Manual for the NMRA compatible DCC-accessory decoder
Assembled WDECN-TN
Parts Kit WDECN-TN-B

1.1 Properties

This model railroad accessory decoder is based on the ATMEL ATTiny2313 microcontroller. The decoder has 4 pairs of outputs and executes most of the DCC[1] commands for accessory decoders as defined by the NMRA[2]. Therefore the decoder can be used with other compatible DCC products and control systems like Arnold-Digital, Uhlenbrock, Lenz-Digital Plus, Roco-Digital, Fleischmann, Digitrax and Zimo.
The software in the decoder is very complete and supports:

- Configuration by means of CV[3] on a dedicated programming track or on the main track (POM[4]). On the programming track CVs can be written and read
- Adjustable duration of the output timing (0.0065536 s – 1.6777 s and continuous)
- NMRA compatible, processes all usual DCC commands for accessory decoders.
- Configurable flashing for each individual output.
- Flashing outputs with adjustable frequency and duty cycle.
- 5 different modes of operation for accessories like dual coil turnout and signal motors, magnetic decouplers or accessories which require continuous outputs like light signals and MRR[5] illumination.
- A second decoder address can be configured to allow for more signal aspects or to automatically control the aspect of one signal by the position of a turnout or the aspect of a following signal.
- Memorization of the actual signal aspect allows to power up in the last state before power down.
- Up to 40 different signal aspects using 2 decoder addresses or 32 signal aspects using a single output address.
- Decoder addressing from 1 - 510 (2040 turnouts) or output addressing from 1 - 2046
- All outputs can be individually inverted (alternating flash lights at crossroads)
- Prototype like dimming between signal aspect transitions. Duration can be defined with a CV.

Hardware

- Low cost, high performance ATMEL ATTINY2313 Microprocessor
- Simple and robust hardware on an industrial quality printed circuit board.
- Small size 50 x 80 mm with four 3 mm screw holes
- Output current 500 mA per output, ca. 1 A per decoder
- Separate terminals for external power supply (MRR transformer) or power from the DCC track voltage.

This product is not a toy! It is not intended for use by children under 14 years. The part kit contains small parts. Keep it out of the hand of children younger than 3 years. Caution: This product has sharp edges and pins which might cause injuries. Misapplication might lead to fire hazard. Please follow the instructions of this manual to avoid injury or hazard by this product.
* Arnold, Digitrax, Lenz, Roco and Zimo are registered trade marks.

2 Wiring the decoder

Terminals 1 and 2 of terminal strip K3 must be connected to the DCC track signal. The polarity of the DCC signal has no influence on the function of the decoder. It will work either way. The ~ terminals of terminal strip K1 must be connected to a MRR transformer with an output voltage of 14 – 18 VAC. If no MRR transformer is available the DCC track voltage may also be applied. This has some disadvantages: the valuable digital DCC power generated by a digital booster[6] is used for turnouts or lamps and not for its original purpose of driving rolling stock. The round rectifier next to K1 is not very well suited to rectify the audio frequent DCC signal and may cause a distortion of the wave form.
The left terminal of terminal strip K1 is connected to the internal ground signal of the decoder. This terminal can be used to power the illumination of mechanical signals where the dual coils and one pole of the illumination is connected to one of the decoder's plus terminals on K4 – K7.

Caution: This internal decoder ground may in no case be connected to any other ground or mass connection of your layout. It can solely be used for accessories which not only require the common positive internal decoder voltage but also the internal ground. The current drawn between the common plus terminals and the internal ground terminal must not cause a decoder overload.

WDecN-TN can easily be configured for 5 different modes of operation, each suited for different applications. These 5 modes are explained in more detail hereafter:

2.1 Mode 0

This mode of operation allows the user to independently control each one of the 8 outputs. Each output can be switched on or off independent of the state of the other outputs. It deploys the standard accessory command as defined by the NMRA. This command contains one particular bit which defines the state of the addressed output, ON or OFF.
Now most of the commercial digital command stations do never send the command to switch an output OFF and leave it up to the decoder to maintain the active output or to switch it off after a time delay.
For this reason mode 0 can only be used with selected command stations. If your command station allows commanding both the ON and OFF state of an output, the WDecN-TN in Mode 0 is the most universal decoder you can think of. It allows controlling turnouts, illumination but also light signals with up to 256 different aspects.

Required configuration:
CV 33 = 0 or 128 (with memorization of the last output state), CV 29 = 128, CV 3 – CV 6 = 0. CV 46 for flashing and CV 37 for dimming can of course also be used in Mode 0. For special applications you can also use the times in CV 3 – CV 6 to limit the duration of the output pulse. E.g. the duration of impulses to electromagnetic decouplers could be limited by a fixed time rather than by the duration of your finger pushing a button. Since there are 4 timers, 2 adjacent outputs share one timer and will both have the same time limitation.

Tip: When you operate the IntelliBox using the LocoNet protocol, both telegrams (ON and OFF) will be send. When operating the IntelliBox directly or using the P50X protocol it will only send the ON commands.

2.2 Mode 1

In mode 1 the 8 decoder outputs are organized in 4 adjacent pairs. In a pair only one output can be active at a time, i.e. the outputs are mutually exclusive. This feature makes mode 1 the ideal mode for twin coil turnout or signal motors or simple signals with 2 aspects only.
To operate twin coil turnout motors following configuration is required:
CV 33 = 1, CV 29, Bit 6 = 0 and CV 3 - CV 6 > 0

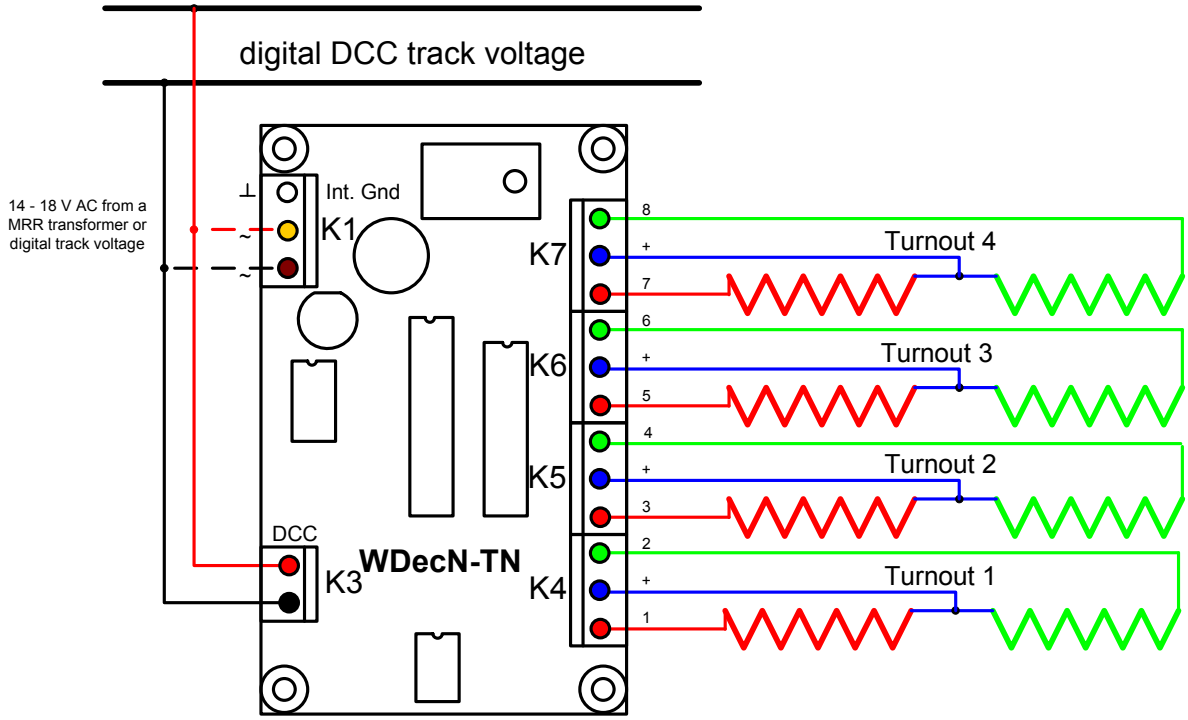


Figure 1 – Connecting 4 twin coil turnout motors

Figure 1 shows the wiring of 4 twin coil motors for turnouts. Each one of these drives contains 2 solenoids which must be connected to the screw terminals of the terminal strips K4 – K7. The common wire of the 2 solenoids must be connected to the center terminal which carries the decoder + supply voltage.
Using CV 3 - CV 6 you define the duration of the output impulse. When the twin coil drive has end of stroke interrupting limit switches, you may also define the maximum possible time delay (255 = 255 x 6.55 ms = 1.67 s).

Caution: If one or more of the CV 3 – CV 6 variables contain a zero value then the corresponding output(s) will be continuously energized. The solenoid of the twin coil drive could get overheated, burn out and/or damage the decoder output. Normal time values are between 25 (0.17 s) and 50 (0.33 s). Larger time values and frequent usage may also lead to overheating drives.

The WDecN-TN in mode 1 can also be used as a signal decoder for 4 signals with each 2 aspects (e.g. green and red). To obtain continuous outputs the timer values in CV 3 – CV 6 must be set to 0.
Of course you can use each one of the 4 output pairs for a different purpose. The pair on K4 may control a turnout; the pair on K5 serves a mechanical signal, while K6 operates on 2 electromagnetic decouplers. Finally K7 operates a light signal with 2 aspects. Timing for K4 is defined by CV 3; the timing for K5 is defined by CV 4, and so on.
Also in mode 1 you can use features like smooth transitioning of aspects, flashing outputs or inverting outputs. See CVs 37, CV 46 and CV 48 for details.

2.3 Mode 2

The outputs of the decoder are grouped in 2 triplets and one pair. K4 and K5 terminal 1 are triplet 1, K5 terminal 2 and K6 make up triplet 2 and the remaining pair of outputs is available on K7. Within a triplet only one output can be active (on) at a time. A triplet can be used to operate a signal with 3 aspects. The simplest case of a signal with 3 aspects would be a signal with just 3 lamps (green, yellow and red) each one connected to an output. Only one lamp can be lit at a time. When signals get more complex, i.e. an aspect is represented by 2 or more lamps, you must use a simple diode matrix to decode these aspects. The wiring diagram in figure 2 shows a pilot signal of the federal German railways that uses 4 lamps to show 3 aspects (Vr0, Vr1 and Vr2).
Please observe that the decoder outputs switch the accessory to internal ground and that the center terminals of K4 – K7 supply the accessory with the internal positive voltage. If you use a diode matrix it must be correspondingly polarized.
A very common diode for this purpose is the 1N4148. It can be used for currents of up to 200 mA. When you apply signals with LEDs you also need to insert current limiting resistors. The resistors can be equally well placed in the anode or cathode of the LED.

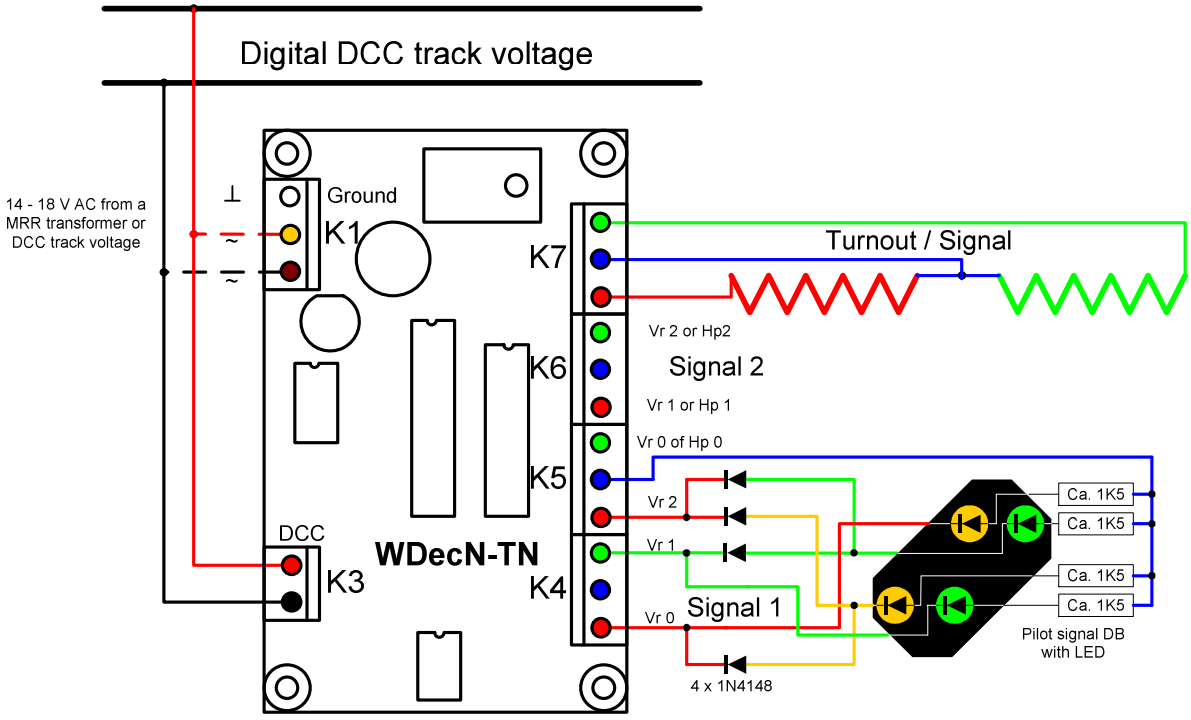


Figure 2 – Wiring 2 signals with each 3 aspects and a twin coil accessory motor.

For the application as shown in figure 2 you need to make following adjustments:
(CV 33 = 2, CV 29, Bit6 = 0, CV 3 = 0, CV 4 = 0, CV 5 = 0, CV 6 > 0)
The remaining outputs on the red and green terminal of terminal strip K7 can be used for a signal with 2 aspects, for a dual coil accessory motor or for 2 electromagnetic decouplers. The timing values in CV 6 must be adopted accordingly:

Connected accessory	**Value in CV 6**
Light signal	0
Twin coil accessory (turnout/signal)	30 – 80
Twin coil accessory (with end of stroke limit switch)	30 – 80, max. 255

Table 1 – Values in CV 6 for different accessories

A configuration example for a Swiss dwarf signal can be found here.

2.4 Mode 3

(CV 33 = 3, CV 29, Bit6 = 0, CV 3 = 0, CV 4 = 0, CV 5 = 0, CV 6 = 0)
Using this mode of operation the decoder outputs are split in 2 groups of each 4 outputs. In a group only one output can be active at any time. You can hook up 2 signals with each 4 aspects. If the aspects are represented by single lamps then these lamps can simply be connected with the 4 available outputs. Only one lamp will be lit at any time. In case your signal is more complex and one or more of the 4 aspects are represented with 2 or more lamps you must insert a diode matrix between signal and decoder to define which lamps are lit for each of the 4 aspects. The wiring example in Figure 3 shows a main signal of the German federal railways which uses 6 lamps to show 4 aspects (Hp0, Hp1, Hp2 und Sh1).
Important: Note: The decoder outputs switch to internal decoder ground. The positive supply voltage is delivered on the 4 center terminals of K4 - K7 (drawn in blue). The diodes in your matrix have to be polarized accordingly. A recommended diode type for a matrix is the low cost 1N4148 with a 200 mA current capacity. Using signals with LED instead of lamps requires the use of current limiting resistor in series with each of the LEDs. The position of the resistor may be chosen in the anode or cathode lead of the LED.
Mode 3 can also be combined with smooth transitioning of aspects, flashing and inverting.

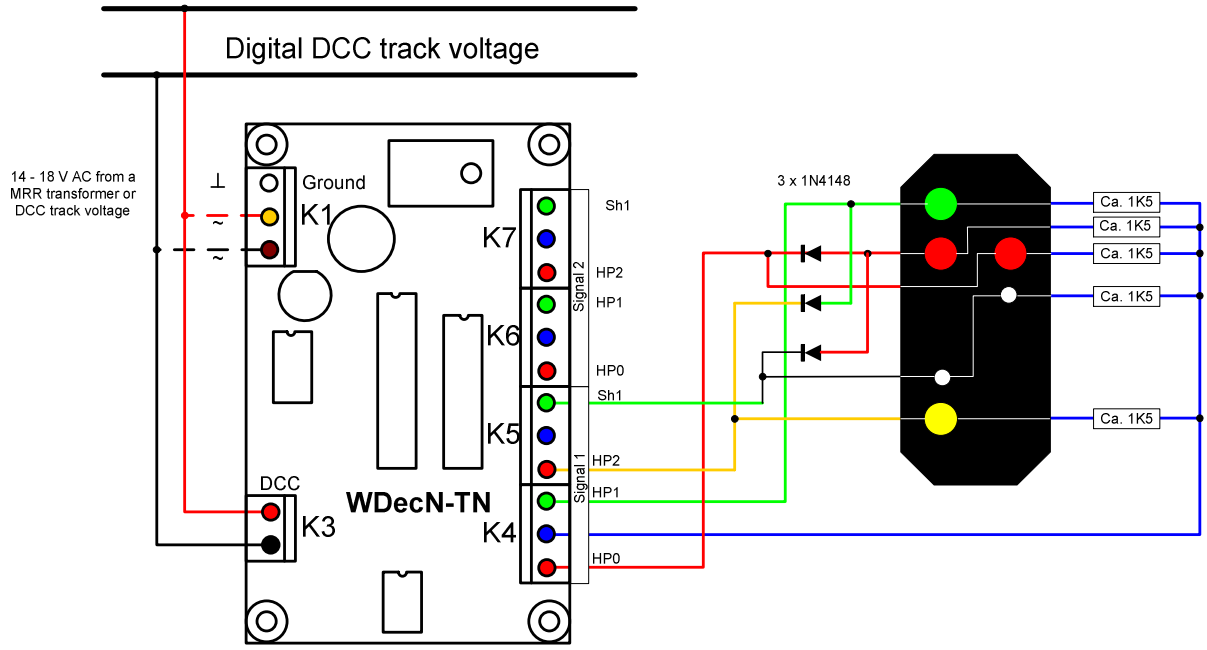


Figure 3 – Wiring 2 signals with each 4 aspects.

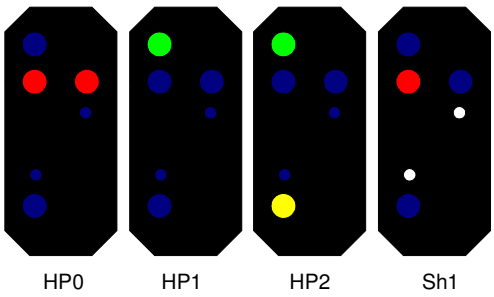


Figure 4 – The aspects Hp0, Hp1, Hp2 and Sh1 are controlled by one half of a WDecN-TN decoder

2.5 Mode 4

(CV 33 = 4, CV 29, Bit6 = 0, CV 3 = 0, CV 4 = 0, CV 5 = 0, CV 6 = 0)
In mode 4 you can freely define the output state of the 8 decoder outputs. Mode 4 is the ideal mode to control more complex light signals. There is no dependency between the outputs, there are no groups and all outputs might be ON or OFF as you desire. On top of that you may define which lamps in what aspect must be flashing.

2.5.1 Single Address Operation

The principle of mode 4 is looking up an aspect from a table of aspects. To pick the desired aspect the decoder evaluates the 8 possible “on” commands for its 8 outputs. It translates these DCC commands to an index with a value of 0 – 7. WDecN-TN takes this index to pick an aspect from a table of 40 aspects. Each of the aspect definitions consists of 2 consequent CVs. The first CV (byte) is a bit pattern which defines the active output bits for the aspect (see Figure 5 “Output mask”). The second CV contains the flashing attributes (see Figure 5 “Flashing mask”).
The table of 40 aspects is contained in the CVs from 49 up to CV 128. In the default single address mode you can only access the first 8 aspects (CV 49 – CV 64). The decoder consumes just one decoder address and the contents of CV 47 must be zero.

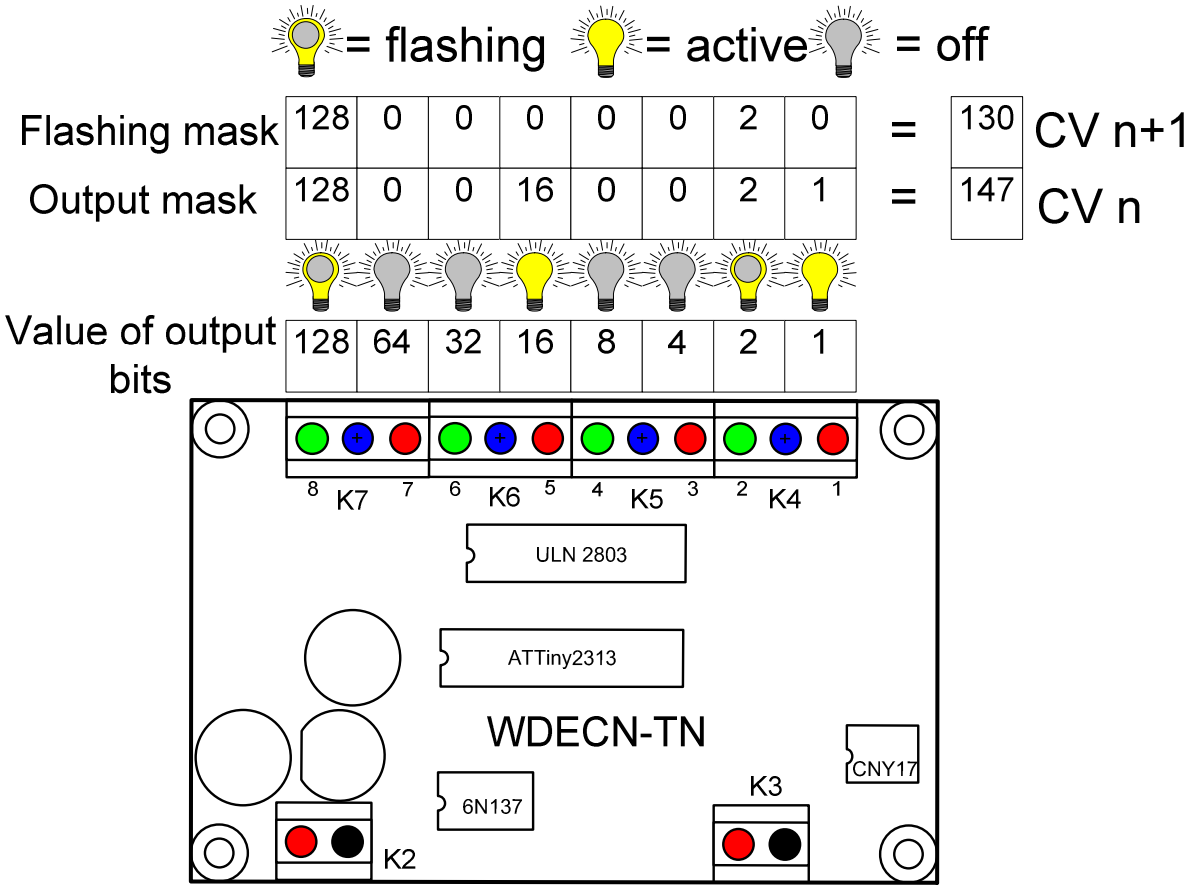


Figure 5 – Output numbering and definitions of the masks for an aspect

In this way the WDecN-TN offers a very easy-to-use way to adapt to the control of any kind of signal with up to 8 aspects. Figure 6 shows a DR HI main signal in combination with a light bar and a pilot signal attached to a WDecN-TN. The total number of LEDs or lamps that can be independently lit must not be more than the physical 8 outputs. If your application requires more than 8 LEDs or lamps then you might consider using a diode matrix to realize

the required function. On the MoBaTron.de web site you will find an example for the wiring and the configuration of a DB signal combination consisting of a main signal and pilot signal with a total of 9 LEDs.

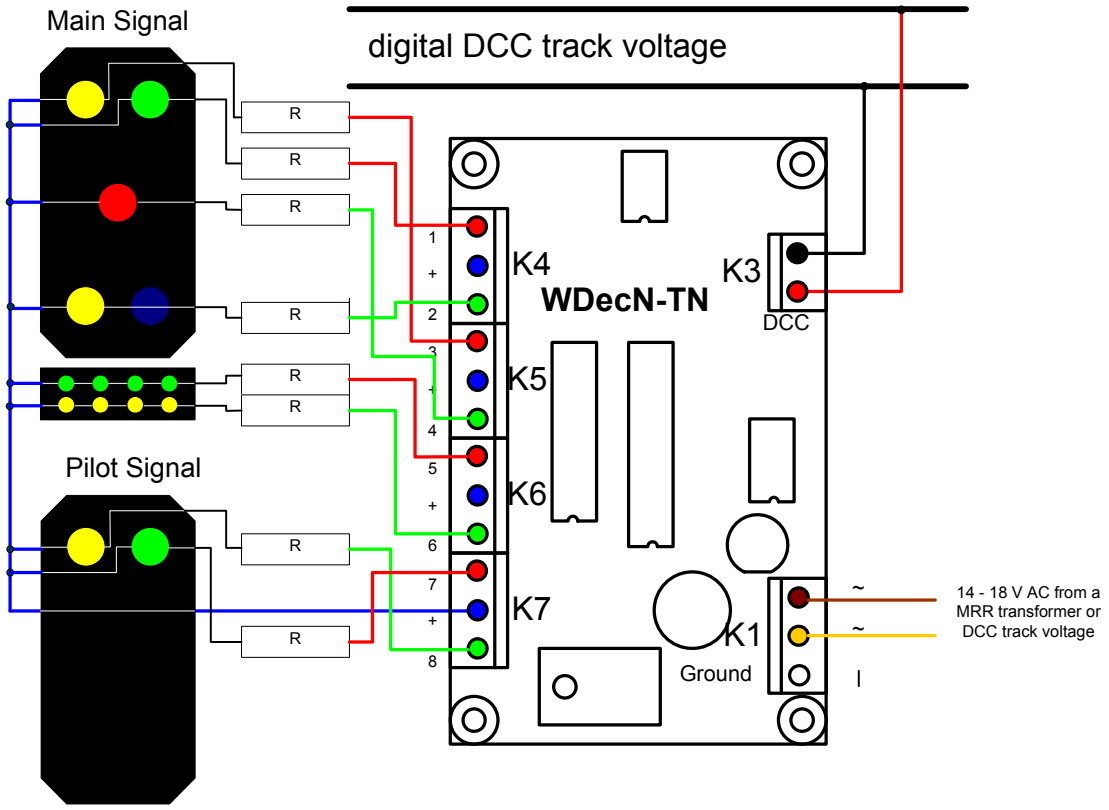


Figure 6 – Wiring a combination of signals in Mode 4

2.5.2 Dual address operation

Many signals can show more than just 8 aspects. With the help of a second decoder address the WDecN-TN can extend the number of displayable aspects to 40 (theoretically 8 x 8 = 64 but limited to 40 due to memory restrictions). The second address must be entered in CV 47 and just consist of the LSB of the address. The MSB of the second address is assumed to be identical to the MSB in CV 9. The second address may be a virtual address, i.e. no decoder uses this address, but it can also be the address of a physical decoder.
In case the second address represents a physical decoder you can make the active aspect depend on the state of that physical decoder (turnout(s) and/or other signal(s)). Especially in combination with pilot signals as is the case with many Hl (DR) and Hp (DB) signals, aspects may change dependent on the state of the next signal (next block). The aspect shown then automatically announces the state of the next signal.
To be completely flexible in configuring the WDecN-TN offers 8 pointers in the array of 40 aspects (CV 49 up to CV128). So for each of the possible 8 states of the decoder under the secondary address, you can assign a block of aspects. You may define 8 blocks each 5 aspects or define 5 blocks each 8 aspects large or even use the same block of aspects for more than once for different states of the secondary decoder.
Use the CVs 38 up to 45 to define the starting indices in the array of aspects. The array of aspects starts with CV49 and goes up to and including CV128. These 40 aspects are numbered 0 to 39 so an index can have a value of 0 up to 39. CV 38 defines the index for the secondary encoder state 0, CV 39 defines the starting index for the secondary encoder state 1, and so on. Figure 7 explains this function graphically.

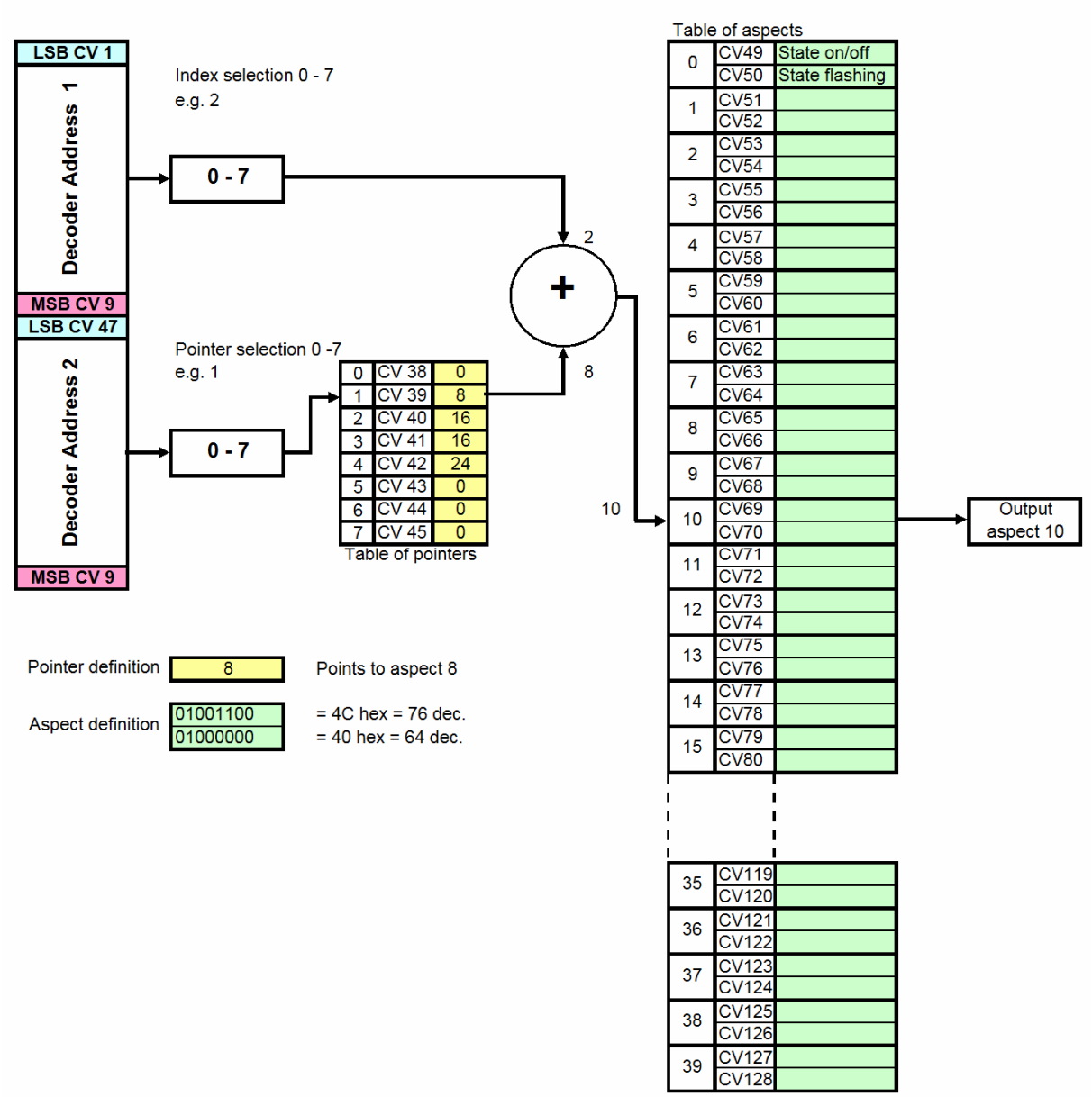


Figure 7 – Selection of signal aspects in mode 4 using 2 decoder addresses

This manual contains a configuration example in which the aspects to be displayed are identical for the states 1 and 2 of the secondary encoder (the next signal in this case). Therefore the index 8 is used twice: once in CV 39 and once in CV40.
Again in this example you see that all non used aspects are configured to show the “Stop” aspect. When anything goes wrong a halt will be displayed.

3 Programming the decoder

The NMRA compatible decoder WDecN-TN must be programmed using so called „Configuration Variables“ (CV). These configuration variables are bytes of information permanently stored in the E²Prom memory of the decoder. The NMRA standards („RP“ = „Recommended Practices“) define a basic mandatory set of variables with fixed functionality but also provide ranges of CVs to be used by the decoder manufacturer for the configuration of the special features of his decoder.

For accessory decoders the NMRA originally reserved the CVs from CV513 up to CV1024. Since many command stations did not and still don't support programming these upper CVs, starting with firmware version V1.2 the WDecN-TN allowed programming the same variables in the both the upper and lower range 1 – 512. In the latest RP 9.2.2 the CVs have now been officially moved from CV513 – CV1024 down to 1 – 512. Usage of 513 – 1024 is now optional but still supported, also by the WDecN-TN. This document refers to both ranges and now mentions the lower range first. E.g. CV 1 (CV513) contains the 6 lowest significant bits of the accessory decoder address or the lower significant Byte of the output address when used with output addressing. Table 8 starting on page 22 shows all implemented CVs.

The factory default value for CV 1 (CV513) is 1. Independent of the selected addressing mode (decoder addressing or output addressing) the decoder accepts all accessory commands sent to address 1.

3.1 Service Mode programming (programming track)

Connect the DCC input terminals on K3 with the programming track output terminals of your command station. Apply 14 -18V AC or DC from a model rail road transformer to the ~ terminals on K1. Follow the instructions of your command station to read or write CVs (direct mode).

Due to the hardware concept of the WDecN-TN decoder it requires an AC or DC supply voltage in the 14 – 18 V range on the ~ terminals on K1 during service mode programming. If no such external power is available, you may consider using the DCC track voltage. Using the programming track voltage for this purpose may work as well. In case of problems consult chapter 6.

The accessory decoder WDecN-TN accepts all standardized DCC commands to read, verify and write CVs. You can operate on bytes or on single bits. It is possible to read and write not-used CVs. Some CVs are marked as “read only”. They can just be read. Trying to write these variables will provoke an error on your command station.

Every successful service mode command will be acknowledged by the decoder. An acknowledge signal very briefly (6 ms) raises the DCC power consumption from the programming track. This raise in power consumption is detected by your command station which will give an acknowledge message in its display. When it expects an acknowledge pulse from the decoder but doesn't get one it reports an error. When reading CVs your command station calculates the value of the CV by repeatedly sending bit verify commands and evaluating the returned acknowledge signals.

3.2 Operations Mode programming (main track)

Even when your preconfigured decoder has been mounted on your layout and receives its DCC commands from the main track you can still change the values of most CVs using the “Operations Mode” programming. This mode is also referred to as **P**rogramming **O**n the **M**ain track (POM). Of course your digital command station must support operations mode programming or “POM”. Please note that POM for accessory decoders differs from POM for multi function decoders (because of the different addressing schemes). For example the Uhlenbrock IntelliBox in V1.5 supports POM only for multi function decoders. The almost identical Fleischmann Twin Center supports both POM for accessory decoders and for multi function decoders.
Using POM you can address the decoder or the output depending of how you configured your decoder to work.

The WDecN-TN in operations mode programming does not supply acknowledge signals like it does in service mode programming. This implies that it is not possible to read variables in operations mode.

3.3 Decoder Addressing Modes

3.3.1 Decoder addressing

A traditional DCC accessory decoder can normally control 4 output pairs (momentary or maintained outputs). Decoders of this type are addressed with a **Decoder Address**. Commands to this address contain information about which pair (2 bit), which output in a pair (1 bit) and what output state is required (1 bit).
A total of 510 decoders is supported, each decoder providing control for 4 accessories. In terms of turnouts this would allow for 2040 turnouts. Decoder 0 is not used and decoder address 511 is reserved for broadcasts commands – commands to be executed by all decoders.
To address a decoder in the range of 1 to 510 a 9 bit address is required. This 9 bit address is split up in a 6 bit part and a remaining 3 bit part. The lower significant 6 bits are stored in CV1 the remaining 3 higher significant bits are stored in CV 9. In CV 29, bit 6 you tell the decoder with a 0 value that it has to process 9 bit addressing information.

How to split up a decoder address in a 6 bit and a 3 bit part is explained elsewhere in this document. A simple method is using Table 11 in the appendix of this manual or using the Excel Tool from the web site . Both tables an tool also give you a cross reference of decoder address and turnout addresses on that decoder.

3.3.2 Output Addressing

For special accessories like signals with many aspects, servo decoders with several positions, or single function decoders – one turnout, one signal, etc. per decoder, the NMRA defined a second addressing scheme with the name **Output Addressing**. This addressing scheme can be mixed with decoder addressing and allows for effective use of the address space for accessories.
Output addressing basically uses a 9 bit address as discussed above and adds the 2 bits defining the output pair to it, so obtaining an 11 bit address.
This 11 bit address provides for a total number of theoretically 2048 accessories. Since the addresses 0 and 2047 (broadcast) are not used, effectively 2046 accessories can be addressed. The 11 bit address is split up in an 8 bit lower significant part and in a 3 bit higher significant part. These values must be stored in CV1 (LSB) and CV 9 (MSB). You inform the WDecN-TN to apply output addressing by setting bit 6 of CV 29 to a “1”.

Especially in combination with the extended commands for accessory decoders, output addressing offers very powerful features. A single WDecN-TN on a single output address can control a signal with up to 32 different aspects.
Of course your digital command station must support these “extended accessory decoder control packets” and not many of them do so.
WDecN-TN can be configured for extended DCC accessory decoder commands by setting CV 29 Bit 5 to a “1” value.

4 WDecN-TN Configuration Variables

This chapter provides detailed information about all Configuration Variables (CVs) of the WDecN-TN accessory decoder. Examples will be used to help understand the functions.

CV 1 (CV 513) contains the 6 lower significant bits of the decoder address or the 8 lower significant bits of the output address. In CV 29 bit 6 you define which of the addressing schemes will be used (0 = decoder addressing, 1 = output addressing). CV 1 can only be used in combination with CV 9 to define a complete 9 bit decoder address or a complete 11 bit output address.

> *Decoder addressing* (see also Appendix A starting at page 28):
> CV 29, Bit6 = 0 : CV 1 = Decoder number%64 (decoder number Modulo 64 or the remainder after a division by 64).
> Example: Decoder number = 200. (Contains the turnouts 797 – 800)
> 200 / 64 = 3 remainder 8 -> CV 1 = 8, CV 9 = 3
>
> *Output addressing:*
> CV 29, Bit6 = 1 : CV 513= output number %256 (output number Modulo 256 or the remainder after a division by 256).
> Example: Output number = 1200.
> 1200 / 256 = 4 remainder 176 -> CV 1 = 176, CV 9 = 4

CV 3 – CV 6 (CV 515 – CV 518) define the duration of the output activation for the output pairs 1 to 4. The time is defined as the number of 6.5536 ms increments. For electromagnetic turnout and signal dual coil drives an activation time of ca. 0.33 s = 50 increments is a good value. Entering a 0 value causes the active output to remain energized until it is explicitly de-energized (e.g. by another aspect, by the other output of a pair).

CV 7 (CV 519) contains the firmware version of the decoder. The actual version is 2.1 which is represented by a value of 21. This is a read only variable.

CV 8 (CV 520) contains the manufacturer identification number. This number is assigned by the NMRA. For the WDecN-TN the manufacturer ID = 24 (MoBaTron.de). This is a read only variable.

CV 9 (CV 521) contains the most significant bits of the decoder or the output address. With CV 29, bit 6 you define whether decoder addressing (bit 6 = 0) or output addressing (bit 6 = 1) is active. CV 9 must be used together with CV1 to specify the complete 9 bit decoder address or a complete 11 bit output address.

> *Decoder addressing* (see also Appendix A starting at page 28):
> CV 29, Bit6 = 0 : CV 9 = Decoder number / 64 (result of the integer division of the decoder number by 64). These are the 3 most significant bits of the 9 bit decoder address.
> Example: Decoder number = 200.
> 200 / 64 = 3 remainder 8 -> CV 9 = 3, CV 1 = 8
>
> *Output addressing:*
> CV 29, Bit6 = 1 : CV 9 = output number / 256 (result of the integer division of the output number by 256).
> Example: Output number = 1200.
> 1200 / 256 = 4 remainder 176 -> CV 9 = 4, CV 1 = 176

CV 29 (CV 541) Configuration of the decoder. This is a bit mask in which single bits activate functionalities. The properties can be changed bit wise. This is the meaning of the bits:

	Meaning	**Default**	**Bit value**
Bit 0	reserved	0	1
Bit 1	reserved	0	2
Bit 2	reserved	0	4
Bit 3	Bi-Directional communication, always off (0)	0	8
Bit 4	Reserved	0	16
Bit 5	Type: 0 = Basic Accessory Decoder, 1 = Extended Accessory Decoder	0	32
Bit 6	Addressing 0 = decoder addressing 1 = output addressing (see chapter 3.3.2)	0	64
Bit 7	Decoder type: 0 = Multi Function Decoder (not implemented) 1 = Accessory decoder	1	128

Table 2 - Properties of CV29

CV 33 (CV 545) defines the mode of operation of the decoder. CV 33 is only valid if the decoder has been configured as basic accessory with decoder addressing (CV 29, bit 5 = 0 and CV 29, Bit 6 = 0). Most of the actual DCC command stations can address the decoder only when it has been configured this way.

Value	**Function**
0	**Mode 0.** Evaluate the status bit in the standard DCC accessory command. Allows to energize or to de-energize the individual outputs of the decoder. This mode is not supported by all digital command stations because they normally do not send commands to de-activate outputs.
1	**Mode 1.** Control of 4 pairs of outputs. Output duration is defined by CV 3 – CV 6. This is the standard for the control of 4 turnouts. Zero values in CV 3 – CV 6 make the outputs maintained and turn the decoder into a signal decoder for 2-aspect signals, illumination, or motorized drives (relays required).
2	**Mode 2.**Control of 2 triplets and one pair of outputs. Can be used to operate two 3-aspect signals and one dual coil accessory or 2-aspect signal. CV 3, 4 and 5 must contain 0. CV 6 defines the behavior of the last pair, maintained or momentary.
3	**Mode 3.** Control of two 4-aspect signals. CV 3 – CV 6 must contain zero values.
4	**Mode 4.** Control of 8 independent outputs. Mode 4 is used to display up to 8, or up to 40 8-bit aspects. Each of these aspects consists of a bit pattern defining the active outputs and a bit pattern defining the flashing property of active outputs. Aspects must be stored in CVs 49 - 128 and are accessed using indices. Using 1 decoder address you can access 8 aspects, using 2 addresses you can access up to 40 aspects. Aspects can be organized in groups and a set of 8 pointers defines the starting index of a group. Which pointer (1 – 8) is used is controlled by the information received on the second decoder address. The second address must be entered in CV47; the pointers are defined in CV 38 – CV 45.
128	Mode 0 with storage of the last state
129	Mode 1 with storage of the last state. Should not be used with turnouts because they remember their last state mechanically.
130	Mode 2 with storage of the last state
131	Mode 3 with storage of the last state.
132	Mode 4 with storage of the last state.

Table 3 – Properties of CV 33

CV 34 (CV 546) defines the frequency of the internal flash generator. The duration of one period must be entered in units of 6.55 ms. For a flashing frequency of 2 Hz (500 ms) you would need to enter a value 500 / 6.55 = 76. The factory default for CV 34 is 100 (~1.5 Hz). See also CVs 35 and 46.

CV 35 (CV 547) is used to define the duty cycle of the internal flashing generator. The value you enter in CV35 must always be less than the value you entered in CV34. If you enter a value equal or greater than the value in CV 34 the flashing turns into steady lighting (> 100% on). When you enter a value of 0 in CV 35, the duty cycle is 0% on and the outputs activated for flashing will be off all the time. See also CVs 34 and 46.

CV 36 (CV 548) controls the smooth transitioning between different signal aspects. On some prototype signals an aspect slowly dims, then there is a short dark phase and the new aspect smoothly appears. The duration of these 3 phases is defined with CV36. The time is expressed in units of 6,55 ms. The factory default for CV36 is 20 which leads to a phase duration of about 120 ms for dimming and lighting up. The dark phase is always half this time. Smooth transitioning does only make sense for light signals and could lead to damage or malfunction when applied to twin coil accessory motors. See also CV37)

CV 37 (CV 549) defines for which of the 8 decoder outputs the smooth transitioning is active (see CV36). CV 37 is a bit mask in which bit 0 represents output 1R; bit 1 represents output 1L; bit 2 corresponds to output 2R and so on. If you want to enable smooth transitioning for all outputs, you would enter a value of 255 in CV37. See also CV 36.

CV 38 – CV 45 (CV 550 – CV 557) contain 8 indices in the array of aspects (CV 49 – CV 128). The indexing in the array of aspects is only active in **mode 4**. If your WDecN-TN only uses its basic decoder address in CV1 and CV9, you can access the range of 8 aspects as defined by the contents of CV 38. The default value of CV38 is 0, so you would be able to access the 8 aspects stored in CV 49 – CV 64. (Changing the contents of CV 38 using POM would allow you to access the other 32 aspects). If your decoder also uses a second address (CV 47 > 0) then the second address controls the selection of the pointer (1 - 8). This mechanism also allows to automatically control the active aspect of a signal based on the status of another decoder be it signal or a turnout decoder.
CV 38 : Index of the first aspect within a group of up to 8 aspects that will e active when the decoder with the secondary address decodes an “on” command for its output #0. The value of CV 38 may range from 0 to 39.
CV 39 : Index of the first aspect within a group of up to 8 aspects that will e active when the decoder with the secondary address decodes an “on” command for its output #1. The value of CV 39 may range from 0 to 39.
Etc. etc. for the CVs 40 – 45.
The tables Table 4, Table 5, Table 6 and Table 7 starting at page 17 show a practical example for the application of WDecN-TN for German Hl signals.

CV 46 (CV 558) is used to define which outputs must flash in modes 0 – 3. Bits 0 - 7 correspond to the outputs 1 – 8. When a bit is set the corresponding active output will flash. Flashing only makes sense for signals and warning lamps. See also CV34 and CV 35.

CV 47 (CV 559) contains the 6 least significant bits of the secondary decoder address that will be evaluated in mode 4 to control the selection of the pointer into the array of aspects. This variable is only active in Mode 4. The most significant 3 bits of the secondary decoder address are taken from CV 9, so both the primary and secondary decoder address must be in same range, sharing the same 3 most significant bits.

CV 48 (CV 560) contains a bit mask which defines which outputs will be inverted. This mask can be used to create alternating flash lights as required for cross roads. CV48 can also be used to generate simple aspects in mode 2 or 3 without having to use a diode matrix. This variable should be left zero when the decoder is used to control dual coil accessories.
A typical example that makes use of inverting outputs is the Swiss dwarf signal with 3 aspects. This signal has 3 lamps. Always 2 out of 3 lamps are lit to show the 3 aspects. Here you will find the documentation for this application.

CV 49, CV 51, CV 53 . . . . CV 127 (CV 561, CV 563, CV 565 . . . . CV 539) contain the up to 40 signal aspects (bit patterns representing active outputs) which can be displayed in 3 ways:

CV 29, bit 5 = 0 and CV29, bit 6 = 0, CV 33 = 4, CV 47 = 0, CV 38 = 0
You can display any one of the first 8 signal aspects

CV 29, bit 5 = 1 and CV 29, bit 6 = 1, CV 47 = 0, CV 33 = 1/default, CV 38 =0/default.
Up to 32 signal aspects can be displayed using the NMRA extended accessory commands. The decoder uses output addressing. Note that extended accessory commands are not supported by all digital command stations.

CV 29, bit 5 = 0 and CV 29, bit 6 = 0, CV 33 = 4, CV 47 > 0
Depending on the status of the secondary decoder in CV 47 the decoder selects a group of aspects to display. Using its own status it picks an aspect from the active group. This mechanism allows to select any one of the up to 40 aspects from the array of aspects (CV 49 – CV 128).

Each one of the 40 aspects needs to be defined in 2 subsequent CVs in the 49 to 128 range. The first one of these 2 CVs contains the bits that must be set active and he second one contains the active bits that must flash. Bits correspond to decoder outputs: Bit 0 = output 1 and Bit 7 is output 8. Table 4, Table 5, Table 6 and Table 7 show an example configuration for an Hl signal with pilot signal and signal bars. This example also shows the dependency on the state of the next signal, e.g. the secondary decoder.

CV 50, CV52, CV 54 . . . . CV 128 (CV 562, CV 564, CV 566 . . . . CV 640) contain the masks that define which of the active outputs in an aspect must flash.

4.1 Extended commands for accessory decoders

These commands have already been implemented in the firmware of the WDecN-TN. Probably none of the known DCC command stations can issue these commands.
The commands are:

- Extended accessory decoder command (allows the selection of one out of 32 signal aspects using one single accessory address).
- Extended accessory decoder broadcast command. This command allows to send a single command which will be received an executed by all accessory decoders capable of executing broadcast commands. Could be used to set all signals to a stop aspect.
- POM for extended accessory decoders. This could be used to change aspects online, e.g. by means of a computer control program.

4.2 Reset to default factory settings

To return the WDecN-TN to factory settings it has to be configured for address 0. This can be achieved by setting both CV1 and CV 9 to a 0 value. The reset to factory defaults does apply to the values in CV 49 – CV 128.

- The Address of the decoder will be set to 1
- The output time delays in CV3 – CV6 will be set to 50 (0.32s)
- Mode of operation (CV 33 = 1 / standard turnout decoder)
- Storage of last state will be disabled
- Decoder addressing will be active (CV 29, Bit 6 = 0)
- Standard accessory decoder command will be active (CV 29, Bit 5 = 0)
- Smooth transitioning between signals aspects will be off (CV 36 = 20, CV 37 = 0)
- Flashing and inverting will be disabled (CV46 = 0, CV48 = 0)
- The secondary decoder address (CV 47) will be set zero.

4.3 Example configuration for Mode 4

	Pilot signal		Main signal							
	yellow	green	yellow line	green line	red	top yellow	bottom yellow	green		
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value	Index/aspect
CV 49	1	0	0	0	1	0	0	0	**136**	0 / Hp0
CV 50	0	0	0	0	0	0	0	0	**0**	
CV 51	1	0	0	0	0	1	1	0	**134**	1 / Hl12a
CV 52	1	0	0	0	0	0	0	0	**128**	
CV 53	1	0	1	0	0	1	1	0	**166**	2 / Hl12b
CV 54	1	0	0	0	0	0	0	0	**128**	
CV 55	0	1	0	1	0	1	1	0	**86**	3 / Hl11
CV 56	0	1	0	0	0	0	0	0	**64**	
CV 57	0	1	0	0	0	1	0	0	**68**	4 / Hl10
CV 58	0	0	0	0	0	0	0	0	**0**	
CV 59	1	0	0	0	1	0	0	0	**136**	5 / Hp0
CV 60	0	0	0	0	0	0	0	0	**0**	
CV 61	1	0	0	0	0	1	0	0	**136**	6 / Hp0
CV 62	0	0	0	0	0	0	0	0	**0**	
CV 63	1	0	0	0	0	1	0	0	**136**	7 / Hp0
CV 64	0	0	0	0	0	0	0	0	**0**	

Table 4 – Example configuration for an Hl main signal with pilot signal and light bars. The signal controlled by the secondary decoder address shows the Halt aspect (value 0). CV 38 = 0

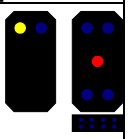
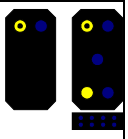
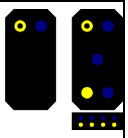
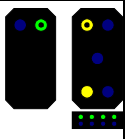
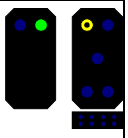
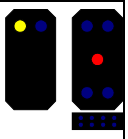
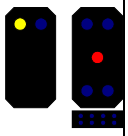
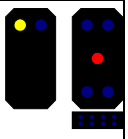
	Pilot signal		Main signal							
	yellow	green	yellow line	green line	red	top yellow	bottom yellow	green		
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value	Index / aspect
CV 65	1	0	0	0	1	0	0	0	**136**	8 / Hp0 
CV 66	0	0	0	0	0	0	0	0	**0**	
CV 67	1	0	0	0	0	1	1	0	**134**	9 / Hl9a 
CV 68	1	0	0	0	0	1	0	0	**132**	
CV 69	1	0	1	0	0	1	1	0	**166**	10 / Hl9b 
CV 70	1	0	0	0	0	1	0	0	**132**	
CV 71	0	1	0	1	0	1	1	0	**86**	11 / Hl8 
CV 72	0	1	0	0	0	1	0	0	**68**	
CV 73	0	1	0	0	0	1	0	0	**68**	12 / Hl7 
CV 74	0	0	0	0	0	1	0	0	**4**	
CV 75	0	0	0	0	0	0	0	0	**0**	13 / Hp0 
CV 76	0	0	0	0	0	0	0	0	**0**	
CV 77	0	0	0	0	0	0	0	0	**0**	14 / Hp0 
CV 78	0	0	0	0	0	0	0	0	**0**	
CV 79	0	0	0	0	0	0	0	0	**0**	15 / Hp0 
CV 80	0	0	0	0	0	0	0	0	**0**	

Table 5 – Example configuration for an Hl main signal with pilot signal and light bars. The signal controlled by the secondary decoder address (next signals) shows the aspect „slow speed / 40/60 km/h“. CV 39 = 8, CV 40 = 8

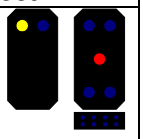
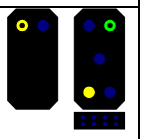
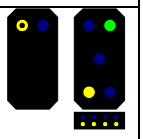
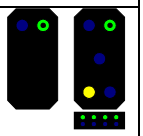
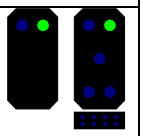
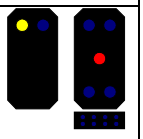
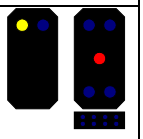
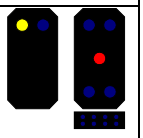
	Pilot signal		Main signal							
	yellow	green	yellow line	green line	red	top yellow	bottom yellow	green		
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value	Index / aspect
CV 81	1	0	0	0	1	0	0	0	**136**	16 / Hp0 
CV 82	0	0	0	0	0	0	0	0	**0**	
CV 83	1	0	0	0	0	0	1	1	**131**	17 / Hl6a 
CV 84	1	0	0	0	0	0	0	1	**128**	
CV 85	1	0	1	0	0	0	1	0	**162**	18 / Hl6b 
CV 86	1	0	0	0	0	0	0	0	**128**	
CV 87	0	1	0	1	0	0	1	1	**83**	19 / Hl5 
CV 88	0	1	0	0	0	0	0	1	**65**	
CV 89	0	1	0	0	0	0	0	1	**65**	20 / Hl4 
CV 90	0	0	0	0	0	0	0	1	**1**	
CV 91	1	0	0	0	1	0	0	0	**136**	21 / Hp0 
CV 92	0	0	0	0	0	0	0	0	**0**	
CV 93	1	0	0	0	1	0	0	0	**136**	22 / Hp0 
CV 94	0	0	0	0	0	0	0	0	**0**	
CV 95	1	0	0	0	1	0	0	0	**136**	23 / Hp0 
CV 96	0	0	0	0	0	0	0	0	**0**	

Table 6 – Example configuration for an Hl main signal with pilot signal and light bars. The decoder with the secondary address (next signal) shows „limited speed/ 100 km/h“. CV 41 = 16

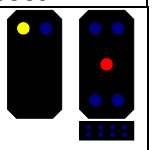
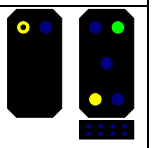
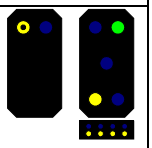
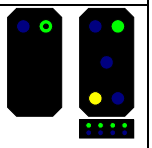
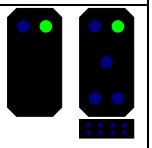
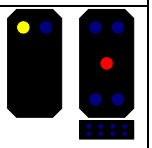
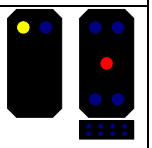
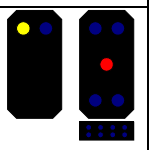
	Pilot signal		Main signal							
	yellow	green	yellow line	green line	red	top yellow	bottom yellow	green		
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value	Index / aspect
CV 97	1	0	0	0	1	0	0	0	**136**	24 / Hp0 
CV 98	0	0	0	0	0	0	0	0	**0**	
CV 99	1	0	0	0	0	0	1	1	**131**	25 / Hl3a 
CV 100	1	0	0	0	0	0	0	0	**128**	
CV 101	1	0	1	0	0	0	1	1	**163**	26 / Hl3b 
CV 102	1	0	0	0	0	0	0	0	**128**	
CV 103	0	1	0	1	0	0	1	1	**83**	27 / Hl2 
CV 104	0	1	0	0	0	0	0	0	**64**	
CV 105	0	1	0	0	0	0	0	1	**65**	28 / Hl1 
CV 106	0	0	0	0	0	0	0	0	**0**	
CV 107	1	0	0	0	1	0	0	0	**136**	29 / Hp0 
CV 108	0	0	0	0	0	0	0	0	**0**	
CV 109	1	0	0	0	1	0	0	0	**136**	30 / Hp0 
CV 110	0	0	0	0	0	0	0	0	**0**	
CV 111	1	0	0	0	1	0	0	0	**136**	31 / Hp0 
CV 112	0	0	0	0	0	0	0	0	**0**	

Table 7 – Example configuration for a main signal with pilot signal (DR Hl Signal).The decoder with the secondary address (next signal) shows the aspect “safe, full speed” (status=5). CV 42 = 24, CV 43, 44 and 45 contain zeros, so they point to the aspects for Halt on next signal.

4.4 Summary of all CVs

CV #	CV # (optional)	CV Name	Default value	Comment
1	513	Decoder Address LSB	1	1 - 63
2	514	Auxiliary activation	0	Bit mask 0-255 (not implemented)
3	515	Time On F1 (outputs 1 and 2)	50	0 –255, 0 = continuous output
4	516	Time On F2 (outputs 3 and 4)	50	0 –255, 0 = continuous output
5	517	Time On F2 (outputs 3 and 4)	50	0 –255, 0 = continuous output
6	518	Time On F2 (outputs 3 and 4)	50	0 –255, 0 = continuous output
7	519	Manufacturer Version Info	21	Read Only (V 2.1)
8	520	Manufacturer ID	24	Read Only (MoBaTron.de = 24)
9	521	Decoder Address MSB	0	0 – 7 (max. 512 Decoders)
10	522	Reserved by NMRA for future use	255	
11	523	Reserved by NMRA for future use	255	
12	524	Reserved by NMRA for future use	255	
13	525	Reserved by NMRA for future use	255	
14	526	Reserved by NMRA for future use	255	
15	527	Reserved by NMRA for future use	255	
16	528	Reserved by NMRA for future use	255	
17	529	Reserved by NMRA for future use	255	
18	530	Reserved by NMRA for future use	255	
19	531	Reserved by NMRA for future use	255	
20	532	Reserved by NMRA for future use	255	
21	533	Reserved by NMRA for future use	255	
22	534	Reserved by NMRA for future use	255	
23	535	Reserved by NMRA for future use	255	
24	536	Reserved by NMRA for future use	255	
25	537	Reserved by NMRA for future use	255	
26	538	Reserved by NMRA for future use	255	
27	539	Reserved by NMRA for future use	255	
28	540	bi-directional communication configuration	255	Bit mask (not implemented)
29	541	Accessory decoder configuration	128	Bit mask
30	542	Reserved by NMRA for future use	255	
31	543	Reserved by NMRA for future use	255	
32	544	Reserved by NMRA for future use	255	
33	545	Configuration of mode of operation	1	0 – 4, 128 – 132
34	546	Flashing frequency	100	100 x 0,00655 s=0,65536s (ca. 1,7 Hz)
35	547	Flashing duty cycle	50	CV 547 < CV 546
36	548	Smooth transition time f. signal aspects	20	ca. 120 ms
37	549	Smooth transition mask	0	Bit mask 0 – 255
38	550	Index for signal aspect 1 of next signal	0	1 – 40 which aspect must be shown?
39	551	Index for signal aspect 2 of next signal	0	1 – 40 which aspect must be shown?
40	552	Index for signal aspect 3 of next signal	0	1 – 40 which aspect must be shown?
41	553	Index for signal aspect 4 of next signal	0	1 – 40 which aspect must be shown?
42	554	Index for signal aspect 5 of next signal	0	1 – 40 which aspect must be shown?
43	555	Index for signal aspect 6 of next signal	0	1 – 40 which aspect must be shown?
44	556	Index for signal aspect 7 of next signal	0	1 – 40 which aspect must be shown?
45	557	Index for signal aspect 8 of next signal	0	1 – 40 which aspect must be shown?
46	558	Flashing output mask (Modes 0 - 3, see CV 33)	0	Which outputs must be flashing?
47	559	Next signal decoder address LSB (6 Bits)	0	MSB = CV 9
48	560	Inversion mask	0	0 – 255 which outputs must be inverted?
49	561	Bit pattern aspect 1	0	Index 0
50	562	Flashing mask for aspect 1	0	Index 0
51	563	Bit pattern aspect 2	0	Index 1
52	564	Flashing mask for aspect 2	0	Index 1
53	565	Bit pattern aspect 3	0	Index 2
54	566	Flashing mask for aspect 3	0	Index 2
55	567	Bit pattern aspect 4	0	Index 3
56	568	Flashing mask for aspect 4	0	Index 3
57	569	Bit pattern aspect 5	0	Index 4
58	570	Flashing mask for aspect 5	0	Index 4
59	571	Bit pattern aspect 6	0	Index 5
60	572	Flashing mask for aspect 6	0	Index 5
61	573	Bit pattern aspect 7	0	Index 6
62	574	Flashing mask for aspect 7	0	Index 6
63	575	Bit pattern aspect 8	0	Index 7
64	576	Flashing mask for aspect 8	0	Index 7
65	577	Bit pattern aspect 9	0	Index 8

66	578	Flashing mask for aspect 9	0	Index 8
67	579	Bit pattern aspect 10	0	Index 9
68	580	Flashing mask for aspect 10	0	Index 9
69	581	Bit pattern aspect 11	0	Index 10
70	582	Flashing mask for aspect 11	0	Index 10
71	583	Bit pattern aspect 12	0	Index 11
72	584	Flashing mask for aspect 12	0	Index 11
73	585	Bit pattern aspect 13	0	Index 12
74	586	Flashing mask for aspect 13	0	Index 12
75	587	Bit pattern aspect 14	0	Index 13
76	588	Flashing mask for aspect 14	0	Index 13
77	589	Bit pattern aspect 15	0	Index 14
78	590	Flashing mask for aspect 15	0	Index 14
79	591	Bit pattern aspect 16	0	Index 15
80	592	Flashing mask for aspect 16	0	Index 15
81	593	Bit pattern aspect 17	0	Index 16
82	594	Flashing mask for aspect 17	0	Index 16
83	595	Bit pattern aspect 18	0	Index 17
84	596	Flashing mask for aspect 18	0	Index 17
85	597	Bit pattern aspect 19	0	Index 18
86	598	Flashing mask for aspect 19	0	Index 18
87	599	Bit pattern aspect 20	0	Index 19
88	600	Flashing mask for aspect 20	0	Index 19
89	601	Bit pattern aspect 21	0	Index 20
90	602	Flashing mask for aspect 21	0	Index 20
91	603	Bit pattern aspect 22	0	Index 21
92	604	Flashing mask for aspect 22	0	Index 21
93	605	Bit pattern aspect 23	0	Index 22
94	606	Flashing mask for aspect 23	0	Index 22
95	607	Bit pattern aspect 24	0	Index 23
96	608	Flashing mask for aspect 24	0	Index 23
97	609	Bit pattern aspect 25	0	Index 24
98	610	Flashing mask for aspect 25	0	Index 24
99	611	Bit pattern aspect 26	0	Index 25
100	612	Flashing mask for aspect 26	0	Index 25
101	613	Bit pattern aspect 27	0	Index 26
102	614	Flashing mask for aspect 27	0	Index 26
103	615	Bit pattern aspect 28	0	Index 27
104	616	Flashing mask for aspect 28	0	Index 27
105	617	Bit pattern aspect 29	0	Index 28
106	618	Flashing mask for aspect 29	0	Index 28
107	619	Bit pattern aspect 30	0	Index 29
108	620	Flashing mask for aspect 30	0	Index 29
109	621	Bit pattern aspect 31	0	Index 30
110	622	Flashing mask for aspect 31	0	Index 30
111	623	Bit pattern aspect 32	0	Index 31
112	624	Flashing mask for aspect 32	0	Index 31
113	625	Bit pattern aspect 33	0	Index 32
114	626	Flashing mask for aspect 33	0	Index 32
115	627	Bit pattern aspect 34	0	Index 33
116	628	Flashing mask for aspect 34	0	Index 33
117	629	Bit pattern aspect 35	0	Index 34
118	630	Flashing mask for aspect 35	0	Index 34
119	631	Bit pattern aspect 36	0	Index 35
120	632	Flashing mask for aspect 36	0	Index 35
121	633	Bit pattern aspect 37	0	Index 36
122	634	Flashing mask for aspect 37	0	Index 36
123	635	Bit pattern aspect 38	0	Index 37
124	636	Flashing mask for aspect 38	0	Index 37
125	637	Bit pattern aspect 39	0	Index 38
126	638	Flashing mask for aspect 39	0	Index 38
127	639	Bit pattern aspect 40	0	Index 39
128	640	Flashing mask for aspect 40	0	Index 39

Table 8 – Summary of all CVs for the NMRA compatible accessory decoder. The gray shade shows the mandatory CVs as defined by the NMRA standard RP 9.2.2. All other fields are used to define the specific decoder features.

5 Implemented DCC-Commands

This is a summary of all NMRA commands which can be executed by the WDecN-TN accessory decoder.

```
Reset Packet      [preamble]0[00000000]0[00000000]0[EEEEEEEE]1

Basic Packet      [preamble]0[10AAAAAA]0[1AAACDDD]0[EEEEEEEE]1
                            AAAAAA    AAA                          = Decoder Address
                                         C                         = Output State
                                          DDD                      = Coil (0-7)
                                                EEEEEEEE           = Checksum

Broadcast Packet  [preamble]0[10111111]0[1000CDDD]0[EEEEEEEE]1

Extended Packet   [preamble]0[10AAAAAA]0[0AAA0AA1]0[000XXXXX]0[EEEEEEEE]1
                            AAAAAA    AAA AA                       = Output Address
                                                 XXXXX             = Signal Aspect
                                                 00000             = Stop Aspect
                                                         EEEEEEEE  = Checksum

Ext. Broadcast    [preamble]0[10111111]0[00000111]0[000XXXXX]0[EEEEEEEE]1


Bas.Op.Mode.Prog  [preamble]0[10AAAAAA]0[1AAACDDD]0[CVACCESS]0[EEEEEEEE]1
                            AAAAAA    AAA1DDD                      = Output Address
                            AAAAAA    AAA0000                      = Decoder Address
                                                 CVACCESS          = DCC Programming CMD
                                                         EEEEEEEE  = Checksum

Ext.Op.Mode.Prog  [preamble]0[10AAAAAA]0[0AAA0AA1]0[CVACCESS]0[EEEEEEEE]1


Dec.Ack.Request   [preamble]0[10AAAAAA]0[0AAACDDD]0[00001111]0[EEEEEEEE]1

Serv.Mode Prog.   [preamble]0[0111CCVV]0[VVVVVVVV]0[DDDDDDDD]0[EEEEEEEE]1
                              CC                                   = Command
                              CC                                   = 01 Verify Byte
                              CC                                   = 11 Write Byte
                              CC                                   = 10 Bit Manipulation
                                VV   VVVVVVVV                      = CV Number
                                                 DDDDDDDD          = New Value
                                                         EEEEEEEE  = Checksum

CVACCESS                  [1110CCVV]0[VVVVVVVV]0[DDDDDDDD]0[EEEEEEEE]1
                              CC                                   = Command
                              CC                                   = 01 Verify Byte
                              CC                                   = 11 Write Byte
                              CC                                   = 10 Bit Manipulation
                                VV   VVVVVVVV                      = CV Number
                                                 DDDDDDDD          = New Value
                                                         EEEEEEEE  = Checksum
```

Table 9 – All decoded DCC commands

6 Solving Problems

6.1 Electromagnetic interferences

Using dual coil accessory motors with end of stroke limit switches may cause a substantial amount of radio frequent interferences and voltages spikes on the wiring. The WDecN-TN decoder has been designed to be highly resistant to these interferences, so normally there will be no influence on its function. When interferences nevertheless cause problems, like turning off maintained outputs or other irregularities occur, you should check the decoder wiring. Keep wires a short as possible. Don't arrange or wrap accessory wires around or nearby a decoder. Long wires will work like an antenna.
If the problems cannot be solved, you insert one or more ferrite beads in the accessories common lead (+Voltage). This causes inductivity which blocks HF signals.
A 100% effective elimination of high frequency interferences and voltage spikes can be achieved by mounting protections diodes over the solenoids. The anodes of the diodes must be pointing to the common + lead. The disadvantage of this method is that your accessories can not be used on conventional layouts with ac power supply for accessories.
Also „Transient Voltage Suppressors" with nominal voltage values of 24 or 30 V mounted across the + and output terminals of the decoder you can effectively avoid voltage spikes from your accessory to reach the decoder electronics and so avoid malfunctioning due to limit switches in the decoder output leads.

6.2 Short circuits and overload

The decoder is equipped with a "self healing" fuse. This fuse is a positive temperature coefficient resistor which has low impedance at normal temperatures. The fuse is intended to protect the decoder against overloading the outputs. The time constant of the fuse is rather high, so it may take several 100 ms for the fuse to heat up, increase its resistance and switch off the overload. When the overload situation is removed the fuse cools down again and assumes the original low impedance.
For protection against hard short circuits and wiring errors the fuse may not be fast enough to protect the output stage of the decoder. The impedances of your power supply and the wiring to your decoder also have a current limiting effect during a short circuit situation. In case of a short circuit the total impedance of all components (wiring, fuse, encoder PCB) decides whether or not the output stage of the decoder (an integrated circuit of the type ULN2803) will be damaged or not. In case of damage to this inexpensive output driver, it can easily be exchanged (IC-socket).

6.3 Service Mode Programming, command station reports "error"

You have connected your WDecN-TN with the programming track and are trying to read or write a configuration variable. Your digital command station just reports "error".

- Did you attach an AC or DC power supply with 14 – 18V to the ~ terminals of terminal strip K1?
- Writing to a "read only" variable will provoke this error, because the decoder doe not acknowledge this illegal operation.
- Did you activate the right programming mode on your command station? WDecN-TN supports only direct programming (CV byte wise or CV bit wise). Programming

modes like register programming or paged mode will also provoke this error message.
- Please check the decoder type. The label on the microprocessor should say **WDecN-TN**. The almost identical WDecD-TN decoder cannot be programmed on the programming track.

6.4 Service Mode Programming, command station reports “no Loco”

You have connected your WDecN-TN with the programming track outputs of your command station and are trying to write or read a configuration variable. You command stations responds with “no loco” or “no decoder”. This indicates that there is a too low or no load on the programming track output.

- Check the wiring between the programming track output of your command station and terminal strip K3 on the decoder. Using a voltmeter in AC mode, do you read a voltage on K3? Is this voltage at least 10V? Is the solder connection between these terminals and the printed circuit board of the WDecN-TN still intact? Maybe you broke the solder joint by excessive torque on the screw terminal?
- WDecN-TN uses very little power of the available power on the programming track. A command station with a low sensitivity can interpret this as if the decoder was missing. You can easily solve this problem by increasing the load on the programming track by placing a resistor of 1 to 2 kOhm in parallel to the encoder.
- Very often the command station uses a relay to provide the programming track with limited DCC power. Due to the low load on the programming track outputs the resistance of the relay contacts may increase over time and cause the digital command station to see a too small load. Mechanical shock / vibration may cure the contacts.
- Please test the label on the microprocessor. It should say **WDecN-TN**. The almost identical WDecD-TN accessory decoder cannot be programmed using the programming track.

6.5 The decoder does not work at all

WDecN-TN is shipped with factory settings that make it a normal turnout decoder for 4 dual coil controlled turnout motors. The Decoder address is set to 1. This means that it will control the turnouts 1 – 4. You hooked up some turnouts or lamps and are testing the decoder. You pus the buttons for turnouts 1 – 4 but nothing happens.

- Check the wiring. Did you hook up the digital track voltage to K3? Did you supply an AC or DC voltage in the range of 14 – 18 V on the ~ terminals of the K1 strip?
- Is your command station in keyboard mode? Did you activate decoder address 1 or accessory address 1 and up on your keyboard / station? On a multi protocol command station, did you activate the DCC protocol for accessories?
- Are your accessories/ lamps connected correctly and are they functional? Do they work with conventional switches and ac/dc power?
- Again check the label on the processor chip. It should say “**WDecN-TN**”. The almost identical WDecM-TN accessory does not react on DCC track commands (just on Motorola Format).
- Check the decoder for mechanical damage. Did electronic parts get out of the printed circuit board? Are all integrated circuits properly seated in their sockets?

7 Parts kit WDecN-TN-B

7.1 Parts list in the order of insertion

Part	Qt	Type	Grid mm/Type	Reference
Diode	1	1N4007	D035	D6
Diode	4	1N 4148	DO35	D1, D2, D3, D4
Metal film resistor	1	4k7	0204	R1
Metal film resistor	1	270R	0207	R2
Metal film resistor	1	100R	0204	R3
Metal film resistor	2	2k2	0207	R6, R7
Metal film resistor	1	1k	0204	R4
Metal film resistor	1	10k	0204	RR
Programmed controller	1	ATTiny2313	DIP20	IC1
Output driver	1	ULN 2803	DIP18	IC2
Voltage regulator 5V	1	7805	TO220	IC3
Opto coupler	1	6N137	DIP8	IC4
Opto coupler	1	CNY17-III	DIP6	IC5
Capacitor MKT	10	100nF	5	C3,C4,C5,C6,C7,C8, C9,C10,C11,C12
Capacitor MKT	1	4,7nF	5	CR
Capacitor MKT	1	1µF	5	C2
Transistor NPN	1	BC547	TO92	T1
Capacitor radial	1	470µF 35V	5	C1
Bridge rectifier	1	80V		B1
Self healing fuse	1	RXEF050		F1
Screw terminal 3-Pol	5	ARK120/3	5	K1, K4, K5, K6, K7
Screw terminal 2-Pol	1	ARK120/2	5	K3

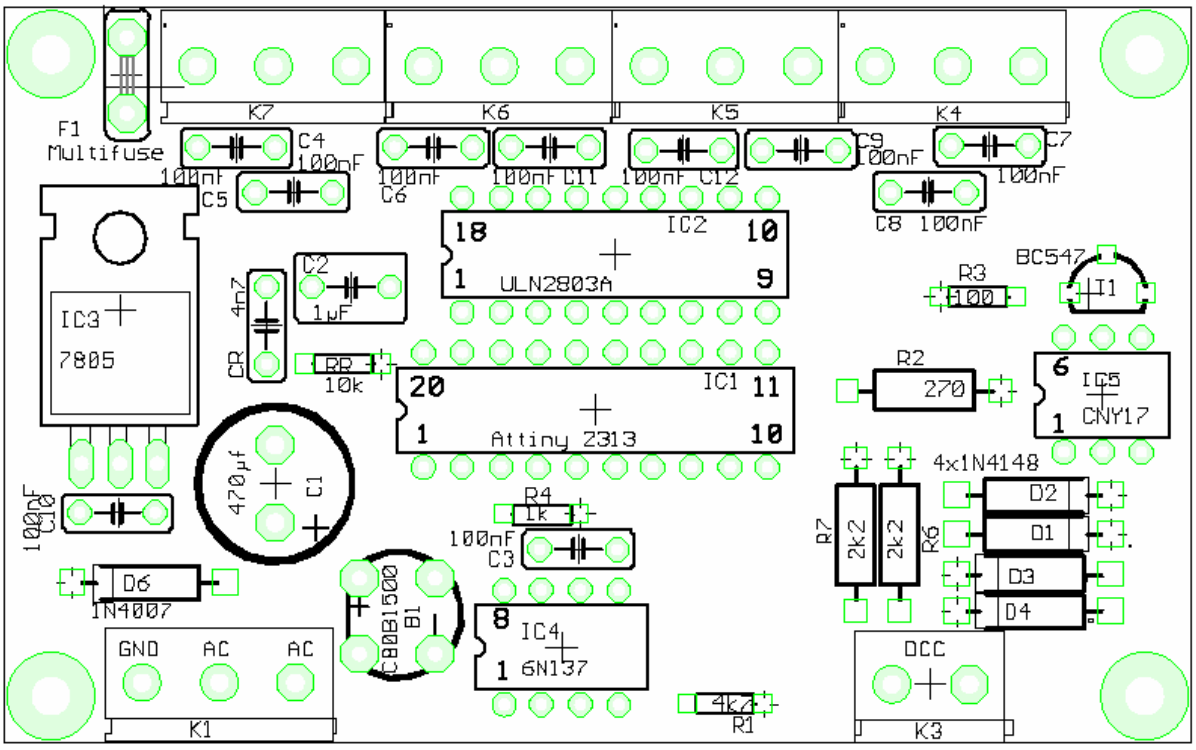


Table 10 – Parts List and Figure 8 – PCB layout for WDecN-TN

7.2 WDecN-TN Schematic

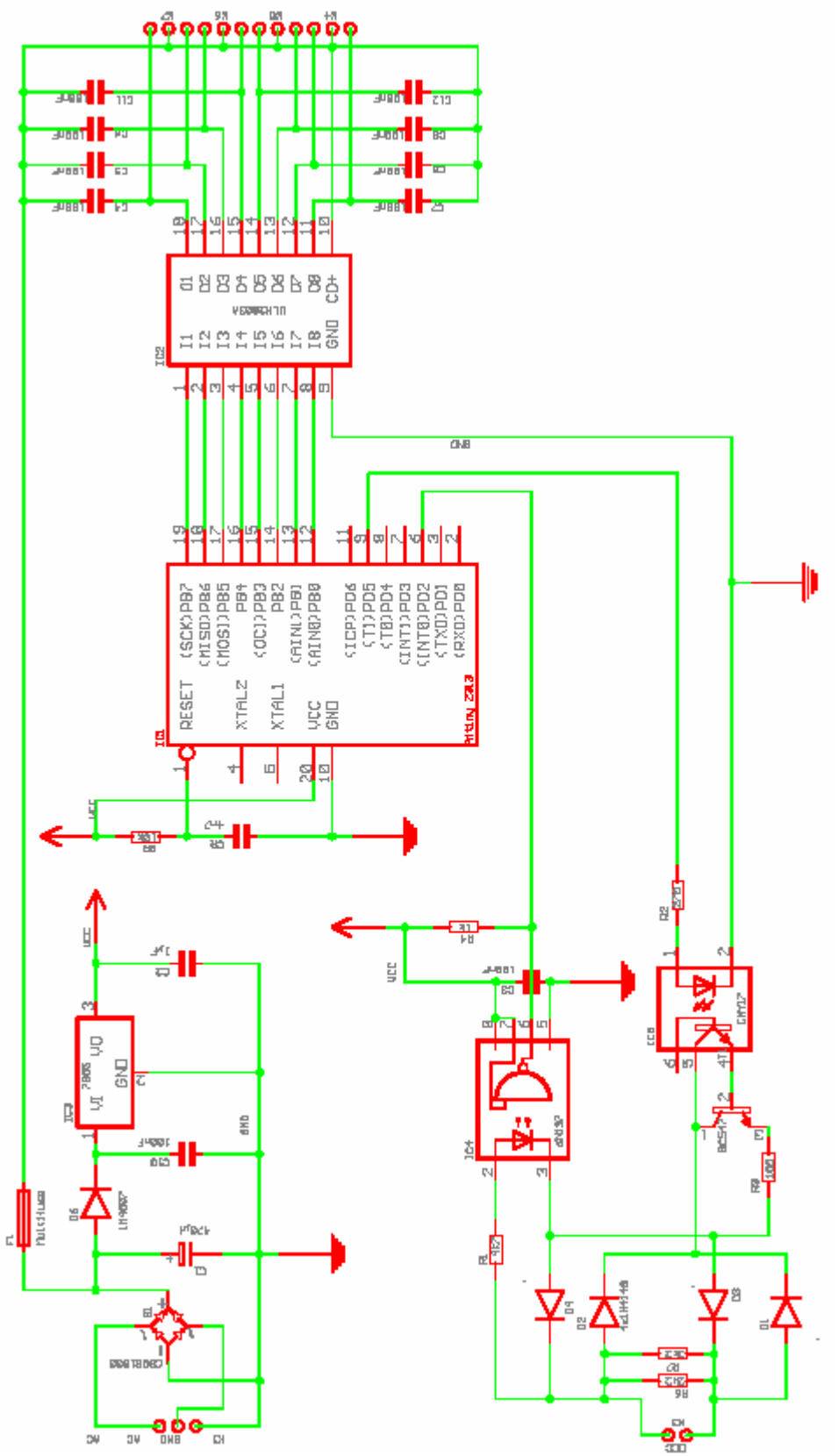


Figure 9 – WDecN-TN Schematic

8 Appendix A Addressing

Decoder	CV 1	CV 9	Acc.	Decoder	CV 1	CV 9	Acc.	Decoder	CV 1	CV 9	Acc.
1	1	0	1 - 4	65	1	1	257 – 260	129	1	2	513 - 516
2	2	0	5 - 8	66	2	1	261 – 264	130	2	2	517 - 520
3	3	0	9 - 12	67	3	1	265 – 268	131	3	2	521 - 524
4	4	0	13 - 16	68	4	1	269 – 272	132	4	2	525 - 528
5	5	0	17 - 20	69	5	1	273 – 276	133	5	2	529 - 532
6	6	0	21 - 24	70	6	1	277 – 280	134	6	2	533 - 536
7	7	0	25 - 28	71	7	1	281 – 284	135	7	2	537 - 540
8	8	0	29 - 32	72	8	1	285 – 288	136	8	2	541 - 544
9	9	0	33 - 36	73	9	1	289 – 292	137	9	2	545 - 548
10	10	0	37 - 40	74	10	1	293 – 296	138	10	2	549 - 552
11	11	0	41 - 44	75	11	1	297 – 300	139	11	2	553 - 556
12	12	0	45 - 48	76	12	1	301 – 304	140	12	2	557 - 560
13	13	0	49 - 52	77	13	1	305 – 308	141	13	2	561 - 564
14	14	0	53 - 56	78	14	1	309 – 312	142	14	2	565 - 568
15	15	0	57 - 60	79	15	1	313 – 316	143	15	2	569 - 572
16	16	0	61 - 64	80	16	1	317 – 320	144	16	2	573 - 576
17	17	0	65 - 68	81	17	1	321 – 324	145	17	2	577 - 580
18	18	0	69 - 72	82	18	1	325 – 328	146	18	2	581 - 584
19	19	0	73 - 76	83	19	1	329 – 332	147	19	2	585 - 588
20	20	0	77 - 80	84	20	1	333 – 336	148	20	2	589 - 592
21	21	0	81 - 84	85	21	1	337 – 340	149	21	2	593 - 596
22	22	0	85 - 88	86	22	1	341 – 344	150	22	2	597 - 600
23	23	0	89 - 92	87	23	1	345 – 348	151	23	2	601 - 604
24	24	0	93 - 96	88	24	1	349 – 352	152	24	2	605 - 608
25	25	0	97 - 100	89	25	1	353 – 356	153	25	2	609 - 612
26	26	0	101 - 104	90	26	1	357 – 360	154	26	2	613 - 616
27	27	0	105 - 108	91	27	1	361 – 364	155	27	2	617 - 620
28	28	0	109 - 112	92	28	1	365 – 368	156	28	2	621 - 624
29	29	0	113 - 116	93	29	1	369 – 372	157	29	2	625 - 628
30	30	0	117 - 120	94	30	1	373 – 376	158	30	2	629 - 632
31	31	0	121 - 124	95	31	1	377 – 380	159	31	2	633 - 636
32	32	0	125 - 128	96	32	1	381 – 384	160	32	2	637 - 640
33	33	0	129 - 132	97	33	1	385 – 388	161	33	2	641 - 644
34	34	0	133 - 136	98	34	1	389 – 392	162	34	2	645 - 648
35	35	0	137 - 140	99	35	1	393 – 396	163	35	2	649 - 652
36	36	0	141 - 144	100	36	1	397 – 400	164	36	2	653 - 656
37	37	0	145 - 148	101	37	1	401 – 404	165	37	2	657 - 660
38	38	0	149 - 152	102	38	1	405 – 408	166	38	2	661 - 664
39	39	0	153 - 156	103	39	1	409 – 412	167	39	2	665 - 668
40	40	0	157 - 160	104	40	1	413 – 416	168	40	2	669 - 672
41	41	0	161 - 164	105	41	1	417 – 420	169	41	2	673 - 676
42	42	0	165 - 168	106	42	1	421 – 424	170	42	2	677 - 680
43	43	0	169 - 172	107	43	1	425 – 428	171	43	2	681 - 684
44	44	0	173 - 176	108	44	1	429 – 432	172	44	2	685 - 688
45	45	0	177 - 180	109	45	1	433 – 436	173	45	2	689 - 692
46	46	0	181 - 184	110	46	1	437 – 440	174	46	2	693 - 696
47	47	0	185 - 188	111	47	1	441 – 444	175	47	2	697 - 700
48	48	0	189 - 192	112	48	1	445 – 448	176	48	2	701 - 704
49	49	0	193 - 196	113	49	1	449 – 452	177	49	2	705 - 708
50	50	0	197 - 200	114	50	1	453 – 456	178	50	2	709 - 712
51	51	0	201 - 204	115	51	1	457 – 460	179	51	2	713 - 716
52	52	0	205 - 208	116	52	1	461 – 464	180	52	2	717 - 720
53	53	0	209 - 212	117	53	1	465 – 468	181	53	2	721 - 724
54	54	0	213 - 216	118	54	1	469 – 472	182	54	2	725 - 728
55	55	0	217 - 220	119	55	1	473 – 476	183	55	2	729 - 732
56	56	0	221 - 224	120	56	1	477 – 480	184	56	2	733 - 736
57	57	0	225 - 228	121	57	1	481 – 484	185	57	2	737 - 740
58	58	0	229 - 232	122	58	1	485 – 488	186	58	2	741 - 744
59	59	0	233 - 236	123	59	1	489 – 492	187	59	2	745 - 748
60	60	0	237 - 240	124	60	1	493 – 496	188	60	2	749 - 752
61	61	0	241 - 244	125	61	1	497 – 500	189	61	2	753 - 756
62	62	0	245 - 248	126	62	1	501 – 504	190	62	2	757 - 760
63	63	0	249 - 252	127	63	1	505 – 508	191	63	2	761 - 764
64	0	1	253 - 256	128	0	2	509 – 512	192	0	3	765 - 768

Table 11 Decoder addressing in CV 1 and CV 9, Decoders 1 to 192

De-coder	CV 1	CV 9	Acc.	De-coder	CV 1	CV 9	Acc.	De-coder	CV 1	CV 9	Acc.
193	1	3	769 - 772	257	1	4	1025 - 1028	321	1	5	1281 - 1284
194	2	3	773 - 776	258	2	4	1029 - 1032	322	2	5	1285 - 1288
195	3	3	777 - 780	259	3	4	1033 - 1036	323	3	5	1289 - 1292
196	4	3	781 - 784	260	4	4	1037 - 1040	324	4	5	1293 - 1296
197	5	3	785 - 788	261	5	4	1041 - 1044	325	5	5	1297 - 1300
198	6	3	789 - 792	262	6	4	1045 - 1048	326	6	5	1301 - 1304
199	7	3	793 - 796	263	7	4	1049 - 1052	327	7	5	1305 - 1308
200	8	3	797 - 800	264	8	4	1053 - 1056	328	8	5	1309 - 1312
201	9	3	801 - 804	265	9	4	1057 - 1060	329	9	5	1313 - 1316
202	10	3	805 - 808	266	10	4	1061 - 1064	330	10	5	1317 - 1320
203	11	3	809 - 812	267	11	4	1065 - 1068	331	11	5	1321 - 1324
204	12	3	813 - 816	268	12	4	1069 - 1072	332	12	5	1325 - 1328
205	13	3	817 - 820	269	13	4	1073 - 1076	333	13	5	1329 - 1332
206	14	3	821 - 824	270	14	4	1077 - 1080	334	14	5	1333 - 1336
207	15	3	825 - 828	271	15	4	1081 - 1084	335	15	5	1337 - 1340
208	16	3	829 - 832	272	16	4	1085 - 1088	336	16	5	1341 - 1344
209	17	3	833 - 836	273	17	4	1089 - 1092	337	17	5	1345 - 1348
210	18	3	837 - 840	274	18	4	1093 - 1096	338	18	5	1349 - 1352
211	19	3	841 - 844	275	19	4	1097 - 1100	339	19	5	1353 - 1356
212	20	3	845 - 848	276	20	4	1101 - 1104	340	20	5	1357 - 1360
213	21	3	849 - 852	277	21	4	1105 - 1108	341	21	5	1361 - 1364
214	22	3	853 - 856	278	22	4	1109 - 1112	342	22	5	1365 - 1368
215	23	3	857 - 860	279	23	4	1113 - 1116	343	23	5	1369 - 1372
216	24	3	861 - 864	280	24	4	1117 - 1120	344	24	5	1373 - 1376
217	25	3	865 - 868	281	25	4	1121 - 1124	345	25	5	1377 - 1380
218	26	3	869 - 872	282	26	4	1125 - 1128	346	26	5	1381 - 1384
219	27	3	873 - 876	283	27	4	1129 - 1132	347	27	5	1385 - 1388
220	28	3	877 - 880	284	28	4	1133 - 1136	348	28	5	1389 - 1392
221	29	3	881 - 884	285	29	4	1137 - 1140	349	29	5	1393 - 1396
222	30	3	885 - 888	286	30	4	1141 - 1144	350	30	5	1397 - 1400
223	31	3	889 - 892	287	31	4	1145 - 1148	351	31	5	1401 - 1404
224	32	3	893 - 896	288	32	4	1149 - 1152	352	32	5	1405 - 1408
225	33	3	897 - 900	289	33	4	1153 - 1156	353	33	5	1409 - 1412
226	34	3	901 - 904	290	34	4	1157 - 1160	354	34	5	1413 - 1416
227	35	3	905 - 908	291	35	4	1161 - 1164	355	35	5	1417 - 1420
228	36	3	909 - 912	292	36	4	1165 - 1168	356	36	5	1421 - 1424
229	37	3	913 - 916	293	37	4	1169 - 1172	357	37	5	1425 - 1428
230	38	3	917 - 920	294	38	4	1173 - 1176	358	38	5	1429 - 1432
231	39	3	921 - 924	295	39	4	1177 - 1180	359	39	5	1433 - 1436
232	40	3	925 - 928	296	40	4	1181 - 1184	360	40	5	1437 - 1440
233	41	3	929 - 932	297	41	4	1185 - 1188	361	41	5	1441 - 1444
234	42	3	933 - 936	298	42	4	1189 - 1192	362	42	5	1445 - 1448
235	43	3	937 - 940	299	43	4	1193 - 1196	363	43	5	1449 - 1452
236	44	3	941 - 944	300	44	4	1197 - 1200	364	44	5	1453 - 1456
237	45	3	945 - 948	301	45	4	1201 - 1204	365	45	5	1457 - 1460
238	46	3	949 - 952	302	46	4	1205 - 1208	366	46	5	1461 - 1464
239	47	3	953 - 956	303	47	4	1209 - 1212	367	47	5	1465 - 1468
240	48	3	957 - 960	304	48	4	1213 - 1216	368	48	5	1469 - 1472
241	49	3	961 - 964	305	49	4	1217 - 1220	369	49	5	1473 - 1476
242	50	3	965 - 968	306	50	4	1221 - 1224	370	50	5	1477 - 1480
243	51	3	969 - 972	307	51	4	1225 - 1228	371	51	5	1481 - 1484
244	52	3	973 - 976	308	52	4	1229 - 1232	372	52	5	1485 - 1488
245	53	3	977 - 980	309	53	4	1233 - 1236	373	53	5	1489 - 1492
246	54	3	981 - 984	310	54	4	1237 - 1240	374	54	5	1493 - 1496
247	55	3	985 - 988	311	55	4	1241 - 1244	375	55	5	1497 - 1500
248	56	3	989 - 992	312	56	4	1245 - 1248	376	56	5	1501 - 1504
249	57	3	993 - 996	313	57	4	1249 - 1252	377	57	5	1505 - 1508
250	58	3	997 - 1000	314	58	4	1253 - 1256	378	58	5	1509 - 1512
251	59	3	1001 - 1004	315	59	4	1257 - 1260	379	59	5	1513 - 1516
252	60	3	1005 - 1008	316	60	4	1261 - 1264	380	60	5	1517 - 1520
253	61	3	1009 - 1012	317	61	4	1265 - 1268	381	61	5	1521 - 1524
254	62	3	1013 - 1016	318	62	4	1269 - 1272	382	62	5	1525 - 1528
255	63	3	1017 - 1020	319	63	4	1273 - 1276	383	63	5	1529 - 1532
256	0	4	1021 - 1024	320	0	5	1277 - 1280	384	0	6	1533 - 1536

Table 11 Decoder addressing in CV 1 and CV 9, Decoders 193 to 384

Decoder	CV 1	CV 9	accessory
385	1	6	1537 - 1540
386	2	6	1541 - 1544
387	3	6	1545 - 1548
388	4	6	1549 - 1552
389	5	6	1553 - 1556
390	6	6	1557 - 1560
391	7	6	1561 - 1564
392	8	6	1565 - 1568
393	9	6	1569 - 1572
394	10	6	1573 - 1576
395	11	6	1577 - 1580
396	12	6	1581 - 1584
397	13	6	1585 - 1588
398	14	6	1589 - 1592
399	15	6	1593 - 1596
400	16	6	1597 - 1600
401	17	6	1601 - 1604
402	18	6	1605 - 1608
403	19	6	1609 - 1612
404	20	6	1613 - 1616
405	21	6	1617 - 1620
406	22	6	1621 - 1624
407	23	6	1625 - 1628
408	24	6	1629 - 1632
409	25	6	1633 - 1636
410	26	6	1637 - 1640
411	27	6	1641 - 1644
412	28	6	1645 - 1648
413	29	6	1649 - 1652
414	30	6	1653 - 1656
415	31	6	1657 - 1660
416	32	6	1661 - 1664
417	33	6	1665 - 1668
418	34	6	1669 - 1672
419	35	6	1673 - 1676
420	36	6	1677 - 1680
421	37	6	1681 - 1684
422	38	6	1685 - 1688
423	39	6	1689 - 1692
424	40	6	1693 - 1696
425	41	6	1697 - 1700
426	42	6	1701 - 1704
427	43	6	1705 - 1708
428	44	6	1709 - 1712
429	45	6	1713 - 1716
430	46	6	1717 - 1720
431	47	6	1721 - 1724
432	48	6	1725 - 1728
433	49	6	1729 - 1732
434	50	6	1733 - 1736
435	51	6	1737 - 1740
436	52	6	1741 - 1744
437	53	6	1745 - 1748
438	54	6	1749 - 1752
439	55	6	1753 - 1756
440	56	6	1757 - 1760
441	57	6	1761 - 1764
442	58	6	1765 - 1768
443	59	6	1769 - 1772
444	60	6	1773 - 1776
445	61	6	1777 - 1780
446	62	6	1781 - 1784
447	63	6	1785 - 1788
448	0	7	1789 - 1792
449	1	7	1793 - 1796
450	2	7	1797 - 1800
451	3	7	1801 - 1804
452	4	7	1805 - 1808
453	5	7	1809 - 1812
454	6	7	1813 - 1816
455	7	7	1817 - 1820
456	8	7	1821 - 1824
457	9	7	1825 - 1828
458	10	7	1829 - 1832
459	11	7	1833 - 1836
460	12	7	1837 - 1840
461	13	7	1841 - 1844
462	14	7	1845 - 1848
463	15	7	1849 - 1852
464	16	7	1853 - 1856
465	17	7	1857 - 1860
466	18	7	1861 - 1864
467	19	7	1865 - 1868
468	20	7	1869 - 1872
469	21	7	1873 - 1876
470	22	7	1877 - 1880
471	23	7	1881 - 1884
472	24	7	1885 - 1888
473	25	7	1889 - 1892
474	26	7	1893 - 1896
475	27	7	1897 - 1900
476	28	7	1901 - 1904
477	29	7	1905 - 1908
478	30	7	1909 - 1912
479	31	7	1913 - 1916
480	32	7	1917 - 1920
481	33	7	1921 - 1924
482	34	7	1925 - 1928
483	35	7	1929 - 1932
484	36	7	1933 - 1936
485	37	7	1937 - 1940
486	38	7	1941 - 1944
487	39	7	1945 - 1948
488	40	7	1949 - 1952
489	41	7	1953 - 1956
490	42	7	1957 - 1960
491	43	7	1961 - 1964
492	44	7	1965 - 1968
493	45	7	1969 - 1972
494	46	7	1973 - 1976
495	47	7	1977 - 1980
496	48	7	1981 - 1984
497	49	7	1985 - 1988
498	50	7	1989 - 1992
499	51	7	1993 - 1996
500	52	7	1997 - 2000
501	53	7	2001 - 2004
502	54	7	2005 - 2008
503	55	7	2009 - 2012
504	56	7	2013 - 2016
505	57	7	2017 - 2020
506	58	7	2021 - 2024
507	59	7	2025 - 2028
508	60	7	2029 - 2032
509	61	7	2033 - 2036
510	62	7	2037 - 2040
511	63	7	2041 - 2044

Table 12 Decoder addressing in CV 1 and CV 9, decoders 385 to 511

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Glossary:

[1] DCC = Digital Command Control
[2] NMRA = National Model Railroad Association
[3] CV = Configuration Variable, also known as parameter
[4] POM = **P**rogramming **O**n the **M**ain track = Operations Mode Programming
[5] MRR = Model RailRoad
[6] Booster = Power amplifier for the digital track signal
[7] Multi Function Decoder = Loco decoder for motor and function control.