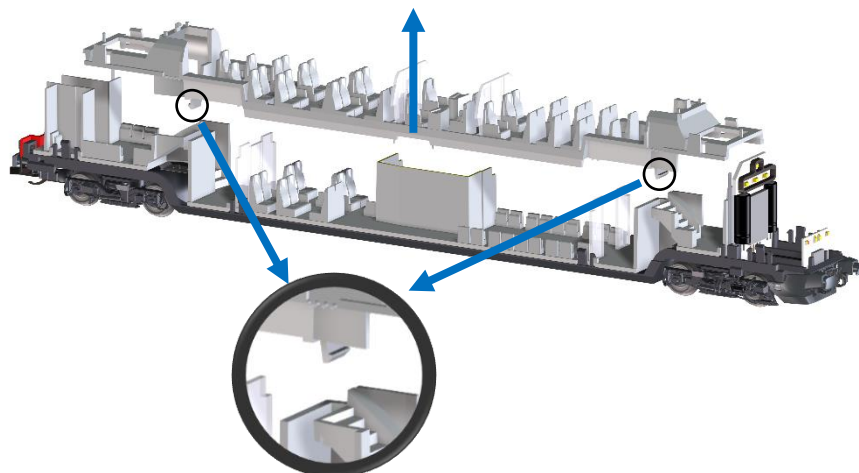
#### Step 1:

Remove the body, for that spread the body at the doors position.



#### Step 2:

Next step is to demount the upstairs interior. It snaps on the downstairs interior.



**Step 3:**

The interior lightning is made for the normal coach and also for the driving cab coach. So it needs to get shorten for the driving cab coach. Trim the length of the front pcb at the row of holes. Use a sharp knife or a cutting disc for that.

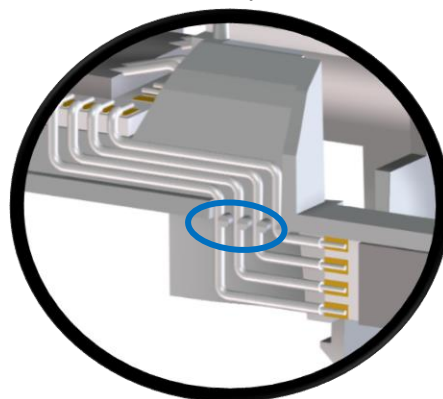
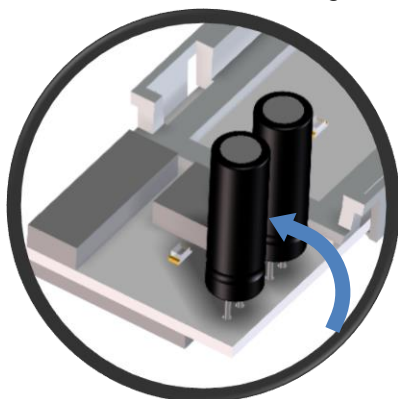


**Step 4:**

Now the circuit boards need to be snapped onto the upper interior. For fixing the two lower circuit boards, use the included circuit board holders, which need to be pressed onto the pins at the bottom of the upper interior.

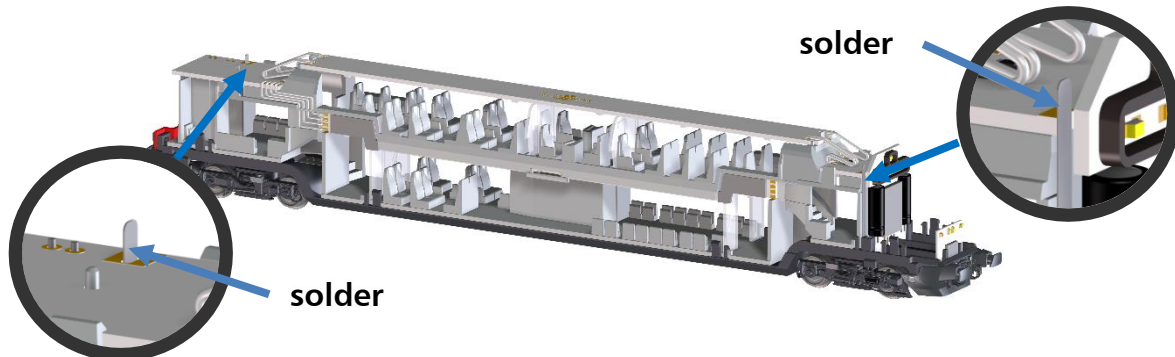


Then, the capacitors have to get bented by 90 degrees into their installation position and the wires of the lower circuit board have to get arranged and fixtured between the pins.



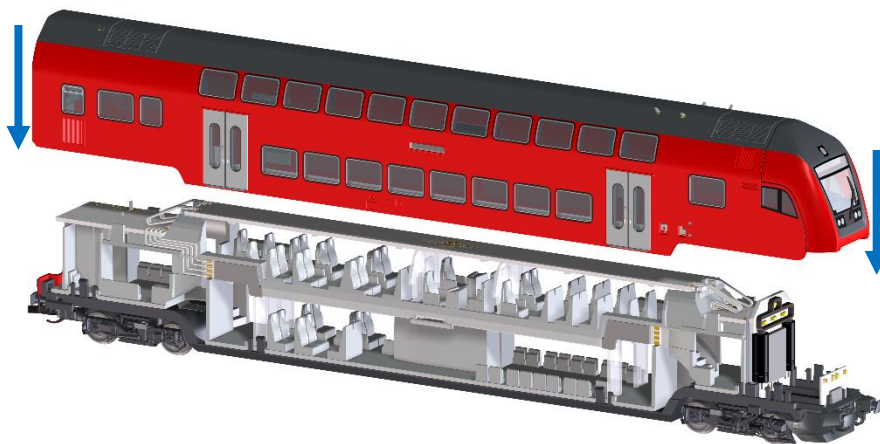
**Step 5:**

Now the upper interior can be snapped on in place. While that pay attention to the contact rails. The need to stuck trough the pcb's. After that they need to be soldered.



**Step 6:**

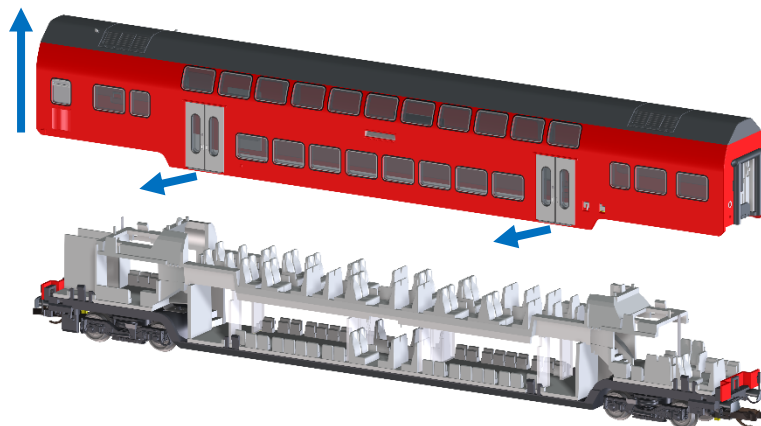
After a function test, the body can be stucked back on.



## 2.2 Double-deck coach

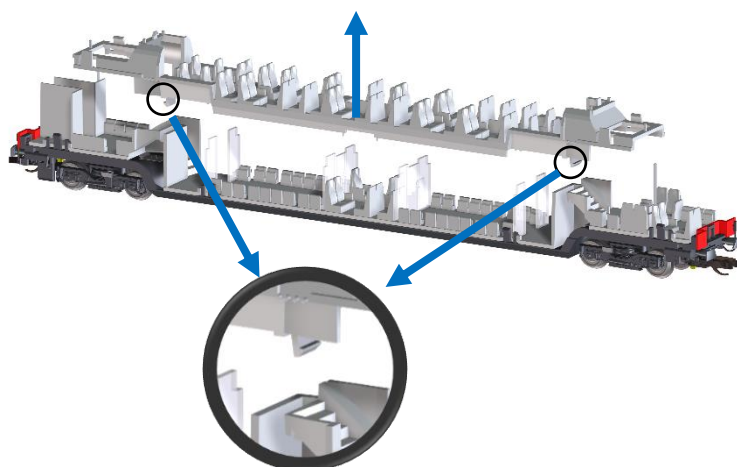
### Step 1:

Remove the body, for that spread the body at the doors position.



### Step 2:

Next step ist o demount the upstairs interior. Ist snapped on the downstairs interior.

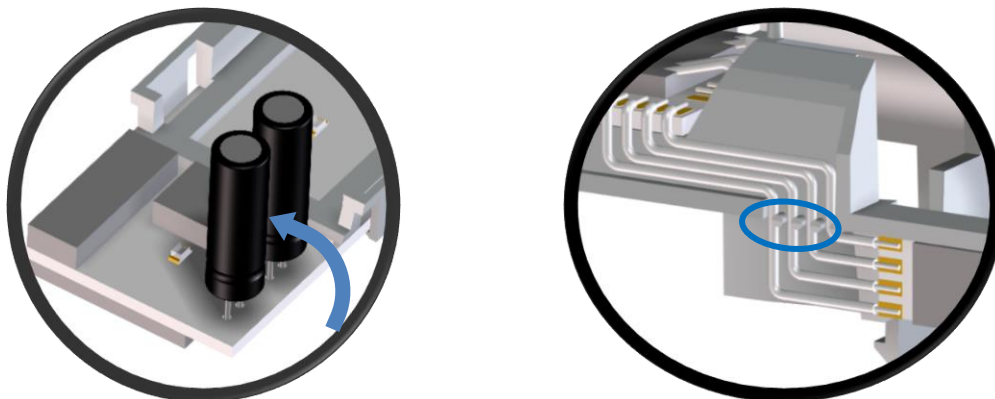


### Step 3:

Now the circuit boards need to be snapped onto the upper interior. For fixuring the two lower circuit boards, use the included circuit board holders, which need to be pressed onto the pins at the bottom of the upper interior.

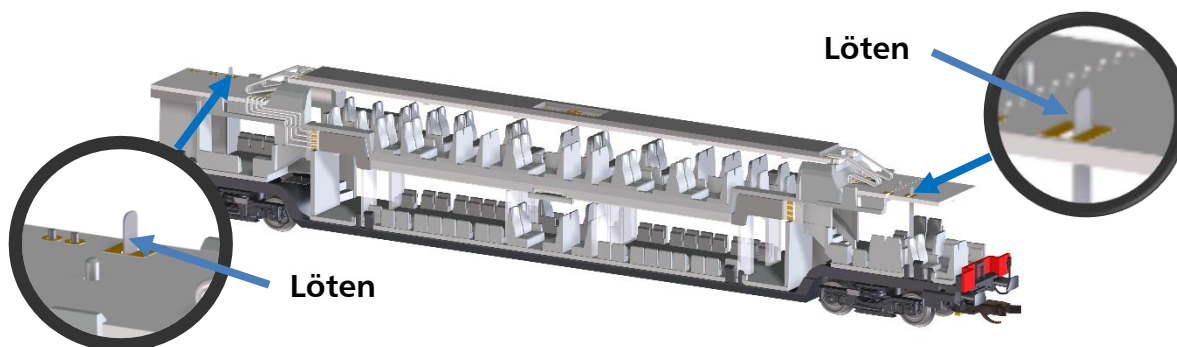


Then, the capacitors have to get bented by 90 degrees into their installation position and the wires of the lower circuit board have to get arranged and fixtured between the pins.



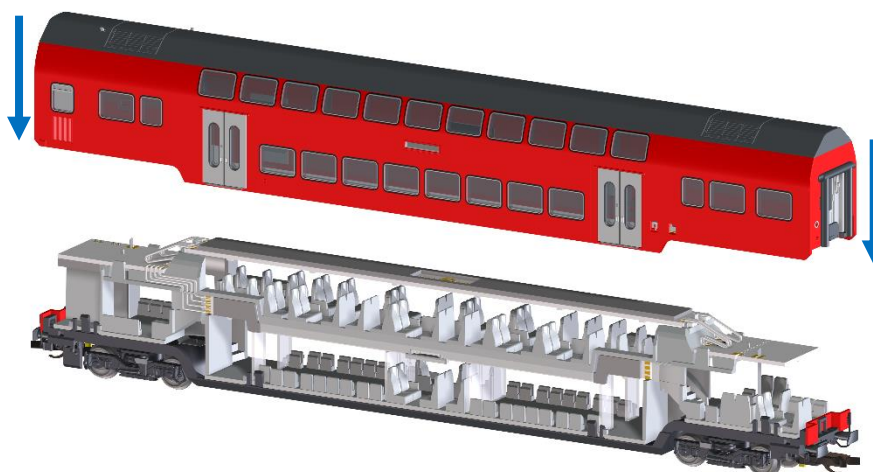
**Step 4:**

Now the upper interior can be snapped on in place. While that pay attention to the contact rails. The need to stuck trough the pcb's. After that they need to be soldered.



**Step 5:**

After a function test, the body can be stucked back on.



### 3. Function output mapping

The integrated decoder has 8 outputs, so that single or groups of LED's can be switched on or off separately.

#### 3.1 Function outputs

- AUX1 = direction board lightning
- AUX2 = white light; downstairs
- AUX3 = blue light; downstairs
- AUX4 = white light; back corridor
- AUX5 = white light; toilet
- AUX6 = white light; upstairs
- AUX7 = blue light; upstairs
- AUX8 = white light; front corridor

#### 3.2 Function button mapping

The function button mapping is chosen like it's matching to the front lighting of the driver's cab.

F1	direction board lightning (AUX1)
F3	White light (AUX2 + AUX4 + AUX6 + AUX8)
F4	Blue light (AUX3 + AUX7)
F5	Toilet (AUX5)

## 4. Standard CV – programming

**-WARNING-** : To make sure you are programming only the lighting decoder you must activate the secondary address (see 4.1.1)

You can write CV's on Programming Track (PT) or Main Track (PoM), read only on PT.

### 4.1 Adress programming

The on board function decoder of the interior light can be used either with short addresses (1-127) or long addresses (1-9999). The factory default setting is short addressing (bit5 of CV29 is 0), with the address 3 (CV1 = 3).

The address can be changed by placing the decoder on the Programming Track (PT) or Main Track (PoM), and changing the CV1 value, according to the instructions of your Command Station.

If long addressing is needed, the addressing mode must be changed in the configuration CV of the decoder (bit5 of CV29). Changing the bit5 value of CV29 to 1 will activate the long addressing mode, and the decoder will respond to the long address specified in CV17 and CV18. Bit5 has a decimal value of 32, so changing bit5 to binary 1 is equivalent with adding 32 to the decimal value of CV29 (CV29 has the factory default value 6, activating bit5 means, to add 32 to this value,  $6 + 32 = 38$ , the new value for CV29 will be 38).

The long addresses will be calculated with the following algorithm (in our example we will consider the long address 2000):

- divide the desired long address with 256 (in our example  $2000 / 256 = 7$ , remainder = 208)
- add 192 to the result and program it in CV17 ( $7 + 192 = 199$ , program the value 199 in CV17)
- program the value of the remainder of the division in CV18 (program the value 208 in CV18)

After programming CV29, CV17 and CV18 with the mentioned values, the decoder can be accessed with the address 2000. To switch back to short addressing, the bit5 of CV29 must be deactivated.

#### 4.1.1 Secondary address (decoder lock)

This will be necessary while using the interior lightning at driving cab coaches.

When using multiple decoders within the same housing, a secondary address is needed to be able to select each decoder. In this way all the decoders that are inside the same housing (carriage body) can be programmed on the Programming Track without removing them. The secondary addresses are programmed into CV16 before the decoders (in our case the interior lighting with the onboard decoder) is being assembled in the housing. The range of secondary addresses is between 1 and 7 (value of 0 means that secondary addressing is not used). This allows the use of maximum 7 decoders in the same carriage or locomotive housing, which is more than enough.

If the value of CV16 is not equal to zero, the decoders will accept programming commands only if the secondary decoder address that is about to be programmed is written prior in CV15, and it matches the value in CV16 (it should be the same as decoder'S CV16 value).

When using secondary address, it is important to know that the only CV that can be read and written without knowing the secondary address is CV15. For this reason the used values are limited to the range of 1 to 7. If the secondary decoder address is forgotten, within 7 try's it can be found.

**Assigning secondary addresses to each decoder of the railcar or carriage sets, when placing them on the Programming Track, only the decoder for which the CV15 = CV16 will be programmed. In this way we can program all the decoders independently, even if they are all on the programming track at the same time.**

**For example:** The driving cab coach should be equipped with interior light. This model has an OnBoard function decoder. That means that before you install the interior lighting, the OnBoard function decoder must be programmed with a secondary address 1 (CV16=1).

Now you can install the interior light. It should get the secondary address 2. For that you need to write CV16=2. The the interior light will be available for programming using the secondary address 2.

During operation both decoders are accessed on short (primary) address 3, which is the standard (default) decoder address, but they can be programmed separately/individually selecting their secondary addresses in CV15.

This means if you want to program the OnBoard function decoder, you must write the secondary address to CV15 (CV15=1). Now only the OnBoard function decoder with this secondary address will be programmed, the interior light (and all others) is (are) locked.

If you want to program the interior light, prior doing this, you must program its secondary address to CV15 by writing CV15=2.

### 4.1.2 Consist address

The On-Board Decoder supports the Advanced Consist functions. To activate this feature, the consist address must be set in CV19. When the content of CV19 is different from 0, the decoder will perform functions that are defined in CV21 and CV22 if they are transmitted to the consist address.

Functions in CV21 and CV22 will not be performed if they are transmitted to the base address. All other functions will be performed while they are sent to the base address (defined in CV1 or CV17/CV18).

Bit	Bit0	Bit1	Bit2	Bit3	Bit4	Bit5	Bit6	Bit7
value	1	2	4	8	16	32	64	128
CV21	F1	F2	F3	F4	F5	F6	F7	F8
CV22	F0 fwd.	F0 rev.	F9	F10	F11	F12	-	-

Example: if we want to use F0F, F0R, F3 and F4 with consist address, the following values are to be written in CV21 = 12 and in CV22 = 3.

Speed and direction commands will be sent to all decoders within the same consist. In this way the headlights (of locomotives) and taillight of carriages can be turned on and off, based on the direction commands sent to the consist addresses, while the interior lights in different carriages can be turned on and off based on their individual base addresses.

For note: The speed steps setting in CV29 must match the speed step setting of the Command Station for both base and consist addresses.

### 4.2 Decoder-Reset

The factory default CV values are specified in the CV table "Default value" column. The decoder can load the factory default values anytime by resetting it. The value 8 must be written in CV8 to reset the decoder to the factory default CV values.

### 4.3 Function-mapping

Each function (from F0 to F28) can be used to activate/deactivate one or more outputs (from the total of 8 outputs) of the on-board decoder. The relationship between functions and outputs is called Function Mapping. The mapping is performed by programming like the bit-mask shows.

For the **functions F0** (generally called light function) and **F1** the mapping can be defined separately for each **driving direction**, so 4 CV's are used for each function. The other functions (F2-F16) don't depend on the driving direction, so 2 CV's are used for each function, to map the function to each physical output of the On Board Decoder.

AUX		16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
bit		7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	
F-button	CV	Not available																
F0	33									128	64	32	16	8	4	2	1	
forw.	34	128	64	32	16	8	4	2	1									
F0	35									128	64	32	16	8	4	2	1	
backw.	36	128	64	32	16	8	4	2	1									
F1	37									128	64	32	16	8	4	2	1	
forw.	38	128	64	32	16	8	4	2	1									
F1	39									128	64	32	16	8	4	2	1	
backw.	40	128	64	32	16	8	4	2	1									
F2	41									128	64	32	16	8	4	2	1	
	42	128	64	32	16	8	4	2	1									
F3	43									128	64	32	16	8	4	2	1	
	44	128	64	32	16	8	4	2	1									
F4	45									128	64	32	16	8	4	2	1	
	46	128	64	32	16	8	4	2	1									
F5	47									128	64	32	16	8	4	2	1	
	48	128	64	32	16	8	4	2	1									
F6	49									128	64	32	16	8	4	2	1	
	50	128	64	32	16	8	4	2	1									
F7	51									128	64	32	16	8	4	2	1	
	52	128	64	32	16	8	4	2	1									
F8	53									128	64	32	16	8	4	2	1	
	54	128	64	32	16	8	4	2	1									
F9	55									128	64	32	16	8	4	2	1	
	56	128	64	32	16	8	4	2	1									
F10	57									128	64	32	16	8	4	2	1	
	58	128	64	32	16	8	4	2	1									
F11	59									128	64	32	16	8	4	2	1	
	60	128	64	32	16	8	4	2	1									
F12	61									128	64	32	16	8	4	2	1	
	62	128	64	32	16	8	4	2	1									
F13	160									128	64	32	16	8	4	2	1	
	161	128	64	32	16	8	4	2	1									
F14	162									128	64	32	16	8	4	2	1	
	163	128	64	32	16	8	4	2	1									
F15	164									128	64	32	16	8	4	2	1	
	165	128	64	32	16	8	4	2	1									
F16	166									128	64	32	16	8	4	2	1	
	167	128	64	32	16	8	4	2	1									
...	...									128	64	32	16	8	4	2	1	
	...	128	64	32	16	8	4	2	1									
F28	190									128	64	32	16	8	4	2	1	
	191	128	64	32	16	8	4	2	1									

For example:

If you want to use function F2 to activate output 4, CV41 and CV42 will be used for mapping (which configures / maps F2).

Bit3 is used to activate Output 4, its decimal value is 8, so CV41 will be programmed with the value 8, and CV42 with the value of 0.

If we want to use F2 to activate Output3 too, we will add to the previously determined value the corresponding value for Output3 (bit2, with a decimal value 4). CV41 will be programmed with the sum of  $4 + 8 = 12$ . If Out13 and 14 will be used with F2, the corresponding bits are bit4 and bit5 in CV42, with the values 16 and 32, thus CV42 will be programmed with the value  $16 + 32 = 48$ .

For functions F0 and F1, 4 CVs are used for mapping, two for each travel direction. F0 is factory configured in such a way that all outputs are activated for both directions. F1 is factory configured to activate Output1 for both directions.

### 4.4 DC operation

When powered on the decoder will check if DCC signal is present on the track and execute the received commands. If DC voltage is present on the track for more than a timeout period, the decoder will switch to analog mode and will turn on the functions configured in CV13 and CV14. The timeout period is set in CV11, and it is equal to CV11 decimal value \* 8ms. The maximal value is 2,048s.

CV12 and CV29 are influencing the decoder behavior related to protocols.

The meaning of CV12 bits is described at the table.

CV12 bit	Value	Working mode (protocol)
0	0	DC mode OFF
	1	DC mode ON
2	0	DCC mode(protocol) OFF
	4	DCC mode(protocol) ON

CV29 bit 2 will turn off the analog conversion if it is set to 0 so the Function Decoder will not switch to analog mode when digital communication is off. For safety reasons, even if bit 0 of CV12 is set to 0 (DCC mode = OFF), CV12 can still be modified over DCC. The DCC programming commands are executed even if DCC digital mode is turned off.

By default the DC analog and DCC operations are activated.

F1+F3+F4+F5 is configured for both travel directions (Bit 2 set in CV29 and CV13 activated for the use of the F functions in both directions.  $CV13 = 1+4+8+16 = 29$ ). When the circuit board is connected to a DC analog voltage, all outputs of the function decoder are switched on.

To switch on other functions in analog DC voltage operation, they must be defined in CV13 and CV14. The mapping of the function must be defined in advance according to the steps described in the table below. So only the functions F0, and F1-F14 can be used in DC operation.

	F0 fwd.	F0 rev	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14
bit	0	1	0	1	2	3	4	5	6	7	2	3	4	5	6	7
CV13			1	2	4	8	16	32	64	128						
CV14	1	2									4	8	16	32	64	128

#### 4.5 Onboard power pack (SPP)

The On-Board Decoder has its own integrated power pack (SPP). The SPP allows the On-Board Decoder to operate up to 20 seconds without power from the rails (depending on the lights consumption and capacitor charge status). The **timeout value** is set in **CV222**, in steps of 80 ms (the default value is 255, CV value \* 80 ms = 20 seconds). When this period expires, in the absence of the track power, even if the SPP is not fully discharged, the decoder will disable all its outputs.

The value set in the CV222 also applies to analogue DC operation. It takes about 30-40 seconds for a full charge, but it can be used after just 20 seconds.

To avoid very high consumption when several SPP modules are used in the same setup (layout) it is strongly recommended to use a **start delay** (different values for each of the decoders). The delay can be set in **CV221** in seconds (value 2=2s), and it represents the time after which the charging of the SPP module will started after the track is powered on. **When multiple decoders are used on the same track, this time should have different values to avoid the simultaneous start-up of all SPPs.**

#### 4.6 Other functions

##### User Data

CV105 and CV106 are two CVs that can be used to save user identifiers (serial number, etc.). The particularity of these two CVs is that after a reset their contents will not be erased.

##### Last command safe

The OnBoard decoder has a feature to save the last function command received. This feature can be activated programming the value 1 in CV152. With this feature activated, the decoder will start up activating the functions that were active before power interruption, even if DCC commands were not received to activate these functions.

##### DCC quality

The DCC Signal Quality Indicator (QoS = Quality of Signal) is saved in CV219 as percentage (in the range 0-100%). The lowest QoS value detected by the decoder from the last reading is written in CV218.

CV223 contains the function number which activation will trigger the saving of the current QoS values into the decoder non-volatile memory (EEPROM). Saving the instantaneous values is done by activating (turn ON and turn OFF) this function from the Command Station (or tOm Programmer). In CV223 the number of the function must be entered (for example for function F28, the value 28 must be entered in CV223).

Without activating the function number given in CV223 (turn On, then Off), the values in the corresponding CVs will not be updated!

**Temperature**

CV216 & 217

Description will follow

**Error Save**

CV30

Description will follow

**Output protection level**

CV99

Description will follow

## 5. Effects for function outputs

### 5.1 Light intensity

The light intensity of the LEDs connected to the outputs of the onboard decoder can be changed individually by changing the values of CV120 to CV135. The factory default value for each of them is the decimal value 255 (maximal intensity). The 255 value in any of these CVs, result in a continuous output at maximum intensity level of the corresponding output.

There are several effects available (which can be extended with further firmware upgrades) their parameters are globally defined in CVs 112-117.

In CV170 the PWM signal frequency used for all outputs is set. The default value is 2 (500 Hz).

CV170 value	Output PWM frequency
0	125 Hz
1	250 Hz
2	500 Hz

### 5.2 Light effects

The effects are configured for each of the outputs in CVs 136-152. The CVs must be programmed

value	effect
0	No effect
1	Fade effect
2	Fluorescent (neon) effect
3	Flickering effect
4	Defective Neon effects
8	Blinking effect, symmetrical
9	Blinking effect, symmetrical, with fade effect
10	Blinking effect, asymmetrical 1/4-ON; 3/4-OFF
11	Blinking effect, asymmetrical 1/4-ON; 3/4-OFF, with fade effect
12	Blinking effect, asymmetrical 3/4-ON; 1/4-OFF
13	Blinking effect, asymmetrical 3/4-ON; 1/4-OFF, with fade effect
14	Blinking effect with custom parameters
15	Blinking effect with custom parameters, random number of blinks
16	Ditch Light 1
17	Ditch Light 2
18	Firebox
32	Turn On Delay (can be added to any other effect)
64	Turn Off Delay (can be added to any other effect)
128	Random sequence generator (can be added to any other effect)

The modules are delivered with the outputs configured for fade operation (CV136 till CV152 are set to value 1).

### 5.2.1 Fade effect

CV112 and CV113 define the progressive On and Off time if the Fade effect is used.  
value 1 = 8ms, 15 = 120ms, 125 = 1000ms

### 5.2.2 Fluorescent (neon) effect

In CV114 the On delay is defined for the neon effect. It can be set from fast (value 0) to slow delay (value 7).

### 5.2.3 Flickering effect

In CV116 the flickering period is given for the flickering lamp effect. It can be set from fast (value 0) to slow flickering (value 7).

### 5.2.4 Defective Neon effects

The Defective Neon effects repetition time can be set in CV117. It can be set from fast (value 0) to slow repetition (value 7)

### 5.2.5 Flashing effects

In this chapter we will use the following abbreviations:

- TTP = Total Time Period (=TPxN)
- TP = Time Period (=TP-ON+TP-OFF)
- TP-ON = Time Period – (Light Pulse) ON
- TP-OFF = Time Period – (Light Pulse) OFF
- N = Number of Time Periods

While the effect is activated with a function, the TTP duration is repeated continuously. Each TTP duration is composed by  $N \times (TP) + \text{pause time}$  and  $TP=TP-ON+TP-OFF$ .

The **effects 8 through 13** have predefined TP-ON and TP-OFF values. These are defined as percentage of TTP (see the table on the previous page). **The value of N is 1, so TTP=TP.** Therefore, the only user accessible parameter is the TTP.

At the effects 14 and 15, each of the parameters (TTP, TP-ON, TP-OFF and N) can be set individually for each output. The pause time will be calculated automatically (pause time exist only if  $TTP > 1 + N \times TP$ ).

CV - TTP	101	Blink Effect period
CV - TP-ON	102	Blink Effect Pulse length
CV - TP-OFF	103	Blink Effect Pause length
CV - N	104	Blink Effect repetition number

All time durations are counted like "Value" x 8ms. Consequently, that means that the maximum TTP is  $255 * 8ms = 2040ms = 2.04s$ .

### 5.2.5.1 Symmetrical / asymmetrical flashing effect

With the **symmetrical** flashing effect, you get an equal on/off blinking time with period equal to TTP, so TP=TTP.

If you want to have an instant blinking you need to program effect number 8, for using the fade IN/OUT effect number 9 must be used (table chapter 5.2). **TP-ON** and **TP-OFF** is 50% TTP.

The time duration is defined at CV - TTP (table 5.2.5).

The fade time will be defined at CV112 and CV113 (see 5.2.1).

With the **assymmetrical** flashing effect you get an unequal on/off blinking time with TP=TTP.

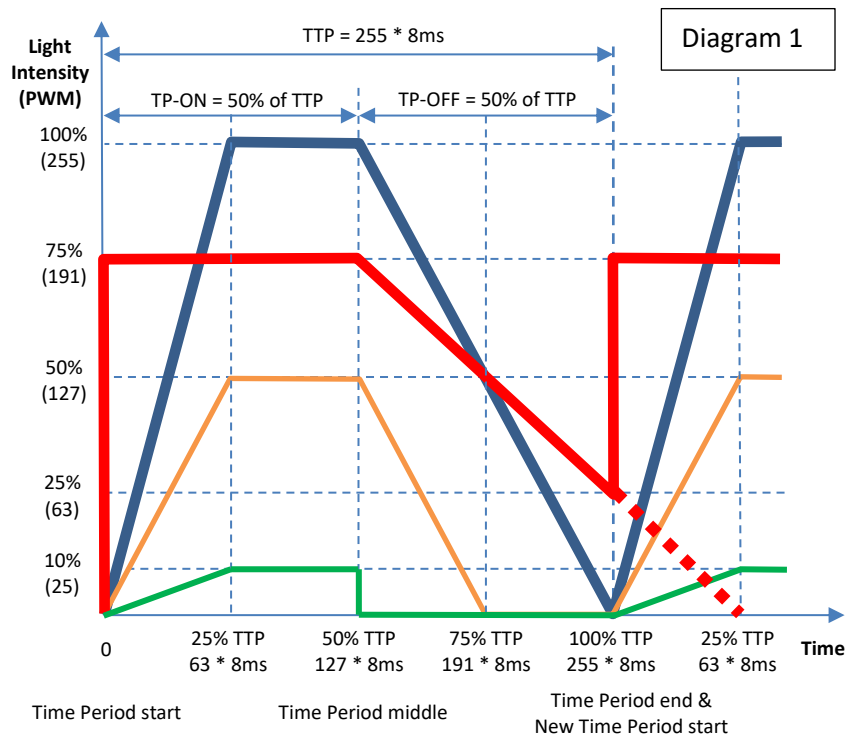
- If you want to have a 25% TP-ON; 75% TP-OFF of TTP instant blinking you need to program effect number 10, for the same with fade IN/OUT effect number 11.
- If you want to have a 75% TP-ON; 25% TP-OFF of TTP instant blinking you need to program effect number 12, for the same with fade IN/OUT effect number 13.

The time duration is defined at CV - TTP (table 5.2.5).

The fade time will be defined at CV112 and CV113 (see 5.2.1).

#### Fade effect:

If you use the effects 9, 11 and 13 there will be a delay between the ON command and the moment the LED will reach the prescribed light intensity and there will be a delay between the OFF command and the moment when the LED will be completely off. For a better understanding of Diagram 1 is illustrating the above behaviour for effect 9 with different light intensity and fade-in/out settings.



- The blue trace has the settings (AUX1): CV112=63 (fade in), CV113=126 (fade out), CV120 (PWM)=255 and CV125=255 TTP
- The orange trace has the settings (AUX1): CV112=63 (fade in), CV113=63 (fade out), CV120 (PWM)=127 and CV125=255 TTP
- The green trace has the settings (AUX1): CV112=63 (fade in), CV113=0 (fade out), CV120 (PWM)=25 and CV125=255 TTP
- The red trace has the settings (AUX1): CV112=0 (fade in), CV113=191 (fade out), CV120 (PWM)=191 and CV125=255 TTP

### Detailed explanation of diagram 1:

The examples are all based on a TTP=255 with effect 9 (symmetrical flashing (TP-ON&TP-OFF 50% of TTP) effect with fade IN/OUT) on AUX1.

The **blue** trace:

- The **PWM value (CV120)** is 255.
- It reaches the maximum PWM of 255 in the set **fade in value (CV112)** = 63, so 504ms.
- It begins to fall at 50% TTP and reaches PWM=0 after the **fade out (CV113)** set time of 126=1008ms.

The **orange** trace:

- The **PWM value (CV120)** is 127.
- It reaches the maximum PWM of 127 in the set **fade in value (CV112)** = 63, so 504ms.
- It begins to fall at 50% TTP and reaches PWM=0 after the **fade out (CV113)** set time of 63=504ms.

The **green** trace:

- The **PWM value (CV120)** is 25.
- It reaches the maximum PWM of 25 in the set **fade in value (CV112)** = 63, so 504ms.
- It begins to fall at 50% TTP and reaches PWM=0 instant, because the set **fade out value (CV113)** = 0.

The **red** trace:

- The **PWM value (CV120)** is 191.
- It reaches the max. PWM of 191 instantly, because the set **fade in value (CV112)** = 0.
- It begins to fall at 50% TTP and reaches PWM=0 **NOT** because the **fade out (CV113)** is set at **value 191**.
- If the **fade in or fade out value is higher then it's percentage of TTP** (in that case 50%), **the trace stops to fall at this point where the time runs out**. This can be used for a pulsing light for example. In that case the lowest PWM is at 25%, before it starts to rise again.

### 5.2.5.2 Custom flashing effect

#### Custom flashing effect with defined number of blinks

With the custom flashing effect (CV136=14) you can define TTP, TP-ON, TP-OFF and N independently following certain constrictions.

There are some rules and limits to consider:

The TTP value should be counted as minimum of  $1 + N * TP$ . If TTP is equal or smaller than that value, the output will be continuously on with a short light dip at the end of the sequence.

TP-ON and TP-OFF values should be bigger than value 2, to have a visible effect. 16ms are difficult to notice. If TP-ON = 0 then the output (LED) will be always off and if TP-OFF = 0 then the output (LED) will be always on.

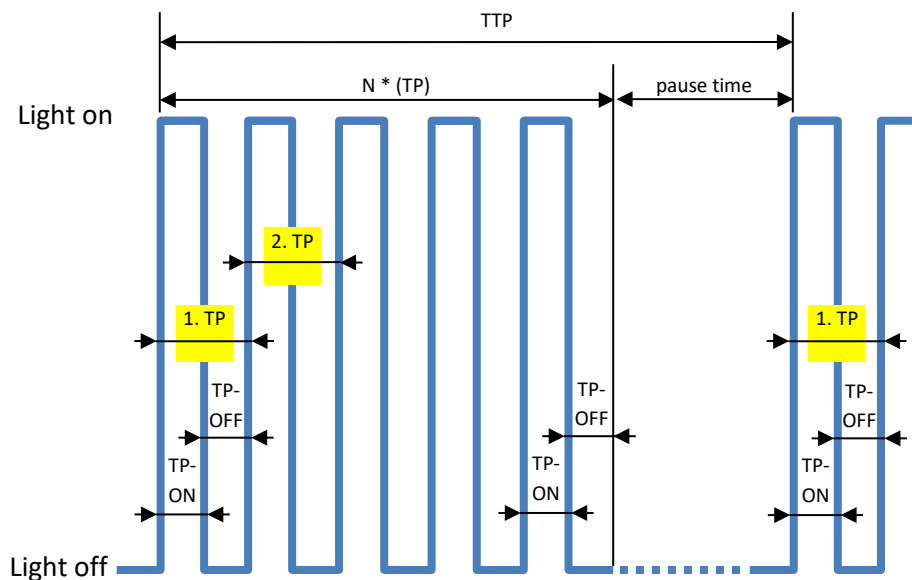


Diagram 2,  $TTP > 1 + N * TP$ ;  $TP-ON = TP-OFF$  and  $N=5$  (remember  $TP=TP-ON+TP-OFF$ )

The CV assignment of the parameters to the respective outputs can be found in the table from chapter 5.2.5.

When an effect is set up and turned on it will run in loop, as you can see in Diagram 2, until it is turned off.

Please notice that if  $TTP > 1 + N * TP$  than after requested pulses are shot, it will be a pause time until the next sequence starts over.

If  $TTP = 1 + N * TP$  than the new sequence will start at once after the last TP is over.

#### Custom flashing effect with random number of blinks

The Custom flashing effect with random number of blinks (CV136=15) is the nearly the same as the "normal" custom flashing effect. The only difference is that the number of sequences "N" will be generated randomly by the software.

### **5.3 Random sequence generator function**

If you are activating the random sequence generator function for an output, it will switch on and off without the need of switching on and off a function.

To select an output for the random sequence, the value 128 (bit 7) of the individual output effect CVs must be set.

**The switching period of the random sequence is defined in CV115 in the range of 1-255 seconds.** As a result, after each elapse of the random period, the state of the outputs which have the random effect activated will change to a new on/off state, which is random based. It gives a very realistic effect to a carriage, when rolling on the track, and some of the compartment lights are switched on, or off.

The number of random states increases dramatically with the increase of the outputs selected for this function. We recommend the use of 2-4 of the outputs with the random sequence to get an efficient visual effect.

### **5.4 Turn On/Off Delay**

All outputs can be turned on and/or off with a delay specified in CV111 (turn on delay) and CV110 (turn off delay). These delays are common for all outputs and can be set in 8ms steps. The maximal possible delay value is  $8 \cdot 255 = 2040$  ms, approximately 2 second.

The switching on and off for each of the effects applied to an output can be executed with a delay. In the case of using the delay option on a certain output, the output will be activated after receiving the activation command (Function) with a delay time set in CV111, and will be deactivated after receiving the deactivation command (Function) with a delay time set in CV110.

## 6. CV table

In the table on the following pages are listed all the CVs of the Decoder. We recommend that you change the CV values only if you are sure of their function and the impact of your action. Incorrect CV settings can negatively affect the performance of the Decoder or cause incorrect responses to the commands transmitted from the command station.

The "Factory Default Values" column contains the "factory" value of the CVs (after a decoder reset, all CVs will have the appropriate value in this column), the column "Value Range" contains the range of usable values for each CV and the "Description" column contains the name (if there is an established name) and information about the CV function.

CV	Default value	Value range	Description			
1	3	0-127	Decoder Address Short, 7 bits			
7	1	-	Software Version (only readable)			
8	78	8	Manufactured ID/RESET (readable 78 = train-O-matic, Write value 8 to reset the decoder to the factory default values)			
11	25	0-255	Packet time-out value = CV11 * 8ms (default time = 200ms)			
12	5	0-255	Power source conversion, DCC and DC mode enabled			
13	29 = 1 +  4 + 8 + 16	0-255	Analog Mode, Alternate Mode Function Status F1 - F8			
			Bit 0	0	(0)	F1 not active
				1	(1)	F1 active
			Bit 1	0	(0)	F2 not active
				1	(2)	F2 active
			Bit 2	0	(0)	F3 not active
				1	(4)	F3 active
			Bit 3	0	(0)	F4 not active
				1	(8)	F4 active
			Bit 4	0	(0)	F5 not active
				1	(16)	F5 active
			Bit 5	0	(0)	F6 not active
				1	(32)	F6 active
			Bit 6	0	(0)	F7 not active
				1	(64)	F7 active
			Bit 7	0	(0)	F8 not active
1	(128)	F8 active				
14	0	0-255	Analog Mode, Alternate Mode Function. Status F0f, F0r, F9 - F14,			
			Bit 0	0	(0)	F0 forward not active
				1	(1)	F0 forward active
			Bit 1	0	(0)	F0 revers not active
				1	(2)	F0 revers active
			Bit 2	0	(0)	F9 not active
				1	(4)	F9 active
			Bit 3	0	(0)	F10 not active
				1	(8)	F10 active
			Bit 4	0	(0)	F11 not active
				1	(16)	F11 active
			Bit 5	0	(0)	F12 not active
				1	(32)	F12 active
			Bit 6	0	(0)	F13 not active
				1	(64)	F13 active
			Bit 7	0	(0)	F14 not active
1	(128)	F14 active				
15	0	0-7	Lock Value: Enter the value to match Lock ID in CV16 to unlock CV programming. No action and no ACK will be performed by the decoder when Lock Value is different than Lock ID. In this situation only CV15 write is allowed.			
16	0	0-7	Lock ID: To prevent accidental programming use unique ID number for decoders with same address (0-7) like 1-loco decoder, 2-sound decoder, 3-Function Decoder, ...			
17	195	192-255	Extended Address, Address High			
18	232	0-255	Extended Address, Address Low			

CV	Default value	Value range	Description																																																								
19	0	0-127	Consist Address If CV19 > 0: Speed and direction is governed by this consist address (not the individual address in CV #1 or #17+18); functions are controlled by either the consist address or individual address, see CV21 & CV22.																																																								
20	0	0-102	Long Consist Address, High Byte (upper 2-3 digits of address, 000xx-102xx)																																																								
21	0	0-255	<p>Functions defined here will be controlled by the consist address.</p> <table border="1"> <tr> <td rowspan="2">Bit 0</td> <td>0</td> <td>(0)</td> <td>F1 for individual address</td> </tr> <tr> <td>1</td> <td>(1)</td> <td>F1 for consist address</td> </tr> <tr> <td rowspan="2">Bit 1</td> <td>0</td> <td>(0)</td> <td>F2 for individual address</td> </tr> <tr> <td>1</td> <td>(2)</td> <td>F2 for consist address</td> </tr> <tr> <td rowspan="2">Bit 2</td> <td>0</td> <td>(0)</td> <td>F3 for individual address</td> </tr> <tr> <td>1</td> <td>(4)</td> <td>F3 for consist address</td> </tr> <tr> <td rowspan="2">Bit 3</td> <td>0</td> <td>(0)</td> <td>F4 for individual address</td> </tr> <tr> <td>1</td> <td>(8)</td> <td>F4 for consist address</td> </tr> <tr> <td rowspan="2">Bit 4</td> <td>0</td> <td>(0)</td> <td>F5 for individual address</td> </tr> <tr> <td>1</td> <td>(16)</td> <td>F5 for consist address</td> </tr> <tr> <td rowspan="2">Bit 5</td> <td>0</td> <td>(0)</td> <td>F6 for individual address</td> </tr> <tr> <td>1</td> <td>(32)</td> <td>F6 for consist address</td> </tr> <tr> <td rowspan="2">Bit 6</td> <td>0</td> <td>(0)</td> <td>F7 for individual address</td> </tr> <tr> <td>1</td> <td>(64)</td> <td>F7 for consist address</td> </tr> <tr> <td rowspan="2">Bit 7</td> <td>0</td> <td>(0)</td> <td>F8 for individual address</td> </tr> <tr> <td>1</td> <td>(128)</td> <td>F8 for consist address</td> </tr> </table>	Bit 0	0	(0)	F1 for individual address	1	(1)	F1 for consist address	Bit 1	0	(0)	F2 for individual address	1	(2)	F2 for consist address	Bit 2	0	(0)	F3 for individual address	1	(4)	F3 for consist address	Bit 3	0	(0)	F4 for individual address	1	(8)	F4 for consist address	Bit 4	0	(0)	F5 for individual address	1	(16)	F5 for consist address	Bit 5	0	(0)	F6 for individual address	1	(32)	F6 for consist address	Bit 6	0	(0)	F7 for individual address	1	(64)	F7 for consist address	Bit 7	0	(0)	F8 for individual address	1	(128)	F8 for consist address
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28	-	-	Reserved																																																								
29	6 = 2 + 4	0-63	<p>Configuration Data</p> <table border="1"> <tr> <td rowspan="2">Bit 0</td> <td>0</td> <td>(0)</td> <td>Driving Direction normal</td> </tr> <tr> <td>1</td> <td>(1)</td> <td>Driving Direction reversed</td> </tr> <tr> <td rowspan="2">Bit 1</td> <td>0</td> <td>(0)</td> <td>14 speed steps</td> </tr> <tr> <td>1</td> <td>(2)</td> <td>28/128 speed steps</td> </tr> <tr> <td rowspan="2">Bit 2</td> <td>0</td> <td>(0)</td> <td>Power Source Conversion NMRA Digital Only (only DCC)</td> </tr> <tr> <td>1</td> <td>(4)</td> <td>Power Source Conversion Enabled (DC + DCC)</td> </tr> <tr> <td rowspan="2">Bit 3</td> <td>0</td> <td>(0)</td> <td>Bi-Directional Communications (Rail-Com) disabled</td> </tr> <tr> <td>1</td> <td>(8)</td> <td>Bi-Directional Communications (Rail-Com) enabled</td> </tr> <tr> <td rowspan="2">Bit 5</td> <td>0</td> <td>(0)</td> <td>One byte addressing (short addressing at CV1)</td> </tr> <tr> <td>1</td> <td>(32)</td> <td>Two bytes addressing (extended/long addressing)</td> </tr> </table>	Bit 0	0	(0)	Driving Direction normal	1	(1)	Driving Direction reversed	Bit 1	0	(0)	14 speed steps	1	(2)	28/128 speed steps	Bit 2	0	(0)	Power Source Conversion NMRA Digital Only (only DCC)	1	(4)	Power Source Conversion Enabled (DC + DCC)	Bit 3	0	(0)	Bi-Directional Communications (Rail-Com) disabled	1	(8)	Bi-Directional Communications (Rail-Com) enabled	Bit 5	0	(0)	One byte addressing (short addressing at CV1)	1	(32)	Two bytes addressing (extended/long addressing)																					
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30	0	0/1	Error CV. If the read-out value is "1", an overcurrent event occurred since the last reset. The value can be cleared with programming "0" to CV30																																																								

CV	Default value	Value range	Description			
33	0	0-255	F0, forward move mapping			
			Bit 0	0	(0)	AUX1 not active
				1	(1)	AUX1 active
			Bit 1	0	(0)	AUX2 revers not active
				1	(2)	AUX2 active
			Bit 2	0	(0)	AUX3 not active
				1	(4)	AUX3 active
			Bit 3	0	(0)	AUX4 not active
				1	(8)	AUX4 active
			Bit 4	0	(0)	AUX5 not active
				1	(16)	AUX5 active
			Bit 5	0	(0)	AUX6 not active
				1	(32)	AUX6 active
			Bit 6	0	(0)	AUX7 not active
				1	(64)	AUX7 active
Bit 7	0	(0)	AUX8 not active			
	1	(128)	AUX8 active			
34		0-255	Reserved			
35	0	0-255	F0, backward move mapping, same bit meaning with CV33			
36		0-255	Reserved			
37	1	0-255	F1 forward move mapping, same bit meaning with CV33			
38		0-255	Reserved			
39	1	0-255	F1, backward move mapping, same bit meaning with CV33			
40		0-255	Reserved			
41	0	0-255	F2 mapping, same bit meaning with CV33			
40		0-255	Reserved			
43	170	0-255	F3 mapping, same bit meaning with CV33			
44		0-255	Reserved			
45	68	0-255	F4 mapping, same bit meaning with CV33			
46		0-255	Reserved			
47	16	0-255	F5 mapping, same bit meaning with CV33			
48		0-255	Reserved			
49	0	0-255	F6 mapping, same bit meaning with CV33			
50		0-255	Reserved			
51	0	0-255	F7 mapping, same bit meaning with CV33			
52		0-255	Reserved			
53	0	0-255	F8 mapping, same bit meaning with CV33			
54		0-255	Reserved			
55	0	0-255	F9 mapping, same bit meaning with CV33			
56		0-255	Reserved			
57	0	0-255	F10 mapping, same bit meaning with CV33			
58		0-255	Reserved			
59	0	0-255	F11 mapping, same bit meaning with CV33			
60		0-255	Reserved			
61	0	0-255	F12 mapping, same bit meaning with CV33			
62		0-255	Reserved			
99	31	4-47	Output protection level			
101	127	0-255	Blink Effect period			
102	2	0-255	Blink Effect Pulse length			
103	12	0-255	Blink Effect Pause length			
104	3	0-255	Blink Effect repetition number			
105	255	0-255	User data (not affected by decoder reset)			
106	255	0-255	User data (not affected by decoder reset)			
110	25	0-255	Output switching off delay time			
111	25	0-255	Output switching on delay time			
112	25	1-127	Fade IN Light Effect delay, in 8ms steps (default 200ms)			
113	15	1-127	Fade OUT Light Effect delay, in 8ms steps (default 120ms)			
114	3	0-7	Fluorescent Tube Start, Blinking Delay 1-÷8 delay step [0 ÷ 7]			
115	10	1-255	Random Time Period, 1s ÷ 255s			
116	3	0-7	Flicker Period: Fast-Slow 0 ÷ 7			
117	3	0-7	Defective Neon effects repetition time, 0 fast repetition, 7 slow repetition			
118	64	0-255	Second configuration CV			
			Bit 6	0	(0)	LED's signalling during boot-load operation disabled
				1	(64)	LED's signalling during boot-load operation enabled

CV	Default value	Value range	Description																																								
119		0-255	Reserved																																								
120	128	0-255	AUX1 Light intensity																																								
121	128	0-255	AUX2 Light intensity																																								
122	128	0-255	AUX3 Light intensity																																								
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136	1	0-255	Effect for AUX1: <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>value</th> <th>effect</th> </tr> </thead> <tbody> <tr><td>0</td><td>No effect</td></tr> <tr><td>1</td><td>Fade effect</td></tr> <tr><td>2</td><td>Fluorescent (neon) effect</td></tr> <tr><td>3</td><td>Flickering effect</td></tr> <tr><td>4</td><td>Defective Neon effects</td></tr> <tr><td>8</td><td>Blinking effect, symmetrical</td></tr> <tr><td>9</td><td>Blinking effect, symmetrical, with fade effect</td></tr> <tr><td>10</td><td>Blinking effect, asymmetrical 1/4-ON; 3/4-OFF</td></tr> <tr><td>11</td><td>Blinking effect, asymmetrical 1/4-ON; 3/4-OFF, with fade effect</td></tr> <tr><td>12</td><td>Blinking effect, asymmetrical 3/4-ON; 1/4-OFF</td></tr> <tr><td>13</td><td>Blinking effect, asymmetrical 3/4-ON; 1/4-OFF, with fade effect</td></tr> <tr><td>14</td><td>Blinking effect with custom parameters</td></tr> <tr><td>15</td><td>Blinking effect with custom parameters, random number of blinks</td></tr> <tr><td>16</td><td>Ditch Light 1</td></tr> <tr><td>17</td><td>Ditch Light 2</td></tr> <tr><td>18</td><td>Firebox</td></tr> <tr><td>32</td><td>Turn On Delay (can be added to any other effect)</td></tr> <tr><td>64</td><td>Turn Off Delay (can be added to any other effect)</td></tr> <tr><td>128</td><td>Random sequence generator (can be added to any other effect)</td></tr> </tbody> </table>	value	effect	0	No effect	1	Fade effect	2	Fluorescent (neon) effect	3	Flickering effect	4	Defective Neon effects	8	Blinking effect, symmetrical	9	Blinking effect, symmetrical, with fade effect	10	Blinking effect, asymmetrical 1/4-ON; 3/4-OFF	11	Blinking effect, asymmetrical 1/4-ON; 3/4-OFF, with fade effect	12	Blinking effect, asymmetrical 3/4-ON; 1/4-OFF	13	Blinking effect, asymmetrical 3/4-ON; 1/4-OFF, with fade effect	14	Blinking effect with custom parameters	15	Blinking effect with custom parameters, random number of blinks	16	Ditch Light 1	17	Ditch Light 2	18	Firebox	32	Turn On Delay (can be added to any other effect)	64	Turn Off Delay (can be added to any other effect)	128	Random sequence generator (can be added to any other effect)
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64	Turn Off Delay (can be added to any other effect)																																										
128	Random sequence generator (can be added to any other effect)																																										
137	1	0-255	Effect for AUX2: same bit meaning with CV136																																								
138	1	0-255	Effect for AUX3: same bit meaning with CV136																																								
139	1	0-255	Effect for AUX4: same bit meaning with CV136																																								
140	1	0-255	Effect for AUX5: same bit meaning with CV136																																								
141	1	0-255	Effect for AUX6: same bit meaning with CV136																																								
142	1	0-255	Effect for AUX7: same bit meaning with CV136																																								
143	1	0-255	Effect for AUX8: same bit meaning with CV136																																								
144		0-255	Reserved																																								
145		0-255	Reserved																																								
146		0-255	Reserved																																								
147		0-255	Reserved																																								
148		0-255	Reserved																																								
149		0-255	Reserved																																								
150		0-255	Reserved																																								
151		0-255	Reserved																																								
152	0	0-1	Save Last State: 0 – saving is disabled; 128 – saving is enabled																																								

CV	Default value	Value range	Description			
160	0	0-255	F13 mapping			
			Bit 0	0	(0)	AUX1 not active
				1	(1)	AUX1 active
			Bit 1	0	(0)	AUX2 revers not active
				1	(2)	AUX2 active
			Bit 2	0	(0)	AUX3 not active
				1	(4)	AUX3 active
			Bit 3	0	(0)	AUX4 not active
				1	(8)	AUX4 active
			Bit 4	0	(0)	AUX5 not active
				1	(16)	AUX5 active
			Bit 5	0	(0)	AUX6 not active
				1	(32)	AUX6 active
			Bit 6	0	(0)	AUX7 not active
				1	(64)	AUX7 active
Bit 7	0	(0)	AUX8 not active			
	1	(128)	AUX8 active			
161		0-255	Reserved			
162	0	0-255	F14 mapping, same bit meaning with CV160			
163		0-255	Reserved			
164	0	0-255	F15 mapping, same bit meaning with CV160			
165		0-255	Reserved			
166	0	0-255	F16 mapping, same bit meaning with CV160			
167		0-255	Reserved			
168	0	0-255	F17 mapping, same bit meaning with CV160			
169		0-255	Reserved			
170	0	0-255	F18 mapping, same bit meaning with CV160			
171		0-255	Reserved			
172	0	0-255	F19 mapping, same bit meaning with CV160			
173		0-255	Reserved			
174	0	0-255	F20 mapping, same bit meaning with CV160			
175		0-255	Reserved			
176	0	0-255	F21 mapping, same bit meaning with CV160			
177		0-255	Reserved			
178	0	0-255	F22 mapping, same bit meaning with CV160			
179		0-255	Reserved			
180	0	0-255	F23 mapping, same bit meaning with CV160			
181		0-255	Reserved			
182	0	0-255	F24 mapping, same bit meaning with CV160			
183		0-255	Reserved			
184	0	0-255	F25 mapping, same bit meaning with CV160			
185		0-255	Reserved			
186	0	0-255	F26 mapping, same bit meaning with CV160			
187		0-255	Reserved			
188	0	0-255	F27 mapping, same bit meaning with CV160			
189		0-255	Reserved			
190	0	0-255	F28 mapping, same bit meaning with CV160			
191		0-255	Reserved			
216	-	0-255	Actual temperature (available only after first activation of function from CV223)			
217	100	0-255	Temperature limit			
218	100	0-100	Worst QoS (Quality of Signal) value, saved by activating then deactivating function set in CV223. Read only			
219	100	0-100	QoS (Quality of Signal) current value, saved activating then deactivating function set in CV223. Read only			
220	-	-	Reserved			
221	1	0-255	SPP (Smart Power Pack) start delay in seconds, default 1s			
222	255	0-255	SPP (Smart Power Pack) Timeout=80ms * Value. Ex: 80ms * 20 = 1,6s. Default value = 20,4s			
223	28	0-255	Special function key to save QoS and temperature (default F28)			
226	2	0-2	Software PWM Outputs frequency (0 = 125 Hz, 1 = 250 Hz, 2 = 500 Hz)			
227	2	0-7	Hardware PWM Outputs frequency 38Hz – 38KHz, default 610Hz			