FD micro Function Decoder

User Manual

– version 0.0.6 –

by

Please read this manual carefully before proceeding with the product installation!!! Even if our products are very robust, incorrect wiring and/or usage may damage the module!

Normal operation of the product requires that the defined technical parameters to be met.

During storage, installation and operation keep the product in dry environment and away of direct sunshine.

A soldering tool may be necessary for the installation and/or mounting of the devices, which requires special care.

When installing the product, if it is not protected with heat shrinkable tube, make sure that no side of the board is in contact with conductive materials.

Contents

1. Important information

Please read this first chapter

- FD micro decoders are designed exclusively for use in model trains. Any other use is forbidden.
- Any connection must be made without the connected power supply. Please make sure that during installation, the locomotive is not powered, not even accidentally.
- Avoid applying blows or mechanical pressure on the decoder.
- Do not remove the heat shrink tube from the decoder (on models fitted with a protective sleeve).
- Ensure that neither the FD micro decoder nor the unused wires do not come into electrical contact with the locomotive chassis (short-circuit risk). Insulate the ends of any unused wires.
- Do not solder extension cables on the decoder circuit board except in cases strictly necessary (connections to sound modules, power packs).
- It is forbidden to wrap the decoder in an insulating tape, as this may cause overheating.
- Observe the wiring of the decoder and any external components as recommended in this manual. Wrong wiring / connection can cause damage to the FD micro decoder.
- Make sure that there is no wires trapped by the locomotive transmission system when reassembling it.
- Any power source used must be protected by fuse or electronics to avoid any danger that may arise in a short circuit. Use only transformers or power supplies specially designed for electric trains.
- Do not let FD micro decoders to be used by unattended children. FD micro decoders are not a toy.
- Do not use FD micro decoders in wet environments

2. Abbreviations

DCC	-	Digital Command Control
DC	-	Direct Current
NMRA	-	National Model Railroad Association
CV	-	Configuration Variable
PT	-	Programming Track
PoM	-	Programming On the Main
MSB	-	Most Significant Byte (or Bit)
LSB	-	Least Significant Byte (or Bit)
FL	-	Front Light
RL	-	Rear Light
SPP	-	Smart Power Pack
n.c.	-	not connected

3. User manual contents

We congratulate you for purchasing a FD micro decoder. This manual is divided into several chapters, which show you step-by-step how to install and customize a FD micro decoder. Chapter 4 and 5 provide an overview of the features and parameters of the decoders. Chapter 6 contains the general description of the decoders. Chapter 7 describes in detail the installation of decoders in locomotives. Please familiarize yourself with the type of engine and the type of interface existing in the locomotive before going through this chapter. FD micro decoders can be operated with most commercially available control systems for electric train models.

Factory default values for configuration variables (CVs) and functions are found in Chapter 9. You can change the default settings of your FD micro decoder as desired. Chapters 10 - 16 explain configurable parameters, and how to customize them. We recommend reading the chapters 10-12 for setting the address and engine control parameters to be able to customize the decoder for your locomotive optimally.

Chapter 26 contains all the CVs of the decoders.

4. Main features

- NMRA compliant Generic DCC mobile function decoder (no motor drive capability)
- PT or PoM programming modes
- Operation even in analog mode (DC), with configurable active functions
- Short (1-127) and long (128-9999) configurable addresses
- 14, 28/128 speed steps
- Two power outputs with integrated LEDs current limiter resistor (active low outputs, with consumer connected between output and common plus)
- For logic level outputs for LEDs (active high outputs, with consumer connected between output and ground)
- Multiple effects available for each output
- Output Mapping to functions F0, F1-F28
- Bidirectional communication RAILCOM
- SUSI© interface available on Out3, Out4
- Outputs configurable for Smart Power Pack (SPP ©) control
- Upgradable software via the programmer, even with the decoder mounted in the locomotive
- Reduced dimensions allow for use on the scale H0, TT and N

5. Technical specifications

- Supply voltage range: 4 ÷ 24Vdc or 4 ÷ 20Vac
- Withstand for short time to 38Vdc
- Stand by current (all outputs off): < 10 mA
- Maximum current for each output: 200 mA
- Maximum current consumption @16Vdc: 40mA (all LEDs ON)
- Decoder size is as in Table 1*: FD Micro variants*
- Weight: 4÷6 g
- Protection class: IP00
- Operating temperature: 0 ºC ÷ +60 ºC
- Storage temperature: -20 ºC ÷ +60 ºC
- Humidity: max 85 % non-condensing

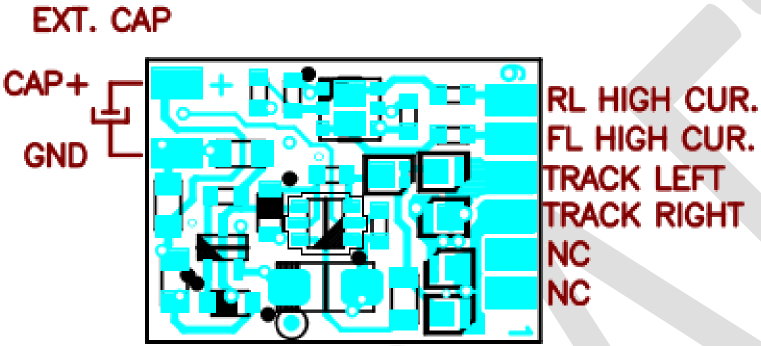
6. General description of FD Micro decoders

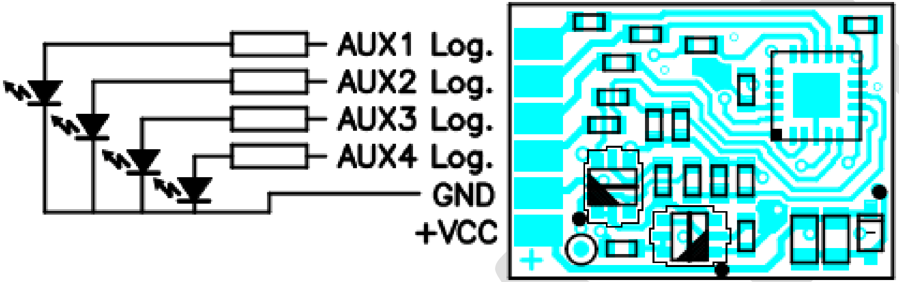
FD Micro function decoders are designed to be used in Z, N, TT, H0, H0e scale models. The different models are differentiated by the connector type. From functional and programming point of view they are identical.

From the following table you can find the identification code for each FD micro variant.

Table 1: FD Micro variants

Connector - wires	tOm order code	Dimensions without connector
NEM651 straight	02010106	14x9x3,3mm
NEM651 in angle	02010107	14x9x3,3mm
NEM651 + 4 Wires	02010108	14x9x3,3mm
5 Wires	02010109	14x9x3,3mm
NEM652 + 5 Wires	02010110	14x9x3,3mm
NEXT18 + 10 Wires	02010111	14,2x9,2x3mm
2 Wires	02010112	14,2x9,2x3mm


EXT. CAP
CAP+
GND
RL HIGH CUR.
FL HIGH CUR.
TRACK LEFT
TRACK RIGHT
NC
NC


AUX1 Log.
AUX2 Log.
AUX3 Log.
AUX4 Log.
GND
+VCC

7. Decoder installation

Before installing a digital decoder, especially in older used models, it is a good idea to make sure that the model is operating properly in DC. To do this, perform the following operations:

- Clean the wheels and the blades
- Check the motor condition, measure the idle current of the motor powered by 5-10V, which should not exceed 200÷300mA, if necessary clean the brushes and the collector.
- Check the transmission system, if necessary, clean and lubricate the axes and the sprockets.
- If the locomotive is equipped with light bulb, check if they are rated to 16V. Replace them if necessary.

In the case of locomotives prepared for digitization, the installation of the decoders equipped with the standard connectors (NEXT18, NAM651, NEM652) is done by extracting the dummy module for analog operation from the connector on the motherboard. In the thus released connector, insert the decoder by following the key (INDEX) or follow the instructions received with the locomotive.

The NEXT18, NEM 651 and NEM652 decoders can be inserted in wrong position (180º rotated). None of the decoders will get defective, but they will malfunction or not function at all as shown below:

- NEXT18 – Will work but travel direction and directional lights will be reversed
  NEM651 – Will not work at all
  NEM652 – The travel direction will be reversed, and the directional lights will not work

In the DC locomotives that are not prepared for digitization, a wired decoder (which has only connection wires) must be chosen and installed. The wires are color coded (as in the NMRA standard), the connections will be as shown in the following drawing.

For Out1 (FL) and Out2 (RL) the common will be connected to Common V+. For Out3 … Out6 the common will be connected to GND. These connections are available in standard connector pins, wires, or soldering pads, as illustrated in above pictures.

The Light Emitting Diodes (LED) are polarity sensitive. Connecting them in the wrong way will not damage either the decoder or the LED but the LED will not light

8. Setting up the decoder

Before connecting to the digital Command Station please make sure that:

- All connections were made in the right way
- There are no short circuits or loose/poor connections
- The wiring is not touching moving parts

If the decoder that is to be programmed is already installed in a locomotive, it is recommended to power it on placed on a programming track assuring that it is the only one connected.

The first action after powering on is to perform a reset (write any value but not 128 in CV8) to make sure that factory default values are loaded and to set the desired new address in CV1. The decoder comes with default address 3 that can be changed also to extended address (see Decoder address).

During the read/write process the Command Station is sending the requests and the decoder is sending back an acknowledge pulse that must be >100mA. In very few cases the 100mA is not reached so the Command Station cannot receive the confirmation. CV132 is used to increase the acknowledgement current pulse. Switching bits to 1 will turn on the specific output, so more current will be drawn from the locomotive.

9. Decoder address

The Function decoder support either short address (1÷127) or long address (1÷9999). The factory default address is short (CV29 factory default value is 10 so bit 5 = "0") and the address is 3 (CV1 = 3).

The decoder address is stored in CV1 and can be changed with the Command Station.

To change the decoder address to long format, set Bit 5 of CV29 to "1". In this way the decoder will have the long address stored in CV17 and CV18.

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, remaining = 208)
- Add 192 to the result and program it in CV17 (7 + 192 = 199; program the value of 199 in CV17)
- Program the value of the remaining of the division in CV18 (program the value of 208 in CV18)

Program CV 29 the last one after the long address is stored in CV17 and CV18. After programming the 3 CVs as described above, the decoder can be accessed with the address 2000. Change bit 5 of CV29 to "0" to switch back to short address mode.

When a value is written in CV1, the consist address will be automatically deleted, and the extended address will be automatically disabled!

9.1. Consist address

Consists address is used for trains with more than one motor decoder (and motors). The Command Station must be able to send individual commands as well as global commands to the decoders in the multi-motor trains.

The Function decoders support 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. All other functions will be performed while they are sent to the base address (defined in CV1 or CV17/CV18).

Functions in CV21(F8-F1), CV22(F12-F9, F0R, F0F) will not be performed if they are transmitted to the base address. For bit value “0” the function will only be enabled with the individual address, for value 1 the function will only be enabled with the consist address (see The decoder CV table).

Example: if we want to use F0F, F0R, F3 and F4 with consist address, the following values are to be written in CV21 = 12 (00001100) and in CV22 = 3 (00000011).

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.

Only functions F0, F1÷F12 can be used in consist mode. The speed steps setting in CV29 must match the speed step setting of the command station for both base and consist addresses.

10. Resetting the decoder

The default Configuration variables (CVs) values can be found in **The decoder CV table**. Most of the values can be changed by the user. Programing any value in CV8 will reset the Function Decoder to factory default CVs.

11. Function Mapping

The assignment between Functions and Outputs is known as Function Mapping. The Function Decoder supports Standard and Extended Function Mapping, and this can be changed with CV96 as follows: CV96 = 1 (default) means Standard Function Mapping, CV96 = 6 means Extended Function Mapping.

11.1. Standard Function Mapping

The ~~NME~~ FD micro Function Decoder is configured by default to use a Standard Function Mapping. Each Function (from F0 to F28) can be used to activate ~~one or both~~ any combination of Outputs. The configuration is performed by programming the corresponding bits in CV33÷CV62.

The decoder has a total of 6 outputs and each Function Mapping requires one CV. For the light function (F0) the mapping can be defined separately for each travel direction so 2 CVs are used. The other functions (F1÷F28) are not travel direction dependent so one CV is enough. One bit value is assigned in the CV that maps the function of each decoder board physical output (exception is F0 with 2 CVs). Bit0 correspond to OUT1 and bit1 to OUT2 an so on.

If the function activates the corresponding physical output, the decimal values for each bit (powers of 2) will be considered. If the function does not use the corresponding output, the bit value will be set to zero. The mapping CV will be programmed with the sum of the decimal values of each active output.

Example: if you want to use function F2 to activate OUT1, CV36 will be used for mapping (which configures/maps F2). For this bit0 of CV36 must be set to “1” (binary) so the decimal value will be 1. F2 will activate also OUT2 when bit1 of CV36 will be set to "1" (binary), decimal value will be 2. If both outputs are ON than CV36 will have a decimal value of 3 (3 = 1 + 2).

11.2. Extended Function Mapping

To use Extended Function Mapping in CV96 must be written the value 6. In this mode CV33÷CV62 value are ignored. The Extended Function Mapping uses groups of 16 CVs for each output, from which not all are use (some CVs are reserved for further use).

Table 2 shows the byte structure.

Table 2

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Reverse	Forward	Function number					

In this mode each output can be turned on with two different functions stored in CV120÷CV121 for OUT1 and CV136÷CV137 for OUT2. Bit6 and bit7 of these CVs is controlling the direction dependency of the functions. Setting bit7 to binary "1" (which is equivalent with adding decimal 128 to the CV value), the corresponding function will set the output in reverse direction only. Setting bit6 to binary "1" (which is equivalent with adding decimal 64 to the CV value), the corresponding function will set the output in forward direction only. Setting both bits (6&7) to binary 1, the corresponding output will be always turned on independent to direction and function state.

The mapping mode is described in Table 3.

Table 3

CV120,121,136,137 value	**Description**
n (n ≤ 28)	Function number “n” will turn on the corresponding output in forward and reverse direction
n + 128 (n ≤ 28)	Function number “n” will turn on the corresponding output in reverse direction only
n + 64 (n ≤ 28)	Function number “n” will turn on the corresponding output in forward direction only
28 < n < 64	settings have no effect
n + 192 (n ≤ 28) (192 = 128 + 64)	output always turned on

Examples:

- If OUT1 must be turned on with F0 in forward direction only, CV120 or CV121 value must be 0 + 64 = 64 (decimal).
- If OUT2 must be turned on with F2 in reverse direction only, CV136 or CV137 value must be 2 + 128 = 130 (decimal).
- An unused CV will have the value 63, which has no effect as in Table 3.

With the function configured in CV122 (for OUT1) and CV138 (for OUT2), the corresponding output activation can be disabled. The usage is almost similar with the one described in Table 3 with the difference that the effect is opposite, the output will be turned off instead of being turned on.

Example:

- if the value 68 = 64 + 4 is written in CV122, function F4 will disable OUT1 in forward direction only.

12. Dimming, Fade and Effects

The effects are defined separately for each output by writing the effect number in the corresponding CV: CV124 for OUT1 and CV140 for OUT2 and so on.

In this chapter we will use the following abbreviations:

- TSD = Total Sequence Duration
- P-ON = Light Pulse ON Duration
- P-OFF = Light Pulse OFF Duration
- N = Number of pulses/sequences

The effects list can be found in Table 4 and description of the effects with some examples will follow.

Table 4

Effect number	Effect description	Note
0	Lights switch ON and OFF with no effect	
1	Lights switch ON and OFF with fade effect	See CV 112, CV113
2	Lights switch ON with specific Neon flicker effect	See CV114, CV116
3	Flicker effect, continues slow flickering (visible if light intensity > 16)	See CV123, CV139
4	Defective neon effect (Flickering)	
5	Output used for SPP	
8	Symmetrical flashing, with blinking period TSD, instant on/off	See CV125, CV141
9*	Symmetrical flashing with fade IN/OUT	See CV125, CV141, CV123, CV139
10	Asymmetrical flashing 1/4-ON; 3/4-OFF	See CV125, CV141
11*	Asymmetrical flashing 1/4-ON; 3/4-OFF with fade IN/OUT	See CV125, CV141, CV123, CV139
12	Asymmetrical flashing 3/4-ON; 1/4-OFF	See CV125, CV141
13*	Asymmetrical flashing 3/4-ON; 1/4-OFF with fade IN/OUT	See CV125, CV141, CV123, CV139
14	Custom blinking: TSD, P-ON, P-OFF and N can be defined independently following certain constrictions described below	OUT1 CV124÷CV126 OUT2 CV140÷CV144
15	Custom blinking with random number of blinks	OUT1 CV124÷CV126 OUT2 CV140÷CV144

*see Figure 3

PWM (light intensity) setting is affecting all the effects. For the effects that have fade/diming (the ones with * in the Table 4) the light intensity setting will also affect the effect behavior. Effect 0 means that the output will be switched on and off instantly.

Effects 1 to 4 are non-repetitive effects, meaning that that the lights must be turned on and off manually by the user. For effects 1 to 3 the effect behavior can be changed with the CVs mentioned in the “Note” column.

All the effects starting with number 8 are repetitive and the duration of the effect sequence can be set by the user in certain limits. For these effects there are some rules that must be followed to make sure that the effect behavior is as intended.

Certain settings will affect ~~both~~ all outputs and they are in CV112÷CV117 and other settings are set individually for each output. CV123÷CV128 are for OUT1 and CV139÷CV144 are for OUT2. Table *5* is showing the available settings and ranges.

Table 5

Name	CV# for OUT1	CV# for OUT2	Value range*
FadeIN Effect, 8ms steps (default 200ms)	112		1÷127
FadeOUT Effect, in 8ms steps (default 120ms)	113		1÷127
Fluorescent Tube Start, Blinking Delay 1÷8	114		0÷7
Random Time Period, 1s÷255s	115		1÷255
Flicker Period: Fast-Slow 0÷7	116		0÷7
Defective Neon effect repetition time, 0=fast, 7=slow	117		0÷7
Light intensity, 0=OFF, 255=maximum	123	139	0÷255
Effect number (see Table 4)	124	140	0÷4, 8÷15
Total sequence duration (TSD)	125	141	4÷255
Light Pulse ON duration (P-ON)	126	142	1÷252
Light Pulse OFF duration (P-OFF)	127	143	1÷252
Number of pulses/sequence (N)	128	144	1÷63

*see below range details and examples.

Technically all the CVs can accept value ranges from 0 to 255 still there are values that are pointless to use or have no visible effect.

All time durations are counted like “Value” * 8ms. Consequently, that means that the maximum TSD is 255 * 8ms = 2040ms = 2.04s.

There are some rules and limits to consider:

- TSD value should be counted as minimum of 1 + N * (P-ON + P-OFF). If TSD is equal or smaller than that value, the output will be continuously on with a short light dip at the end of the sequence.
- P-ON and P-OFF value should be bigger than 2 to have a visible effect. 8ms are difficult to notice and 0 means no effect. If P-ON = 0 than the output (LED) will be always off and if P-OFF = 0 than the output (LED) will be always on.
- P-ON is visible for 8ms if N = 1 and TSD ≥ 5.

Figure 2

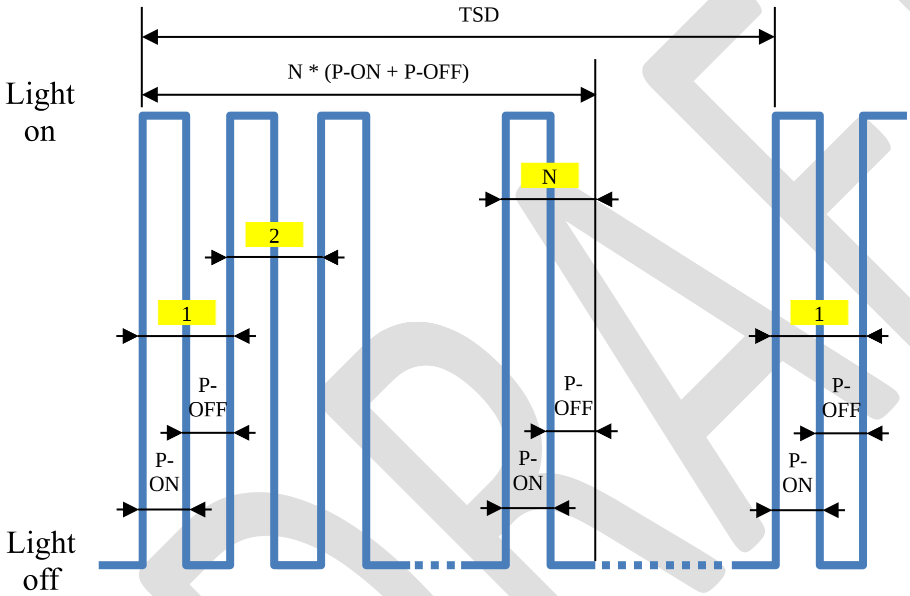


Figure 2 shows a diagram where TSD > 1 + N * (P-ON + P-OFF) and P-ON = P-OFF

Still P-ON and P-OFF can be independently configured as shown in Table 5 following also the rules shown above.

When an effect is set up and turned on it will run in loop, as you can see in Figure 2, until it is turned off. Please notice that if TSD > 1 + N * (P-ON + P-OFF) than after requested pulses are shot it will be a light off period until the next sequence starts over. If TSD = 1 + N * (P-ON + P-OFF) than the new sequence will start at once after pulse N is over.

Effects 8÷13 need only the TSD CV to be defined since the ON/OFF ratio is predefined. However, for the effects that have also ON/OFF fade effect, the light intensity value will affect the visual experience as described below.

For the effects 9, 11 and 13 the prescribed light intensity will affect the ON/OFF duration since 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 Figure 3 is illustrating the above behavior for effect 9 with different light intensity and fade-in/out settings.

In Figure 3 the effect 9 was chosen that means that the ON/OFF duration is 50% each. Since this effect has also fade-in/out that can have duration between 0 and 127 it means that we should consider that after 50% of the TSD the light will not be off but the fade-off will start with the prescribed value.

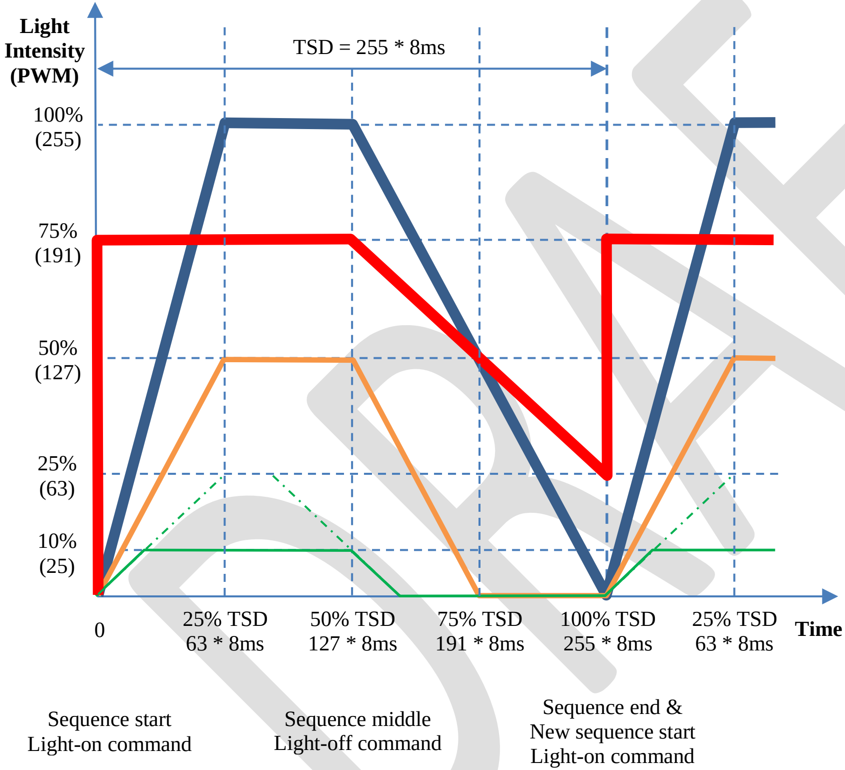
The current example is based on an TSD=255 with effect 9. This was chosen to make it easier since the TSD will have 255-time steps and the PWM that at 100% light intensity is at “step” 255.

So, if we make fade in (CV112) = 63, and we set the light intensity to 25 (10%), 127 (50%) and 255 (100%) we will have the response as in raising part of the green, orange and blue trace in Figure 3. What is to be noticed is that the maximum light intensity will be reached in different moments. Here is the reason of this: if the number of steps to reach the maximum prescribed light intensity (PWM) is smaller than the number of prescribed time steps (in this case for the green trace CV123/139 = 25 < CV112 = 63) than the maximum PWM will be reached earlier than the prescribed value in CV112. For the current example the green trace will reach the maximum PWM after 25 time steps (the number of PWM steps will be equal with the number of time steps) that means 10% of TSD.

The orange and the blue trace have the maximum PWM value bigger than the number of time steps. Orange is 127 and blue is 255 and both must reach the maximum PWM in the prescribed value of CV122 = 63. This will happen since if CV112 value is smaller than the PWM value than the CV112 value will be followed and PWM will rise faster to reach the requested value in the defined timeframe. In this example for the orange trace PWM will rise two times faster and for the blue trace will rise 4 times faster. The dotted green lines are shoving the path of a trace if the value of the PWM is equal with the value of CV112. All above explanations are valid also if for the descending part of the traces considering the value of CV113.

The green and the orange trace have the CV112 = CV113 = 63. The blue trace has the CV113 (fade-out) = 126 so it will reach 0 value of the PWM (light off) at the end of TSD.

Figure 3


Light
Intensity
(PWM)
TSD = 255 * 8ms
100%
(255)
75%
(191)
50%
(127)
25%
(63)
10%
(25)
0
25% TSD
63 * 8ms
50% TSD
127 * 8ms
75% TSD
191 * 8ms
100% TSD
255 * 8ms
25% TSD
63 * 8ms
Time
Sequence start
Light-on command
Sequence middle
Light-off command
Sequence end &
New sequence start
Light-on command

As you noticed the value of CV113 is set to 126 and not to 127 as anyone should expect. Setting CV112 and CV113 to 127 will have an exceptional result since having this value set in the two CVs the rise and fall speed will not be increase so PWM will change on step (up or down) / one time step. This is explained below and shown in Figure 3 by the red trace.

The red trace has the following settings: CV112 = 0, CV113 = 127, CV123/CV139 (PWM) = 191. The effect is still 9 and CV125/CV141 (TSD) = 255. With this setting this is what will happen: the light with turn on with no effect (PWM will switch to 191 instantly) and it will stay on at 75% of full PWM until the middle of the TSD when the dim will start. Since the PWM will make one step each time step of 8ms there will be not enough remaining steps to the end of the sequence so that the PWM will reach zero. To be more specific, at the end of the TSD, PWM will go down to 25% (63). The other way around, if CV112 = 127 and PWM is set to 255 (using the same effect settings as above) than PWM will never reach the maximum value but it will reach the maximum of 127.

To make it short, the PWM will rise faster if the number of time steps is smaller than the number of PWM steps with one exception: if the value of time steps is 127 and the PWM steps number is >127 than PWM will change on step at one time step in both directions (up and down).

13. Multiple protocol operation (analog and digital operation)

The FD micro Function Decoder can work in 2 different track environments: DCC and DC. 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 timeout period, the decoder will switch to analog mod and will turn on functions configured in CV13,14. The timeout period is set in CV11 and it is equal to CV11 decimal value * 8ms. The possible maximal value is nearly 2s.

CV12, CV14, CV29 are influencing the decoder behavior related to protocols. The meaning of CV12 bits is described in . 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.

CV13 and CV14 are responsible for the Function Decoder behavior in analog environment. The factory default value is CV14 = 3 and that means that forward and reverse lights are turned on in analog mode, according with the direction of travel.

Table 6:

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

For safety reasons, even if bit 0 of CV12 is set to 0 (DCC mode = OFF), CV12 can still be modified via DCC. DCC programming commands are steel executed even if DCC digital mode is turned off.

If you want to activate other functions in analog ~~AC /~~ DC mode, they must be defined in CV13 and CV14 and their Function Mapping must be defined as in in **Function Mapping** chapter.

Only functions F0, F1÷F14 can be turned on in analog DC ~~or AC~~ mode.

14. Secondary address (decoder lock)

When using multiple decoders within the same housing (carriage or locomotive), it is useful to use a secondary address that will allow selecting a certain decoder. In this way each decoder can be programed independently on the Programing Track without the need to remove it from the housing. The secondary addresses must be programmed in each decoder CV16 (LockID) before assembling in the housing. The range for the secondary addresses is 1÷7 (0 means secondary addressing is disabled). So maximum 7 different decoders can be placed in the same housing.

In this case the programing commands will be accepted only by the decoder that has the CV16 stored value matching the value written in CV15 (LockValue).

WARNING: CV16 can be programmed only if the correct value is programmed in CV15.

If Secondary Address is enabled (CV16 ≠ 0), the only CV that accepts read/write is CV15. So, in case that the value of CV16 is not known the only way to find it out is to write values from 1 to 7 in CV15 until the decoder will respond.

Assigning secondary addresses to each decoder before mounting them in the railcar (locomotive) or carriage sets allows individual decoder programing on the Programming Track so only the decoder that has the same value in CV15 and CV16 will be programmed.

The decoder lock is useful also if you want to prevent accidental CV changes.

15. Bidirectional communication (RailCom)

"Bidirectional" means that the transfer of information under the DCC protocol is not only to the decoder but also in the opposite direction. Thus, the decoder can send messages such as confirmation of receipt of commands, address, actual speed, internal temperature, load and other status information.

The RailCom operating principle is based on the introduction of a cutout by the control station at the end of each DCC package where it interrupts the power supply and short-circuits the two lines. In these windows the decoders send a few bytes of data that are received by detector connected betwen locomotiv and control station or by control station itself (if its capable to receiv railcom informations).

The data packet is divided into two channels. On the first channel, the address (short, long, or consist) of the decoder is transmitted. On the second channel, CV handling POM responses are delivered (reading, writing result).

RailCom communication can be deactivated from CV29-Bit3 (0 - RailCom inactive, 1 - RailCom active). Channels 1 and 2 are enabled in CV28 Bit0 and Bit1. The automatic switch off of channel 1 transmission can be enabled from bit2 of CV28.

16. Special functions

By calling our special functions we can get information about:

- The internal temperature of the decoder
- the quality of the received DCC signal

To save the values of these parameters to the non-volatile memory (EEPROM) of the decoder, in CV223 is set the function number which activation will trigger the saving. Saving the instantaneous values is done by activating this function from the control station (or tOm Programmer).

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

The internal (saved) temperature of the decoder can be read from CV216. The temperature is given in degrees Celsius. In CV217 is set a temperature limit, which if is exceeded, the decoder will stop working, until the temperature fall below this limit.

The DCC Signal Quality Indicator (QoS = Quality of Signal) is read from CV219. The read value is given in percent (in the range 0-100%). The lowest QoS value detected by the decoder from the last reading, it's writed in CV218. To reset the default value, enter CV218 value 100 [%]. (before reading, activate the save function set in CV223)

17. SUSI

The FD micro Function Decoder have SUSI interface available on Out3(SUSI-CLK), Out4(SUSI-DATA) logic level outputs. The interface is used for sound or function decoders. It is strongly recommended to use the standard wire colors as in **Error! Reference source not found.** to avoid wrong connections.

Attention! Improper connection of the SUSI module may cause damage to the SUSI module

17.1. Programming SUSI modules

Like other digital decoders, SUSI sound decoders can be personalized by changing some operating parameters. The values of these parameters are stored in CV897 to CV1024. The SUSI sound decoder is programmed via the FD micro decoder. Depending on the CV number, the FD micro decoder will identify whether this CV should be written or read from a SUSI module connected to the decoder interface. Please refer to the SUSI decoder user manual before programing it.

The SUSI modules CVs can be written either in PT or PoM mode. Because some digital systems allow writing and reading of CVs only up to CV255, a special mechanism for these digital systems has been implemented in the FD micro decoder. Two CVs are dedicated to provide access to the higher level of the SUSI modules CVs. CV97 is used as index, and CV98 is used as transport CV. The target SUSI decoder CV number is composed of the value of CV97 + 800. CV98 is the container of the value that is to be written or read to / from the CV97 + 800. Below are 2 examples of read/write procedure.

Examples:

- If you want to write value “1” in CV910 of the SUSI module, you must write “110” (910 - 800 = 110) in CV97 and value “1” in CV98. After entering value “1” in CV98, the FD micro decoder will transmit a command on the SUSI interface to the sound module (or the function decoder) to write the value “1” in CV910.
- If you want to read the content of CV 902 from the SUSI module that is connected to the FD micro decoder interface, enter the value 102 (902 - 800 = 102) in CV97, and read the CV98 value. This value is equal to the value contained in CVC 902 of the sound module (or function decoder) connected to the FD micro decoder.

Bit1 of CV118 will enable/disable the SUSI interface. The factory default setting is SUSI disabled (Bit1 of CV118 = “0”)

18. Using external capacitors or a power pack

In some model layouts, due to the wear of rails and deposits of different materials on the tracks, the contact between rails and wheels are imperfect. They cause power outages, with jerky running, especially at low speed. These inconveniences can be eliminated using buffer capacitors (220 µF / 25V or for better results higher but not exceeding 2200 µF) or uninterruptible power supplies SPP.

To connect these devices, the FD micro function decoder has 2 contacts on one side of the PCB. The position of the 2 contacts to which the wires are attached can be determined from the images General description of FD Micro decoders.

Installing these devices requires quality soldering equipment and experience. Our warranty does not cover defects due to inappropriate interventions and soldering

The capacitors are charged in series thru a 100 **Ω** resistors, limiting their charging current, therefore the digital control systems will not interpret the capacitor charging current as short-circuit. The diode is designed to provide the required power or the maximum current available to the internal circuits of the decoder in the absence of tension on the rails.

The Function Decoder has a charge/discharge circuit included, so no other resistor and/or diode are needed.

The black wire will be soldered to the GND and the red one to the Vcc. After making the connections, we can use a heat shrinkable tube or insulating tape for insulation.

Disconnect / remove buffer capacitors before programming the decoders. The use of buffer capacitors does not facilitate the programming of decoders CVs in PT (programming track) mode.

Uninterruptible power supplies SPP (Smart Power Pack or equivalent) removes this inconvenience, allowing both write and read of CVs in the traditional way without having to remove them. Switching off the SPP source during programming is done automatically by the FD micro through the third wire (Charge).

To connect the SPP modules, use the 2 contacts located on one of the FD micro sides, an one of the OUT3-OUT6 outputs for the Charge wire, as can be seen in the pictures in General description of FD Micro decoders. Details of the connection can be found in the manual of the SPP.

To proper operation of the SPP the corresponding output effect number must be changed to 5.

SPP sources work only in digital mode, in analog mode they are disabled (see CV29 configuration). To avoid very high consumption, due to the simultaneous loading of non-interruptible sources, when powering model layout with multiple SPPs, there is a start delay. Thus, in CV221 we can set in seconds the time after which the SPP module is started from the moment of the power is applied in the track. When multiple decoders are used at the same track, this time will be set different in order to avoid the simultaneous start of all SPPs. The SPP modules allow decoders to run for up to 4 seconds without power from rails (fully loaded, depending on consumption). This duration is set in CV222, in steps of 16ms (default value 255, CV_value * 16ms = 4 seconds). After this period expired in the absence of the DCC signal, even if the SPP its not fully discharged, the decoder will disable all it's outputs. The functions will be resumed only after witch the DCC signal reappears.

19. Firmware update

You can update FD Micro function decoder operating software (called firmware) at any time. New firmware versions are used to eliminate errors (bugs) when operating decoders or to implement new functions.

The firmware update can be performed with the tOm Programmer without having to remove the decoder from the locomotive.

The tOm Programmer's operating software and firmware upgrade files can be downloaded from the train-O-matic site. For the firmware upgrade procedure, please refer to the tOm Programmer's user manual.

The current firmware version can be read from the following CVs:

CV253	Firmware version
CV254	Firmware subversion
CV254	Build version, upper byte
CV256	Build version, lower byte

The current manual describes the functionalities of the decoder with of firmware version 1.2.28.

20. User data

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

21. Other functions

The Function Decoder has a function to save the last function command received. This feature can be activated programming the decimal value 1 in CV100. If this feature is activated than the decoder will turn on all the functions that were active before a power outage/interruption. This will happen even if the DCC command were not received to activate them. The functions F0 to F28 are saved by this feature.

22. The decoder CV table

In the table below the columns are named as follows:
- “CV” column contains the configuration variable number
- “Default Value” column contains the "factory" value of the CVs (after a decoder reset, all CVs will have the appropriate value in this column)
- "Value Range" column contains the range of usable values for each CV
- "Description" column contains the name (if there is an established name) and information about the CV function.

Table 7:

CV	Default value	Value range	Description
1	3	0÷127	Decoder Address Short, 7 bits
7	2	-	Software Version (only readable)
8	78	-	Manufactured ID/RESET (readable 78 = train-O-matic, any written value will reset the decoder to the factory default values
11	25	0-255	Packet time-out value = CV11 * 8ms (default time-Out200ms)
12	5	0-255	Power source conversion, DCC and DC mode enabled

CV	Default value	Value range	Description
13	0	0÷255	Analog Mode, Alternate Mode Function Status F1-F8 Bit 0 = 0(0): F1 not active in Analog mode = 1(1): F1 active in Analog mode Bit 1 = 0(0): F2 not active in Analog mode = 1(2): F2 active in Analog mode Bit 2 = 0(0): F3 not active in Analog mode = 1(4): F3 active in Analog mode Bit 3 = 0(0): F4 not active in Analog mode = 1(8): F4 active in Analog mode Bit 4 = 0(0): F5 not active in Analog mode = 1(16): F5 active in Analog mode Bit 5 = 0(0): F6 not active in Analog mode = 1(32): F6 active in Analog mode Bit 6 = 0(0): F7 not active in Analog mode = 1(64) F7 active in Analog mode Bit 7 = 0(0): F8 not active in Analog mode = 1(255): F8 active in Analog mode

CV	Default value	Value range	Description
14	1 = 1	0÷255	Analog Mode, Alternate Mode Function. Status F0f, F0r, F9-F14, Bit 0 = 0(0): F0 forward not active in Analog mode = 1(1): F0 forward active in Analog mode Bit 1 = 0(0): F0 revers not active in Analog mode = 1(2): F0 revers active in Analog mode Bit 2 = 0(0): F9 not active in Analog mode = 1(4): F9 active in Analog mode Bit 3 = 0(0): F10 not active in Analog mode = 1(8): F10 active in Analog mode Bit 4 = 0(0): F11 not active in Analog mode = 1(16): F11 active in Analog mode Bit 5 = 0(0): F12 not active in Analog mode = 1(32): F12 active in Analog mode Bit 6 = 0(0): F13 not active in Analog mode = 1(64) F13 active in Analog mode Bit 7 = 0(0): F14 not active in Analog mode = 1(255): F14 active in Analog mode

CV	Default value	Value range	Description
15	0	0÷7	LockValue: 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 LockValue is different than LockID. In this situation only CV15 write is allowed.
16	0	0÷7	LockID: 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	192	192÷255	Extended Address, Address High
18	3	0÷255	Extended Address, Address Low
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.

CV	Default value	Value range	Description
21	0	0÷255	Functions defined here will be controlled by the consist address. Bit 0 = 0(0): F1 controlled by individual address = 1(1): …. by consist address Bit 1 = 0(0): F2 controlled by individual address = 1(2): …. by consist address Bit 2 = 0(0): F3 controlled by individual address = 1(4): …. by consist address Bit 3 = 0(0): F4 controlled by individual address = 1(8): …. by consist address Bit 4 = 0(0): F5 controlled by individual address = 1(16): …. by consist address Bit 5 = 0(0): F6 controlled by individual address = 1(32): …. by consist address Bit 6 = 0(0): F7 controlled by individual address = 1(64): …. by consist address Bit 7 = 0(0): F8 controlled by individual address = 1(255): …. by consist address

CV	Default value	Value range	Description
22	3	0÷63	Functions defined here will be controlled by the consist address. Bit 0 = 0(0): F0 (forward) controlled by individual address = 1(1): …. by consist address Bit 1 = 0 (0): F0 (reverse) controlled by individual address = 1(2): …. by consist address Bit 2 = 0(0): F9 controlled by individual address = 1(4): …. by consist address Bit 3 = 0(0): F10 controlled by individual address = 1(8): …. by consist address Bit 4 = 0(0): F11 controlled by individual address = 1(16): …. by consist address Bit 5 = 0(0): F12 controlled by individual address = 1(32): …. by consist address

CV	Default value	Value range	Description
28	3	0÷7	RailCom configuration Bit 0 = 0(0): CH1 Address Broadcast Off = 1(1): CH1 Address Broadcast On Bit 1 = 0(0): CH2 Data Transmission Off = 1(2): CH2 Data Transmission On Bit 2 = 0(0): CH1 Dynamic mode Off = 1(2): CH1 Dynamic mode On

CV	Default value	Value range	Description
29	14 = 2 + 4 + 8	0÷63	Configuration Data Bit 0 = 0(0): Locomotive Direction normal = 1(1): Locomotive Direction reversed Bit 1 = 0(0): FL controlled by bit 4 in Speed and Direction instructions = 1(2): FL controlled by bit 4 in Function Group One instruction[1] 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 disabled = 1(8): Bi-Directional Communications enabled Bit 4 – Not Used Bit 5 = 0(0): One byte addressing (short addressing) = 1(32): Two bytes addressing (extended/long addressing) Bit 6 – Not Used Bit 7 – Not Used

[1] See NMRA S-9.2.1

CV	Default value	Value range	Description
33	1	0÷255	F0, Forward move mapping Bit 0 = 0(0): OUT1 not active on F0 forward = 1(1): OUT1 active on F0 forward Bit 1 = 0(0): OUT2 not active on F0 forward = 1(2): OUT2 active on F0 forward Bit 2 = 0(0): OUT3 not active on F0 forward = 1(4): OUT3 active on F0 forward Bit 3 = 0(0): OUT4 not active on F0 forward = 1(8): OUT4 active on F0 forward Bit 4 = 0(0): OUT5 not active on F0 forward = 1(16):OUT5 active on F0 forward Bit 5 = 0(0): OUT6 not active on F0 forward = 1(32):OUT6 active on F0 forward

CV	Default value	Value range	Description
34	2	0÷255	F0, backward move mapping Bit 0 = 0(0): OUT1 not active on F0 backward = 1(1): OUT1 active on F0 backward Bit 1 = 0(0): OUT2 not active on F0 backward = 1(2): OUT2 active on F0 backward Bit 2 = 0(0): OUT3 not active on F0 backward = 1(4): OUT3 active on F0 backward Bit 3 = 0(0): OUT4 not active on F0 backward = 1(8): OUT4 active on F0 backward Bit 4 = 0(0): OUT5 not active on F0 backward = 1(16):OUT5 active on F0 backward Bit 5 = 0(0): OUT6 not active on F0 backward = 1(32):OUT6 active on F0 backward

CV	Default value	Value range	Description
35	1	0÷255	F1 mapping Bit 0 = 0(0): OUT1 not activated with F1 = 1(1): OUT1 activated with F1 Bit 1 = 0(0): OUT2 not activated with F1 = 1(2): OUT2 activated with F1 Bit 2 = 0(0): OUT3 not activated with F1 = 1(4): OUT3 activated with F1 Bit 3 = 0(0): OUT4 not activated with F1 = 1(8): OUT4 activated with F1 Bit 4 = 0(0): OUT5 not activated with F1 = 1(16):OUT5 activated with F1 Bit 5 = 0(0): OUT6 not activated with F1 = 1(32):OUT6 activated with F1
36	2	0÷255	F2 mapping, same bit meaning with CV35
37	4	0÷255	F3 mapping, same bit meaning with CV35
38	8	0÷255	F4 mapping, same bit meaning with CV35
39	16	0÷255	F5 mapping, same bit meaning with CV35
40	32	0÷255	F6 mapping, same bit meaning with CV35
41	0	0÷255	F7 mapping, same bit meaning with CV35

CV	Default value	Value range	Description
42	0	0÷255	F8 mapping, same bit meaning with CV35
43	0	0÷255	F9 mapping, same bit meaning with CV35
44	0	0÷255	F10 mapping, same bit meaning with CV35
45	0	0÷255	F11 mapping, same bit meaning with CV35
46	0	0÷255	F12 mapping, same bit meaning with CV35
47	0	0÷255	F13 mapping, same bit meaning with CV35
48	0	0÷255	F14 mapping, same bit meaning with CV35
49	0	0÷255	F15 mapping, same bit meaning with CV35
50	0	0÷255	F16 mapping, same bit meaning with CV35
51	0	0÷255	F17 mapping, same bit meaning with CV35
52	0	0÷255	F18 mapping, same bit meaning with CV35
53	0	0÷255	F19 mapping, same bit meaning with CV35
54	0	0÷255	F20 mapping, same bit meaning with CV35
55	0	0÷255	F21 mapping, same bit meaning with CV35
56	0	0÷255	F22 mapping, same bit meaning with CV35
57	0	0÷255	F23 mapping, same bit meaning with CV35
58	0	0÷255	F24 mapping, same bit meaning with CV35
59	0	0÷255	F25 mapping, same bit meaning with CV35
60	0	0÷255	F26 mapping, same bit meaning with CV35

CV	Default value	Value range	Description
61	0	0÷255	F27 mapping, same bit meaning with CV35
62	0	0÷255	F28 mapping, same bit meaning with CV35
96	1	1, 6	Output mapping mode: 0 – NMRA (CV33 – ÷CV62) 6 – extended mapping (CV120 – ÷CV215~~151~~)
97	100		SUSI CV transport, SUSI CV = 800 + CV97value (default CV900)
98	-		SUSI DATA transport, Accessing CV = 800 + CV97value
100	0	0÷1	Enable saving last functions state: 0 – disabled; 1 - enabled
101	0	0÷255	Saved last function state F0, F1-F4
102	0	0÷255	Saved last function state F5-F12
103	0	0÷255	Saved last function state F13-F20
104	0	0÷255	Saved last function state F21-F28
105	0	0÷255	USER data (not affected by decoder reset)
106	0	0÷255	USER data (not affected by decoder reset)
112	25	1÷127	FadeIN Light Effect delay, in 8ms steps (default 200ms)
113	15	1÷127	FadeOUT Light Effect delay, in 8ms steps (default 120ms)
114	3	0÷7	Fluorescent Tube Start, Blinking Delay 1-÷8 delay step [0÷0 ... 7]
115	10	1÷255	Random Time Period, 1s-÷255s
116	3	0÷7	Flicker Period: Fast-Slow 0÷ ... 7

CV	Default value	Value range	Description
117	3	0÷7	Defective Neon effects repetition time, 0 fast repetition, 7 slow repetition
120	64	0÷255	First function number which turn on Out1
121	63	0÷255	Second function number which turn on Out1
122	63	0÷255	Function number which must be turned off, for Out1 to can be turned on
123	127	0÷255	Out1 Light intensity (see Table 4)
124	81	0÷255	Effect selection for Output1 (see Table 4)
125	127	0÷255	Out1 Blink period (Bp), in 8ms steps, max: 2s, Bp > n * (Bpl + Bpp) (see Table 4)
126	2	0÷255	Out1 Blink pulse length (Bpl), in 8ms steps, max: 2s
127	12	0÷255	Out1 Blink pause length (Bpl), in 8ms steps, max: 2s
128	3	0÷255	Out1 number of Blinks pulsesBlink repetition time (n)
136	64	0÷255	First function number which turn on Out2
129	?	0÷255	Out1 turn on delay
130	?	0÷255	Out1 turn OFF delay
131	?	0÷255	reserved
132	?	0÷255	reserved
133	?	0÷255	reserved
134	?	0÷255	reserved
135	?	0÷255	reserved
136	128	0÷255	Function nr.1 to be ON for Out2

CV	Default value	Value range	Description
137	2	0÷255	Function nr.2 to be ON for Out2
138	63	0÷255	Function nr.1 to be OFF for Out2
139	255	0÷255	Out2 Light intensity (PWM) (see Table 4)
140	1	0÷255	Out2 Effect (see Table 4)
141	127	0÷255	Out2 Blink period (see Table 4)
142	2	0÷255	Out2 Blink Pulse length
143	12	0÷255	Out2 Blink Pause length
144	3	0÷255	Out2 Blink repetition time (see Table 4)
145	0	0÷255	Out2 turn ON delay
146	0	0÷255	Out2 turn OFF delay
147	255	0÷255	reserved
148	255	0÷255	reserved
149	255	0÷255	reserved
150	255	0÷255	reserved
151	255	0÷255	reserved
152	3	0÷255	Function nr.1 to be ON for Out3
153	63	0÷255	Function nr.2 to be ON for Out3
154	63	0÷255	Function nr.1 to be OFF for Out3
155	255	0÷255	Out3 Light intensity (PWM)

CV	Default value	Value range	Description
156	1	0÷255	Out3 Effect
157	127	0÷255	Out3 Blink period
158	2	0÷255	Out3 Blink Pulse length
159	12	0÷255	Out3 Blink Pause length
160	3	0÷255	Out3 Blink repetition time
161	0	0÷255	Out3 turn ON delay
162	0	0÷255	Out3 turn OFF delay
163	255	0÷255	reserved
164	255	0÷255	reserved
165	255	0÷255	reserved
166	255	0÷255	reserved
167	255	0÷255	reserved
168	4	0÷255	Function nr.1 to be ON for Out4
169	63	0÷255	Function nr.2 to be ON for Out4
170	63	0÷255	Function nr.1 to be OFF for Out4
171	255	0÷255	Out4 Light intensity (PWM)
172	1	0÷255	Out4 Effect
173	127	0÷255	Out4 Blink period
174	2	0÷255	Out4 Blink Pulse length

CV	Default value	Value range	Description
175	12	0÷255	Out4 Blink Pause length
176	3	0÷255	Out4 Blink repetition time
177	0	0÷255	Out4 turn ON delay
178	0	0÷255	Out4 turn OFF delay
179	255	0÷255	reserved
180	255	0÷255	reserved
181	255	0÷255	reserved
182	255	0÷255	reserved
183	255	0÷255	reserved
184	5	0÷255	Function nr.1 to be ON for Out5
185	63	0÷255	Function nr.2 to be ON for Out5
186	63	0÷255	Function nr.1 to be OFF for Out5
187	255	0÷255	Out5 Light intensity (PWM)
188	1	0÷255	Out5 Effect
189	127//1	0÷255	Out5 Blink period
190	2//4	0÷255	Out5 Blink Pulse length
191	12//24	0÷255	Out5 Blink Pause length
192	3//1	0÷255	Out5 Blink repetition time
193	0	0÷255	Out5 turn ON delay

CV	Default value	Value range	Description
194	0	0÷255	Out5 turn OFF delay
195	255	0÷255	reserved
196	255	0÷255	reserved
197	255	0÷255	reserved
198	255	0÷255	reserved
199	255	0÷255	reserved
200	6	0÷255	Function nr.1 to be ON for Out6
201	63	0÷255	Function nr.2 to be ON for Out6
202	63	0÷255	Function nr.1 to be OFF for Out6
203	255	0÷255	Out6 Light intensity (PWM)
204	1	0÷255	Out6 Effect
205	127//93	0÷255	Out6 Blink period
206	2//4	0÷255	Out6 Blink Pulse length
207	12//24	0÷255	Out6 Blink Pause length
208	3//1	0÷255	Out6 Blink repetition time
209	0	0÷255	Out6 turn ON delay
210	0	0÷255	Out6 turn OFF delay
211	255	0÷255	reserved
212	255	0÷255	reserved

CV	Default value	Value range	Description
213	255	0÷255	reserved
214	255	0÷255	reserved
215	255	0÷255	reserved
216		0÷255	Chip temperature read out. Prior the readout function set in CV223 must be switched On and Off
217	100	0÷255	Temperature protection triggering threshold, default 100°C
218	-	0÷100	Worst QoS (Quality of Service) value, saved activating then deactivating function set in CV223. Read only
219	-	0÷100	QoS (Quality of Service) current value, saved activating then deactivating function set in CV223. Read only
220	0	0÷255	reserved
221	2	0÷255	SPP (Smart Power Pack) start delay in seconds, default 10s
222	255	0÷255	SPP (Smart Power Pack) Timeout=16ms*Value Ex: =16ms*16=256ms
223	28	0÷255	Function number which enables saving of QoS and Temperature value in CVs

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