Digital technology

Index

1. Introduction

Congratulations for the purchase of a TILLIG quality model. This control car has an On-Board Decoder, so we are giving you all the information you need to adjust all the features, as you want.

Our model of Wittenberger control car offers you the following functions:

- Driving direction-dependent front light


- Direction board lightning

- High Beam

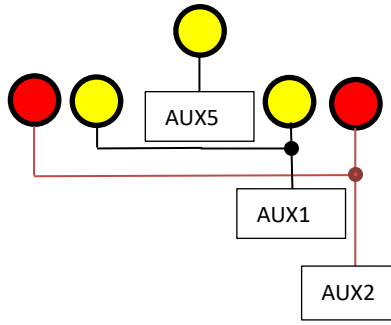
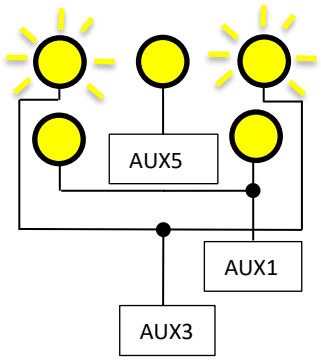
- Integrated power cap

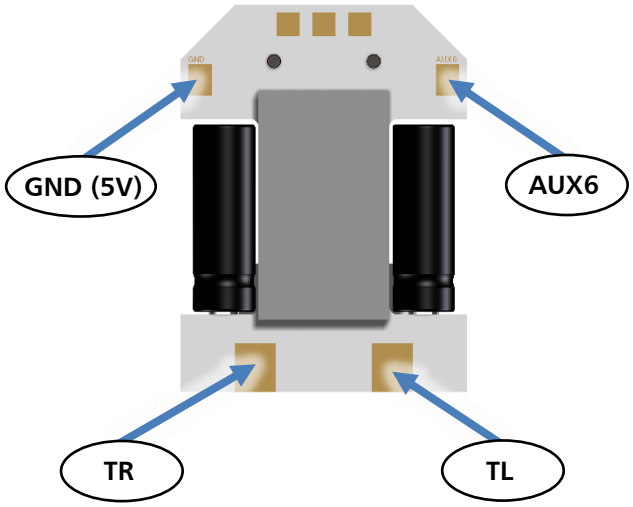
On each page of this manual, you will find the hardware-software index at the bottom left. This shows the development status of the PCBs and the software of the On-Board Decoder To be sure that you have the right variant, you can take a look at the operating instructions enclosed with the product. There you will find the spare parts list. The item number of the PCB receives the HW-SW index. If this index does not exist, you can assume that it is HW01SW01.

2. Function output mapping

Below you will find the factory preprogramed function output mapping description that is user editable. So you can change the function output mapping as you wish.

2.1 Function outputs

AUX1+5/AUX2 for direction-dependent front light 	AUX3 for high beam 
AUX4 for direction board lightning	AUX6 as solder pads



Attention: AUX6 is a logical level output, capable of direct LED driving. The anode of the LEDs must be connected to the VCC (5V) pad.

The cathode of the LEDs (with an optional series resistor in the value range 1 kOhm to 10 kOhm) should be connected to the AUX6

2.2 Function button mapping

The On-Board Decoder has the following function button mapping.

F0	white light / red light, driving direction-dependent
F1	direction board lightning
F2	high beam
F3	AUX6

3. Standard CV – programming

-WARNING- : To make sure you are programming only the On-Board decoder you must activate the secondary address (see 3.2 Secondary address)

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

3.1 Address programming

The On-Board decoder can be used either with short addresses (1-127) or long addresses (1-10239). 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), and changing the CV1 value, according to the instructions of your Command Station. (CV1 can be modified only in PT mode)

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.

3.2 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 On-Board 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 Wittenberger control car can be equipped with interior light. That means that before you install the interior lighting, the On-Board 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 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 On-Board decoder, you must write the secondary address to CV15 (CV15=1). Now only the On-Board 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.

If you accidentally block the decoder by writing an unknown value in CV16, you must write the value 255 in CV15. This special value will remove the LOCKED state and will program CV15 with the value of CV16. As a result of writing CV15 with the value 255, the decoder will be UNLOCKED without losing the possibility to LOCK it again by changing the value of CV15.

The value 0 for CV16 means an UNLOCKED decoder, whatever value is written in CV15.

3.3 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.

3.4 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.

3.5 Function Mapping

The assignment between Functions and Outputs is known as Function Mapping. The On-Board Decoder supports Standard and Extended Function Mapping. **By default, the extended function mapping is used.** This can be changed with CV96 as follows:

- CV96 = 1 means Standard Function Mapping
- CV96 = 6 means Extended Function Mapping.

3.5.1 Standard Function Mapping

Each Function (from F0 to F28) can be used to activate 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 used. 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 corresponds to Out1 and bit1 to Out2 and so on.

The programming will be done using the values from the table below.

Example: if you want to use function F2 to activate AUX1, 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 then CV36 will have a decimal value of 3 (3 = 1 + 2).

OUTPUT		AUX1	AUX2	AUX3	AUX4	AUX5	AUX6
bit		0	1	2	3	4	5
function	CV						
F0 fwd.	33	1	2	4	8	16	32
F0 rev.	34	1	2	4	8	16	32
F1	35	1	2	4	8	16	32
F2	36	1	2	4	8	16	32
F3	37	1	2	4	8	16	32
F4	38	1	2	4	8	16	32
F5	39	1	2	4	8	16	32
F6	40	1	2	4	8	16	32
F7	41	1	2	4	8	16	32
F8	42	1	2	4	8	16	32
F9	43	1	2	4	8	16	32
F10	44	1	2	4	8	16	32
…							
F28	62	1	2	4	8	16	32

3.5.2 Extended Function Mapping

By default, the CV96 of the On-Board Decoder is set to the value 6, so it's using the extended function mapping. In this mode CV33-CV62 values are ignored.

The Extended Function Mapping uses 3 CVs for each output, from which not all need to be used, two for turning outputs on and one for turning off, if the function number is activated.

The following table shows the value structure.

Description	Reverse	Forward	Without function	Function number (F0-28)
Value	128	64	29-63	0-28

As you can see, the function number F0-F28 can be used. In addition, the values 128 for the direction of travel backwards and 64 for the direction of travel forward can be added. If a value of 29-63 is written, then the function number has no function.

The following table shows which outputs are depending to which CV's.

Output	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6
First Function Number AUX **on**	CV120	CV136	CV152	CV168	CV184	CV200
Second Function Number AUX **on**	CV121	CV137	CV153	CV169	CV185	CV201
Third Function Number AUX **off**	CV122	CV138	CV154	CV170	CV186	CV202

Examples:

- If AUX1 must be turned on with F0 in forward direction only, CV120 or CV121 value must be 0 + 64 = 64 (decimal).
- If AUX2 must be turned on with F2 in reverse direction only, CV136 or CV137 value must be 2 + 128 = 130 (decimal).
- If the value 68 = 64 + 4 is written in CV122, function F4 will disable AUX1 in forward direction only.

3.6 DC operation

When powered on the decoder will check if the 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 the CV11's decimal value * 8ms. The maximal value is 2,048s.

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

The meaning of CV12 bits is described in the table.

CV12 Bit number	Value	Operation 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 operation 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 the DCC digital mode is turned off.

By default, both the DC analog and DCC operations are activated.

The functions activated in analog DC mode are defined in CV13 and CV14, described in the table below. The Function Mapping must be defined as in the Function Mapping chapter. Only the functions F0 (direction dependent), and F1-F14 can be used in DC operation. By default, the CV setting for F0 (both travel directions) and F1 are configured to be turned on in analog DC mode. CV14 has the default value of 3 and CV13 has the default value of 1.

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

3.7 SPP operation (power pack)

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.**

3.8 Other functions

3.8.1 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.

3.8.2 Last command/function save

The On-Board decoder has a feature to save the last function command received. This feature can be activated programming the value 1 in CV100. 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.

3.8.3 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. Write 100 in CV218 to reset to the default value (before reading, activate the save function set in CV223).

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

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

4. Effects for function outputs

4.1 Light intensity (PWM)

The PWM (light intensity) of the LEDs connected to the outputs of the On-Board Decoder can be changed individually by changing the values of the following CV's:

	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6
CV - PWM	123	139	155	171	187	203

The factory default value for each of them is the decimal value 255 (maximal intensity).

4.2 Light effects

The effects are defined separately for each output by writing the effect number in the corresponding CV:

	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6
CV – Effect number	124	140	156	172	188	204

The list of effects can be found in the table below. Their description with examleswill follow in the next chapters.

Effect number	Effect description	Note
0	Lights switch ON and OFF with no effect	
1	Lights switch ON and OFF with fade effect	See 5.2.1
2	Lights switch ON with specific Neon flicker effect	See 5.2.2
3	Flicker effect, continues slow flickering (visible if light intensity > 16)	See 5.2.3
4	Defective neon effect (Flickering)	See 5.2.4
8	Symmetrical flashing, with blinking period TSD, instant on/off	See 5.2.5.1
9*	Symmetrical flashing with fade IN/OUT	See 5.2.5.1
10	Asymmetrical flashing 25%-ON; 75%-OFF	See 5.2.5.1
11*	Asymmetrical flashing 25%-ON; 75%-OFF with fade IN/OUT	See 5.2.5.1
12	Asymmetrical flashing 75%-ON; 25%-OFF	See 5.2.5.1
13*	Asymmetrical flashing 75%-ON; 25%-OFF with fade IN/OUT	See 5.2.5.1
14	Custom flashing with defined number of blinks: TSD, P-ON, P-OFF and N can be defined independently following certain constrictions described below	See 5.2.5.2
15	Custom flashing with random number of blinks	See 5.2.5.2

Attention: The PWM (light intensity) setting is affecting all the effects. For the effects which are using the fade/dimming (the ones with * in the table) the light intensity setting will also affect the effect behaviour.

4.2.1 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

4.2.2 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).

4.2.3 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).

4.2.4 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)

4.2.5 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 x (TP) + 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 x TP).

	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6	Value
CV - TTP	125	141	157	173	189	205	4 - 255
CV - TP-ON	126	142	158	174	190	206	1 - 252
CV - TP-OFF	127	143	159	175	191	207	1 - 252
CV - N	128	144	160	176	192	208	1 - 63

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

4.2.5.1 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 programm 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 4.2.5).
The fade time will be defined at CV112 and CV113 (see 4.2.1).

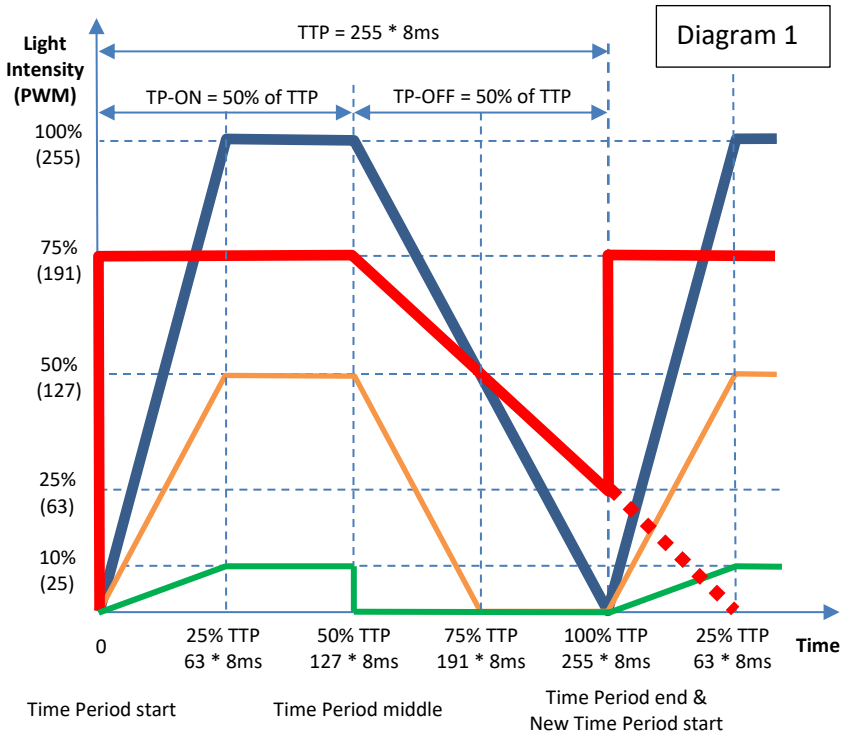
With the **assymmetrical** flashing effect you get an unequal on/off blinking time with TP=TPP.

- 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 4.2.5).
The fade time will be defined at CV112 and CV113 (see 4.2.1).

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), CV123 (PWM)=255 and CV125=255 TTP
- The orange trace has the settings (AUX1): CV112=63 (fade in), CV113=63 (fade out), CV123 (PWM)=127 and CV125=255 TTP
- The green trace has the settings (AUX1): CV112=63 (fade in), CV113=0 (fade out), CV123 (PWM)=25 and CV125=255 TTP
- The red trace has the settings (AUX1): CV112=0 (fade in), CV113=191 (fade out), CV123 (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 (CV123)** 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 (CV123)** 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 (CV123)** 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 (CV123)** 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.

4.2.5.2 Custom flashing effect

Custom flashing effect with defined number of blinks

With the custom flashing effect **(CV124=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 than the output (LED) will be always on.

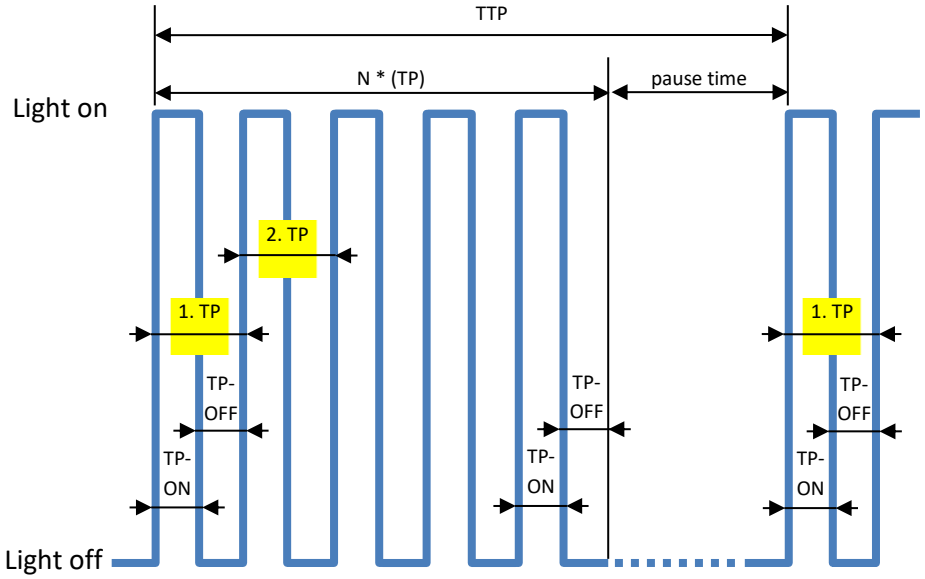


Diagram 2, TTP > 1 + N * TP; TP-ON = TP-OFF and N=5 (remember TP=TP-ON+TP-OFF)

The CV assignment of the parameters to the respective outputs can be found in the table from chapter 4.2.5.

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 **(CV124=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.

4.3 Turn On/Off Delay

Each output can be turned on and/or off with a delay specified in the CV Turn ON delay and CV Turn OFF delay. These delays can be set in 8ms steps. The maximal possible delay value is 8*255 = 2040ms, approximately 2 second. To establish which output will use delays the following CVs are available:

	AUX1	AUX2	AUX3	AUX4	AUX5	AUX6
Turn ON delay	129	145	161	177	193	209
Turn OFF delay	130	146	162	178	194	210

5. Firmware update

You can update On-Board Decoder operating software (called firmware) 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 **"TILLIG Programmer", item number 66205,** without having to remove the decoder.

The firmware upgrade files can be downloaded from the TILLIG - website.

The current firmware version can be read from the CVs 253-256.

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	3	-	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	1 = 1	0-255	Analog Mode, Alternate Mode Function Status F1 - F8
14	3 = 1 +2	0-255	Analog Mode, Alternate Mode Function. Status F0f, F0r, F9 - F14,
15	255	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	255	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	192	192-255	Extended Address, Address High
18	3	0-255	Extended Address, Address Low

CV 13:

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

CV 14:

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

<table>
<tr><th>CV</th><th>Default value</th><th>Value range</th><th>Description</th></tr>
<tr><td>19</td><td>0</td><td>0-127</td><td>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.</td></tr>
<tr><td>20</td><td>0</td><td>0-102</td><td>Long Consist Address, High Byte (upper 2-3 digits of address, 000xx-102xx)</td></tr>
<tr><td>21</td><td>0</td><td>0-255</td><td>Functions defined here will be controlled by the consist address.
<table>
<tr><td>Bit 0</td><td>0</td><td>(0)</td><td>F1 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(1)</td><td>F1 for consist address</td></tr>
<tr><td>Bit 1</td><td>0</td><td>(0)</td><td>F2 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(2)</td><td>F2 for consist address</td></tr>
<tr><td>Bit 2</td><td>0</td><td>(0)</td><td>F3 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(4)</td><td>F3 for consist address</td></tr>
<tr><td>Bit 3</td><td>0</td><td>(0)</td><td>F4 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(8)</td><td>F4 for consist address</td></tr>
<tr><td>Bit 4</td><td>0</td><td>(0)</td><td>F5 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(16)</td><td>F5 for consist address</td></tr>
<tr><td>Bit 5</td><td>0</td><td>(0)</td><td>F6 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(32)</td><td>F6 for consist address</td></tr>
<tr><td>Bit 6</td><td>0</td><td>(0)</td><td>F7 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(64)</td><td>F7 for consist address</td></tr>
<tr><td>Bit 7</td><td>0</td><td>(0)</td><td>F8 for individual adress</td></tr>
<tr><td></td><td>1</td><td>(128)</td><td>F8 for consist address</td></tr>
</table></td></tr>
<tr><td>22</td><td>0</td><td>0-63</td><td>Functions defined here will be controlled by the consist address.
<table>
<tr><td>Bit 0</td><td>0</td><td>(0)</td><td>F0 forward for individual address</td></tr>
<tr><td></td><td>1</td><td>(1)</td><td>F0 forward for consist address</td></tr>
<tr><td>Bit 1</td><td>0</td><td>(0)</td><td>F0 revers for individual address</td></tr>
<tr><td></td><td>1</td><td>(2)</td><td>F0 revers for consist adress</td></tr>
<tr><td>Bit 2</td><td>0</td><td>(0)</td><td>F9 for individual address</td></tr>
<tr><td></td><td>1</td><td>(4)</td><td>F9 for consist address</td></tr>
<tr><td>Bit 3</td><td>0</td><td>(0)</td><td>F10 for individual address</td></tr>
<tr><td></td><td>1</td><td>(8)</td><td>F10 for consist address</td></tr>
<tr><td>Bit 4</td><td>0</td><td>(0)</td><td>F11 for individual address</td></tr>
<tr><td></td><td>1</td><td>(16)</td><td>F11 for consist address</td></tr>
<tr><td>Bit 5</td><td>0</td><td>(0)</td><td>F12 for individual address</td></tr>
<tr><td></td><td>1</td><td>(32)</td><td>F12 for consist address</td></tr>
</table></td></tr>
<tr><td>28</td><td>-</td><td>-</td><td>Reserved</td></tr>
<tr><td>29</td><td>14
=
2
+4
+8</td><td>0-63</td><td>Configuration Data
<table>
<tr><td>Bit 0</td><td>0</td><td>(0)</td><td>Driving Direction normal</td></tr>
<tr><td></td><td>1</td><td>(1)</td><td>Driving Direction reversed</td></tr>
<tr><td>Bit 1</td><td>0</td><td>(0)</td><td>14 speed steps</td></tr>
<tr><td></td><td>1</td><td>(2)</td><td>28/128 speed steps</td></tr>
<tr><td>Bit 2</td><td>0</td><td>(0)</td><td>Power Source Conversion NMRA Digital Only (only DCC)</td></tr>
<tr><td></td><td>1</td><td>(4)</td><td>Power Source Conversion Enabled (DC + DCC)</td></tr>
<tr><td>Bit 3</td><td>0</td><td>(0)</td><td>Bi-Directional Communications (Rail-Com) disabled</td></tr>
<tr><td></td><td>1</td><td>(8)</td><td>Bi-Directional Communications (Rail-Com) enabled</td></tr>
<tr><td>Bit 5</td><td>0</td><td>(0)</td><td>One byte addressing (short addressing at CV1)</td></tr>
<tr><td></td><td>1</td><td>(32)</td><td>Two bytes addressing (extended/long addressing)</td></tr>
</table></td></tr>
<tr><td>33</td><td>1</td><td>0-255</td><td>F0, Forward move mapping
<table>
<tr><td>Bit 0</td><td>0</td><td>(0)</td><td>AUX1 not active</td></tr>
<tr><td></td><td>1</td><td>(1)</td><td>AUX1 active</td></tr>
<tr><td>Bit 1</td><td>0</td><td>(0)</td><td>AUX2 revers not active</td></tr>
<tr><td></td><td>1</td><td>(2)</td><td>AUX2 active</td></tr>
<tr><td>Bit 2</td><td>0</td><td>(0)</td><td>AUX3 not active</td></tr>
<tr><td></td><td>1</td><td>(4)</td><td>AUX3 active</td></tr>
<tr><td>Bit 3</td><td>0</td><td>(0)</td><td>AUX4 not active</td></tr>
<tr><td></td><td>1</td><td>(8)</td><td>AUX4 active</td></tr>
<tr><td>Bit 4</td><td>0</td><td>(0)</td><td>AUX5 not active</td></tr>
<tr><td></td><td>1</td><td>(16)</td><td>AUX5 active</td></tr>
<tr><td>Bit 5</td><td>0</td><td>(0)</td><td>AUX6 not active</td></tr>
<tr><td></td><td>1</td><td>(32)</td><td>AUX6 active</td></tr>
</table></td></tr>
<tr><td>34</td><td>2</td><td>0-255</td><td>F0, backward move mapping, same bit meaning with CV33</td></tr>
<tr><td>35</td><td>1</td><td>0-255</td><td>F1 mapping, same bit meaning with CV33</td></tr>
<tr><td>36</td><td>2</td><td>0-255</td><td>F2 mapping, same bit meaning with CV33</td></tr>
<tr><td>37</td><td>4</td><td>0-255</td><td>F3 mapping, same bit meaning with CV33</td></tr>
</table>

CV	Default value	Value range	Description
38	8	0-255	F4 mapping, same bit meaning with CV33
39	16	0-255	F5 mapping, same bit meaning with CV33
40	32	0-255	F6 mapping, same bit meaning with CV33
41	64	0-255	F7 mapping, same bit meaning with CV33
42	128	0-255	F8 mapping, same bit meaning with CV33
43	0	0-255	F9 mapping, same bit meaning with CV33
44	0	0-255	F10 mapping, same bit meaning with CV33
45	0	0-255	F11 mapping, same bit meaning with CV33
46	0	0-255	F12 mapping, same bit meaning with CV33
47	0	0-255	F13 mapping, same bit meaning with CV33
48	0	0-255	F14 mapping, same bit meaning with CV33
49	0	0-255	F15 mapping, same bit meaning with CV33
50	0	0-255	F16 mapping, same bit meaning with CV33
51	0	0-255	F17 mapping, same bit meaning with CV33
52	0	0-255	F18 mapping, same bit meaning with CV33
53	0	0-255	F19 mapping, same bit meaning with CV33
54	0	0-255	F20 mapping, same bit meaning with CV33
55	0	0-255	F21 mapping, same bit meaning with CV33
56	0	0-255	F22 mapping, same bit meaning with CV33
57	0	0-255	F23 mapping, same bit meaning with CV33
58	0	0-255	F24 mapping, same bit meaning with CV33
59	0	0-255	F25 mapping, same bit meaning with CV33
60	0	0-255	F26 mapping, same bit meaning with CV33
61	0	0-255	F27 mapping, same bit meaning with CV33
62	0	0-255	F28 mapping, same bit meaning with CV33
96	6	1, 6	Output mapping mode: 1 – NMRA (CV33 - CV62) 6 – extended mapping (CV120 - CV215)
100	0	0-1	Enable saving last functions state: 0 – disabled; 1 - enabled
105	255	0-255	User data (not affected by decoder reset)
106	255	0-255	User data (not affected by decoder reset)
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): Out1/Out2 output signalling during boot-load operation disabled = 1(64): Out1/Out2 output signalling during boot-load operation enabled
120	128	0-255	First function number which turn on AUX1
121	63	0-255	Second function number which turn on AUX1
122	63	0-255	Function number which must be turned off so AUX1 can be turned on
123	255	0-255	AUX1 Light intensity (PWM)
124	1	0-255	AUX1 Effect
125	127	0-255	AUX1 Total Time Period, in 8ms steps, max: 2s
126	2	0-255	AUX1 Time Period – (Light Pulse) ON, in 8ms steps, max: 2s
127	12	0-255	AUX1 Time Period – (Light Pulse) OFF, in 8ms steps, max: 2s
128	3	0-255	AUX1 Number of Time Periods
129	0	0-255	AUX1 Turn ON delay
130	0	0-255	AUX1 Turn OFF delay
136	64	0-255	First function number which turn on AUX2
137	63	0-255	Second function number which turn on AUX2
138	63	0-255	Function number which must be turned off so AUX2 can be turned on
139	255	0-255	AUX2 Light intensity (PWM)
140	1	0-255	AUX2 Effect
141	127	0-255	AUX2 Total Time Period, in 8ms steps, max: 2s
142	2	0-255	AUX2 Time Period – (Light Pulse) ON, in 8ms steps, max: 2s
143	12	0-255	AUX2 Time Period – (Light Pulse) OFF, in 8ms steps, max: 2s
144	3	0-255	AUX2 Number of Time Periods
145	0	0-255	AUX2 Turn ON delay
146	0	0-255	AUX2 Turn OFF delay
152	130	0-255	First function number which turn on AUX3
153	63	0-255	Second function number which turn on AUX3
154	63	0-255	Function number which must be turned off so AUX3 can be turned on

CV	Default value	Value range	Description
155	255	0-255	AUX3 Light intensity (PWM)
156	1	0-255	AUX3 Effect
157	127	0-255	AUX3 Total Time Period, in 8ms steps, max: 2s
158	2	0-255	AUX3 Time Period – (Light Pulse) ON, in 8ms steps, max: 2s
159	12	0-255	AUX3 Time Period – (Light Pulse) OFF, in 8ms steps, max: 2s
160	3	0-255	AUX3 Number of Time Periods
161	0	0-255	AUX3 Turn ON delay
162	0	0-255	AUX3 Turn OFF delay
168	1	0-255	First function number which turn on AUX4
169	63	0-255	Second function number which turn on AUX4
170	63	0-255	Function number which must be turned off so AUX4 can be turned on
171	255	0-255	AUX4 Light intensity (PWM)
172	1	0-255	AUX4 Effect
173	127	0-255	AUX4 Total Time Period, in 8ms steps, max: 2s
174	2	0-255	AUX4 Time Period – (Light Pulse) ON, in 8ms steps, max: 2s
175	12	0-255	AUX4 Time Period – (Light Pulse) OFF, in 8ms steps, max: 2s
176	3	0-255	AUX4 Number of Time Periods
177	0	0-255	AUX4 Turn ON delay
178	0	0-255	AUX4 Turn OFF delay
184	5	0-255	First function number which turn on AUX5
185	128	0-255	Second function number which turn on AUX5
186	63	0-255	Function number which must be turned off so AUX5 can be turned on
187	255	0-255	AUX5 Light intensity (PWM)
188	1	0-255	AUX5 Effect
189	127	0-255	AUX5 Total Time Period, in 8ms steps, max: 2s
190	2	0-255	AUX5 Time Period – (Light Pulse) ON, in 8ms steps, max: 2s
191	12	0-255	AUX5 Time Period – (Light Pulse) OFF, in 8ms steps, max: 2s
192	3	0-255	AUX5 Number of Time Periods
193	0	0-255	AUX5 Turn ON delay
194	0	0-255	AUX5 Turn OFF delay
200	3	0-255	First function number which turn on AUX6
201	63	0-255	Second function number which turn on AUX6
202	63	0-255	Function number which must be turned off so AUX6 can be turned on
203	255	0-255	AUX6 Light intensity (PWM)
204	1	0-255	AUX6 Effect
205	127	0-255	AUX6 Total Time Period, in 8ms steps, max: 2s
206	2	0-255	AUX6 Time Period – (Light Pulse) ON, in 8ms steps, max: 2s
207	12	0-255	AUX6 Time Period – (Light Pulse) OFF, in 8ms steps, max: 2s
208	3	0-255	AUX6 Number of Time Periods
209	0	0-255	AUX6 Turn ON delay
210	0	0-255	AUX6 Turn OFF delay
216	-	-	Reserved
217	-	-	Reserverd
218	-	0-100	Worst QoS (Quality of Service) value, saved by 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	-	-	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	Function number which enables saving of QoS in CV218 - CV219
227	2	0-7	Outputs PWM frequency 38Hz – 38KHz, default 610Hz
253	3	-	Firmware version
254	3	-	Firmware subversion
255	0	-	Build version, upper byte
256	44	-	Build version, lower byte