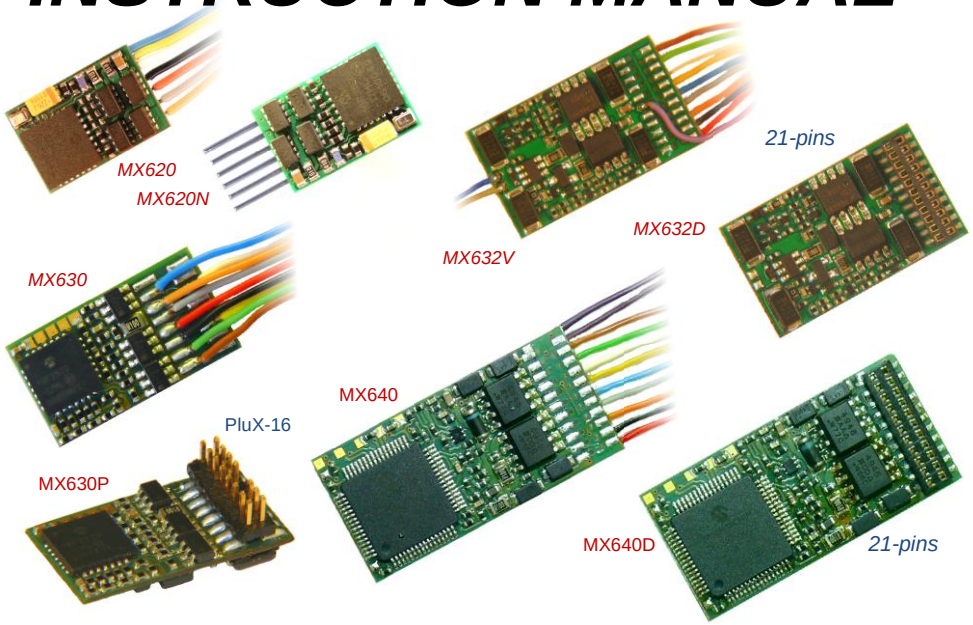
INSTRUCTION MANUAL



MINIATURE – DECODER

MX621, MX621N, MX621R, MX621F (MX620, MX620N..)

H0 – DECODER

MX630, MX630R, MX60F, MX630P

H0, (0) –DECODERS with More Power

MX631, MX631R, MX631F, MX631D, MX631C

H0, 0 – High Output Decoder

MX632, MX632R, MX632D, MX632C, MX632V, W

H0, (0) – SOUND DECODER

MX640, MX640R, MX640F, MX640D, MX640C, MX642, MX642R, MX642F, MX642D, MX642C

EDITION

First edition. SW version 25.0 for MX620, MX630, MX64D and MX640 – 2009 07 15
Corrections regarding decoder types for C-Sinus, and dim mask 2 --- 2009 07 25
SW-Version 26.0 --- 2009 09 26
New MX632 decoder family included --- 2009 12 05
New MX631 decoder family included and CV amendments --- 2010 03 01

1. Overview....2
2. Technical Information....3
3. Addressing and Programming – CV table....7
4. Additional notes to Configuration Variables (CV's)....19
5. "Function mapping" as per NMRA Standard; and ZIMO - Extensions....28
6. ZIMO SOUND – Selection and Programming....34
7. "Bi-directional communication"....44
8. Installation and wiring....44
9. MX64D, MX64DM, MX640D for C-Sinus / SoftDrive-Sinus....52
10. ZIMO decoders and competitor systems....53
11. Special - CV - Sets....54
12. Converting binary to decimal....54
13. Operating with Märklin MOTOROLA systems....55
14. DC - Analog Operation....55
15. AC - Analog Operation....55
16. ZIMO Decoder Software Update....56

A hard copy of this instruction manual is not part of a decoder purchase. Hard copies can be ordered from ZIMO (a nominal fee may apply) but can also be downloaded as a pdf document at no charge from www.zimo.at .

NOTE:

ZIMO decoders contain an EPROM which stores software that determines its characteristics and functions. The software version can be read out form CV #7 and #65.

The current version may not yet be capable of all the functions mentioned in this manual. As with other computer programs, it is also not possible for the manufacturer to thoroughly test this software with all the numerous possible applications.

Installing new software versions later can add new functions or correct recognized errors. SW updates can be done by the end user for all ZIMO decoders since production date October 2004, see chapter "Software Update"!

Software updates are available at no charge if performed by the end user (except for the purchase of a programming module); Updates and/or upgrades performed by ZIMO are not considered a warranty repair and are at the expense of the customer. The warranty covers hardware damage exclusively, provided such damage is not caused by the user or other equipment connected to the decoder. For update versions, see www.zimo.at.

1. Overview

These decoders are suitable for N, HOe, HOm, TT, HO, OO, Om and O gauge engines with standard or core less motors (Faulhaber, Maxxon etc.)
They operate primarily in the **NMRA-DCC data format** with any NMRA-DCC compatible system, as well as the **MOTOROLA protocol** within Märklin systems and other MOTOROLA command stations. Zimo decoders also be operate in **DC analog mode** with DC power packs (including PWM). Beginning with the July 2009 software version, ZIMO decoders received noticeable improvements in this regard and MX630 as well as MX632 decoders can be operated with AC analog (Märklin Transformers with over-voltage pulses for direction change).

MX621 *Family* *(MX620)*	**Miniature-Decoder,** thoroughly equipped with all ZIMO characteristics and features, software is identical to the larger decoder types. TYPICAL APPLICATION: for the installation in N, HOe, HOm but also HO engines with limited available space.

Different MX621 versions (or MX620 – predecessor of the MX621):

MX621	7 highly flexible wires (120 mm long) for track, motor and 2 functions. Solder pads are available for additional function outputs and SUSI.
(MX620)	
MX621N	MX621 with 6-pin interface per NEM651 and NMRA RP 9.1.1. Interface is mounted on circuit board, no wires.
MX621R	MX621 with 8-pin interface per NEM652 and NMRA RP 9.1.1 on 70mm wires.
MX621F	MX621 with 6-pin interface per NEM651 and NMRA RP 9.1.1 on 70mm wires.

MX630 *Family*	**Compact HO loco decoder,** for universal applications. TYPICAL APPLICATION: Locomotives in HO, O or similar scale where space is limited. Due to excellent dielectric strength (50V), the decoder is also suitable for analog operation with the old Märklin transformers.

Different versions according to their connections:

MX630	9 highly flexible wires (120 mm long) for power, motor, 4 function outputs. Solder pads are available for 2 additional outputs, logic level outputs or servo control and SUSI.
MX630R	MX630 with 8-pin interface per NEM652 and NMRA RP 9.1.1 on 70mm wires.
MX603F	MX630 with 6-pin interface per NEM651 and NMRA RP 9.1.1 on 70mm wires.
MX630P	MX630 with **16-pin PluX interface** on circuit board.
MX631 *Family*	**H0 Decoder,** similar to MX630 but with more power and e**nergy storage circuit.** TYPICAL APPLICATION: H0 and small 0-scale engines. Due to excellent dielectric strength (50V), the decoder is also suitable for analog operation with the old Märklin transformers.

Different versions according to their connections:

MX631	11 Wires (120mm) for track, motor, 4 function outputs, solder pads for 2 more function outputs, logic level outputs, servo control, SUSI.
MX631R	8-pin plug per NEM652 on 70mm wires.
MX631F	6-pin plug per NEM651 on 70mm wires.
MX631D	**21-pin "MTC" interface** direct on circuit board.
MX631C	For **Märklin** and **Trix** engines with C-Sinus and Softdrive motor.

MX632 *Family*	**High output decoder, 8 function outputs, energy storage circuit.** TYPICAL APPLICATION: H0 and 0 scale engines or similar scales, especially for engines with low voltage light bulbs (1.5 or 5.0V).

Different versions according to their connections:

MX632	11 Wires (120mm) for track, motor, 4 function outputs, solder pads for 4 more function outputs, logic level outputs, servo control, SUSI.
MX632R	8-pin plug per NEM652 on 70mm wires.
MX632D	**21-pin "MTC" interface** direct on circuit board.
MX632C	For **Märklin** and **Trix** engines with C-Sinus and Softdrive motor.
MX632V, VD ***MX632W, WD***	Version with **low voltage supply** for **function outputs:** Ausführungen mit **Niederspannungsversorgung** für die **Fu-Ausgänge:** …V - 1,5 V …W - 5 V …VD or …WD - with 21-pin interface.

MX640 *Family*	**HO decoder** with **SOUND. Energy storage circuit only on MX642.** TYPICAL APPLICATION: H0 locomotives as well as 0 gauge or similar with limited space. MX640: 1.1 Watt , MX642: 3 Watt audio.

Different versions according to their connections:

MX640, MX642	Version with 11 highly flexible wires (120 mm long) for power, motor, 4 function outputs, speakers. Solder pads for 2 additional outputs, logic level outputs and SUSI.
MX640R…2R	With 8-pin plug per NEM652 and NMRA RP 9.1.1 on 70mm wires.
MX640F…2F	With 6-pin plug per NEM651 and NMRA RP 9.1.1 on 70mm wires.
MX640D…2D	With **21-pin interface on circuit board** (according to NMRA RP 9.1.1.).
MX640C…2C	For **Märklin** and **Trix** engines with C-Sinus or Softdrive motor.
MX642P22…P16	With **PluX22** or **PluX16** interface.

2. Technical Information

Allowable Track voltage **) .....minimum 10 V
MX620…….. max. 20V
MX621……..max. 40V
MX640 ……..…….. max. 24V
MX630, MX631, MX632, MX642 o……perated with DCC or DC….. max. 30V
MX630, MX631, MX632, MX642 operated with AC analog;…..Pulse.. max. 50V

Maximum continuous motor current . MX620, MX621 ..... 0.8 A
MX630 …. ..... 1.0 A
MX631, MX640, MX642 … ..... 1.2 A
MX632 ..... 1.6 A

Peak motor current……MX620, MX621……1.5 A
MX630, MX631, MX632, MX640, MX642 for @ 20 sec….2.5 A

Maximum total function output, continuous *)…….MX620, MX621..... 0.5 A
MX630, MX631, MX632, MX640, MX642 ..... 0.8 A

Maximum continuous current for LED outputs ..…only MX640, MX642…….... 10 mA ea

Maximum continuous total current (motor **and** functions)…… = maximum continuous motor current

Operating temperature ..... - 20 to 100 °C

MX640, MX642: Memory size for sound samples…….. 32 Mbit
MX640, MX642: Sample rate……depending on sound sample……..…11 or 22 kHz
MX640, MX642: Number of independent sound channels …… 4
MX640, MX642: Sound amplifier output (Sinus)……..…….MX640: 1.1W, MX642: 3 W
MX640: Loud speaker impedance ……...MX640: minimum 8 Ohm, MX642: minimum 3 Ohm

Operating temperature ..... - 20 to 100 °C

Dimensions (L x W x H) … ..... MX620, MX620N (excluding pins) …..... 14 x 9 x 2.5 mm
MX621, MX621N (excluding pins)..……12 x 8.5 x 2.0 mm
MX630, MX630P (height w/o pins) ..... 20 x 11 x 3.5 mm
MX631 ..... 20.5 x 15.5 x 4.0 mm
MX632 ..... 28 x 15.5 x 4.0 mm
MX640 ..... 32 x 15.5 x 6.0 mm
MX642, MX642P (height w/o pins) ..... 30 x 15 x 4.5 mm

*) The short circuit protection is carried out for the total current of all outputs. In the unlikely event that the outputs are turned off due to cold-start problems of light bulbs (power surge at turn-on leading to a short), the "soft-start" option should be utilized (see CV #125 = 52 etc.)!

**) Note when operating with a DiMAX command station (Massoth): The DiMAX 1200Z command station is designed to keep the track voltage at 24V (which would exceed the DCC norm only marginally). In reality however the voltage laid on the track varies with the load (especially older command stations); starting at 30V at idle (dependent of mains voltage). Most ZIMO decoders, with the exception of the MX620, are able to deal with the excessive voltage; the MX640 however just barely (It is unlikely that a MX620 decoder is used with a DiMAX command station). Lowering the track voltage to an allowable level by adding a "fake load" (about 0.5A) would be an advantage to the regulating circuit.

**) Roco Lokmaus Systems also tend to put excessive idle voltages on the track (although not as serious, @ 26V), which could present a problem for the MX620 decoder. Other ZIMO decoder types would not be affected.

Disclaimer related to Märklin/Trix locomotives (especially with C-Sinus):

Märklin/Trix is not concerned about compatibility of their locomotives with third party products. Their decoder interfaces change often without notice. ZIMO can therefore not guarantee that the method of connection and operation described in this manual is possible with every locomotive. We are equally not liable for damages or destruction of locomotives and/or decoders as a result of mismatched interfaces.

Software Update:

ZIMO DCC decoders are equipped to handle software updates by the user. A device capable of decoder update is required (ZIMO decoder update module **MXDECUP, system-cab MX31ZL** or **command station MX10).** The update process is carried out by either a USB stick / SD card (MX31ZL / MX10) or by a PC with Windows operating system and the program "ZIMO Sound Program" **ZSP** or the "ZIMO Rail Center" **ZIRC.**

The same hardware and software is also used to load sound projects into ZIMO sound decoder.

There is **no need to remove the decoder or to open up the locomotive.** Just set the locomotive on a section of track connected to the update module and start the update with the computer or other equipment mentioned above.

NOTE: Equipment inside the locomotive that is connected directly with the track (that is, not powered by the decoder) can interfere with the update procedure. The same goes for energy buffers that are installed without heeding the advice in the "Installation and wiring" chapter, section "Use of an external energy source" (regarding a choke coil).

See the **last chapter** in this manual for more information on updating decoders or www.zimo.at !

SW updates are of course still available for a small fee by sending decoders to ZIMO or your ZIMO dealer.

Overload and Thermal Protection:

The motor and function outputs of ZIMO decoders are designed with lots of reserve capacities and are additionally protected against excessive current draw and short circuits. Cutouts are encountered if the decoder is overloaded.

Even though the decoder is well protected, do not assume it is indestructible. Please pay attention to the following:

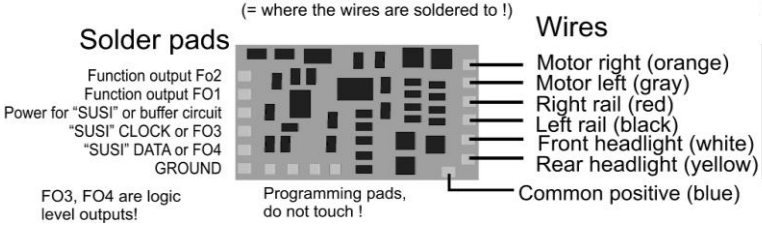
Faulty decoder hook-up, *connecting the motor leads to track power for instance or an overlooked connection between the motor brushes and rail pick-ups is not always recognized by the overload protection circuit and could lead to damage of the motor end stage or even a total destruction of the decoder.*

Unfit or defective motors *(e.g. shorted windings or commutator) are not always recognized by their high current consumption, because these are often just short current spikes. Nevertheless, they can lead to decoder damage including damage to end stages due to long-term exposure.*

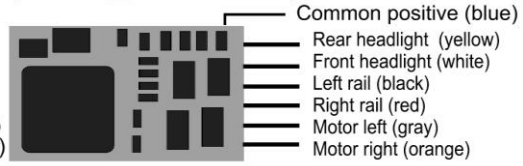
The end stages of loco decoders (motor as well as function outputs) are not only at risk of high current but also ***voltage spikes,*** *which are generated by motors and other* ***inductive consumers.*** *Depending on track voltage, such spikes can reach several hundred volts and are absorbed by special protection circuits inside the decoder.*

All ZIMO decoders are equipped with temperature sensors to measure their own operating temperature. Power to the motor will be turned off once that temperature exceeds 100°C. The headlights start flashing rapidly, at about 5 Hz, to make this state visible to the operator. Motor control will resume automatically after a drop in temperature of about 20°C, typically in 30 to 60 seconds.

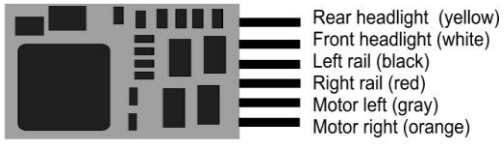
MX620, MX620R, MX620F
Connection side
(= where the wires are soldered to !)



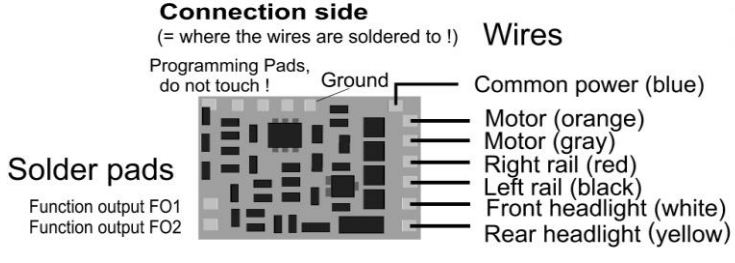
MX620, MX620R, MX620F
Controller side
(= Wires are **not** soldered to this side)



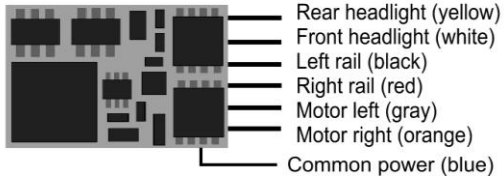
MX620N (= MX620 with 6-pin connector)
Controller side
(This is the correct installation position !)



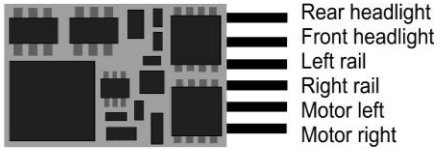
MX621, MX621R, MX621F
Connection side
(= where the wires are soldered to !)



MX621, MX621R, MX621F
Controller side
(= back side, where the wires are **not** soldered to !)

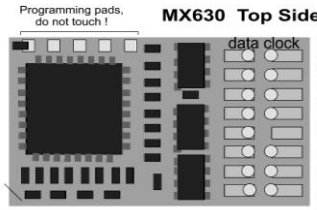


MX621N (= MX621 with 6-pin interface)
Controller side
(this is the correct installation position !))



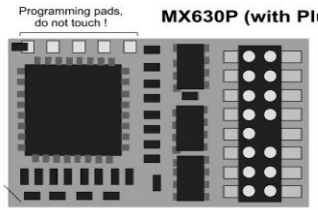
MX630 Top Side, wired

MX630 Top Side, pin-out



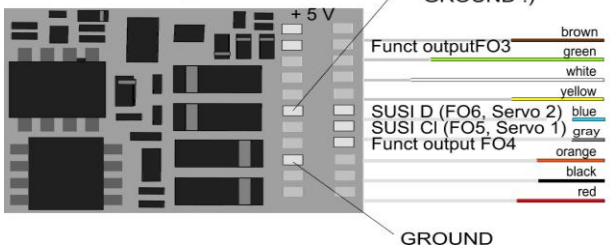
SUSI, Servo's (2, 1) or FO6, FO5		
Common (+)	Ground	
Motor right	Front headl.	
Motor left	Common (+)	
Right rail	--- (Index)	
Left rail	Rear headl.	
Function output	FO1	FO3
Function output	FO2	Fo4

MX630P (with PluX16)



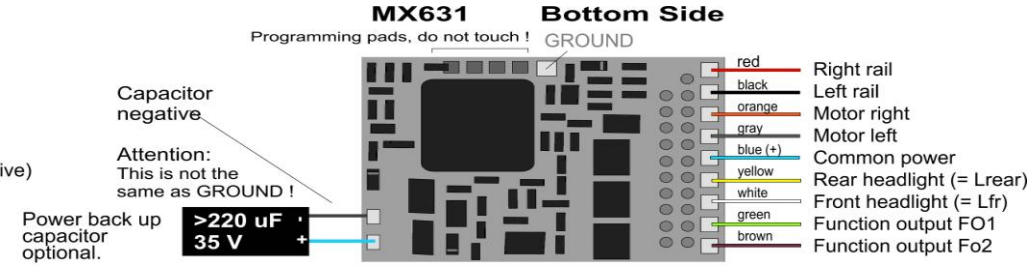
SUSI, Servo's (2, 1) or FO6, FO5		
Common (+)	Ground	
Motor right	Front headl.	
Motor left	Common (+)	
Right rail	--- (Index)	
Left rail	Rear headl.	
Function output	FO1	FO3
Function output	FO2	FO4

MX631 Top Side

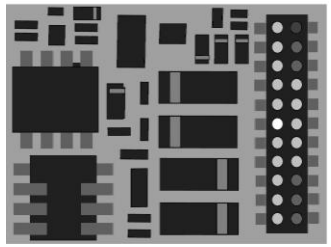


Function output FO2
Function output FO1
Front headlight (= Lfr)
Rear headlight (= Lrear)
Common power (also Cap. positive)
Motor left
Motor right
Left rail
Right rail

MX631 Bottom Side

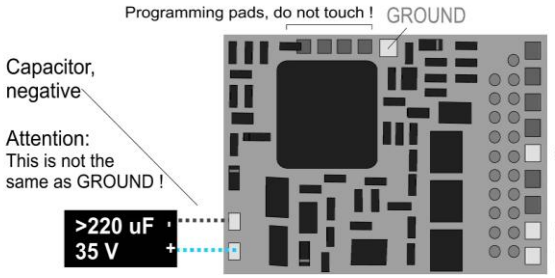


MX631D, C Top Side



+ 5 V	Index pin
Function output FO3	n.c.
Function output FO2	n.c.
Function output FO1	Front headlight (= Lfr)
Common positive	Rear headlight (= Lrear)
Capacitor negative	SUSI Data (FO6, Servo 2)
Motor connection 1	SUSI Clock (FO5, Servo 1)
Motor connection 2	Function output FO4
GROUND	n.c.
Left rail	n.c.
Right rail	n.c.

MX631D, C Bottom Side

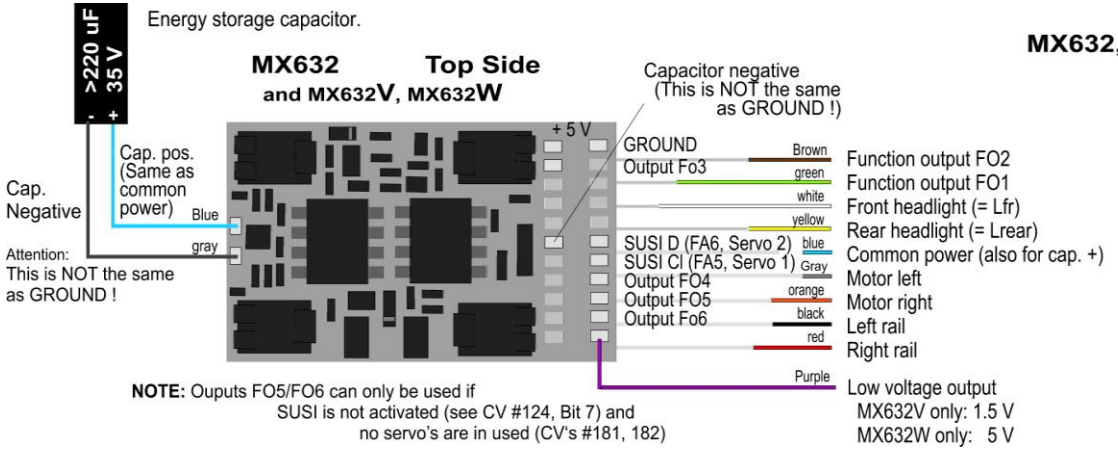


C versions differ from the D versions by the use of function output FO3 and FO4:

MX631D: FO3 and FO4 outputs are “normal” amplified outputs (same as headlights, FO1 etc.).

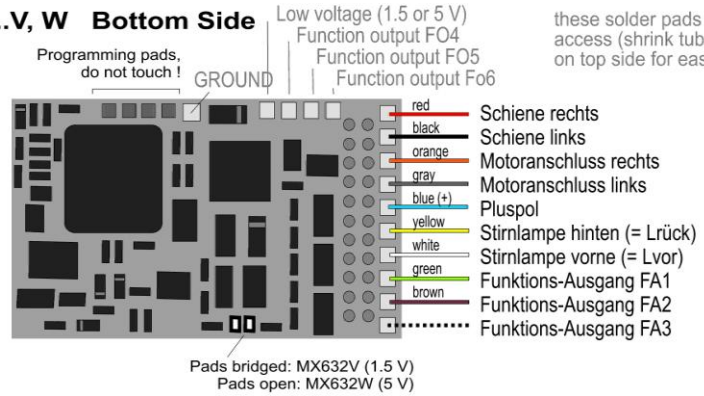
MX631C: FO3 and FO4 are logic level outputs.

MX632 Top Side and MX632V, MX632W



NOTE: Ouputs FO5/FO6 can only be used if SUSI is not activated (see CV #124, Bit 7) and no servo’s are in used (CV’s #181, 182)

MX632, ..V, W Bottom Side

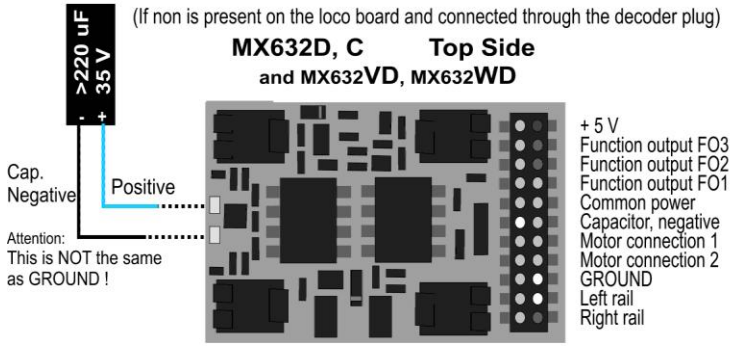


these solder pads are difficult to access (shrink tube), use solder pads on top side for easier access !

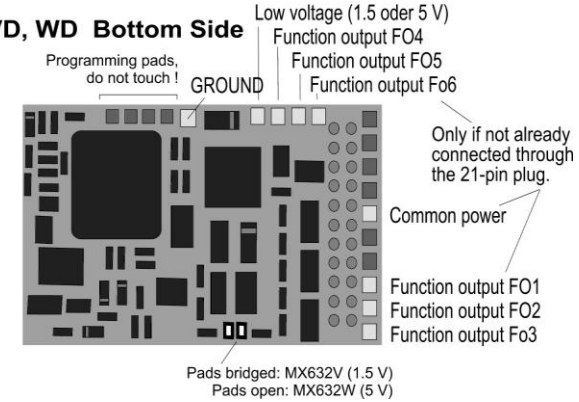
Optional energy storage capacitor

(If non is present on the loco board and connected through the decoder plug)

MX632D, C Top Side and MX632VD, MX632WD



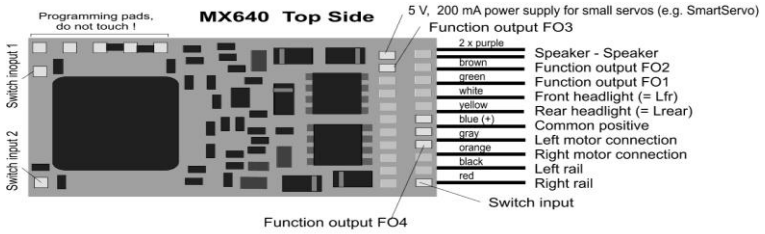
MX632D, C, VD, WD Bottom Side

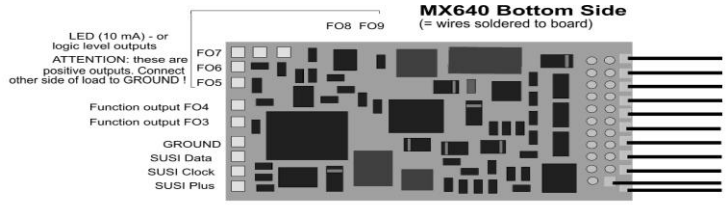


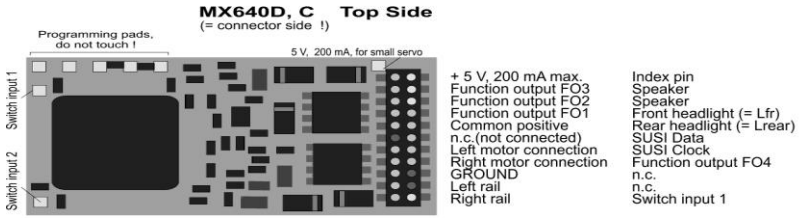
C versions differ from the D versions by the use of function output FO3 and FO4:

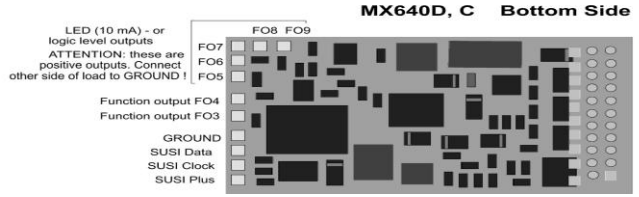
MX632D: FO3 and FO4 outputs are “normal” amplified outputs (same as headlights, FO1 etc.).

MX632C: FO3 and FO4 are logic level outputs.

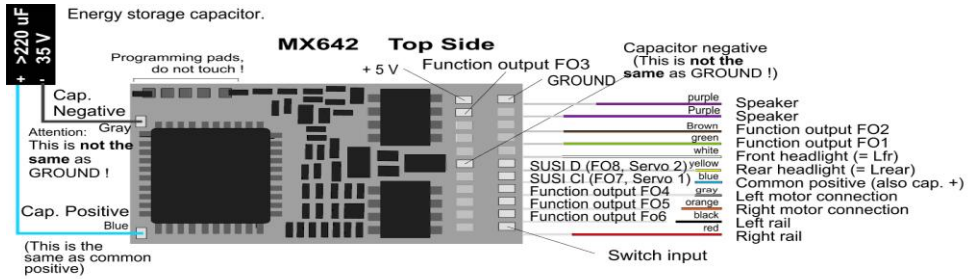


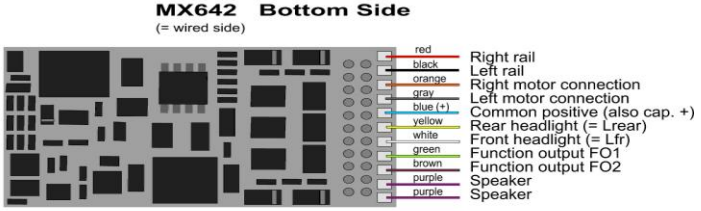


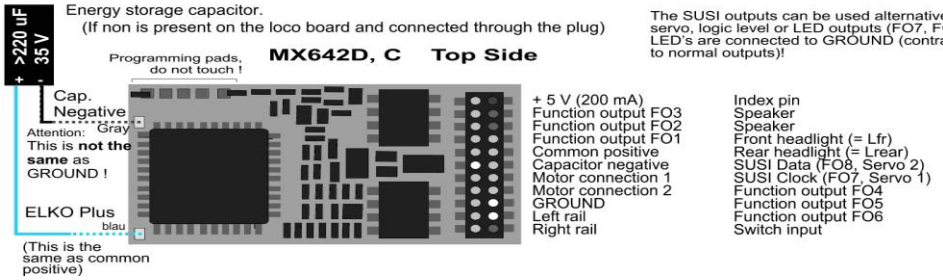




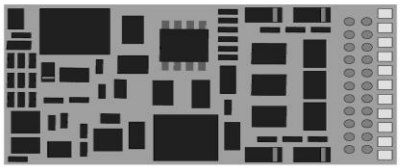
ATTENTION:
In some engines the MX640D must be installed right side up, in others upside down.







The SUSI outputs can be used alternatively as servo, logic level or LED outputs (FO7, FO8); LED's are connected to GROUND (contrary to normal outputs)!



ATTENTION:
On some engines the MX640D must be installed right side up, on other up side down.

3. Addressing and Programming – CV table

Every loco decoder requires a separate unique address with which the loco is controlled using a cab. **All NMRA-DCC compliant decoders have 3 as their factory default address** (NMRA standardized decoder address at delivery).

DECODER INSTALLATION:

After installing the new decoder in a locomotive (see chapter "Installation and wiring"), it can be tested with address #3. As a minimum, either the motor or headlights need to be connected (better yet both), to enable decoder acknowledgment during programming. Doing a complete installation before programming the decoder is often more practical.

THE ADDRESSING AND PROGRAMMING PROCEDURE:

The programming and read-out **procedure** of addresses and configuration variables is covered in detail in the **instruction manual for the cab (MX21, MX31....).** For other systems consult the appropriate manual.

Programming a decoder with a PC and ADaPT software (by E.Sperrer, software developer) is a lot easier and more convenient!

Technical note to decoder acknowledgments during programming:

When programming or reading CV's with the DCC system or a computer, each successful programming step will be acknowledged by the decoder and displayed on the cab and/or monitor.

The acknowledgment is based on short power pulses that the decoder generates by briefly turning the motor and headlights on, which the command station recognizes (at the programming track output). It follows that the acknowledgment and read out of a decoder is only successful if the current consumption is high enough, which means that the motor and headlights have to be connected or at least one of the two.

The decoder won't use the headlights for acknowledgment if CV #60 is set to a value of 40 or less. This is to prevent damage to bulbs since this setting is often used in conjunction with low voltage bulbs. The motor is then the only load used for acknowledgments.

The following pages show:

▲ **Helpful hints** for CV programming

next

▲ **CV tables** with configuration variables from **#1** to **#255**

next (Chapter 4 & 5):

▲ **Additional Notes** (CV's) and **Function Mapping**

next (Chapter 6, only valid for sound decoders):

▲ **ZIMO SOUND Selection and Programming;** description of basic functionality, operating procedures and

▲ **CV TABLES** with configuration variables from **#256** to **#511,** valid for all types of the MX640 sound decoder family

HELPFUL HINTS FOR CV PROGRAMMING:

If you are familiar with CV programming please skip this section and go directly to the CV table below!

CV programming is not the same for all CV's. While the programming procedure is the same for all CV's, the calculation of the individual CV values varies.

For some CV's it is obvious what the value is supposed to be and can easily be derived from the "Range" and/or "Description" column in the CV table. This kind of CV acts similar to a volume control. For instance, CV#2 determines the minimum speed applied at speed step 1:

CV	Designation	Range	Default	Description
	Vstart	1 – 252 (See add. notes)	2	Entered value = internal speed step assigned to lowest cab speed step. Bit 4 in CV # 29 has to be 0; otherwise individual speed table is active.

The "range" column states that any value from 1 to 252 may be used. The higher the value the faster the engine runs at speed step 1 and vice versa.

Another similar CV is the "dimming" factor in CV #60:

CV	Designation	Range	Default	Description
#60	Reduced function output voltage (Dimming)	0 - 255	0	The actual function output voltage can be reduced by PWM. Useful to dim headlights, for example. Example values: # 60 = 0 or 255: full voltage # 60 = 170: 2/3 of full voltage. # 60 = 204: 80% of full voltage.

Again, the range column states that any value from 1 to 252 may be used and in the "description" column it is explained that the brightness of the light increases with the value.

Other CV's are easier to understand if you think of them as a small switch board, where you can turn individual switches ON or OFF. Such a CV is made up of 8 "individual switches" called Bits and the group of Bits is known as a Byte (which is the CV itself or the switch board, if you will). On some CV's you can change the setting of all 8 Bits (switches) and on others only a select few. The Bits (switches) are numbered from 0 to 7 and each has a specific value (**see the chapter "Converting binary to decimal"** for more on binary calculations). Each Bit is turned ON by adding its value to the CV and turned OFF by subtracting its value. Add up the values of each Bit you want to turn ON and enter the total to the CV.

One such CV is CV #29 (next page):

CV	Designation	Range	Default	Description
#29	Basic configuration CV #29 is calculated by adding the value of the individual bits that are to be "on": Values to turn "on": Bit 0: 1 Bit 1: 2 Bit 2: 4 Bit 3: 8 Bit 4: 16 Bit 5: 32 Bit 6: 64 Bit 7: 128 ZIMO MX21, MX31… cabs also display the individual bits; calculating bit values is no longer necessary!	0 - 63	2	Bit 0 - Train direction: 0 = normal, 1 = reversed Bit 1 - Number of speed steps: 0 = 14, 1 = 28 Note: 128 speed steps are always active if corresponding information is received! Bit 2 - DC operation (analog): *) 0 = off 1 = on Bit 3 - RailCom („bidirectional communication") 0 = deactivated 1 = activated see CV #28! Bit 4 - Individual speed table: 0 = off, CV # 2, 5, 6, are active. 1 = on, according to CV 's # 67 – 94 Bit 5 - Decoder address: 0 = primary address as per CV #1 1 = ext. address as per CV #17+18 Bits 6 and 7 are to remain 0!

As explained in the description column of that CV, you can only change the setting of Bit 0, 1, 2, 3, 4 and 5. Bits 6 and 7 have to remain OFF (0) because they are not yet used for anything. To calculate the total CV value you have to first look at the description field of that CV and determine which Bit (switch) you want to have ON. Let's say we want speed steps 28 active, reverse the loco's direction because it doesn't agree with the cab's direction indication and we want to use the individual speed table. This means we have to have the Bits 1, 0 and 4 turned ON (= 1). All other Bits can be OFF (= 0). In the "Designation" field it shows the value for each Bit: Bit 0 = 1, Bit 1 = 2, Bit 2 = 4, Bit 3 = 8, Bit 4 = 16, Bit 5 = 32, Bit 6 = 64, and Bit 7 = 128. If we want to have Bits 1, 0 and 4 turned ON we add up the values for these Bits (2 + 1 + 16) and enter the total of 19 to CV #29.

Lastly there is a third kind of CV that sort of fits between the other two. Here you don't have to worry about Bits and their values. With those CV's the digit's position and value determines a specific action. Some of those digit positions act like a simple ON/OFF switch and others like a volume control.

For example, CV #56 can be used for fine-tuning a motor:

CV	Designation	Range	Default	Description
#56	Back-EMF control P and I value	0 – 199 (See add. notes)	0 (is equal to 55, mid-range) But: default is not suitable for **coreless motors, i.e. MAXXON, FAULHABER!** Use "100" instead.	Back-EMF compensation is calculated by PID algorithm (Proportional/Integral - Differential); modifying these values may improve the compensation characteristics in certain cases. 0 - 99: for „normal" DC motors (LGB etc) 100 - 199: for coreless (MAXXON, Faulhaber, etc...) Tens digit: Proportional (P) value; by default (0) is set to mid value and automatic adjustment with the goal of jerk free running. Proportional effect can be modified with settings of 1 – 4 and 6 – 10 (instead of the default 0 = 5). Ones digit: Integral (I) value; is set by default to a mid value. The Integral effect can be modified with settings of 1 – 9 instead of the default 0 = 5).

As you can see in the "Range" field you can use any number between 0 and 199. However if you read the "Description" field it explains that each digit position controls a specific function. In this case, the hundredth digit (_xx) sets the decoder up for a coreless motor, the tens digit (x_x) modifies the proportional and the ones digit (xx_) the integral action. The hundredth digit acts just like a switch. If you use the hundredth digit (1__) the coreless motor function is turned ON. If you don't use it (_xx), the function is turned OFF. So for a normal DC motor you would only use the ones and tenth digit. With the tens digit (0 – 9) you can modify the proportional value and with the ones digit (0 – 9) the integral value.

Don't worry about the terms "proportional" or "integral" - just use the **"Step by step CV adjustment procedure"** later in the manual.

THE CONFIGURATION VARIABLES:

Configuration Variables can be defined within the programming procedures to improve the driving characteristics of a locomotive, sound playback of sound decoders and for many other application specific adjustments.

The meaning of Configuration Variables (CV's) is in part standardized by the NMRA DCC RECOMMENDED PRACTICES, RP-9.2.2. There are however certain CV's that are for Zimo decoders only, in some cases exclusively for specific types of Zimo decoders.
Always use the specifications for the decoder in question, since the value range may differ between manufacturers, even with standardized CV's; in this case use the table below.

CV	Designation	Range	Default	Description
#1	Primary "short" address	1 – 127	3	The "short" (1-byte) loco addresses; Is active when Bit 5 in CV #29 is 0.
#2	Vstart	1 – 252 (See add. notes)	1	Entered value = internal speed step assigned to lowest cab speed step. Bit 4 in CV # 29 has to be 0; otherwise individual speed table is active.
#3	Acceleration rate	0 - 255	2	Multiplied by 0.9 equals' acceleration time in seconds from stop to full speed. Sound decoder: sound project determines value for CV #3.
#4	Deceleration rate	0 - 255	1	Multiplied by 0.9 equals' deceleration time in seconds from full speed to complete stop. Sound decoder: sound project determines value for CV #4.
#5	Vhigh	0 – 252 (See add. notes)	1 (= 252)	Entered value = internal speed step assigned to highest cab speed step, according to the number of speed steps selected (14, 28 or 128). 0 and 1 = no effect. Bit 4 in CV #29 has to be 0, otherwise speed table is active.
#6	Vmid	1, A useful value for CV #6 is ¼ to ½ of the value in CV #5 (See add. notes)	1 (= about 1/3 of top speed)	Entered value = internal speed step assigned to the cabs center speed step (=step 7,14 or 63 according to the number of speed steps selected: 14, 28 or128) "1" = default (is the same as entering a value of 85, which is 1/3 of full speed with speed regulator in center - bent speed curve). The curve is automatically flattened and prevents a noticeable jump in speed in the center area! Bit 4 in CV #29 has to be 0, otherwise speed table is active.
#7	Software version ALSO SEE **CV #65** for sub-version number and	Read only CV A read-out always displays the decoder version number. Pseudo programming values for Lokmaus 2		The value in **CV #7** indicates the **Software version.** The **sub-version Number** is stored in **CV #65** and must be read-out separately. --- **For Lokmaus-2 users:** Pseudo-programming ("Pseudo" because programmed value is not really stored) is a pre-step

CV	Designation	Range	Default	Description
	Special procedure when programming with a "Lokmaus 2" and similar low level systems. See section "Operation within other systems" in this manual! and for special procedure when programming high-number CV's with "medium" level systems such as Intellibox or Lenz; especially for sound sample selection and sound CV's. As an example: CV #300 = 100	are: 1, 2, 10, 11, 12, 20, 21, 22 and for sound programming: 110, 120, 130, 210, 220, 230 (see chapter 6)		for programming or reading out of higher CV's (> #99) and/or higher values (>99) with a system that is limited in accessing high CV's and high CV values: Ones digit = 1: The CV content entered during the actual programming will be increased by 100. Ones digit = 2: … will be increased by 200. Tens digit = 1: The CV number entered during the actual programming will be increased by 100. Tens digit = 2: …. will be increased by 200. One hundredth digit = 1: The CV number revaluation above remains in effect until the decoder is powered down. One hundred digit = 2: The CV number revaluation above remains in effect until the Pseudo programming is cancelled with CV #7 = 0. See section „ ZIMO decoders and competitor systems "!
#8	Manufacturer ID and HARD RESET with CV #8 = 8 or CV #8 = 0 or LOADING of special CV sets	Read only Reading out the decoder always shows "145", which is ZIMO's assigned number. For pseudo programming see "Description" column on the right.	145 (= ZIMO)	The stored value of this CV is the ID number issued by the NMRA for the decoder manufacturer; for Zimo it is: 145 ("10010001") Pseudo-Programming ("Pseudo" = programmed value is not really stored): **CV #8 = "8" -> HARD RESET**(NMRA standard); all CV's reset to default values as shown in this CV table independent of any active CV sets or sound projects; that is, the decoder is being restored to the same state it was in at delivery. ATTENTION: Sound may not play back after this reset. Use CV #8 = 0 instead. **CV #8 = "0" -> HARD RESET** (ZIMO special reset) for sound decoders: all CV's reset to current sound project or the CV's are reset to the last CV set used (see below: load CV sets). Can also be used when the CV set number is not known. **CV #8 = "xx" -> Loading of CV set** provided it exists in the decoder (most often country specific or model specific, i.e. for locos of a specific manufacturer). CV #8 = "9" -> HARD RESET for LGB-operation (14 speed steps, pulse chain commands); otherwise identical to CV #8 = 8.
#9	Motor frequency	55	55	= 55: Default motor control with high frequency (20

CV	Designation	Range	Default	Description
	and EMF sampling rate **Recommendations for MAXXON and FAULHABER (coreless motors):** **CV #9 = 22** or **21** usually together with CV #56 = 100.	High frequency, mid-range sampling rate 01- 99 High frequency, modified sampling rate or 255-176 Low frequency (See add. Notes, "Step by step CV…")	High frequency, mid-range sampling rate (earlier SW versions had 0 as default but with same result as 55)	/ 40 kHz) and an EMF-sampling rate that automatically adjusts between 200Hz (low speed) and 50Hz, and medium sampling time. <> 55: Modification of automatic adjustments with tens digit for sampling rate and ones digit for sampling time. Tens digit 1 - 4: Reduced sampling rate compared to default (less noise!) Tens digit 6 - 9: Increased sampling rate compared to default (to improve low speed performance!) Ones digit 1 – 4: EMF sampling time shorter than default setting (good for coreless motors for less noise, more power) Ones digit 5 - 9: EMF sampling time longer than default (may be needed for 3-pole motors or similar). Example: Typical approach for rough running at low speeds: CV #9 = 55 (default), 83, 85… …for large coreless motor (O-gauge): CV #9 = 55 (default), 11, 22… = 255 - 176: Low frequency (only for old, usually AC motors!) PWM according to formula (131+ mantissa*4) *2exp. Bit 0-4 is "mantissa"; Bit 5-7 is "exp". Motor frequency is the reciprocal of the PWM. Examples of low frequencies: # 9 = 255: frequency of 30 Hz, # 9 = 208: frequency of 80 Hz, # 9 = 192: frequency of 120 Hz.
#10	EMF Feedback cut-off NOTE: This CV is seldom required.	0 – 252 (See add. notes)	0	Assigns an internal speed step above which back EMF intensity is reduced to the level defined in CV #113. CV #10, #58 and #113 together define a back-EMF curve. = 0: default curve is valid.
#13	Analog functions	0 - 255	0	Selects function outputs F1 to F8 that should be "ON" in analog mode. Each bit equals one function: Bit 0 = F1, Bit 1 = F2 … Bit 7 = F8. See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#14	Analog functions and Acceleration and deceleration for analog operation.	0 - 127	64 (Bit 6 = 1)	Bits 0 to 5: Select function outputs F9 to F12 as well as headlights that should be "ON" in analog mode. Each bit equals one function (Bit 0 = front headlight, Bit 1 = rear headlight, Bit 2 = F9 …..Bit 5 = F12). Bit 6 = 1: Analog operation without acceleration and deceleration according to CV #3 and #4. Bit 6 = 0: Analog operation with acceleration and deceleration according to CV #3 and #4. Bit 7 = 0: unregulated DC operation Bit 7 = 1: regulated DC operation

CV	Designation	Range	Default	Description
#17 + #18	Extended address	128 - 10239	0	The long 5-digit primary address (>127). This address is only active when Bit 5 in CV #29=1. Otherwise address entered in CV #1 is active (<127).
#19	Consist address	0 - 127	0	An additional address that is used to operate several locos in a consist. If a consist address is assigned to this CV, commands for the primary and extended addresses (CV's #1 and #17/18) will be ignored by the decoder. This CV is seldom used within ZIMO systems, since it is more comfortable to build and control consists with the cab (using the "normal" single addresses).
#21	Consist functions for F1 - F8	0 - 255	0	Selected functions that should operate with the consist address. (Bit 0 for F1, Bit 1 for F2, Bit 2 for F3 etc.) Applicable Bits set to 0 = function controlled by single address. Applicable Bits set to 1 = function controllable by consist address. See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#22	Consist address active for headlights	0 - 3	0	Select whether the headlights are controlled with consist address or single address (Bit 0 for front headlight, Bit 1 for rear headlight) Applicable Bit = 0: function output controlled with single address Applicable Bit = 1: function output controllable by consist address See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#23	Acceleration trimming NOTE: This CV is seldom required.	0 - 255	0	To temporarily adapt the acceleration rate to a new load or when used in a consist. Bit 0 - 6: entered value increases or decreases acceleration time in CV #3. Bit 7 = 0: adds above value. = 1: subtracts above value. See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#24	Deceleration trimming NOTE: This CV is seldom required.	0 - 255	0	To temporarily adapt deceleration rate to load or when used in consist. Bit 0 - 6: entered value increases or decreases deceleration time in CV #4. Bit 7 = 0: adds above value. = 1: subtracts above value. See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!

CV	Designation	Range	Default	Description
#27	Direction dependent stops with asymmetrical DCC signal (Lenz "ABC" method	0, 1, 2, 3	0	This CV activates the direction dependent stopping feature with asymmetrical DCC signal (also known as Lenz "ABC"). Bit 0 = 1: Stops are initiated if voltage in right rail is higher than left rail (in direction of travel). THIS, CV #27 = 1, IS THE COMMON APPLICTION for this feature (provided the decoder is wired to the rail correctly). Bit 1 = 1: Stops are initiated if voltage in left rail is higher than right rail (in direction of travel). Stopping is directional if only one of the two bits is set (not both). Traveling in the opposite direction will have no effect. Use the other bit In case the train stops in the wrong direction! Bit 0 and Bit 1 = 1 (CV #27 = 3): Stops in both directions, regardless of rail polarity. NOTE: See CV #134 for setting the asymmetrical threshold if problems are encountered (e.g. train won't stop with asymmetrical signal or stops without asymmetrical signal present. See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#28	RailCom Configuration	0 – 3	3	Use of RailCom channels (only active if RaiCom is turned on with CV #29, Bit 3): Bit 0 = 0: Channel 1 turned OFF (Broadcast) 1: Channel 1 turned ON (Broadcast) Bit 1 = 0: Channel 2 OFF (Data) 1: Channel 2 ON (Data) **NOTE: CV #28** for RailCom **has been dropped** temporarily by the "RailCom working group" and later reinstated slightly modified.
#29	Basic configuration CV #29 is calculated by adding the value of the individual bits that are to be "ON": Values to turn Bit "ON": Bit 0: 1 Bit 1: 2 Bit 2: 4 Bit 3: 8 Bit 4: 16 Bit 5: 32 Bit 6: 64 Bit 7: 128 ZIMO MX21, MX31… cabs also display the individual bits; calculating bit values is no longer	0 - 63	14 = Bit sequence 0000 1110	Bit 0 - Train direction: 0 = normal, 1 = reversed Bit 1 - Number of speed steps: 0 = 14, 1 = 28 Note: 128 speed steps are always active if corresponding DCC packets are received! Bit 2 - DC operation (analog): *) 0 = disabled 1 = enabled Bit 3 - RailCom („bidirectional communication") 0 = deactivated 1 = activated Bit 4 - Individual speed table: 0 = off, CV # 2, 5 and 6 are active. 1 = on, according to CV 's # 67 – 94 Bit 5 - Decoder address: 0 = primary address as per CV #1 1 = ext. address as per CV #17+18 Example: #29 = 2: normal direction, 28 speed steps, DCC operation only, speed table according to

CV	Designation	Range	Default	Description
	necessary!			CV #2, 5, 6, primary address as in CV #1. #29 = 14: DC mode and RailCom added. #29 = 22: DC mode and individual speed table according to CVs #67 – 94 added. #29 = 0: 14 (instead of 28) speed steps, necessary for some older third party systems. *) When using track-polarity dependent **DC brake sections,** set **CV #29, Bit 2 = "0" and CV 124, Bit 5 = "1"!** *) For polarity independent DC braking (**Märklin brake-modules**) set CV #29, Bit 2 = "0" and CV 124, Bit 5 = "1" and additionally CV #112, Bit 6 = "1"!
#33 #34 #35 #36 #37 #38 #39 #40 #41 #42 #43 #44 #45 #46	Function mapping	(See add. notes)	1 2 4 8 2 4 8 16 4 8 16 32 64 128	Function mapping according to NMRA: #33 - 46 = Outputs 1, 2, 4...are mapped by default to F0 - F12, which means that: Headlights are switched with direction and F0, Function output FO1 is switched with F1, Function output FO2 is switched with F2, Function output FO3 is switched with F3, and so on… See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#49	Signal controlled acceleration	0 - 255	0	ZIMO signal controlled speed influence (HLU) with ZIMO MX9 track section module or future module or when using the "asymmetrical DCC signal" stopping method (Lenz ABC). The content of this CV, multiplied by 0.4, equals the time in seconds for the acceleration event from standstill to full speed.
#50	Signal controlled deceleration	0 - 255	0	ZIMO signal controlled speed influence (HLU) with ZIMO MX9 track section module or future module or when using the "asymmetrical DCC signal" stopping method (Lenz ABC). The content of this CV, multiplied by 0.4, equals the time in seconds for the deceleration event (braking) from full speed to standstill.
#51 #52 #53 #54 #55	Signal dependent speed limits #52 for "U", #54 for "L", #51, 53, 55 for intermediate steps	0 - 252	20 40 (U) 70 110 (L) 180	ZIMO signal controlled speed influence (HLU) with ZIMO MX9 track section module or future module: Each of the 5 speed limits (CV's #51 – 55) that can be applied with the ZIMO "signal controlled speed influence" can be defined with an internal speed step.

CV	Designation	Range	Default	Description
#56	Back-EMF control P and I value **Recommendations for MAXXON, FAULHABER** and other **coreless motors:** **CV #56 = 100…** (default value 55 is not suitable) …usually together with CV #9 = 22 0r 21.	55 High frequency with medium sample algorithm. 0 – 199 modified settings (See add. notes)	55 High frequency with medium sample algorithm. (earlier SW versions had 0 as default but with same result as 55)	Back-EMF compensation is calculated by PID algorithm (Proportional/Integral - Differential); =55: Decoder adjusts itself automatically; in certain cases it may be necessary to modify the control characteristics by programming different values. 0 - 99: modified setting for "normal" DC motors 100 - 199: modified setting for coreless motors (MAXXON, Faulhaber, etc.) Tens digit: Proportional (P) value; is set by default to a mid value (5) and adjusts automatically with the goal of jerk free running. Proportional effect can be modified with settings of 1 – 4 and 6 – 10 (instead of the default 5). Ones digit: Integral (I) value; is set by default to a mid value (5). The Integral effect can be modified with settings of 1 – 9 instead of the default 5. Example: Typical test values to combat jerky motion at low speed: from CV #56 = 55 (default) to 33, 77, 73…
#57	Voltage reference	0 – 255 (See add. notes)	0	The entered value divided by ten is the peak voltage applied to the motor at full speed. #57 = 0: results in automatic adjustment to current track voltage (relative reference). NOTE: The default setting CV #57 = 0 is only suitable in connection with stabilized track voltage, which is the case with all ZIMO command stations. With systems that can't keep the track voltage stable, CV #57 should really be set to the available track voltage when under full load. EXAMPLE: The idle track voltage is 22V (which is unimportant) but the voltage drops to 16V at full load, then CV #57 should be set between 140 and 160. The decoder then tries to keep the train speed steady regardless of the actual track voltage, as if the track voltage is always at 14V (with CV #57 = 140) or 16V (with CV #57 = 160). CV #57 has a similar effect as CV #5; many users prefer this adjustment over CV #5!
#58	Back-EMF intensity	0 – 255 (See add. notes)	255	Intensity of back-EMF control for lowest speed step. If required, an "intensity curve" can be achieved using CV #10, 58 and 113 to reduce load regulation at higher speeds. Example: # 58 = 0: no back-EMF # 58 = 150: medium compensation, # 58 = 255: maximum compensation.

CV	Designation	Range	Default	Description
#59	Signal dependent reaction time	0 - 255	5	ZIMO signal controlled speed influence (HLU) with ZIMO MX9 track section module or future module or when using the "asymmetrical DCC signal" stopping method (Lenz ABC): This value is the delay in tenth of a second until it starts a signal controlled acceleration after receiving a higher speed limit command.
#60	Reduced function output voltage (Dimming) Affects all function outputs. If only certain outputs should be affected use the dimming mask in CV #114 additionally.	0 - 255	0	The actual function output voltage can be reduced by PWM. Useful to dim headlights, for example. Example values: CV #60 = 0 or 255: full voltage CV #60 = 170: 2/3 of full voltage. CV #60 = 204: 80% of full voltage. NOTE: Bulbs with voltage ratings as low as 12V can be dimmed with this CV without damage even if track voltages are considerably higher; but not bulbs rated for 5V or 1.5V. These must be powered with an appropriate low voltage, which the decoder types MX630V or MX64DV are capable of providing.
#61	Special ZIMO function mapping	0 – 7, 97, 98, 99 (See chapter "Function mapping")	0	For applications not covered by NMRA function mapping (CV #33 - #46), for example: "Swiss lighting"; see "function mapping – ZIMO extensions". = 97: Alternative function mapping without "left-shift" (see chapter "Function mapping"). = 98: starts a flexible function mapping for directional function control.
#65	Subversion number	Read only CV!		This CV indicates a possible subversion number of a version noted in CV #7 (i.e. Version 4.2: CV #7 = 4 and CV #65 = 2). 0 - 99: Normal subversions 100 - 199: Beta-Versions 200 - 255: Special versions (usually for loco manufacturers)
#67-94	Individual speed table	0 – 252 (See add. notes)	**)	User programmable speed table. Each CV corresponds to one internal speed step that can be "mapped" to an external step (in-between speed steps will be interpolated when using 128 speed steps). Only active if Bit 4 in CV #29 is set to 1.
#66 #95	Directional speed trimming	0 - 255 0 - 255	0 0	Multiplication of the current speed by "n/128" (n is the trim value in this CV) #66: for forward direction #95: for reverse direction
#105 #106	User data	0 – 255 0 – 255	0 0	Free memory space to store user supplied data.

CV	Designation	Range	Default	Description
#112	Special ZIMO configuration bits Values to turn Bit "ON": Bit 0: 1 Bit 1: 2 Bit 2: 4 Bit 3: 8 Bit 4: 16 Bit 5: 32 Bit 6: 64 Bit 7: 128 ZIMO MX21, MX31… cabs also display the individual bits; calculating bit values is no longer necessary!!	0 – 255	4 = 00000100 ATTENTION In some software versions: Bit #2 = 0 (loco ID is then turned off!)	Bit 1 = 0: Normal „service mode" ACKnowledgement by actuating motor and headlights. = 1: If the normal acknowledgement in Service Mode does not work because no motor or headlights are connected to the decoder or the total current draw is too low, the special high frequency / high power pulses can be activated as additional ACKnowledgement; this is at the least helpful within a ZIMO environment, but it is at present not known how well this works with other DCC systems. NOTE: Bit 1 of this CV used to activate a motor brake in earlier software versions. This feature has been moved to CV #151! Bit 2 = 0: Loco number recognition OFF = 1: ZIMO loco number recognition ON (Turning the loco number recognition off prevents a possible ticking sound if this feature is not used). The loco number pulses are turned off automatically when the decoder is operated by a non-ZIMO system. Bit 3 = 0: reacts only to the (new) NMRA-MAN-Bit, **12 function mode** = 1: reacts to old MAN bit also, **8 function mode** Bit 4 = 0: Pulse chain recognition OFF = 1: Pulse chain recognition ON (use with LGB systems) Bit 5 = 0: 20 kHz motor control frequency = 1: 40 kHz motor control frequency Bit 6 = 0: normal (also see CV #129 description) = 1: non-directional DC braking („Märklin-Brake mode) Bit 7 = 0: no pulse chain generation = 1: Generates pulse chain commands for LGB sound modules on output FO1. Only in MOTOROLA format: Bit 3 = 0: normal, 4 functions for each address = 1: next higher address is used to control 4 more functions, for a total of 8 functions, which is otherwise not possible within a MOTOROLA system.
#113	EMF reduction Note: This CV is rarely necessary	0 – 255 (See add. notes)	0	Intensity of back-EMF is reduced above the speed step defined in CV #10, to the value entered here. Together, CV #10, #58 and #113 define a BEMF curve. If set to 0, BEMF is totally cut-off above the speed step defined in CV #10.
#114	Dimming mask	Bits 0 - 7	0	Function outputs entered here will **not** be dimmed as per CV #60. Bit 0 = front headlight Bit 1 = rear headlight Bit 2 = function output FO1 Bit 3 = function output FO2 Bit 4 = function output FO3 Bit 5 = function output FO4 Bit 6 = function output FO5 Bit 7 = function output FO6 Bit value=0: Output will be dimmed to the value defined in CV #60. Bit value=1: Output will not be dimmed. Example: CV #114 = 60: Outputs FO1, FO2, FO3 and FO4 will not be dimmed; front and rear headlights will be dimmed according to CV #60. See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#115	Uncoupler control (KROIS and ROCO couplers) "Pull-in" time and "hold" voltage CV # 115 can be used alternatively for second dim value (dimming 0-90% using ones digit; tens digit must be 0)	0 – 99 See add. notes	0	Active only if "uncoupling" is selected (with value of "48") in CV #125.....132: Tens digit (0 – 9): Time in seconds as per table below the coupler receives full voltage (pull-in time): Value: 0 1 2 3 4 5 6 7 8 9 Full voltage for: 0 **0.1** 0.2 0.4 0.8 1 2 3 4 5 sec. Ones digit (0 to 9): hold-in power in percent of track voltage, 0 - 90%. Applied after the pull-in time elapsed (necessary for ROCO uncoupler, not needed for KROIS coupler).
#116	Automated uncoupling procedure "Coupler waltz"	0 – 99 0 – 199 See add. notes	0	Tens digit (0 – 9): Length of time the loco should move away from train; values as in CV #115. Ones digit (0 – 9) x 4 = Internal speed step applied to loco (Momentum per CV #3 etc.) Hundredths digit = 0: No tension relieve. = 1: Tension relieve: loco moves toward coupler (to relieve tension) before moving away. Example: CV #116 = 61: Loco uncouples and drives away from train for 2 seconds at speed step 4. CV #116 = 155: Loco pushes first against train to unload couplers, uncouples and then drives away from train for 1 second at speed step 20.
#117	Flasher functions Outputs are assigned in CV #118.	0 – 99	0	Duty cycle for flasher function: Tens digit = ON time (0 = 100msec…..9 = 1 sec) Ones digit = OFF time (0 = 100msec…..9 = 1 sec) Example: CV #117 = 55: Flashes evenly at the same ON/OFF time.

CV	Designation	Range	Default	Description
#118	Flashing mask - Defines which outputs operate as flashers according to rhythm programmed in CV #117.	Bits 0 – 7	0	Selects the outputs that are supposed to flash when turned ON. Bit 0 = front headlight Bit 1 = rear headlight Bit 2 = function output FO1 Bit 3 = function output FO2 Bit 4 = function output FO3 Bit 5 = function output FO4 Bit values = 0: no flasher Bit values = 1: output flashes when turned ON. Bit 6 = 1: FO2 flashes inverse! Bit 7 = 1: FO4 flashes inverse! EXAMPLE: CV #118 = 12: FO1 and FO2 are defined as flashers. CV #118 = 168: Alternate flashing of FO2 and FO4 (wig-wag). See chapter “Converting binary to decimal” for Bit value calculation or use cab’s **binary programming** function!
#119	Low beam mask for F6 - Output assignment for (example) low/high beam headlights	Bits 0 - 7	0	Assigns outputs to be dimmed with F6 (CV #60 determines dim value). Typical application: LOW/HIGH BEAM. Bit 0 = front headlight Bit 1 = rear headlight Bit 2 = function output FO1 Bit 3 = function output FO2 Bit 4 = function output FO3 Bit 5 = function output FO4 Bit values = 0: no low beam function Bit values = 1: Low beam with F6 key, brightness determined by value in CV #60. Bit 7 = 0: normal effect of F6. = 1: effect of F6 inverted. EXAMPLE: CV #119 = 131: Headlights switch from low to high beam with function key F6. See chapter “Converting binary to decimal” for Bit value calculation or use cab’s **binary programming** function!
#120	Low beam mask for F7	Bits 0 - 7		Same as in CV #119 but for F7 key.
#121	Exponential acceleration	0 – 99 (See add. notes)	0	Acceleration time (momentum) can be stretched in the lower speed range: Tens digit: Percentage of speed range to be included (0 to 90%). Ones digit: Exponential curve (0 to 9). EXAMPLE: CV #121 = 11 or 25: typical initial test values.
#122	Exponential deceleration	0 – 99 (See add. notes)	0	Deceleration time (momentum) can be stretched in the lower speed range: Tens digit: Percentage of speed range to be included (0 to 90%). Ones digit: Exponential curve (0 to 9). EXAMPLE: CV #122 = 11 or 25: typical initial test values.
#123	Adaptive acceleration and deceleration	0 – 99 (See add. notes)	0	Raising or lowering the speed to the next internal step occurs only if the preceding step is nearly reached. The tolerance for reaching the preceding step can be defined by this CV (the smaller this value the smoother the acceleration/deceleration). Value 0 = no adaptive accel. or decel. Tens digit: 0 - 9 for acceleration Ones digit: 0 - 9 for deceleration EXAMPLE: CV #123 = 11: strongest effect; sometimes affects the start up too much. CV #123 = 22: typical setting.
#124	Shunting key functions: Momentum reduction or deactivation and Low gear and DC stopping (also see description in CV #29).	0 - 4, 6 and Bit 5 for DC stopping and **Bit 7** switches outputs between SUSI and logic level.	0	Selects shunting key for LOW GEAR ACTIVATION: Bit 4 = 1 (and Bit 3 = 0): F3 as half speed key Bit 3 = 1 (and Bit 4 = 0): F7 as half speed key Selects shunting key for MOMENTUM DEACTIVATION: Bit 2 = 0 (and Bit 6 = 0): “MN” key for shunting, Bit 2 = 1 (and Bit 6 = 0): F4 key for shunting Bit 6 = 1 (Bit 2 is irrelevant): F3 as shunting key. Effect of above key (MN, F3 or F4) on MOMENTUM: Bit 1, 0 = 00: no effect with above key’s = 01: removes momentum of CV #121 + #122 = 10: CV #3 + #4 reduced to ¼. = 11: removes all momentum above. **Bit 5 = 1:** “DC stopping”, see CV **#**29 **Bit 7 = 0:** SUSI active instead of normal functions **= 1:** Normal function outputs instead of SUSI EXAMPLES: F3 for shunting key: CV #124 = 8. F3 for shunting key and F4 to remove momentum completely: Bits 0, 1, 2 & 4 = 1; that is CV #124 =23. F3 for half-speed key and removing momentum: Bits 0, 1, 4 &6 = 1; that is CV #124 = 83. See chapter “Converting binary to decimal” for Bit value calculation or use cab’s **binary programming** function!

CV	Designation	Range	Default	Description
#125[1]	**Special effects** American lighting effects, Uncoupler (time-limited) activation, automated output activation (ON/OFF) to meet different criteria, "Soft start" of function outputs at activation **for Function output** **"Front headlight"**, by default with F0 in forward direction, unless assigned different through function mapping. Effects can be further adjusted and modified with CV's #62 - 64 and CV #115 (for uncoupler).		0	The CV definitions described here are valid for CV #125 through #132. Some of the functions below may not necessarily be suitable for CV #125 and #126 as these outputs are usually connected to headlights. Bits 1, 0 = xxxxxx00: active in both directions = xxxxxx01:active in forward direction =xxxxxx10:active in reverse direction ATTENTION in case of CV #125 and #126: change CV's #33, 34.... if direction is wrong! Bits 7, 6, 5, 4, 3, 2 = Effects code 765432(xx= Bits1&0 for direction, see above!) = 000001xx Mars light = 000010xx Random Flicker = 000011xx Flashing headlight = 000100xx Single pulse strobe = 000101xx Double pulse strobe = 000110xx Rotary beacon simulation = 000111xx Gyralite = 001000xx Ditch light type 1, right = 001001xx Ditch light type 1, left = 001010xx Ditch light type 2, right = 001011xx Ditch light type 2, left = 001100xx Uncoupler as in CV#115 = 001101xx Soft start up of function output = 001110xx Automatic stop lights for street cars, afterglow at stop, see CV #63 = 001111xx Function output turns itself off at speed >0 (i.e. turns off cab light at start). = 010000xx Function output turns itself off after 5 min. (i.e. to protect a smoke generator from overheating). = 010001xx Turns itself off after 10 minutes. = 010010xx Speed or load dependent **smoke generation** for **steam engines** as per CV's 137 – 139 (i.e. pre-heating at stand still, heavy smoke at high speed or high load). Smoke turns itself off as per CV #353; function key has to be pressed to reactivate smoke. = 010100xx Load dependent **smoke generation** for **diesel engines** as per CV's #137 – 139 (i.e. pre-heating at stand still, heavy smoke at high speed or high load). See CV #133 for synchronized control of fans through FO4. Smoke turns itself off as per CV #353; function key has to be pressed to reactivate smoke. EXAMPLES You want : Program CV #125 to: Mars light forward only - 00000101 = 5 Gyralite independent of direction - 00011100 = 28 Ditch type 1 left, only forward - 00100101 = 37 **Uncoupler - 00110000 = 48** **Soft start of output - 00110100 = 52** **Automatic stop light - 00111000 = 56** Automatic cab light OFF - 00111100 = 60 Auto. smoke OFF after 5 min – 01000000 = 64 Auto. smoke OFF after 10 min – 01000100 = 68 Speed/load depen. smoke - 01001000 = 72 Speed/load depen. diesel smoke - 01010000 = 80 See chapter "Converting binary to decimal" for Bit value calculation or use cab's **binary programming** function!
#126	**Special effects** for rear headlight (default F0 reverse)		0	Bits 1, 0 = xxxxxx00: active in both directions = xxxxxx01:active in forward direction =xxxxxx10:active in reverse direction ATTENTION in case of CV #125 and #126: change CV's #33, 34.... if direction is wrong! See CV #125 for details.
#127	**Special effects** for FO1 (default F1)		0	See CV #125 for details.
#128	**Special effects** for FO2 (default F2)		0	See CV #125 for details.
#129 - #132	**Special effects** for FO3, FO4, FO5, FO6 (default F3, F4, F5, F6)		0	See CV #125 for details.
#62	Light effects modifications	0 - 9	0	Change of minimum dimming value (FX_MIN_DIM)
#63	Light effects modifications or Stop light OFF delay	0 – 99 0-255	51	Tens digit: sets cycle time (0 - 9, default 5), or start up time during soft start (0 - 0,9s) Ones digit: extends "off" time For stop light afterglow (001110xx in CV #125, 126 or 127): Time in tenths of a second the stop lights remain on after the street car comes to a full stop (range: 0 – 25 sec.).
#64	Light effects modifications	0 - 9	5	Ditch light off-time modification

[1] Note to ditch lights: Ditch lights are only active when headlights and function F2 (#3 on Zimo cab) are on, which is prototypical for North American railroads. The ditch lights will only be working if the applicable bits in CV #33 and 34 are on (the definition in CV #125 - 128 in itself is not enough but a necessary addition).
Example: If ditch lights are defined for F1 and F2, the bits #2 and 3 in CV #33 and 34 have to be set accordingly (i.e. CV # 33 = 13 (00001101), CV #34 = 14 (00001110).

CV	Designation	Range	Default	Description
#133	Function output 4 (FO4) as virtual cam sensor output for external sound modules or FO4 for synchronized fan control of smoke generators on steam engines	0, 1	0	= 0 (Default): FO4 is available as a normal function output that is, not as cam sensor output. = 1: FO4 sends cam sensor signals, either virtual signals or signals of a real cam sensor. See CV's #267 and 268!
		FO4 controls DIESEL engine smoke fan if the special effect "010100xx" is selected; at any function key. Fan speed is defined in CV's #351 and 352.		NOTE: Fan control is also influenced by the sound project. NOTE: Large scale decoders (not covered in this manual) offer more adjusting possibilities for fans through FO10.
#134	Asymmetrical threshold for stopping with asymmetrical DCC signal (Lenz ABC method).	1 - 14, 101 - 114, 201 - 214 = 0,1 - 1,4 V	106	Hundredths digit: Sensitivity adjustment, changes the speed with which the asymmetry is being recognized. = 0: fast recognition (but higher risk of errors, i.e. unreliable stopping). = 1: normal recognition (@ 0.5 sec.), pretty save results (default). = 2: slow recognition (@ 1 sec.), very reliable. Tenths and ones digit: Asymmetrical threshold in tenths of a volt. The voltage difference between the two half waves of the DCC signal is the minimum required to be recognized as asymmetrical that starts the intended effect (usually braking and stopping of a train). Also see CV #27! = 106 (Default) therefore means normal recognition at 0.6 V. This value has proven itself to be appropriate under normal conditions; by using 4 diodes to generate the asymmetry, see chapter 4!
#135	Km/h – Speed regulation - Activating, control and range definition	2 – 20 See chapter "Add. Notes", section „km/h – speed regulation"!	0	= 0: km/h – Regulation turned off; the "normal" speed regulation is in effect. Start with Pseudo-Programming („Pseudo" = programmed value is not being stored): CV #135 = 1 -> Initiates a calibration run (see chapter 4, „km/h – speed regulation") Continue with "normal" programming of CV #135 (programmed value will be stored): = 2 to 20: speed steps / km/h – factor; e.g.: = 10: each step (1 to 126) represents 1 km/h: that is step 1 = 1 km/h, step 2 = 2 km/h, step 3 = 3 km/h… = 20: each step represents 2 km/h; step 1 = 2 km/h, step 2 = 4 km/h, last step 126 = 253 km/h. = 5: each step represents .5 km/h; step 1 = .5 km/h, step 2 = 1 km/h, last step 126 = 63 km/h.

CV	Designation	Range	Default	Description
#136	km/h – Speed regulation - Control number read-out	See chapter "Add. Notes", section „km/h – speed regulation"!	-	A numeric value can be read-out after a successful calibration run, which was used to calculate the speed. This value is interesting because it is (almost) independent from the selected speed during the calibration run. The uniformity of the resulting values from several calibration runs may be an indication of the calibration quality. See chapter 4!
	Definition of smoke generator characteristic, connected to FO 1 – 6. (provided a "smoke" function is selected for the appropriate output in CV #127-132)			The values in CV #137 – 139 define a smoke characteristic for the function outputs (FO1, FO2, FO3, FO4, FO5 or FO6; referred to below as FOx), provided a "smoke function" for a diesel or steam engine has been selected in the associated CV #127 – 132 (i.e. 010010xx, 010011xx, 010100xx or 010101xx).
#137	PWM at stand still	0 – 255	0	CV #137: PWM of FOx at standstill
#138	PWM at steady speed	0 – 255	0	CV #138: PWM of FOx at cruising speed
#139	PWM during acceleration	0 - 255	0	CV #139: PWM of FOx at acceleration (PWM = Pulse With Modulation)
#140	Distance controlled stopping (constant stopping distance) Select braking method and braking process	0 - 255	0	Activates distance controlled stopping as per CV #141 in place of time-constant braking according to CV #4. = 1: automatic stops with "signal controlled speed influence" or "asymmetrical DCC signal". = 2: manual stops using the cab. = 3: automatic and manual stops. The start of braking is delayed in all the above cases (= 1, 2, 3), if the train travels at less than full speed to prevent an unnecessary long "creeping" (recommended). On the other hand: = 11, 12, 13 selection as above, but braking starts immediately after entering the brake section.
#141	Distance controlled stopping (constant stopping distance) Distance calculation	0 - 255	0	This CV defines the "constant stopping distance". The right value for the existing stop sections has to be determined by trial. Use these figures as a starting point: CV #141 = 255 is about 500m (500 yards) for a real train or 6m (18 ft) in HO. CV #141=50 about 100 m (100 yards) for a real train or 1.2m in H0 (4 ft).
#142	Distance controlled stopping (constant stopping distance) High-speed correction using the ABC method	0 - 255	12	The recognition delay (see CV #134), but also unreliable electrical contact between rails and wheels has a larger effect on a stop point at higher speeds than at lower speeds. This effect is corrected with CV #142. = 12: Default. This setting usually works fine if CV #134 is set to default also.
#143	… compensation using the HLU method	0 - 255	0	The HLU method is more reliable than the ABC method; no recognition delay is usually required in CV #134; this CV can remain at default value 0.

CV	Designation	Range	Default	Description
#144	Programming and update lock	Bits 6, 7	0 or 255 (255 = „FF“, has the same effect on “old” decoders as 0 has on the new)	This CV was introduced to prevent unintentional decoder changes or loss of functions due to an inadvertent entry to the update mode. = 0: Unrestricted CV programming and updating. Bit 6 = 1: No programming possible in **service mode:** protection against unintentional programming. Note: “on-the-main” programming is still possible. Bit 7 = 1: Software updates normally executed with the MXDECUP, MX31ZL or future devices are blocked. (Unlock this CV with “on-the-main” programming)
#145	Alternative motor control method	0, 1, 10, 11, 12	0	= 0: normal control mode (DC & coreless motors (Faulhaber, Maxxon)) = 1: special control for low-impedance DC motors (often Maxxon); this mode allows the connection of a capacitor (10 or 22uF) to the decoders positive and ground pads which puts less stress on the decoder and motor (but only if a capacitor is actually present !). This method has not been tested much. = 10: “normal” C-Sinus and Softdrive-Sinus control mode (same as CV #112, Bit 0 = 1), FO4 is fixed and not available as a function output. = 11: alternative C-Sinus / Softdrive Sinus control mode, FO4 is available as normal function output (not suitable for all C-Sinus or Soft drive-Sinus equipped locomotives). = 12: special C-Sinus and Softdrive-Sinus control mode for interfaces requiring the normal motor output instead of the otherwise more common C-Sinus output, FO4 is fixed and not available as function output. =13: special C- / Softdrive-Sinus control mode for the Märklin “Gottardo” engine (and possibly future Märklin engines). FO3 is fixed and not available as function output. It is required for switching front/rear wipers with directions.
#146	Compensation for gear backlash during direction changes in order to reduce start-up jolt.	0 - 255	0	Some free play between gears of a drive train is required to prevent them from binding. This backlash may be more severe on some engines than on others, especially when fitted with a worm gear. An engine with a worn gearbox also exhibits excessive backlash. Excessive backlash leads to a peculiar behavior especially when changing the direction: When the motor starts spinning in the opposite direction it doesn’t move the engine because it has to eliminate the backlash first. And to make matters worse, the motor starts to accelerate already during this phase. When the motor finally starts to move the engine, the motor’s speed has exceeded the normal start-up rpm, which results in an unpleasant jolt. This can be avoided with the help of

CV	Designation	Range	Default	Description
				CV #146. = 0: no effect = 1 to 255: the motor spins at minimum rpm (according to CV #2) for a specific time and only starts to accelerate after this time has elapsed. This CV will only be executed during a direction change. How much time is required to overcome the backlash depends on various circumstances and can only be determined by trial and error. Typical values are: = 100: the motor turns about 1 revolution or a maximum of 1 second at the minimum speed. = 50: about ½ a turn or max. ½ second. = 200: about 2 turns or max. 2 seconds. Important: CV #2 (minimum speed) has to be set correctly, that is the engine has to move with the lowest speed step (1 of 128 or 1 of 28). Also, CV #146 is only useful if the load regulation is set to maximum or at least close to it (i.e. CV #58 = 200 – 255).
#147 #148 #149 #150	Experimental CV’s for test purposes. The use of these experimental CV’s disables the automatic settings in order to find out whether automatic settings have a negative effect on motor control. The CV’s #147 – 149 will be removed again from future decoder software.		0 0 0 0	--- CV #147 Timeout --- Useful start value: 20 Too small a value leads to jerky behavior. Too large a value leads to poor low speed control. =0: automatic control (CV #147 has no effect) --- CV #148 D-Value --- Useful start value: 20 Too small a value leads to poor regulation (too little, too slow, engine jerks. Too large a value leads to over compensation, the engine runs rough/vibrates. =0: automatic control (CV #148 has no effect) --- CV #149 P-Value --- =0: automatic control (CV #149 has no effect) =1: P-Value is fixed as per CV #56 (tens digit) --- CV #150 Regulation at full speed --- The normal regulation at full speed is always 0. This can be changed with CV #150. Example: CV #58 = 200, CV #10 = 100, CV #113 = 80 und CV #150 = 40 --> Result: Regulation at speed step 1 is 200 (of 255, almost 100%), at speed step 100 it is 80 (@1/3rd of 255), at speed step 252 (full speed) it is 200 (of 255, almost fully regulated). **We kindly ask for your cooperation. Please send us your test results!**
#151	Motor brake	0 - 9	0	To prevent engines without worm gears from rolling away on inclines. =0: No motor brake =1 … 8: The motor brake is gradually actuated when the target speed 0 is reached during

CV	Designation	Range	Default	Description
				braking (reaches full braking over 1, 2 … 8 seconds by shorting both motor end stages). =9: Applies full motor brake immediately when speed 0 is reached by shorting both motor end stages. NOTE: The motor brake function was available in Bit 0 of CV #112 up to June 2009 (before SW version 25). It could be selected but was not adjustable as it is now.
#152	Dim Mask 2 = Excluding specific function outputs from dimming as per CV #60 This is a continuation of Dim Mask 1 in CV #114 and direction bit mapping.	Bits 0 – 5 and 6	0 0	Selected function outputs will **not** be dimmed to the dim value in CV #60. Bit 0 = function output FO7 Bit 1 = function output FO8 Bit 2 = function output FO9 Bit 3 = function output FO10 Bit 4 = function output FO11 Bit 5 = function output FO12 Corresponding Bit = 0: Output is dimmed to the value programmed in CV #60. Corresponding Bit = 1: Output is not dimmed. Bit 6 = 0: FO3 & FO4 can be mapped with normal NMRA function mapping (CV #33…). =1: Active direction Bit for FO3&FO4 that is: FO3 is turned ON in reverse FO4 is turned ON in forward direction. (NOTE: FO3 & FO4 can no longer be mapped with regular NMRA function mapping if Bit #6 = 1)
#161	Servo outputs: Protocol	0 - 3 CV #161 must be set to "2" for **Smart Servo RC-1!**	0	Bit 0 = 0: Servo protocol with positive pulses. = 1: Servo protocol with negative pulses. Bit 1 = 0: Control wire active during movement = 1: … always active (consumes power, vibrates at times but holds position even under mechanical load) – use for this setting for Smart Servo RC-1. Bit 2 = 0: Moves to center position if defined for two-key operation (see CV #181/182) when both function keys are OFF. = 1: Servo runs only if function keys are pressed when in two-key operating mode (see CV #181/182).
#162	Servo 1 - Left stop	0 - 255	49 = 1 ms pulse	Defines the servo's left stop position. "Left" may become the right stop, depending on values used.
#163	Servo 1 - Right stop	0 - 255	205	Defines the servo's right stop position.
#164	Servo 1 - Center position	0 - 255	127	Defines a center position, if three positions are used.
#165	Servo 1 - Rotating speed	0 - 255	30 = 3 sec	Rotating speed; Time between defined end stops in tenths of a second (total range of 25 sec).
#166 to #169	As above, but for servo 2			

CV	Designation	Range	Default	Description
#181 #182	Servo 1 Servo 2 Function assignment	0 - 114 90 - 93 from SW-Version 18	0 0	= 0: Servo not in operation = 1: Single-key operation with F1 = 2: Single-key operation with F2 and so on. = 90: Servo action depends on loco direction: forward = turns left; reverse = turns right = 91: Servo action depends on loco stop and direction: turns right when stopped and direction is forward, otherwise turns left. = 92: Servo action depends on loco stop and direction: turns right when stopped and direction is reverse, otherwise turns left. = 93: Servo action depends on loco movement: turns right when loco stopped, left when loco moving; direction makes no difference. = 101: Two-key operation F1 + F2 = 102: Two-key operation F2 + F3 and so on. = 111: Two-key operation F11 + F12 = 112: Two-key operation F3 + F6 = 113: Two-key operation F4 + F7 = 114: Two-key operation F5 + F8 (Two-key mode operates as defined with CV #161, Bit 2)
#250 to #253	Decoder ID SW version 26 or higher	Read only CV	=	The decoder ID (serial number) is automatically entered during production: The first Byte (CV #250) denotes the decoder type; the three other Bytes contain the serial number. The decoder ID is primarily used for automatic address recognition when an engine is place on the layout track (with the help of RailCom) as well is in conjunction with the "load code" for "coded" sound projects (see CV #260 - 263).
#260 to #263	"Load code" for "coded" sound projects SW version 26 or higher	=	=	"Coded" (protected) ready to use sound projects are usually supplied by external ZIMO providers, who get compensated by a load code fee. For a surcharge, new decoders can be ordered with the "load code" installed, which entitles the user to install "coded" sound projects of a selected sound "bundle". The "load code" can also be bought later and entered in to the decoder: After sending the decoder ID (content of CV's #250 – 253) to ZIMO or an approved provider along with the required fee, the user receives the "load code" for a specified bundle of sound projects (i.e. RhB, Heinz Däppen). After entering the "load code" to CV's #260 - 263, the selected sound project can be installed into the decoder. Also see: www.zimo.at and ZIRC software.
MORE configuration variables for SOUND DECODERS are found in the chapter "ZIMO SOUND"!				

4. Additional notes to Configuration Variables (CV's)

Optimal Control, Automated Stops, Effects . . .

Two ways of programming speed curves:

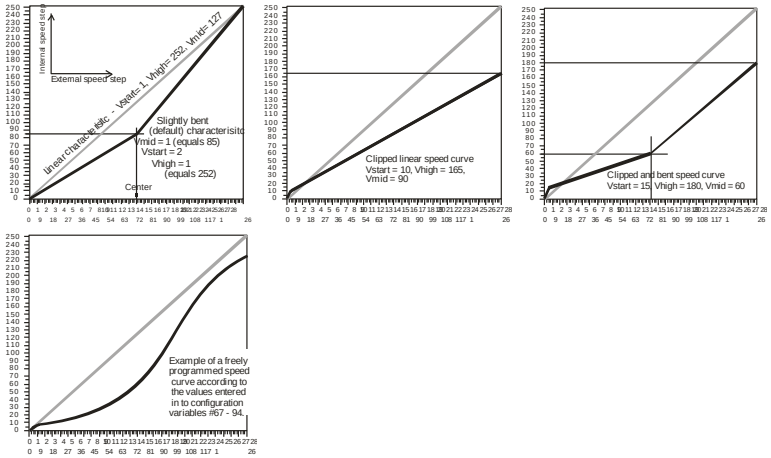
Programmable speed curves can often optimize the driving characteristics of an engine. These curves alter the relationship between the cab's speed regulator settings and the engines speed (that is between 14, 28 or 128 external speed steps of the cab and the 252 internal speed steps of the decoder).

Which one of the two speed curves the decoder applies is determined by Bit 4 of Configuration Variable #29: "0" for the first type - Three Step Programming, defined by just three CV's;"1" for the second type - Programmable Speed Table, defined by 28 individual CV's.

Three step programming: by using the Configuration Variables #2 for Vstart, #5 for Vhigh and #6 for Vmid. Vstart defines one internal speed step out of a total of 252 for the first speed step of the cab, Vhigh for the highest speed step and Vmid for the center speed step of the cab. In this way a simple bent acceleration curve can be achieved with an expanded lower speed range.
A slightly bent curve is active by default (CV #6 = 1), that is the center speed step is set to 1/3 of full speed.

Programmable speed table**:** with the help of the programmable speed table, **free programming** of all **Configuration Variables** from #67 to 94 is possible. Each of the 28 external speed steps is assigned to one internal step (0 to 252). If 128 external speed steps are used, an interpolation algorithm is used to calculate the steps in between.

NOTE: The three step programming is in most cases entirely sufficient for good drivability; the relatively complex procedure of defining a speed table is only recommended with the help of software like ADaPT that graphically draws the speed curve and automatically sends the data to the decoder.



General Note:

The development of the motor control algorithm is an ongoing project and is optimized with each new software version. What we are striving for is an automatic adjustment to the drive train of any given locomotive. The following explanations are becoming less and less important and are only of interest if the locomotive does not run satisfactorily with the default settings.

The case studies in this chapter are often not based on the latest software version and are therefore not recommended to be implemented as is but rather serve as a reference to possible corrections.

In case of ***Faulhaber, Maxxon or similar*** motors (Coreless):
Start programming with ***CV #9 = 22*** and ***CV #56 = 100 ! ! !***

Motor control frequency and EMF scanning rate:

The **motor** is controlled by **pulse with modulation** that can take place at either low or high frequency. This frequency is selected with **configuration variable #9** (NMRA conforming formula, see CV table).

High frequency control: The motor is controlled at 20kHz in default mode or whenever a value of "0" is entered to CV #9, which can be raised to 40kHz with bit 5 in CV #112. The effect is comparable to operating with DC voltage and is likewise just as **noiseless** (no hum as with low frequency) and easy on the motor (minimum thermal and mechanical stress). It is ideal for coreless motors (recommended by Faulhaber!) and other high performance motors (most modern motors, including LGB). It is not recommended however, for AC motors and some older motors.

When operating at high frequency, power to the motor is interrupted periodically in order to determine the current speed by measuring back-EMF (voltage generated by the motor). The more frequently this interruption takes place, that is the higher the **EMF sampling frequency,** the better the load compensation performs (see next page); but that also results in a certain loss of power. This sampling frequency varies automatically in the default mode (CV #9 = 0) between 200Hz at low speed and 50 Hz at maximum speed. CV #9 allows the adjustment of the sampling frequency as well as the sampling time.

* If after CV #56 was programmed to 100 and further improvements are still necessary to **MAXXON, Faulhaber or similar motors,** it is in most cases recommended to select a lower sample time and frequency such as **CV #9 = 11, 12, 21, 31** etc;

* for **older motor constructions** use rather the opposite, e.g. **CV #9 = 88.**
Also see CV table and the following page!

Low frequency control: Entering a value between 176 and 255 to CV #9 drives the motor between **30 and 150 Hz.** Most often used value is 208 for 80 Hz. This is rarely used today and is only suitable for AC motors with field coils.

The load compensation:

All Zimo decoders come equipped with **load compensation,** also known as BEMF to keep a **constant speed,** regardless whether the engine is pulling a short or long train uphill, downhill or around a tight radius (although the speed will not be held 100% constant, especially in the upper speed range). This is accomplished by constantly comparing the desired value (speed regulator setting) and the actual value at the motor, determined with the EMF method (EMF stands for Electro Motive Force, which is power produced by the motor when it is turned without power applied to it).

The **Reference Voltage** used for the BEMF algorithm can be defined by **configuration variable #57** as either absolute or relative (default).

Absolute Reference:
A voltage value is defined in CV #57 as a base line for the BEMF calculation. For example: if 14V is selected (CV value: 140), the decoder then tries to send the exact fraction of the voltage indicated by the speed regulator position to the motor, regardless of the voltage level at the track. As a result the speed remains constant even if the track voltage fluctuates, provided the track voltage (more precisely, the rectified and processed voltage inside the decoder, which is about 2V lower) doesn't fall below the absolute reference voltage.

The "absolute reference" is to be preferred to the "relative reference" when using other vendors' systems (particularly those that don't keep the track voltage stabilized)!

Relative Reference: The speed range is automatically adjusted to the available track voltage, if a 0 is entered to CV #57 (default). Therefore, the higher this voltage is set at the command station (adjustable between 12V and 24V) the faster the train will be over its entire speed range.

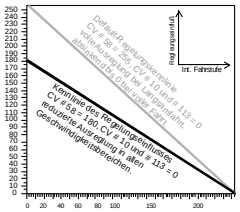
The relative reference is suitable as long as a constant voltage is present (which is the case with all Zimo systems but not all competitor systems) and the resistance along the track is kept to a minimum.

The driving characteristic of an engine can further be optimized by adjusting the **intensity of load compensation.** The goal of load compensation, at least in theory, is to keep the speed constant in all circumstances (only limited by available power). In reality though, a certain reduction in compensation is quite often preferred.

100% load compensation is useful within the low speed range to successfully prevent engines from stalling or picking up speed under load. BEMF should rather be reduced as speed increases, so that at full speed the motor receives full power with little BEMF. A slight grade dependent speed change is often considered more prototypical. Consists also should never be operated with 100% BEMF because it causes the locomotives to fight each other by compensating too hard and too fast, which could lead to derailments.

The degree of load compensation can be defined with **Configuration Variable #58** from no compensation (value 0) to full compensation (value 255). This, in effect, is the amount of compensation applied to the lowest speed step. Typical and proven values are in the range of 100 to 200.

If an even more precise load compensation is required (though hardly ever necessary), **configuration variable #10 and #113** presents a solution. CV #10 defines a speed step at which the **load compensation is reduced to the level defined in CV #113.** Both CV's have to have a value other than 0. If either CV #10 or #113 is set to 0, BEMF is again solely based on CV #58.



Regarding **configurations variable #56** – (proportional and integral control values):

See the following chapter "Step by step CV adjustments….." !

Acceleration and deceleration characteristics (momentum):

Configuration Variables #3 and #4 provide a way of setting a **basic linear acceleration and deceleration rate** according to NMRA rules and regulations. That is, the speed is changed in equal time intervals from one speed step to the next.
To simply achieve smooth transitions during speed changes, a value between 1 and 3 is recommended. The true slow starts and stops begin with a value of about 5. Programming a value higher than 30 is seldom practical!

The momentum can be modified with **Configuration Variables #121 and #122** to an **exponential acceleration and deceleration** rate, independent from each other. This in effect expands the momentum in the lower speed range. The area of this expansion (percentage of speed range) and its curvature can be defined.
A typical and practical value is "25" (as starting point for further trials).

The **adaptive acceleration and deceleration procedure** defined by **configuration variable #123** will not allow a change in speed until the previous target speed step of an acceleration/deceleration event is nearly reached.
Most often applied values are "22 or "11", which can noticeably reduce a start-up jolt (the effect increases with decreasing values).

********** *Step by step CV adjustment procedure to optimize engine performance:*

It is recommended to program a decoder systematically, since the CV settings for load compensation and momentum can result in a certain interaction with each other:

***** To begin, select the highest possible number of speed steps the system can operate in, that would be **128 steps** for Zimo (select the number of speed steps at the cab for the decoder address in question); other systems may operate with only 28 or 14 speed steps. All Zimo decoders operate by default with 28 /128 speed steps (both variants are utilized). If used with systems that are restricted to 14 steps set Bit 1 in CV #29 to 0.

***** Next set the engine to the lowest step, recognizable on the Zimo cab's when the bottom LED next to the speed slider changes color from red to green and/or the speed step 1 is displayed on the screen of the MX21/MX31 cabs (first, change the cab to 128 speed steps for this address, if not done so or if it isn't already the default setting!).

If the engine is now running too slow or not at all, increase the value in **CV #2** (default 2), if it runs too fast decrease the value. If the individual speed table is used (CV #67 - 94, active if bit 4 of CV #29 is set), set the lowest speed step with CV #67 instead and adjust the rest of the speed table CV's accordingly.

***** The EMF sampling process (see previous page) is critical for smooth even low speed behavior and quiet motor performance, which can be modified with **CV #9**. This CV is also used to set the decoder to low frequency motor control, which is required only rarely with older AC motors.

By default (CV #9 = 0), the frequency is set to 20 kHz (can be raised to 40 kHz with Bit 5 of CV #112) and automatically adapts the EMF sample rate to the loco speed. If drivability is not flawless or too much motor noise is audible, fine-tuning is possible as follows:

CV #9 = 0 (default) has the same effect as when CV #9 = 55, that is a medium value for the ones as well as the tens digit. The value of the tens digit (1-9) in CV #9 determines the EMF sampling rate and the value of the ones digit (1-9) the EMF sampling time, which is the time the motor is not powered.

In general: High-efficient motors such as **Faulhaber, Maxxon, Escap** etc (coreless motors) can manage with short measuring times; the ones digit of CV #9 can therefore be set to a value of "2". The ideal EMF sampling rate depends on the loco construction and weight: small, lightweight engines require a rather high sampling rate (i.e. "5") while heavy engines (i.e. O-gauge or large HO engines) work well with a lower sampling rate (i.e. "2"). So for a typical HO engine with coreless motor (i.e. Faulhaber) a setting of **CV #9 = 52** is often a good choice; for O-scale **CV #9 =22.** Further improvements in terms of smooth low speed performance and reduced motor noise may be achieved by trial and error using different tens digit values in CV #9; and of course by means of CV #56 (see below).

If an engine with an **older motor design** runs rough at low speeds, the sample frequency (tens digit) is usually the one that needs to be set to a larger value (>5), which often requires the sample time (ones digit) to be set to a higher value as well (>5); i.e. CV #9 = 88.

***** If, after setting CV #9, the engine still doesn't run smooth enough at the lowest speed step, changing the values of the ones and tens digit in **CV #56** will often improve it. Here also, the default value of "0" is equal to the center setting of 55. These values define the proportional and integral portion of the PID control. By default (CV #56 = 0), the proportional value adjusts itself automatically and the integral value is set to mid-value. Depending on the type of motor, other values than the default value may be useful, such as 77, 88 or 99 for older locos that run rough or 33, 22, or 11 for newer locos with more efficient motors (Faulhaber, MAXXON etc).

A possible overcompensation can be reduced with the help of the integral value (ones digit of CV #56).

For engines with **Maxxon, Faulhaber** (coreless motors) the setting **CV #56 = 100** should be tried first (instead of the default "0" for normal DC motors). This setting is equal to CV #56 = 155, where the hundreds digit "1" causes an adjustment to the center setting to accommodate highly efficient motors. If necessary, further improvements may be achieved by trying different values of the tens and ones digit.

* After improving low speed performance (by increasing the value of CV #56 described above), check that the engine is not running jerkily at mid-speed level that could be caused by high CV #56 values (77, 88…). This effect can be compensated for by reducing the total amount of load compensation in **CV #58** (default "250") down to "200" or "150" or use CV #10 and #113 to cut the load compensation at a speed just below the start of the jerky motion (the compensation is reduced to the level defined with CV #113 at the speed step defined with CV #10).

* If after the above adjustments the engine's speed is still fluctuating, use **CV #57** for further fine-tuning. With a default value of 0, load compensation is based on the measured track voltage. If this voltage fluctuates, the speed will also fluctuate. The cause is usually a DCC system that can't compensate for voltage drops (other than Zimo systems) or dirty wheels or track. To prevent such fluctuations a value representing the selected track voltage x10 is entered to CV #57 (not idle track voltage, rather voltage under load). For example, if an engine needs 14 V (measured under load) a value of 140 should be entered; better yet, keep this value about 20 to 50 points lower to compensate for a slight internal voltage drop in the decoder.

* Next, we check to see whether the loco's initial start is smooth or abrupt. This can be seen well with some momentum added. Temporarily, set some momentum with CV #3 and #4. Start with a value of 5.

There are basically two different kinds of start up jolts: the jolt that happens every time an engine starts up and the one that only shows up after the engine changes direction (i.e. after the engine stopped, changed direction and starts up again). The "direction-change jolt" is due to gearbox backlash; see further down.

For the first kind of start-up jolt, the adaptive acceleration procedure can now be used to eliminate abrupt starts by changing the value of the tents digit in **CV #123.** Start with a value of 20. The lower the value, the stronger the effect will be (e.g. 10 results in the strongest effect for acceleration, 90 the weakest).
A possible jolt when stopping can also be reduced with the help of the ones digit in CV #123. The tens digit is for defining the adaptive acceleration and the ones digit for the adaptive deceleration. CV #123 = 22 reduces the start-up as well as the stop jolt. It may be of advantage to reduce the adaptive deceleration, i.e. CV #123 = 24 in order to improve repeatable stop points in automated operations (routes, block control etc.).

Beginning with SW version 5, the "direction-change jolt" can also be reduced using **CV #146.** Typical values are CV #146 = 50 or 100. See description in the CV table.

* After changing the values in CV #123 the basic momentum may need to be readjusted to your preferences; first with **CV's #3 and #4** (basic momentum). Values higher than default are usually recommended, at a minimum CV #3 = 5 and CV #4 = 3. This improves the engine's performance considerably. Much higher values are suitable for engines equipped with sound in order to match the sound to the engine's movement (with sound decoders as well as external sound modules via SUSI).

Additionally the "exponential acceleration and deceleration" may be applied with **CV #121** and **#122.** This allows for prototypical non-linear momentum coupled with extremely soft starts and stops without compromising the maneuverability in the upper speed range. This stretches the time the locomotive will spend in the lower speed range. Often used values for these CV's are between 25 and 55, which means that 20% to 50% (according to the tens digit) of the total speed range will be included in the exponential acceleration curve, with a medium curvature (ones digit at '5').

Notes on acceleration behavior versus speed steps:

An acceleration or deceleration sequence according to CV #3 and 4 that is the timely succession of speed steps is always based on the internal 252 steps which are spaced identical from 0 to full speed. Neither speed table (three steps nor individual speed table) has any effect on the acceleration or deceleration behavior. The speed tables only define the target speed for a particular speed dialed-in by the cab.

This means that the acceleration or deceleration behavior cannot be improved by a bent speed curve as defined by CV #2, #5, #6 or the individual speed table CV's #67 - 94. The exception to this could only be a cab or computer controlled acceleration or deceleration event. A desired curve in a decoder controlled acceleration or deceleration event however is possible with the "exponential acceleration/deceleration" using CV #121 and #122.

- **If applicable see section "Settings for the signal controlled speed influence"!**
- **If applicable see section "Setting for stopping with ..."!**
- **If applicable see section "Distance controlled stopping" (constant stopping distance)!**

Case studies of practical CV programming:

The fine-tuning of a locomotive is not difficult but represents uncharted territory for many users. The following is meant **to assist you with actual programming cases,** which were performed by ZIMO at customer's or locomotive manufacturer's requests or by close ZIMO partners.

The tuning of a locomotive reflects in part the personal preferences of an individual but must also take into account the special circumstances of its intended application; still valid suggestions can be drawn from it.

It must be pointed out that there can be significant mechanical deviations among mass-produced locomotives even among identical models but even more so between different models, so that further fine-tuning can be of advantage (although it is often not really necessary).

Roco loco of modern design (about 1995 and up) / Original-Roco-Motor

Such locomotives are operating very good even with the decoder's default settings, which is also due to the fact that these locomotives are often used as reference during the ZIMO decoder software development.

The settings below are recommended when used with **non-ZIMO command stations:** CV #57 = xx, i.e. = 120 (12 V) or = 140 (14 V) or = 150 (15 V) etc. as track voltage under load, but not higher than that.	Setting CV #57 to a specific value (i.e. CV #57 = 120) differs from the default setting (CV #57 = 0) in as much as the top speed no longer depends on the current track voltage, provided the track voltage is high enough. For example, if track voltage is >12V and CV #57 set to 120, the decoder regulates top motor speed to 12V. This is an advantage if the **command station is not from ZIMO,** because most of them don't regulate track voltage. Changing this CV makes no difference within a ZIMO system because the track voltage is kept constant (with the exception of voltage drops along the track, due to poor layout wiring). A disadvantage of using CV #57 with a specific value is that the value used has to be in relation to the actual track voltage, which is a manual intervention whereas CV #57 = 0 is self-regulating. CV #57 is also suitable for limiting top speed, alternatively to CV #5 and can of course also be utilized with ZIMO systems. For example: CV #57 = 130 and a track voltage of 18V will reduce the overall speed (all speed steps) by about 25%.
CV #3 = 2 (> 2) CV #4 = 2 (> 2) CV #121 = 11 (>) CV #122 = 11 (>)	A minimal value of "2" in CV #3 and #4 eliminates visible speed changes between speed steps but has not much to do with prototypical momentum, which requires much higher values. Higher values (i.e. CV #3 and #4 = 6, CV #121 and #122 = 33), depending on operating situations and personal taste, are recommended.

Fleischmann locomotive with „Round motor“

The “Round motor” has been Fleischmann’s standard motor until this latest manual revision (2008); a small readjustment of the CV values is appropriate.

Furthermore … especially on these motors it is recommended to **remove the capacitors and bypass the choke coils at the motor.** Attention: often the “worst” capacitors are the ones that are least visible and/or accessible, especially between the motor brushes and rail or frame.

Beginning with SW version 9 of the MX620 and MX64D and the first version of the MX630, these components don’t have to be removed anymore.

CV #56= 33, 44....	It has been demonstrated that reducing the P and I regulation of the BEMF function is beneficial for the “Round motor” (#56 < 55, which is lower than the default value of 0). There is no need to modify CV #9.
CV #57 = xx …	See above („Roco Loc“) !
CV #3 = 2 (> 2) CV #4 = 2 (> 2) CV #121 = 11 (>) CV #122 = 11 (>)	These recommendations are true here as in almost all other cases (see above “Roco Loc“).

NMJ Superline NSB Skd 2220c (small Norwegian switcher engine, built in 2007)

Product of Norsk Modeljernbane, with ***Faulhaber-Motor***,

MX63, *with SW based on the version 30,* is being installed at the factory; this decoder contains special software with a hard reset procedure that sets the decoder back to optimized CV values, similar values as are listed here.

This engine served in the development of the ***regulated analog control!***

ZIMO decoders are very well suited for Faulhaber motors, even with the default settings. An even better result can be achieved with the special Faulhaber setting in CV #56.

CV#9 = 12	That means shorter EMF measuring time and smaller frequency, which leads to reduced noise and extremely low crawling speed.
CV#56 = 155	That means Faulhaber typical measuring time (“1”), medium P/I regulation.
CV#57 = xx …	See above under “Roco Loc“.
CV#112 = 0 That is: Bit 2 = 0, all other Bits are already at 0 by default.	ZIMO loco number ID turned off (Bit 2 = 0), which by default is turned on (Bit 2 = 1, that’s why CV #112 = 4). This prevents small ticking sounds (audible in metal locomotives). This preventive step is only of significance in conjunction with a ZIMO DCC system, because no loco number pulses are produced in other systems (and therefore no ticking sounds can be heard). If on the other hand the loco number identification within a ZIMO systems is being used (MX9 modules with MX9AZN boards), the loco number pulses must of course not be turned off!
CV#3 = 2 (> 2) CV#4 = 2 (> 2) CV#121 = 11 (>) CV # 122 = 11 (>)	These recommendations are true here as in almost all other cases (see above, “Roco Loc“).

Philotrain, 3-part multi unit (Built in 2007)

Product of Philotrain, with ***Faulhaber motor***,

MX64V1, *with SW based on the version 30,* installed by the manufacturer. Similar settings are recommended for newer decoders such as the ***MX630.***

Three part multi unit with low voltage headlight and interior light bulbs; for this reason a MX64V1 with 1.5V low voltage supply for function outputs is being used. The train runs pretty well with a ZIMO decoder as is; although a few changes are beneficial.

CV #9 = 13	Shorter EMF measuring time and smaller frequency, which leads to reduced noise and extremely low crawling speed.
CV #56 = 133	That means Faulhaber typical measuring time (“1”), a little less than medium P/I regulation (both digits “3” instead of “5”) results in best drivability.
CV #57 = xx …	See above under “Roco Loc“.
CV #3 = 2 CV #4 = 2 CV #121 = 11 CV #122 = 33	These settings largely correspond to the general recommendations (see above under “Roco Loc”; only the range of the “exponential braking” (CV #122) was increased, which together with CV #123 results in smooth stops.
CV #123 = 95	The “adaptive acceleration” (“9”) is used here very sparingly (to prevent a start-up jolt), the “adaptive deceleration” (“5”) on the other hand a little stronger; this is - together with CV #122 (see line above) – practical, otherwise it could easily happen that the train, due to the motor’s momentum, at first isn’t slowed down fast enough and then suddenly is stopped too fast. The adaptive deceleration adapts the brake response to the mechanical conditions: The braking distance increases and the locomotive comes to a smooth stop.
CV #112 = 0 That is: Bit 2 = 0, all other Bits are already at 0 by default.	ZIMO loco number ID (Bit 2 = 0) turned off, which by default is turned on (Bit 2 = 1, that’s why CV #112 = 4). This prevents small ticking sounds (audible in metal locomotives). This preventive step is only of significance in conjunction with a ZIMO DCC system, because no loco number pulses are produced in other systems (and therefore no ticking sounds can be heard). If on the other hand the loco number identification within a ZIMO systems is being used (MX9 modules with MX9AZN boards), the loco number pulses must of course not be turned off!

Märklin 8350 / SBB Series 460 / Maxxon-Motor 25260

Märklin-Product, upgraded with Maxxon motor 25260 (13 mm diameter) by SB-Modellbau.

NOTE: the motor used in this heavy model is actually a little under powered and the flywheel is extremely small. For this reason, this locomotive is one that is difficult to control and CV tuning is more important than usual. Even after the fine tuning a certain problem persists during downhill runs, where the locomotive tends to buck a little. Compared to other products, ZIMO decoders manage this locomotive with its motorization quite well (whereby the MX620 is better than the MX64). It is likely that with future control algorithm (SW versions in the coming month and years) a further perfection level may be achieved.

The attainable drivability especially in the extreme low speed range and the reaction to quick load changes are marginally better with the MX620 than with the MX64. This seems astounding considering the large and heavy engine, but might be due to the rather small motor (see above) with the characteristics of an N rather than an HO motor (the MX620 is designed for N-scale motors). Furthermore, an innovative automatic optimization of control parameters is in use, which has not (yet) been implemented in the MX63/MX64.

Equipped with ***MX64**, SW version 30 (March 2007),* favorable CV values are:

CV #9 = 61	Increased EMF frequency, shortened EMF measuring time (typical coreless)
CV #56 = 199	Faulhaber-typical measuring time (“1”), full P/I regulation.
CV #57 = 130	Reduced speed range to about 12V motor voltage.
CV #3 = 3 (> 3) CV #4 = 3 (> 3) CV #121 = 11 (>) CV #122 = 11 (>)	Momentum in CV #3 and #4 should not be much smaller than “3” so that good starting and stopping behavior is still possible; the exponential acceleration/deceleration improves starting and stopping further; still higher values for these variables (i.e. CV #3, #4 = 6, CV #121, #122 = 33) according to operational circumstances and personal taste correspond to even more realistic operations.
CV #123 = 33	Adaptive acceleration and deceleration (medium application) reduces start-up jolt and smoothes out stops.

Equipped with ***MX620** (similar to **MX630**), SW version 3.1 (Nov. 2006),* favorable CV values are:

CV #9 = 61	Increased EMF frequency, shortened EMF measuring time (typical coreless)
CV #56 = 141	Faulhaber-typical measuring time (“1”), low P regulation because the MX620 regulates automatically, reduced I regulation.
CV #57 = 120	Reduced speed range to about 12V motor voltage.
CV #3 = 3 (> 3) CV #4 = 3 (> 3) CV #121 = 11 (>) CV #122 = 11 (>)	Momentum in CV #3 and #4 should not be much smaller than “3” so that good starting and stopping behavior is still possible; the exponential acceleration/deceleration improves starting and stopping further; still higher values for these variables (i.e. CV #3, #4 = 6, CV #121, #122 = 33) according to operational circumstances and personal taste correspond to even more realistic operations.
CV #123 = 52	Low intensity for adaptive acceleration (“5“) because start-up acceleration with values <5 may be hindered and uneven. Stronger intensity for adaptive deceleration (“2”) for smoother stops.

Fleischmann Steam Engine BR55 4155 — *H0 Gauge*

***MX620,** with SW version 9.*

About the decoder: With SW version 9 (July 2008) driving characteristics were significantly improved for “difficult” engines while at the same time the influence of built-in interference components were reduced (although their removal might still be the better option).

The following information is valid only for SW version 9 (and presumably later versions).

CV # 2 = 10	CV #2 is not set to achieve the absolute lowest possible speed but rather for a smooth running engine at the lowest speed possible; this is also of importance with the newly introduced (SW version 9) prevention of the “direction-jolt” per CV #146.
CV # 9 = 85	Increased EMF sampling rate to reduce jerky motion a slow speeds.
CV # 56 = 33	Slightly reduced proportional and integral regulation.
CV # 146 = 50	This takes care of the gear backlash: the motor turns about a half a turn at the lowest speed step (as per CV #2), before it starts to move the wheels. The setting of CV #146 = 50 prevents the motor speed from being raised during this time, which results in a smooth start.
CV # 3 = 3 CV # 4 = 3 CV # 121 = 11 CV # 122 = 11	These settings correspond to the general recommendations.

Tillig Diesel Engine BR218 02703 — *TT Gauge*

***MX620,** with SW version 9.*

About the decoder: see above (“difficult” engine such as Fleischmann BR55)!

The following information is valid only for SW version 9 (and presumably later versions).

CV # 2 = 10	See above (Fleischmann BR55)!
CV # 9 = 63	Slightly increased EMF sampling rate to reduce jerky motion a slow speeds, shorter EMF sampling time.
CV # 56 = 55	Default setting.
CV # 146 = 180	This takes care of the gear backlash: the motor turns almost 2 (!) turns very slowly before it starts to move the wheels. The setting of CV #146 = 180 prevents the motor speed from being raised during this time, which results in a smooth start.
CV # 3 = 3 CV # 4 = 3 CV # 121 = 11 CV # 122 = 11	These settings correspond to the general recommendations.

PIKO Siemens Dispolok ES64	***TT Gauge***
MX620, *with SW version 9.*	
About the decoder: see above (“difficult” engine such as Fleischmann BR55)!	
The following information is valid only for SW version 9 (and presumably later versions).	
CV # 2 = 15	See above (Fleischmann BR55)!
CV # 9 = 85	Increased EMF sampling rate to reduce jerky motion a slow speeds, default (“5”) sampling time.
CV # 56 = 33	Slightly reduced proportional and integral regulation.
CV # 146 = 60	This takes care of the gear backlash: the motor turns about ½ a turn at idle before it starts to move the wheels. The setting of CV #146 = 60 prevents the motor speed from being raised during this time, which results in a smooth start.
CV # 3 = 3 CV # 4 = 3 CV # 121 = 11 CV # 122 = 11	These settings correspond to the general recommendations.

Fleischmann piccolos 7355	***N scale***
MX620, *with SW version 9.*	
The following information is valid only for SW version 9 (and presumably later versions).	
CV # 2 = 4	Slightly raised start-up voltage, which is of advantage for good performance.
CV # 9 = 92	Increased EMF sampling rate to reduce jerky motion a slow speeds, reduced (“2”) sampling time.
CV # 56 = 55	Default setting.
CV # 146 = 110	This takes care of the gear backlash: the motor turns about one turn at idle before it starts to move the wheels. The setting of CV #146 = 110 prevents the motor speed from being raised during this time, which results in a smooth start.
CV # 3 = 3 CV # 4 = 3 CV # 121 = 11 CV # 122 = 11	These settings correspond to the general recommendations.

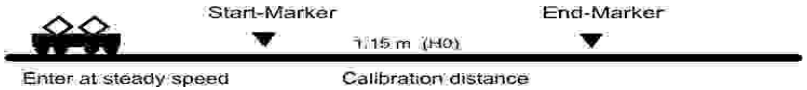
Km/h – Speed regulation - CALIBRATION and operation

The km/h speed regulation is a new, alternative method of **driving with prototypical speeds** in all operating situations: the cab's speed steps (1 to 126 in the so-called "128 speed step mode") will be directly interpreted as km/h. Preferably, all engines of a layout should be set to the same method. Engines equipped with non-ZIMO decoders can be set up similarly through the programmable speed table (although with more effort and less precise because there is no readjustment taking place by the decoder).

The ZIMO readjustment: the decoder is not limited to converting the speed steps to a km/h scale but rather ensures that the desired speed is held, by recalculating the already traveled distance and automatically readjusting itself.

A CALIBRATION RUN; to be performed with each loco:

First, we need to determine the **calibration track:** a section of track that measures 100 scale meters (plus the necessary acceleration and deceleration distances before and after), of course without inclines, tight radii and other obstacles; for example, for HO (1:87) 115cm; for G-scale (1:22.5) 4.5m. Start and end points of the calibration distance need to be marked.



***** Set the loco on the track, with the proper travel direction selected, about 1 to 2 meters before the start marker and the function F0 (headlights) **turned off.** Acceleration times (momentum in CV #3 of the decoder as well as settings in the cab) should be set to 0 or a small value to prevent any speed changes inside the calibration distance. Otherwise, the track length before the calibration marker needs to be increased accordingly.

* The calibration mode is now activated by programming **CV #135 = 1** (operations mode programming). This is a pseudo-programming because the value of 1 does not replace the value already stored in CV #135.

* Move the speed regulator to a **medium speed** position (1/3 to ½ of full speed); the loco accelerates towards the start marker.

* When the engine passes the **start marker, turn on** the function **F0** (headlights); **turn F0 off** again when passing by the **end marker.** This ends the calibration run and the loco may be stopped.

* CV #136 can now be read out for checking purposes. The calibration "result" stored in that CV doesn't mean very much by itself. If however, several calibration runs are performed, the value in CV #136 should approximately be the same every time, even if the traveling speed is varied.

Km/h speed regulation in operation:

CV #135 defines whether the "normal" or km/h operating mode is in use:

CV #135 = 0: The engine is controlled in "normal" mode; a possible km/h calibration run performed earlier has no effect but the calibration results remain stored in CV #136.

CV #135 = 10: each speed step (1 to 126) becomes 1 km/h: that is step 1 = 1 km/h, step2 = 2 km/h, step 3 = 3 km/h ... to step 126 = 126 km/h

CV #135 = 5: each speed step (1 to 126) becomes 1/2 km/h: that is step 1 = .5 km/h, step 2 = 1 km/h, step 3 = 1.5 km/h, ... to step 126 = 63 km/h (for local or narrow gauge railways!)

CV #135 = 20: each speed step (1 to 126) becomes 2 km/h: that is step 1 = 2 km/h, step 2 = 4 km/h, step 3 = 6 km/h, .to step 126 = 252 km/h (High speed trains!)

The speed regulation in km/h is not just useful for direct cab control, but also with speed limits through the "signal controlled speed influence" (CV's 51 – 55). The values entered to those CV's are also being interpreted in km/h.

Mph speed regulation:

A mph speed regulation can be achieved by extending the calibration distance accordingly!

Settings for the ZIMO "signal controlled speed influence" (HLU)

ZIMO digital systems offer a second level of communication for transmitting data from the track sections to engines that are in such sections. The most common application for this is the "signal controlled speed influence", that is the stopping of trains and applying of speed limits in 5 stages issued to the track sections as required with the help of MX9 track section modules or its successors. See ZIMO flyers at www.zimo.at and MX9 instruction manual.

The term **"HLU" method** was coined over the years after the speed limit designation "H" (=Halt or stop), "L" (=Low speed) and "U" (Ultra low speed).

* If the "signal controlled speed influence" is being used (only possible within a ZIMO system), the speed limits "U" and "L" (and the intermediate steps if need be) can be set with configuration variables #51 to #55 as well as acceleration and deceleration values (momentum) with CV #49 and #50 (see CV table).

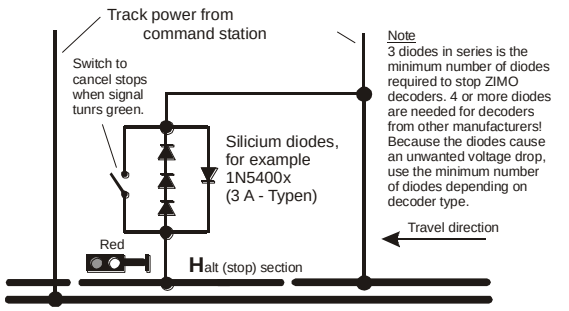
Please note that the signal controlled acceleration and deceleration times are always **added** to the times and curves programmed to CV #3, 4, 121, 122 etc. Signal controlled accelerations and decelerations compared to cab controlled momentum can therefore progress either at the same rate (if CV #49 and #50 is not used) or slower (if CV #49 and/or #50 contain a value of >0), but never faster.

It is of utmost importance for a flawlessly working train control system using the signal controlled speed influence that the stop and related brake sections are arranged properly everywhere on the layout, especially in terms of their length and consistency. Please consult the MX9 instruction manual and the STP manual.

The braking characteristics should be set up on a suitable test track so that all locos come to a complete stop within about 2/3 of the stop section, which is in HO typically about 15 to 20 cm before the end of a stop section (deceleration rate adjusted with CV #4 and CV #50 as well as the reduced speed with CV #52 for "U"). Setting the loco up to stop precisely within the last centimeter of a stop section is not recommended because such an exact stop point is, for various reasons, hardly repeatable every time.

Settings for stopping with ”asymmetrical DCC signal“ (Lenz ABC)

The “asymmetrical DCC signal” is an alternative method for stopping trains at a “red” signal, for example. All that is required is a simple circuit made up of 4 or 5 commercially available diodes.



3 diodes in series (4 when using Schottky diodes) and one in the opposite direction in parallel is the usual arrangement. The different voltage drops across the diodes results in an asymmetry of about 1 to 2V. The direction in which the diodes are mounted determines the polarity of the asymmetry and with it the driving direction a signal stop is initiated.

The asymmetrical DCC signal stop mode needs to be activated in the decoder with CV #27. Normally bit 0 is set, that is CV #27 = 1, which results in the same directional control as the “Gold” decoder from Lenz.

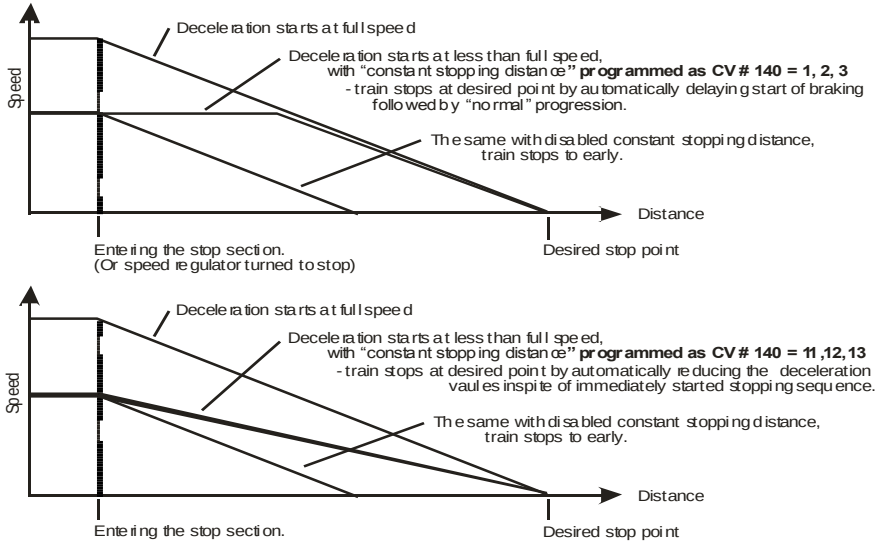
The asymmetrical threshold can be modified with CV #134 if necessary, default is 0.4V. At the time of writing, the “asymmetrical DCC signal” has not been standardized and many DCC systems pay no attention to this feature!

Distance controlled stopping – Constant stopping distance

When the type of constant stopping has been selected with CV #140 (= 1, 2, 3, 11, 12, 13), it keeps the stopping distance as close as possible to the one defined in CV #141, independent of the speed at the start of braking.

This method is especially suitable in connection with automated stops in front of a red signal with the help of the **ZIMO signal controlled speed influence** or the **asymmetrical DCC-signal** (see above). CV #140 is set for this purpose to 1 or 11 (see below for details).

Although of lesser practical value, the distance controlled stopping can also be activated directly by the cab or computer when the speed is set to 0 (by programming CV #140 with appropriate values of 2, 3, 12 or 13).



The distance controlled stopping can take place in two possible ways; see diagram above: **The first** is the **recommended method (CV #140 = 1, etc.),** where the train entering at less than full speed continues at the same speed for some time before it starts braking at a “normal” deceleration rate (same rate as would be applied at full speed).

In the second method (CV #140 = 11, etc.), the train immediately starts with the braking procedure even at slower entry speed into the stop section, which may lead to an un-prototypical behavior. It may however be useful to use this method if used together with decoders from other manufacturers that do not have the capability above, in order to harmonize the brake sequences.

Also, the second method may be the preferred method if distance controlled stopping is used manually (CV #140 = 2 or 12), so that the train reacts immediately to speed changes.

“Distance controlled stopping“, when activated, is exclusively applied to decelerations leading to a full stop but not in speed reductions without stopping (these are still handled by CV #4). Neither is there any influence to acceleration events.

The traveled distance is constantly being recalculated in order to get as close as possible to the desired stop point. The deceleration rate within distance controlled stopping is always applied exponentially, that is the deceleration rate is high in the top speed range followed by gentle braking until the train comes to a full stop; which is *not* controlled by CV #122! The application of CV #121 for exponential acceleration however remains unchanged.

Automated uncoupling procedure;

with coupler tension relieve and loco/train separation:

also see "connecting an electric coupler" in chapter "Installation and wiring":

As described in chapter 7, the control of an electric coupler (System Krois) is defined by CV's #127, 128 etc. (function output effects) and CV #115 (timing).

With the help of CV #116 the decoder can be programmed so that the uncoupling loco automatically moves away (separates) from the adjoining coupler without actuating the speed regulator (which is sometimes inconvenient because the uncoupler key needs to be pressed at the same time).

The TENS DIGIT in CV #116 defines **how long (0.1 to 5 sec)** the loco should move away from the adjoining coupler, the ONES DIGIT defines **how fast (internal speed step 4 to 36)** it should move away, see CV table. The momentum used during this acceleration/deceleration event is governed as usual by the relevant CV's (#3, #4 etc.).

The HUNDREDS DIGIT of CV #116 causes the loco to automatically **push against the adjoining coupler before** the uncoupling process starts in order to relieve coupler tension (otherwise the couplers can't open). The time it takes for this automated tension relieve is a ¼ of the time defined for the loco to move away from the train (tens digit) but at the same speed.

EXAMPLE:

CV #116 = 155 is a typical setting or a good starting point to run some tests: This applies speed step 20 (internal speed step) for 1 second to move away from the train (of which ¼ of that time (0.25 seconds) is first used to automatically used to move against train to unload couplers).

Other hints:

- The "automatic separation" procedure is activated if the tens digit in CV #166 is other than 0; if desired with preceding coupler tension relieve if CV #116 = 100!

- The automatic separation (or the preceding tension relieve) takes place at the moment the coupler is activated, although only if the loco is at rest at the time of coupler activation (speed regulator in 0 position). If the loco is still moving, the uncoupling procedure starts as soon as the loco comes to a full stop provided the coupler function key is still activated.

- The uncoupling procedure stops when the coupler function is turned off (with the corresponding function key) or when the defined times in CV #115 (coupler activation) and #116 (separation) has elapsed.

- Actuating the speed regulator while an automated uncoupling procedure is in progress causes the procedure to be aborted immediately.

- The driving direction during coupler detachment is always according to the cab setting; directional settings in the "Effects" definition for uncoupling (Bits 0 and 1 of CV #127, CV #128 etc.) will not be applied.

Shunting and half-speed functions:

By defining the different Configuration Variables (#3, 4, 121, 122, 123), a prototypical acceleration and deceleration behavior is achieved that often makes shunting very difficult.

With the help of CV #124, a shunting key can be defined (either the dedicated MAN key – only within a ZIMO system - or the F4 or F3 key) with which the acceleration and deceleration rates may be reduced or eliminated all together.

CV #124 may also be used to define either F7 or F3 as low gear key. With this function turned on, the full throttle range is used for half the decoder's speed range, which is just like shifting down into low gear.

Example: The F7 key should act as low gear and the F4 key should reduce the momentum down to ¼. According to the CV table, the bits in CV #124 are to be set as follows: Bit 0 = 0, Bit 1 = 1, Bit 2 = 1 and Bit 3 = 1. The sum of the individual bit values (0+2+4+8 = 14) is entered as a decimal value.

"On-the-fly" - programming (a.k.a. "on-the-main" or "operations mode"):

Configuration variables can not only be changed on the programming track but on the main track as well, without interfering with other trains operating on the layout.

All CV's, with the exception of address CV's, can be modified on the main. Please note though that the verification and read-out of CV values will not be possible until the bidirectional communication is implemented (in the course of 2006 with SW updates for the ZIMO command stations "model 2000" and MX1EC as well as decoders).

If no bidirectional communication is available, "on-the-fly" programming should primarily be used for CV's where a change is immediately visible (e.g. Vstart, Vmax, signal controlled speed influence settings, etc). Don't use it to program the 28 individual speed steps in the speed table for example, which is preferably done at the programming track (where programming can be confirmed through acknowledgments).

Consult the ZIMO cab instruction manual for on-the-fly programming steps!

The allocation of function outputs ("function mapping"):

Depending on decoder type, ZIMO decoders have between 4 and 14 function outputs (FO ...). The loads connected to these outputs, such as headlights, smoke generator etc. are switched on and off with the function keys (F...) of the cab. Which key (F...) controls which function output (FO...) can be specified by a series of Configuration Variables.

The configuration variables #33 to #46 form the NMRA function mapping according to their rules and regulations (see table on the right); this procedure is quite limited though in its application because only one 8-bit register is available for each function and the headlight function is the only one that can be controlled according to travel direction.

Extended flexibility and more directional dependent functions are offered by ZIMO through configuration variable #61:

CV #61 on the one hand offers fixed output assignments, which is especially liked for the Swiss lighting system (CV #61 = 6, 7…). On the other hand it also offers a flexible output assignment by means of a special programming procedure (CV #61 = 98), with which each function/direction combination can be assigned to specific function outputs (e.g. F... – forward/reverse) and additionally allows the definition of an automated turn-off feature, which turns designated function outputs OFF after the loco comes to a full stop.

See also the next 3 pages!

An alternative method for directional functions:

The NMRA function mapping allows only for F0 to be directional that is, only the headlights will switch from front to rear when the loco direction has been changed. All other functions (F1 – F12 or higher) only operate independent of direction.

CV's #125 to 132 (Special Effects) and later possibly more CV's within a special CV block allow more functions to become directional, by utilizing Bits 0 and 1 (while at the same time the actual effect Bits 2 – 7 are left at 0).

Example 1: A couple of **red taillights** are connected to function outputs FO1 and FO2 (front and rear of engine). Both are to be actuated with F1 but should also change with direction. This requires the following CV settings: CV #35 = 12 (Bit 2 for FO1 and Bit 3 for FO2), as well as CV #127 = 1 and CV #128 = 2. Therefore FO1 is only ON in forward direction and FO2 only in reverse.
Special Effect Bits 2 – 7 remain at 0.

Example 2: Contrary to example 1 where the red taillights were switched independent from the white headlights, in this example the headlights and taillights are switched ON/OFF together at the proper end of the locomotive with F0 or F1 (depending on which end the loco is coupled to the train).

This can be done as follows: White front headlights connected to function output "front headlights" / red front taillights to function output FO2 / white rear headlights to function output FO1 / red rear taillights to function output "rear headlights".

CV #33 = 1 (= default, front white headlights on F0forw) / CV #34 = 8 (front red taillights on F0rev !) / CV #35 = 6 (both white headlights as well as red taillights in the rear on F1 !) / CV #126 = 1 / CV #127 = 2 (Direction dependence for rear white and red lights by means of "Special Effects" CV).

Alternative method: Use the function assignment procedure with CV #61 = 98; see dedicated pages in this chapter!

5. "Function mapping"
as per NMRA Standard; and ZIMO - Extensions

The configuration variables **CV #33 to #46** refer to the function keys (F...) of the cab; the single bits to the function outputs (FO...) of the loco decoder. The function keys are matched to the function outputs by setting the appropriate bits (indicated in the table below with ●). Multiple assignments are permissible.

„Mapping" according to NMRA standards with default assignment shown as ●:

NMRA Function	CV	Number key on ZIMO cabs	Additional function outputs (Usually available on large-scale decoders only, but shown here for the sake of completeness.)						Function outputs; (The number of available outputs depends on the decoder type. Always available are the outputs "Front light" and "Rear light".)							
			FA12	FA11	FA10	FA9	FA8	FA7	FA6	FA5	FA4	FA3	FA2	FA1	Rear light	Front light
F0	#33	*1 (L) fw*							*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0●*
F0	#34	*1 (L) re*							*7*	*6*	*5*	*4*	*3*	*2*	*1●*	*0*
F1	#35	*2*							*7*	*6*	*5*	*4*	*3*	*2●*	*1*	*0*
F2	#36	*3*							*7*	*6*	*5*	*4*	*3●*	*2*	*1*	*0*
F3	#37	*4*				*7*	*6*	*5*	*4*	*3*	*2*	*1●*	*0*			
F4	#38	*5*				*7*	*6*	*5*	*4*	*3*	*●*	*1*	*0*			
F5	#39	*6*				*7*	*6*	*5*	*4*	*3●*	*2*	*1*	*0*			
F6	#40	*7*				*7*	*6*	*5*	*4●*	*3*	*2*	*1*	*0*			
F7	#41	*8*	*7*	*6*	*5*	*4*	*3*	*2●*	*1*	*0*						
F8	#42	*(⇧) 9*	*7*	*6*	*5*	*4*	*3●*	*2*	*1*	*0*						
F9	#43	*⇧ 1*	*7*	*6*	*5*	*4●*	*3*	*2*	*1*	*0*						
F10	#44	*⇧ 2*	*7*	*6*	*5●*	*4*	*3*	*2*	*1*	*0*						
F11	#45	*⇧ 3*	*7*	*6●*	*5*	*4*	*3*	*2*	*1*	*0*						
F12	#46	*⇧ 4*	*7●*	*6*	*5*	*4*	*3*	*2*	*1*	*0*						

⇧ **=** *Shift-Key*

The above table shows the default settings; that is, the function key numbers correspond to the same numbered outputs. Therefore the following values were written to the configuration variables:

CV # 33 = 1; CV # 34 = 2; CV # 35 = 4; CV # 36 = 8; CV # 37 = 2; CV # 38 = 4; and so on.

EXAMPLE of changing CV's for individual assignments (●):

F2	# 36	*3*						*7*	*6*	*5●*	*4*	*3●*	*2*	*1*	*0*	
F3	# 37	*4*			*7*	*6*	*5●*	*4*	*3*	*2*	*1*	*0*				
F4	# 38	*5*			*7*	*6●*	*5*	*4*	*3*	*2*	*1*	*0*				

EXAMPLE above: The output #4 (FO4) should be switched in addition to output #2 (FO2) with the F2 key (ZIMO #3 key). Outputs #7 (FO7) and #8 (FO8) should be switched (not additionally but instead) with the F3 and F4 keys, which results in the above configuration (●).

The new values to be entered are as follows: CV36=40; #37=32; #38=64.

ZIMO – Special Function Mapping

Programming the desired number value in the configuration variable #61 activates the corresponding function output assignments. The function F1 as well as some other functions can, according to the NMRA function mapping, be assigned through individual CV's; this makes it possible for example that the function output FO1 can be mapped to function F2 (CV #35 = 4) or that a special "switcher lighting" can be realized (CV #35 = 3: front and rear headlights ON at all times).

CV #61 = 97

Alternative function mapping without "left-shift", for MX640:
CV #67 = 97 overrides the higher CV's "left shift" (from CV #37 on up) of the NMRA function mapping (see previous page), which allows to map higher function keys with lower function outputs (e.g. It is not possible with NMRA function mapping to map F4 to FO1 but it is possible this way).

Therefore:				***FA6***	***FA5***	***FA4***	***FA3***	***FA2***	***FA1***	***Headlight Rear***	***Headlight Front***
F0	#33	*1 (L) fwd*		*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0* ●
F0	#34	*1 (L) rev*		*7*	*6*	*5*	*4*	*3*	*2*	*1* ●	*0*
F1	#35	*2*		*7*	*6*	*5*	*4*	*3*	*2* ●	*1*	*0*
F2	#36	*3*		*7*	*6*	*5*	*4*	*3* ●	*2*	*1*	*0*
F3	#37	*4*		*7*	*6*	*5*	*4* ●	*3*	*2*	*1*	*0*
F4	#38	*5*		*7*	*6*	*5* ●	*4*	*3*	*2*	*1*	*0*
and so on				***and so on***							

CV #61 = 1 or 2

NMRA Function	CV	Numerical keys of ZI-MO cabs	Function outputs: FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward							*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0* ●
F0	#34	1 (L) reverse							*7*	*6*	*5*	*4*	*3*	*2*	*1* ●	*0*
F1	#35	2							*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*
F2	#36	3						●	*7*	*6*	*5*	*4*	*3* ●	*2*	*1*	*0*
F3		4				●						●				
F4	#38	5				*7*	*6*	*5*	*4*	*3*	*2* ●	*1*	*0*			
F5		6					●									
F6		7														
F7		8												●		
F8	#42	Shift – 9	*7*	*6*	*5*	*4*	*3* ●	*2*	*1*	*0*						
F9	#43	Shift – 1	*7*	*6*	*5*	*4* ●	*3*	*2*	*1*	*0*						
F10	#44	Shift – 2	*7*	*6*	*5* ●	*4*	*3*	*2*	*1*	*0*						
F11	#45	Shift – 3	*7*	*6* ●	*5*	*4*	*3*	*2*	*1*	*0*						
F12	#46	Shift – 4	*7* ●	*6*	*5*	*4*	*3*	*2*	*1*	*0*						
Directions Bit														●		

Typical application: F3 (FO9): Sound ON/OFF, F5 (FO8): Bell, F2 (FO7): Whistle when actuating an external (usually older) sound board.

When CV #61 = 1 When CV #61 = 2

CV #61 = 1 or 2 is very similar to the normal NMRA function mapping (which is CV #61 = 0), but…

…for many applications desired: actuation of **FO1** by the driving direction, that is by the **"directional bit"** (when CV #61 =1) or by **F7** (when CV #61 = 2).

CV #61 = 11 or 12

NMRA Function	CV	Numerical keys of ZI-MO cabs	Additional function outputs of MX69V and MX690V (connector #2)						Function outputs of all MX69 / MX690 (connector #1)							
			FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward							7	6	5	4	3	2	1	0●
F0	#34	1 (L) reverse							7	6	5	4	3	2	1●	0
F1	#35	2							7	6	5	4	3	2	1	0
F2	#36	3							7	6	5	4	3●	2	1	0
F3		4				●						●				
F4	#38	5				7	6	5	4	3	2●	1	0			
F5		6														
F6		7						●						●		
F7		8					●									
F8	#42	Shift – 9	7	6	5	4	3●	2	1	0						
F9	#43	Shift – 1	7	6	5	4●	3	2	1	0						
F10	#44	Shift – 2	7	6	5●	4	3	2	1	0						
F11	#45	Shift – 3	7	6●	5	4	3	2	1	0						
F12	#46	Shift – 4	7●	6	5	4	3	2	1	0						
Directions Bit														●		

Typical application: F3 (FO9): Sound ON/OFF, F7 (FO8): Bell, F6 (FO7): Whistle when actuating an external (usually older) sound board with an MX69V.

When CV #61 = 11

When CV #61 = 12

CV #61 = 11, 12 is again very similar to the normal NMRA function mapping, but…

…actuation of **FO1** by the driving direction or **F7** (same as with CV #61 = 1 or 2).

CV #61 = 3 or 4

NMRA Function	CV	Numerical keys of ZIMO cabs	Function outputs													
			FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward							7	6	5	4	3	2	1	0●
F0	#34	1 (L) reverse							7	6	5	4	3	2	1●	0
F1	#35	2							7	6	5	4	3	2	1	0
F2	#36	3						●	7	6	5	4	3●	2	1	0
F3		4 forw.				●						●				
F3		4 rev.				●			●							
F4	#38	5				7	6	5	4	3	2●	1	0			
F5		6					●									
F6		7												●		
F7		8	7	6	5	4	3	2	1	0						
F8	#42	Shift – 9	7	6	5	4	3●	2	1	0						
F9	#43	Shift – 1	7	6	5	4●	3	2	1	0						
F10	#44	Shift – 2	7	6	5●	4	3	2	1	0						
F11	#45	Shift – 3	7	6●	5	4	3	2	1	0						
F12	#46	Shift – 4	7●	6	5	4	3	2	1	0						
Directions Bit														●		

CV61 = 3

CV61 = 4

CV #61 = 3 or 4 are for the most part identical to the allocations on the previous page (CV #61 = 1 or 2), but with a **direction dependent function F3,** which actuates outputs FO3 or FO6 according to driving direction (typical applications are red taillights).

*…Output **FO1** is either controlled by driving direction (when CV #61 = 3), which is the **directions bit,** or with function key F6 (when CV #61 = 4).*

CV #61 = 13 or 14

NMRA Function	CV	Numerical keys of ZIMO cabs	Function outputs													
			FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward							7	6	5	4	3	2	1	0●
F0	#34	1 (L) reverse							7	6	5	4	3	2	1●	0
F1	#35	2							7	6	5	4	3	2	1	0
F2	#36	3							7	6	5	4	3●	2	1	0
F3		4 forw.				●						●				
F3		4 rev.				●			●							
F4	#38	5				7	6	5	4	3	2●	1	0			
F5		6														
F6		7						●						●		
F7		8	7	6	5	4	3●	2	1	0						
F8	#42	Shift – 9	7	6	5	4	3●	2	1	0						
F9	#43	Shift – 1	7	6	5	4●	3	2	1	0						
F10	#44	Shift – 2	7	6	5●	4	3	2	1	0						
F11	#45	Shift – 3	7	6●	5	4	3	2	1	0						
F12	#46	Shift – 4	7●	6	5	4	3	2	1	0						
Directions Bit														●		

CV61 = 13 CV61 = 14

CV # 61 = 13 or 14 are for the most part identical to the allocations on the previous page (CV #61 = 11 or 12), but with a **direction dependent function F3,** which actuates outputs FO3 or FO6 according to driving direction (typical applications are red taillights).

…Actuation of output FO1 with driving direction or F6.

CV #61 = 5 or 15

NMRA Function	CV	Numerical keys of ZIMO cabs	Function outputs													
			FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward							7	6	5	4	3	2	1	0●
F0	#34	1 (L) reverse							7	6	5	4	3	2	1●	0
F1	#35	2							7	6	5	4	3	2	1	0
F2	#36	3						●	7	6	5	4	3●	2	1	0
F3		4 forw.				●						●				
F3		4 rev.				●			●							
F4		5 forw.									●					
F4		5 rev.												●		
F5		6					●			●						
F6		7						●								
F7		8					●									
F8	#42	Shift – 9	7	6	5	4	3●	2	1	0						
F9	#43	Shift – 1	7	6	5	4●	3	2	1	0						
F10	#44	Shift – 2	7	6	5●	4	3	2	1	0						
F11	#45	Shift – 3	7	6●	5	4	3	2	1	0						
F12	#46	Shift – 4	7●	6	5	4	3	2	1	0						
Directions Bit																

CV61 = 15 CV61 = 5

CV #61 = 5 or 15: For electric and diesel locos where **headlights and taillights as well as cab lights** are to be actuated by one function key each (F3 and F4) and dependent on direction. Also included in this assignment are the functions F2 and F5 (if CV #61 = 5) or F6 and F7 (if CV #61 = 15) on outputs FO7 and FO8 (preferably for whistle / bell of older external sound boards). These allocations were retained from the MX69 predecessors MX65 and MX66.

CV #61 = 6

NMRA Function	CV	Numerical keys of ZI-MO cabs	Function outputs													
			FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward											●			●
F0	#34	1 (L) reverse								●					●	
F0 forward if F3 off										●						
F0 reverse if F3 off													●			
F1	#35	2							*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*
F2	#36	3							*7*	*6*	*5*	*4*	*3*●	*2*	*1*	*0*
F3		4 forw.				●						●				
F3		4 rev.				●			●							
F4		5 forw.									●					
F4		5 rev.														
F5		6								●						
F6		7						●								
F7		8					●									
F8	#42	Shift – 9	*7*	*6*	*5*	*4*	*3*●	*2*	*1*	*0*						
F9	#43	Shift – 1	*7*	*6*	*5*	*4*●	*3*	*2*	*1*	*0*						
F10	#44	Shift – 2	*7*	*6*	*5*●	*4*	*3*	*2*	*1*	*0*						
F11	#45	Shift – 3	*7*	*6*●	*5*	*4*	*3*	*2*	*1*	*0*						
F12	#46	Shift – 4	*7*●	*6*	*5*	*4*	*3*	*2*	*1*	*0*						
Directions Bit														●		

CV #61 = 6 or 7: For **Swiss electric and diesel engines.** F3 either actuates a single white or two red lights as taillights.

CV #61 = 6: Function output FO1 and FO4 are switched separately with F4 and direction.

CV #61 = 7: Function output FO1 and FO4 are used for the cab lighting, independent of direction, and switched with F4.

CV #61 = 7

NMRA Function	CV	Numerical keys of ZI-MO cabs	Function outputs													
			FO12	FO11	FO10	FO9	FO8	FO7	FO6	FO5	FO4	FO3	FO2	FO1	Rear light	Front light
F0	#33	1 (L) forward											●			●
F0	#34	1 (L) reverse								●					●	
F0 forward if F3 off										●						
F0 reverse if F3 off													●			
F1	#35	2							*7*	*6*	*5*	*4*	*3*	*2*	*1*	*0*
F2	#36	3						●	*7*	*6*	*5*	*4*	*3*●	*2*	*1*	*0*
F3		4 forw.				●						●				
F3		4 rev.				●			●							
F4		5 forw.									●			●		
F4		5 rev.												●		
F5		6					●			●						
F6		7														
F7		8														
F8	#42	Shift – 9	*7*	*6*	*5*	*4*	*3*●	*2*	*1*	*0*						
F9	#43	Shift – 1	*7*	*6*	*5*	*4*●	*3*	*2*	*1*	*0*						
F10	#44	Shift – 2	*7*	*6*	*5*●	*4*	*3*	*2*	*1*	*0*						
F11	#45	Shift – 3	*7*	*6*●	*5*	*4*	*3*	*2*	*1*	*0*						
F12	#46	Shift – 4	*7*●	*6*	*5*	*4*	*3*	*2*	*1*	*0*						
Directions Bit																

ZIMO – Special function mapping: Function mapping procedure with CV #61 = 98:

This procedure allows free allocation of function outputs to function keys (on the cab), which is not possible by setting fixed values in configuration variables.

To carry out this procedure requires a bit more time and attention from the user.

Preparation: The loco must be on the main track (not on the programming track); the whole procedure is performed with operations mode programming. Set the loco direction to "forward" and turn all functions off.

*** CV #61 = 98** Writing value "98" to CV #61 (in operations mode) starts the actual allocation procedure.

The decoder is now in a special programming mode, which will not end until the whole programming procedure is completed or the loco is lifted from the track for a few seconds.

***** The decoder is now ready to accept the first function output allocation, starting with function output **F0 in forward direction.**

The function outputs to be assigned to F0 in forward direction, are now actuated with the corresponding function keys (i.e. FLf, FLr, F1…F12). Any number of outputs can be included.

Because only one function key (F0) is available for FLf and FLr (headlights), it is necessary to press F0 repeatedly to select the desired configuration (which alternately actuates the front and rear headlights).

The assignment must be confirmed by pressing the **direction's key.**

***** The decoder is now ready to accept the next output assignment for **F0 but now for "reverse".**

Continue as above!

Again, once a selection is made press the **direction's key** to apply.

*** Continue in the same fashion for all function keys** (28 function-direction-combinations)**!**

***** After the last function key (F12 "reverse") has been assigned, the function outputs FLf and FLr (both headlights) are turned on to indicate the end of this programming procedure.

***** The finished allocations are **automatically activated** and CV #61 is set to "99"**.**

Deactivation:

CV # 61 = 0 ... 97 (any value except 98 and 99) deactivates the function assignment and again activates the function mapping according to CV #33 to #46 or CV #61, if a value between 1and 7 is entered. The assignment defined during this procedure though remains stored in the decoder.

Reactivating already stored data:

CV # 61 = 99 Reactivates the defined output allocations.

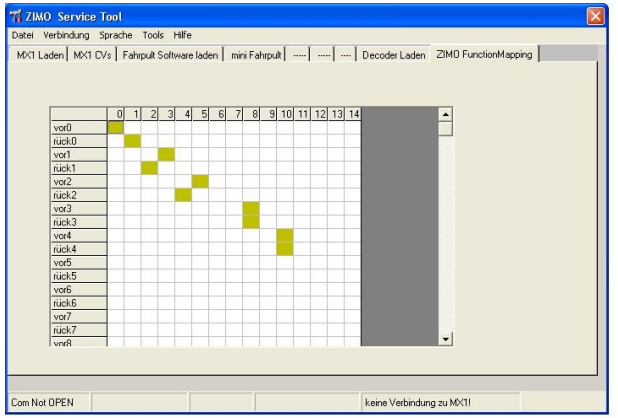
NOTES:

The special effects (US-lighting, uncoupler, soft-start etc) can also be assigned using above procedure. CV's #125, 126 etc. always refer to actual outputs!

It is possible to store and selectively re-activate several function output allocations with the help of the "CV-set" feature!

For a better understanding, the following lists the sequence in which the function keys have to be defined:

1. F0 forward
2. F0 reverse
3. F1 forward
4. F1 reverse
5. F2 forward
6. F2 reverse
7. F3 forward
8. F3 reverse
9. F4 forward
10. F4 reverse
11. F5 forward
12. F5 reverse
13. F6 forward
14. F6 reverse
15. F7 forward
16. F7 reverse
17. F8 forward
18. F8 reverse
19. F9 forward
20. F9 reverse
21. F10 forward
22. F10 reverse
23. F11 forward
24. F11 reverse
25. F12 forward
26. F12 reverse



An easy to work with tool is planned within the framework of the program ***"ZIMO Service Tool " (ZST)*** that replaces the "CV #61 = 98" procedure, where the desired functions can be "mapped" into a table and the procedure described above will be carried out automatically!

6. ZIMO SOUND – Selection and Programming

▶ Shipping decoders with a **ZIMO "sound collection"** installed is the preferred way of delivery and a specialty of the ZIMO sound concept, which is possible due to the large data storage capacity of the decoders: sound samples and CV parameters for several engines (i.e. for 5 engines) are stored in each decoder. The preferred sound for a given locomotive can be selected with the cab (no need to load a different sound sample from the computer).

At the same time, the user is free to change acoustics of a locomotive to his/her own taste by selecting for example a chuff sound from 5 different chuff samples and a whistle from 10 different whistles (or several whistles on different function keys); furthermore a selection of bells, compressors, steam shovel, oil burner or break squeal etc.

The "sound collection" itself is a special form of the "sound projects" (see below) and is also listed at www.zimo.at (under "UPDATE" and "decoder"), ready for download and installation in case the decoder wasn't ordered with the desired sound files.

▶ **Free ZIMO sound projects ("Free D'load")** are available from www.zimo.at (follow "UPDATE", Decoder"), usually in two different versions:

1) as **"ready-to-use" project:** This is a **.zpp file,** which once downloaded, can be installed in to the decoder with the MXDECUP update module or MX31ZL cab (or MX10) and the help of the program **ZIRC (ZIMO Rail Center)** or with the MX31ZL and a USB stick (or MX10 and SD-card) directly, without the need of ZIRC. All function assignments, parameters and CV values that are part of the project will be installed as well.

Even though it is a ready-to-use project, many of the function assignments and settings can still be changed to suit your own taste after the project is installed, with the procedures and CV changes described in the operating manual.

2) as **"full-featured" project:** this is a **.zip file,** which cannot be directly installed into the decoder but must be unzipped and processed by the program **ZSP (ZIMO Sound Program).** Function assignments and CV settings can easily be changed within ZSP and sound files can be edited with a sound editing program or replaced with files from other collections.

After the sound project has been edited, it can be loaded in to the decoder from the program ZSP via the MXDECUP or MX31ZL (or MX10). Individual adjustments can be made to the decoder with the procedures and CV's explained in this manual. The new decoder values can be backed up by sending the data back to ZSP.

▶ **PROVIDER sound projects ("Coded Provider")** are also available for a **small fee** from the **ZIMO sound database,** but can only be used with **"coded decoders",** which are decoders containing the **load code.** "Coded decoders" are bought as such (for a small surcharge) or converted by buying and installing the load code in to normal decoders at a later date. The load code is only valid for one decoder (identified by the **decoder ID**), but entitles the buyer to use all sound projects of a specific sound bundle (i.e. all sound projects from Heinz Däppen). Also see the ZIMO sound database in the UPDATE pages at www.zimo.at.

"Coded Provider" projects are contributions by **external ZIMO partners** (shown as "Provider" in the ZIMO data base such as Heinz Däppen for Rhätische Bahnen and US steam engines), who are paid for their efforts through the sale of the "Load codes".

▶ **"Preloaded" PROVIDER sound projects** are **installed at the factory.** The applicable "load code" fee applies and is added to the decoder price.

▶The sound is **adjustable** and **fine-tunable** with the help of **"incremental programming"** by gradually increasing or decreasing values, without awareness of the different CV values. This includes:

- sound characteristic on level track and no load (as per personal preference from "almost nothing" to full volume);
- how the sound should react to inclines, declines and acceleration events. This allows for a fast adaptation to changing operating situations (single engine or engine on heavy goods train);
- when the water drainage sound should be played at start up, or the break squeal when stopping the train;
- how the steam chuffs should overlap each other at high speed (changing to a constant hiss or still accentuated chuffs);
- and much more.

Selecting the Sound Collection with CV #265 – current layout for the MX640:

(Software and organization of sound will undergo changes over time; CV #265 may not yet be final)

CV	Designation	Range	Default	Description
#265	Loco type selection	1 2 … 101 102 …	1 or 101 (1 for steam, 101 for diesel)	= 0, 100, 200: Reserved for future applications = 1, 2 … 32: Select among various steam sounds stored in the decoder, i.e. for loco BR01, BR28, BR50, etc... Chuff sounds as well as other sounds (whistle, compressor, bell…) will be matched. = 101, 102 … 132: Select among various diesel and electric engines from the Sound Collection.

Note: Until further notice, only a single diesel sound will be loaded (CV #265 = 101)

Operating the sound decoder for the first time (Sound collection "Euro-steam"):

As delivered, the MX640 comes with a typical engine sound activated and function-sounds allocated to function keys:

Function F8 – Sound ON/OFF,

a separate ON/OFF key can be assigned for sounds activated by function keys with CV #311, which could also be F8).

The pre-selected sound in the MX640 with **"European steam collection"** is of a 2-cylinder engine (the chuff rate can only be approximate without further tuning) with automated water drainage and brake squeal as well as some randomly played stationary sound.

The following sounds are allocated to these **function keys:**

F2 – short whistle
F4 – water drain (blow off…)
F5 – long whistle (playable)
F6 – bell
F7 – coal shoveling or oil burner
F9 – compressor
F10 – generator
F11 – injector

F0, F1 and F3 are not allocated for sound by default since they are usually required for other tasks.

The following stationary sounds are allocated to the **random sound generator:**

Z1 – compressor Z2 – coal shoveling Z3 – injector

The switch inputs are allocated to the following by default:

S1 – long whistle S2 – nothing S3 – cam sensor

Special procedures for owners of non-ZIMO DCC systems:

(Owners of ZIMO MX1 "model 2000", EC or HS command stations can skip this half page)

Configuration variables #266 to #355 are used for the selection and allocation of sound samples as well as other settings. Programming CV's in this range is no problem for high-level systems (such as the current ZIMO DCC systems) both in "service mode" or "operations mode".

There are however many DCC systems in use (some still in production) that can only access CV's to #255 or even worse to #127 or CV #99.

If the CV value ranges are also limited (i.e. 0 to 99 instead of 0 to 255): see CV #7.

For such applications, ZIMO sound decoders offer an alternative way of reaching higher CV's via lower numbers. This is done with an initial "Pseudo-Programming" of

CV #7 = 110 or = **120 or = 130**

which increases the CV numbers about to be accessed by 100 or 200. For example:

If programming CV #266 = 45 is not possible, then programming CV #7 = 110 followed by CV #166 = 45 executes the desired programming of CV #266 = 45

or

if neither CV #266 = 45 nor CV #166 = 45 is possible, then programming CV #7 = 120 followed by CV #66 = 45 also leads to the result of CV #266 = 45.

The initial CV #7 – "Pseudo-Programming" state – remains active for further programming (which means CV #267 is entered as #167, CV #300 as #200 and so on) until the decoder is powered down. ATTENTION: After re-booting the system, the "Pseudo-Programming" is lost, that is programming CV #166 is indeed accessing CV #166 again. See below to prevent this!

With **CV #7 = 0**

the "Pseudo-Programming" is stopped, which means that programming CV #166 is again programming this CV.

Using as an initial "Pseudo-Programming"

CV #7 = 210 or 220

achieves the same results as above but remains active even after the system is powered down. This state can only be cancelled with

CV #7 = 0,

which is important to remember, if once again lower CV's need to be programmed!

Selecting a new or replacing the current chuff set (only for steam):

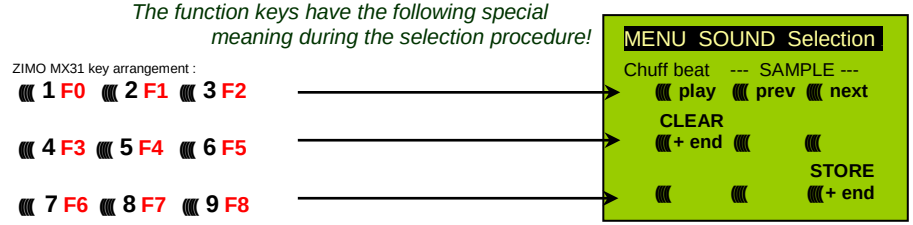
The following procedures are always used in the same way in spite of the flexible decoder layout with different sound sample compilations. It is also worth mentioning that the sound samples can be listened to and evaluated under actual operating conditions (with the engine running), not just on the computer.

The **selection procedure** is started with a "Pseudo-Programming" in operations mode ("on-the-main"): **CV #300 = 100 (only for steam / not possible with DIESEL engines!).**

The "Pseudo-Programming" (meaning that the entered value is not really stored in memory) has the effect that the **function keys F0 to F8** no longer actuate function outputs but instead are now available for **special tasks** within the sound selection procedure. The function keys should be set to momentary, if possible, which would facilitate the procedure.

The function key identifications (and the MX31 cab displays) shown are typical for a ZIMO cab during the selection procedures (and for other sound adjustment procedures) but **is analogous to the function keys of third party cabs,** although the layout may be different.

The function keys have the following special meaning during the selection procedure!



This is a drawing of the planned MX31 display, not an actual picture!

F0 = play: plays back the current chuff sound for evaluation; only possible with the engine at a stand still; the chuff sounds are played automatically when the engine is moving.

F1, F2 = prev., next: plays back the previous or next recording stored in the decoder; the sound file can immediately be evaluated with the engine stopped, with the engine running the selected file replaces the currently active.

F3 = CLEAR + end: The **selection procedure** is **stopped** and the selection is cleared, that is no chuff sound will be played (boiling and blow-off sound remains).

F8 = STORE + end: The **selection procedure** is **stopped** with the last selected chuff set replacing the current set.

The **selection procedure** is also stopped when programming anything else (e.g. **CV #300 = 0** or any other value but also any other CV) or by turning off power to the system. In these cases, the **current chuff set remains.** Such "forced endings" are also useful when the "old" sound should remain as the current sound without first having to locate it again.

The selection procedure is supported with **acoustic signals:**
The **"cuckoo** jingle" sounds when….

…. the last stored chuff sound is reached; use the key to scroll in the opposite direction (F1, F2) to listen to the other stored chuff sounds,
…. playback is tried (F0) but no sound sample available,
…. a wrong key is pressed (F4, F5 etc.)

The **"confirmations jingle"** is played after ending the selection procedure with F3 or F8.

The engines can be **operated normally** during the selection procedure: with speed regulator, direction key and MAN key (the latter only with ZIMO cabs); functions cannot be actuated until the selection procedure is terminated with F3, F8 or by other programming steps, see above.

Selecting boiling, whistle, blow-off and brake squeal sounds:

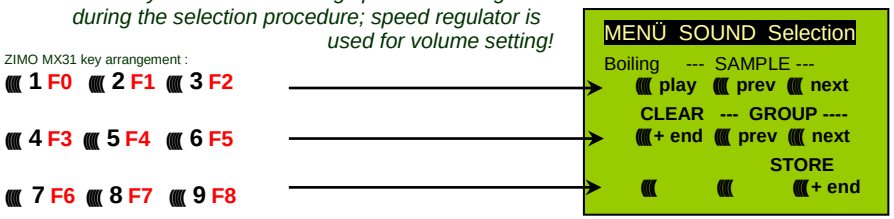
The selection procedures for these "automated background sounds" are initiated with a "Pseudo-Programming" in operations mode programming

CV #300 = 128 for the boiling sound (STEAM only)
CV #300 = 129 for direction-change sound
CV #300 = 130 for the brake squeal
CV #300 = 131 thyristor-control sound (electric engine)
CV #300 = 132 for the "start" whistle
CV #300 = 133 for blow-off sound =cylinder valves (STEAM only)
NOTE: the blow-off sound selected here is also used as the blow-off sound actuated with a function key (see CV #312).
CV #300 = 134 for the driving sound of ELECTRIC engines
CV #300 = 136 for the switchgear sound of ELECTRIC engines

The selection procedure for background sounds is the same as for the selection of chuff sounds EXCEPT: the engine should be at a **stand still** because the **speed regulator** is used **for setting the volume** for the relevant sound file!

Note: these sound files can also be used as function sounds, allocated to function keys (see next page); the automated back-ground sounds can then be cancelled with the function keys.

The function keys have the following special meaning during the selection procedure; speed regulator is used for volume setting!



Function keys are used as with chuff selections:

F0 = play: plays back the currently selected sound.

F1, F2 = prev., next: plays back the previous or next recording.

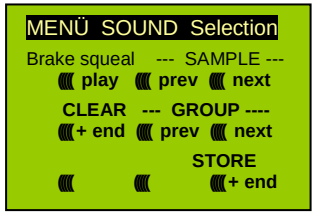
F4, F5 = prev, next : switches between sound groups

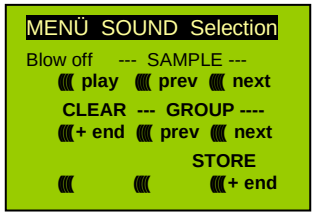
The **speed regulator** acts as volume control for the background sound during selection procedure.

F3 = CLEAR + end: **Selection procedure** is **stopped** and the current sample removed.

F8 = STORE + end: **Selection procedure** is **stopped** and new selection activated.

The **selection procedure** can be **ended** by any other programming procedure or by removing power. Functions cannot be actuated during this procedure !





A simplified procedure (w/o CV #300) is available with MX31 (SW1.2 or higher) or MX31ZL (SW3.06 or higher).

Allocating sound samples to function keys F1 … F12:

A sound sample can be allocated to each function key F1…F12 from the sound samples stored in the decoder. It is al permissible to have a function key assigned for a function output (FO1, FO2 etc.) as well as for a sound function, both of which will be activated when the key is pressed.

The **allocation procedure** for function sounds are initiated with a "Pseudo-Programming" in operations mode programming:

CV #300 = 1 for function F1
CV #300 = 2 for function F2
CV #300 = 3 for function F3
etc.
CV #300 = 20 for function F0 (!)

Note: Function F4 is by default used for water drainage sound (with CV #312); if F4 is to be used for something different, CV #312 must be set to zero (CV #312 = 0).

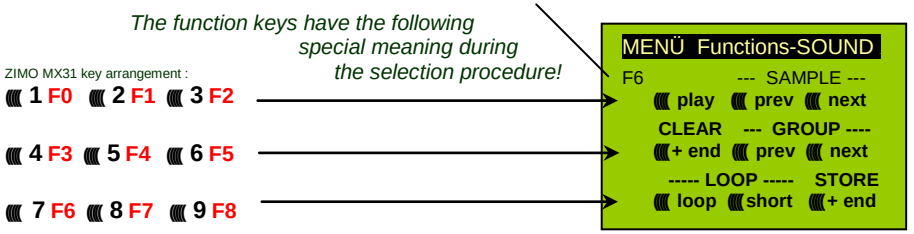
The allocation procedure is very similar to the selection procedures for driving and background sounds, with the difference that sound allocation is not limited to sound samples of a certain group but also allows switching between groups to find the desired sample.

*Sound samples are organized in **groups** for easier location; i.e. groups like "short whistle" / "long whistle" / "horn" / "bell" / "shoveling coal / "announcements" and much more.*

The engine should remain **stationary** though since the **speed regulator** is used **for volume settings** during the allocation procedure!

Depends on entry: F1 . . . F12

The function keys have the following special meaning during the selection procedure!



Drawing of an MX31 display, not a photo!

F0 = play: plays back the current chuff sound for evaluation.

F1, F2 = prev., next: plays back the previous or next recording stored in the decoder.

F4, F5 = prev., next: switches between sound groups (e.g. whistles, bells etc.); plays back the first sample of this group.

The **speed regulator** acts as volume control for the selected sound during allocation procedure.

F6 = loop: If F6 is "on" when exiting the allocation procedures, the sound sample is stored and played back as long as the relevant function key is pressed by repeating the sound between the loop marks (the loop marks are part of the sound file).

Playable whistle!

F7 = short: If F7 is "on" when exiting the allocation procedures, the sound sample is shortened and played back for the duration of the function actuation, by omitting the center portion.

Note: F6 and F7 are only effective provided the loop markers are included in the sample; basic settings are also saved; changes take effect only if F6 or F7 is actuated.

Note: If F6 or F7 are not actuated, the sound sample will always be played back in the same length it was saved, regardless how long the function key is pressed.

F3 = CLEAR + end: The **allocation procedure** is **stopped** without a sound allocated to this function key.

F8 = STORE + end: The **allocation procedure** is **stopped** and the last selected function sound is stored and played back when this function key is pressed.

The **allocation procedure** can also be **ended** by any other programming procedure (e.g. CV #300 = 0 or any other value or CV) or by removing power from the decoder. The "old" allocations remain active in such cases; such "forced endings" are also useful when the "old" sound should remain as the current sound without first having to locate it again.

The selection procedure is supported with **sound signals:**

The **"cuckoo jingle"** sounds when….

…. the last stored sound sample of a group is reached; use the appropriate key (F1, F2) to scroll in the opposite direction to listen to the other stored sounds,

…. the last stored sound group is reached (with F4 or F5); use the appropriate key (F4 or F5) to scroll in the opposite direction.

…. play-back attempted (with F0) but no sound sample is available,

…. a wrong key is pressed.

The **"confirmations jingle"** is played after ending the allocation procedure with F3 or F8

Allocation of sound samples to the random generators Z1…Z8:

MX640 decoders provide 8 simultaneously playing random sound generators. The timing of them is determined by CV's; see "CV table" from CV #315.

A sound sample can be added to each random generator from the pool of samples in the decoder.

The **allocation procedure** for random sound is initiated with a "Pseudo-Programming" in operations mode programming:

CV #300 = 101 for random generator Z1
(Z1 has special logic incorporated for the compressor and should therefore always be used for that)

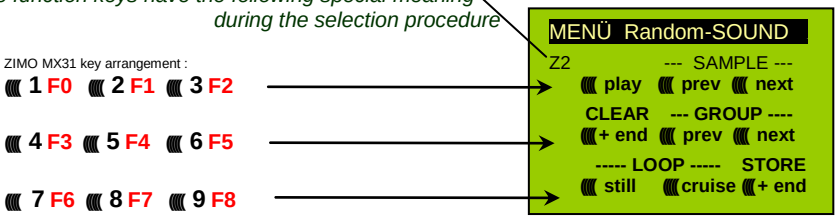
CV #300 = 102 for random generator Z2

CV #300 = 103 for random generator Z3

etc.

Depends on entry: Z1 . . . Z8

The function keys have the following special meaning during the selection procedure



The meaning and action of the function keys is the same as for function sounds (see above):

F0 = play: play back

F1, F2 = prev, next: play back of previous or next sound sample

and so on

but

F6 = still: If F6 is active when ending the allocation procedure, the sound sample is played as random sound at standstill only (default).

F7 = cruise: If F7 is active when ending the allocation procedure, the sound sample is played as random sound when the locomotive is moving.

The allocation procedure for random sound is the same as for function sound!

A simplified procedure (w/o CV #300) is available with MX31 (SW1.2 or higher) or MX31ZL (SW3.06 or higher).

Allocation of sound samples to switch inputs S1 and S2:

The MX640 has 3 switch inputs available, of which two ("1" & "2") are freely available to the user while one ("3") is usually reserved for a cam sensor input; which can also be used for other inputs if not used for a cam sensor (i.e. the virtual cam sensor is used instead). These inputs can accept reed switches, optical or hall-effect sensors and similar; see chapter 8: "Connecting speaker, cam sensor".

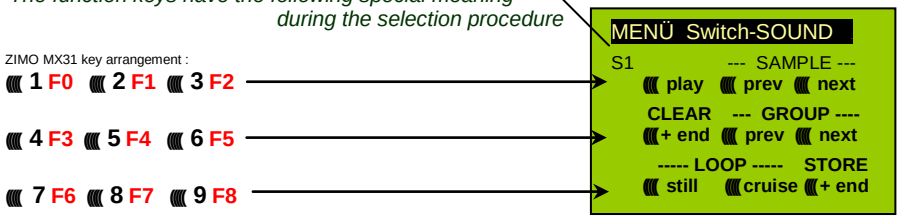
A sound sample can be allocated to each switch input, from the pool of stored samples in the decoder; play-back times can be set with the help of CV's #341, 342 and 343, see CV table.

The switch input **allocation procedure** is initiated with the operations mode Pseudo-Programming

CV #300 = 111 for switch input S1
CV #300 = 112 for switch input S2
CV #300 = 113 for switch input S3
and so on…

Depends on entry: S1…S4

The function keys have the following special meaning during the selection procedure



The meaning and action of the function keys is the same as for function sounds (see above):

F0 = play: play back

F1, F2 = prev, next: play back of previous or next sound sample

and so on

Automated test run to determine the motors "basic load" factor:

The following procedure is necessary to enable load dependent chuff sounds (volume and sound changes with inclines and load….) that is, to optimize the current values.

Technical background:

The load dependent sound is based on EMF (Electro Motive Force) measurements inside the decoder, which is primarily used for keeping the motor speed constant with changes in load. For the decoder to produce the correct sound for the respective driving conditions it has to know first what these measurements are at normal no-load cruising speed (smooth rolling of the engine or train on straight level track) that is, the "basic load" of an engine or train, which due to gearbox losses, power pick-ups etc. is often considerably higher on model trains than on the real railroad. Deviations from this "basic load" will then be interpreted as inclines or declines, which will result in analogously changed chuff sounds.

Initiated with "Pseudo-Programming"

CV #302 = 75

an automated run is performed to record the "basic load" factor in forward direction;

ATTENTION: the engine (or the train) is driven automatically in forward direction for which unoccupied track must be available of at least 5 meters (15 feet), with absolutely no inclines or declines and without any (tight) curves.

With **CV #302 = 76**

an automated recording run can be performed in reverse direction, for locomotives that have different "basic loads" in this direction (otherwise, the basic load in reverse is considered identical to forward).

Note: A "heavy" train (a train with higher rolling resistance due to power pick ups of lighted coaches for example) may have a different "basic load" than an engine with nothing on the hook. A separate recording run may be required for such situation in order to obtain the best load dependent sound.

For easier handling of different "basic loads", provisions will be made with a future SW version that allows the recording of several "basic load" factors and the easy switching between a light running locomotive and a "heavy" train.

A simplified procedure (w/o CV #300) is available with MX31 (SW1.2 or higher) or MX31ZL (SW3.06 or higher).

Programming sound CV's:

Configuration variables are for optimizing the sound effect for a specific locomotive and for special operating situations. The **programming** can be done either on the programming track in **service mode,** on the main track in **operations mode** or with **"incremental programming".**

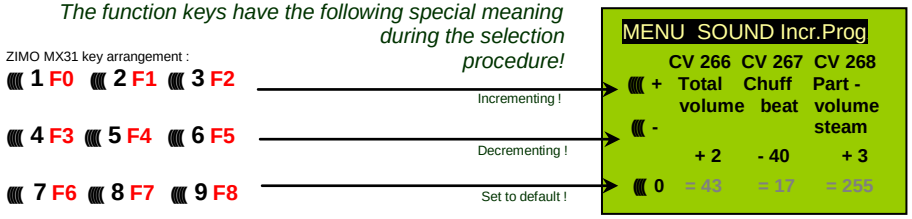
The "incremental programming" is a special process of the "operations mode" programming with the following fundamental principle: the CV's are not programmed with an absolute value (as is normally the case) but rather the current value of a CV is being incremented or decremented by a fixed value (defined in the decoder for each CV).

The function keys of the cab temporarily serve as instruments for the incremental programming during which they cannot be used for function output actuations. The function keys are temporarily assigned for this task with the "Pseudo-Programming"

CV #301 = 66,

which changes the function keys to INC and DEC keys, first for CV #266 (that is the CV number derived from the value 66 + 200).
Several CV's are grouped together in one procedure for an easier and better handling. In the case of CV #301 = 66, not only the leading CV #266 is assigned for incremental programming but also CV #267 and #268.

This is again shown here by means of the ZIMO cab with the special MX31 display, but is valid analogous for the function keys of other cabs.



Drawing of an MX31 display, not a photo!

The last line shown in gray (absolute CV values) will no be available until bidirectional communication is being implemented!

F0, F3, F6 = Incrementing, decrementing and default setting of the lead CV number that was entered during the "Pseudo-Programming" initiation CV #301 = … (or via menu with the MX31).

F1, F4, F7 = Incrementing, decrementing and default setting of the second CV number of that group; which CV's that are part of a group is shown in the CV table or is indicated in the ZIMO MX31 cab display.

F2, F5, F8 = Incrementing, decrementing and default setting of the third CV number of that group (if the group includes 3 CV's).

The incrementing and decrementing of CV values (usually in the 0…255 range) takes place in steps of 1, 5, 10 or 15; this is predefined by the decoder software and cannot be changed. Intermediate values can be entered by direct CV programming, which in reality is hardly necessary.

The **"cuckoo jingle"** sounds when….

…. the upper or lower end of a CV value range is reached!

If RailCom is not available (because the system used is not equipped with RailCom), the value of a particular CV can only be determined by reading it out on the programming track. Although, most of the time this is not necessary since the reaction to a changed CV value can immediately be heard by the changing sound.

Note: All CV and parameter sets can be read out and written to the decoder and, if required, edited with a computer with the help of the MXDECUP programming module!

CV-Table for SOUND CONFIGURATIONS:

The following CV's can be programmed both **"normal"** (i.e. CV #... = ...) and **"incremental"** (Exception: CV #280 for diesel engines). "Incremental programming" is especially useful when the proper value cannot be calculated in advance and must be determined by trial, which is often the case with many sound parameters.

The "Lead CV" in each case is the first of 3 consequential CV's that are edited and shown on the same screen of a ZIMO MX31 cab during the "incremental programming" procedure and is the one to be entered with "Pseudo-Programming" CV #301 = xx (as explained above).

CV	Designation	Value range	INC steps	De-fault	Description
LEAD - CV **#266**	Total volume	0 - 255	5	65	The value "65" results (mathematically) in the highest possible distortion-free playback volume; but values of up to 100 can be perfectly suitable because distortions in this volume range are hardly audible. Plus, the usefulness of a sound also depends on the quality of the sound sample.
#267	Chuff sound frequency with „virtual cam sensor" For STEAM engines also see CV #354	0 - 255	1	70	CV #267 is only active if **CV #268 = 0:** Chuff beats follow the "virtual cam sensor"; an actual cam sensor is not needed in this case. The default setting "70" results in about 4, 6 or 8 chuffs per wheel revolution, depending on the chuff set selected; because it also depends in large part on the motor and gearbox used, an individual adjustment is necessary in most cases in order to achieve the desired chuff frequency. This is the purpose for CV #267: The lower the value the higher the chuff frequency and vice versa. The setting should be performed at lower speeds (around speed step 10), but not at the lowest speed step 1.
#268	Switching to real cam sensor and trigger count for chuff rate For STEAM engines	0 - 255	1	0	= 0: "Virtual" cam sensor is active (to be adjusted with CV #267, see above). = 1: real cam sensor is active (connected to switch input 2 of the MX640, see chapter 8); each negative spike results in a chuff beat. = 2, 3, 4 … real cam sensor, several triggers in sequence (2, 3, 4 …) result in one chuff beat.
LEAD - CV **#269**	Lead-chuff accentuated For STEAM engines	0 - 255	10	0	A typical sound signature of a passing steam engine is that one chuff out of a group of 4 or 6 chuffs is louder in volume than the rest; this effect is already part of the chuff set but can be further amplified with the help of CV #269.
# 270	PROJEKT not functional yet: Longer chuff length at very low speeds For STEAM engines	0 - 255	10	?	PROJECT (not yet implemented): The chuff sounds of a real engine are extended when driving at very low speeds due to the mechanical valve control. This effect can be more or less accentuated with CV #270.
#271	Overlapping effect at high speed For STEAM engines	0 – 255 (useful up to about 30)	1	16	The individual steam chuffs overlap each other at high speed on a real engine. Because the frequency of the chuffs increases but won't shorten to the same extend they will eventually blend in to a weakly modulated swoosh. This is not always desired in model railroading because it doesn't sound that attractive, hence CV #271, with which an adjustment is possible whether the chuff beats should be accentuated at high speed or rather fade away.
LEAD - CV **#272**	Blow-off duration For STEAM engines	0 - 255 = 0 - 25 sec	10	50 = 5 sec	Opening the cylinder valves on a prototype steam engine for the purpose of water drainage is entirely up to the engineer. An automated draining at start-up is more suitable in model railroading; CV #272 defines how long after start-up the blow-off sound should play. Value in CV #272 = time in seconds x 10! Note: If the blow-off sound is also allocated to a function key (as delivered on F4, see CV #312), the automated blow-off sound can be shortened or extended with the relevant function key. Automated blow-off and function blow-off are inevitably the same (per selection/allocation). **= 0**: no blow-off sound played back
#273	Delayed start after blow-off For STEAM engines	0 - 255 = 0 - 25 sec	1	0	Opening the cylinder valves and with it the related blow-off sound on a real steam engine starts most often before the engine even starts to move. This can be imitated with CV #273 by automatically delaying the start. This effect is cancelled when a shunting function with momentum deactivation is being activated (see allocation of F3 or F4 in CV #124!) = 0: no start delay = 1: Special setting for blow-off via speed regulator; no delay but the lowest speed step means "no driving but blow-off instead" (only with 128 speed steps). = 2: Start-up delay in tenths of a second, Recommendation: no value > 20 (> 2 sec
#274	Blow-off schedule For STEAM engines	0 - 255 = 0 - 25 sec	10	30	During shunting operations that often requires many short trips with associated idle times, opening and closing the cylinder valves every time is not usually done. CV #274 causes the blow-off sound to be suppressed if the engine wasn't standing still for the time defined here. Value in CV #274 = time in seconds x 10! Shunting with permanently open cylinder valves

CV	Designation	Value range	INC steps	De-fault	Description
					can be achieved by actuating the function key that is assigned for blow-off sound (F4 by default or by function key assignment with CV #312 = 2, 3, 4…, see above).
LEAD - CV **#275**	Engine (chuff) sound volume at low speed and no-load	0 - 255	10	60	**To set up load dependent sound do the following in the order shown:** *"Automated recording" of the motor's "basic load" factor; see above!* *Check or adjust volume in CV #275 and #276.* *Adjusting CV #277 (should have been "0" up to this point), see below!* *If required also CV #278 and #279.* With this CV the chuff volume at "basic load" (that is under the same conditions as during the automated recording run) is adjusted at a speed of about 1/10 of full speed. Note: For practical purposes (but not absolutely necessary), CV #275 is set by trial and error to the proper value using the "incremental programming" at low speed. Because the volume at various speeds is interpolated between the values in CV #275 and #277 it is **not** necessary to run at an exact speed step during this set-up, as long as it is around 1/10 of full speed. This adjustment is best performed with CV #277 set to "0" (default) so that the setting for "no-load driving" is not influenced by load factors.
#276	Engine (chuff) sound volume at high speed and no-load	0 - 255	10	80	Same procedure as in CV #275 above, but for high speed. CV **#276** defines the "no-load" chuff sound volume at full speed. Set the speed regulator to maximum during this set-up. All notes in CV #275 are also valid for this CV!
#277	Degree of volume change under load for driving (chuff) sound.	0 - 255	10	0 = no change	When deviating from the basic load (as determined by the "Automated recording of the motor's "basic load" factor", see above), the chuff beat volume should be increasing (on inclines) or decreasing on declines (even muted). CV #277 defines the degree of change, which is to be set to the proper value by trial.
LEAD - CV #278	Load change threshold	0 - 255	10	0	With this CV, a change in sound to small load changes can be suppressed (i.e. in curves) in order to prevent chaotic sound impressions. Suitable settings can only be determined by trial (with "incremental programming).

CV	Designation	Value range	INC steps	De-fault	Description
#279	Reaction time to load change	0 - 255	1	0	This CV determines how quick the sound reacts to load changes, whereas the factor is not just time but rather "load-change dependent time" (the bigger the change the faster the effect). This CV is also used to suppress chaotic sound changes. Suitable settings can only be determined by trial (with "incremental programming" of CV's **#**278 and #279 together).
#280	Load influence For DIESEL engines	0 - 255	10	0	This CV determines (at least temporarily in SW version 15) the reaction of the diesel sound to load: RPM levels and load steps of diesel-hydraulic engines, cruise/idle rpm of diesel-electrics and shift points of geared engines. = 0: no influence, dependent on motor rpm = to 255: large influence. It is highly recommended that the automated **test run** with CV #302 = 75 is performed first (see text above under CV #302).
LEAD - CV **#281**	Acceleration threshold for full load sound	0 – 255 (internal speed steps)	1	1	Compared to the "basic load", more powerful and louder chuff sounds should be played back for increased power requirements during accelerations. As is the case with the prototype, the increased sound should be noticeable before the increase in speed becomes visible, since the latter is a result of the increased steam volume supplied to the pistons. It is therefore practical that the heavy acceleration sound is played back when the speed has increased by just one speed step (when no real speed change is noticed), to be able to control the proper sound sequence with the speed regulator. The "engineer" can in this fashion adjust the sound (by increasing the speed by 1 step) in anticipation of an imminent incline. =1: Acceleration sound played back at full volume if speed has increased by just one speed step. = 2, 3…. Acceleration sound played back at full volume only after increasing speed by this number of speed steps; before that: proportional volume.
#282	Duration of acceleration sound	0 - 255 = 0 - 25 sec	10	30 = 3 sec	The acceleration sound should remain for a certain length of time after the speed increased (otherwise each single speed step would be audible, which is unrealistic). Value in CV #282 = time in seconds x 10!
#283	Engine sound volume at full acceleration	0 - 255	10	255	The volume of steam chuffs at maximum acceleration is set with CV #283 (default: 255 = full volume). If CV #281 = 1 (acceleration threshold set to 1 speed step), the volume defined here is applied with each speed increase, even if it's just 1 step.

CV	Designation	Value range	INC steps	De-fault	Description
LEAD - CV **#284**	Threshold for deceleration sound	0 -255 (internal speed steps)	1	1	Steam chuffs should be played back at less volume (or no sound at all) signifying the reduced power requirement during deceleration. The sound reduction logic is analog to a reversed acceleration (per CV #281 to #283). = 1: Reduces sound to minimum (as per CV #286) when speed is reduced by just 1 step. = 2, 3 ... sound reduced to minimum after lowering speed by this number of steps.
#285	Duration of reduced volume on deceleration	0 - 255 = 0 - 25 sec	10	30 = 3 sec	After the speed has been reduced, the sound should remain quieter for a specific time (analog to the acceleration case). Value in CV #285 = time in seconds x 10!
#286	Volume level during deceleration	0 - 255	10	20	CV #286 is used to define the chuff volume during deceleration (Default: 20 = pretty quiet but not muted). If CV #284 = 1 (deceleration threshold set to 1 speed step), the volume defined here is applied with every reduction in speed (even if decreased by just 1 step).
LEAD - CV **#287**	Brake squeal threshold	0 – 255 (internal speed steps)	10	20	The brake squeal should start when the speed drops below a specific speed step. It will be automatically stopped at speed 0 (based on back-EMF results).
#288	Minimum driving time before brake squeal	0 - 255 = 0 - 25 sec	10	50	The brake squeal is to be suppressed when an engine is driven for a short time only. That is usually a shunting run and often without any cars (in reality it is mostly the cars that are squealing not the engine itself!). Note: Brake squeal sounds can also be assigned to a function key (see allocation procedure CV #300 = …), with which they can be played manually or stopped!
#289	Thyristor control: Sound pitch for stepping effect of ELECTRIC engines From SW version 20	1 - 255	10	1	The pitch of the thyristor control sound of many engines (typical example: Taurus) should not ascend evenly but rather in steps. = 1: no stepping effect, even ascend 1 - 255: ascending scale according to the corresponding speed step interval.
LEAD - CV **#290**	Thyristor control: Sound pitch at medium speed for ELECTRIC engines From SW-version 20!	0 - 100	10	40	Percentage of the increased pitch of the thyristor sound at medium speed compared to standstill. Define the “medium speed” in CV #292. = 0: no change, pitch remains the same as at standstill. = 1- 99: corresponding change in pitch = 100: pitch doubles already at “medium speed”.

CV	Designation	Value range	INC steps	De-fault	Description
#291	Thyristor control: Sound pitch at maximum speed for ELECTRIC engines From SW-version 20!	0 - 100	10	100	Percentage of the increased pitch of the thyristor sound at maximum speed compared to standstill. = 0: no change, pitch remains the same as at standstill. = 1- 99: corresponding change in pitch = 100: pitch doubles at “medium speed”.
#292	Thyristor control Speed step for medium speed For ELECTRIC engines	0 - 255	10	100	Internal speed step defined as “medium speed” for the pitch level according to CV #290. The CV’s #290 – 292 form a three-point characteristic curve for the pitch of the thyristor control sound, starting at standstill, whenever the original sample is being played back.
LEAD - CV #293	Thyristor control Volume at steady speed for ELECTRIC engines	0 - 255	10	30	Thyristor control-sound volume at steady speed (no acceleration or deceleration in process). Note: sound changing to load will be set with CV’s #277 and up but is not yet possible with SW-Version 4.
#294	Thyristor control Volume during acceleration for ELECTRIC engines	0 - 255	10	100	Volume during heavier accelerations; the value in CV #294 should be larger than in CV #293 to be useful (so that the volume increases when the engine accelerates). At lesser accelerations a lower volume is selected automatically (exact algorithm is not finalized with SW-Version 4).
#295	Thyristor control Volume during deceleration Motor sound of ELECTRIC engines	0 - 255	10	50	Volume during heavier decelerations (braking); the value in CV #295 may be higher or lower than in CV #293, depending on whether the thyristors are stressed during power feedback to the net (which increases the volume) or not (which rather decreases the volume).
LEAD - CV #296	Motor sound, highest volume for ELECTRIC engines	0 -255	10	100	Maximum volume of motor sound at full speed or at the speed defined by CV #298.
#297	Motor sound, when sound becomes audible for ELECTRIC engines	0 -255	10	30	Internal speed step at which the motor sound becomes audible; the sound starts quietly at this speed and reaches the maximum volume as per CV #296 at the speed defined in CV #298.
#298	Motor sound, starting point of full volume for ELECTRIC engines	0 -255 (> CV#297)	10	128	Internal speed step at which the motor sound reaches full volume; at this speed step the motor sound is played back at full volume according to CV #296.

CV	Designation	Value range	INC steps	De-fault	Description
#299	Motor sound, Sound pitch dependent on speed Electric engines	0 – 255 (> CV#297)	10	100	As the engine speed increases, the motor sound is also increasing in speed, according to this CV. = 0: Pitch (playback speed) will not be raised. = 1 … 100: Intermediate values. = 100: Doubles pitch > 100: same as 100 for now; reserve for SW expansion.
MORE CV's belonging to this group beyond the next table (from CV #344 up) !!!					

The following CV's are not suitable for the "incremental programming", because they either are too difficult to test immediately (large time intervals for random generators) or single bits need to be set. They are programmed the usual way (CV # = …).

CV	Designation	Value range	De-fault	Description
#310	On/off key for engine and random sound	0 - 19, 255	8	Defines the function key (by default F8) that turns the engine sound (chuffs, boiling, blow-off's, brake squeals...) as well as the random sound (compressor, coal shoveling...) ON or OFF. = 255: engine and random sound is always ON.
#311	On/off key for function sound	0 - 19	0	A key can be assigned with which all function sounds (i.e. F2 – whistle, F6 – bell etc.) can be turned on and off. No key is programmed for this at delivery. = 0: does not mean that F0 is assigned for this task but rather that the function sounds are always active. = (#310), if the same value is entered here as in CV #310, the key defined in #310 turns all sound on/off. = 1 ... 12: Assigns separate key to turn function sound on/off.
#312	Blow-off key	0 - 19	4 = F4	Defines a function key to play-back the blow-off sound manually (that is the same sound programmed with CV #300 = 133 to be played back automatically). For example: to do shunting with „open valves". = 0: no key assigned (use this setting if keys are used for other purposes).
#313	Mute key from SW version 2	0 – 19	8	This CV assigns a function key with which the driving sounds can be faded in and out, i.e. when the train becomes invisible after disappearing behind scenery. F8 is used by default, which is already the sound on/off key but now does so softly. = 0: No mute key or mute function.
#314	Mute fade in/out time	0 – 255	0	Time in seconds x 10 for sound fading in/out when mute button is pressed. Range is 25 seconds. =0: 1 sec, which is the same as a value of 10.

CV	Designation	Value range	De-fault	Description
#315	Minimum interval for random generator Z1	0 - 255 = 0 - 255 sec	1	The random generator produces internal pulses in irregular intervals that are used to playback a sound file assigned to the random generator. CV #315 defines the shortest possible interval between two consecutive pulses. Sound samples are assigned to the random generator Z1 with the help of the procedure CV #300 = 101, see above! By default, the compressor is assigned to Z1. Special note to random generator Z1: The random generator Z1 is optimized for the compressor (which should be played back shortly after the train has stopped); therefore the default assignment should be retained or at the most be used for a different compressor. CV #315 also determines the proper time the compressor is started after coming to a stop!
#316	Maximum interval for random generator Z1	0 - 255 = 0 - 255 sec	60	CV #316 defines the maximum time interval between two consecutive pulses of the random generator Z1 (that is most often the start of the compressor); the actual pulses are evenly spaced between the values in CV #315 and #316.
#317	Playback length for random generator Z1	0 - 255 = 0 - 255 sec	5	The sound sample assigned to the random generator Z1 (most often the compressor) is played back for the duration defined in CV #317. = 0: Sample plays once (in the defined duration)
#318 #319 #320	As above but for sound generator Z2	0 - 255 0 - 255 0 - 255	20 80 5	By default, Z2 is assigned for coal shoveling.
#321 #320 #323	As above but for sound generator Z3	0 - 255 0 - 255 0 - 255	30 90 3	By default, Z3 is assigned for the injector.
#324 #325 #326	As above but for sound generator Z4	0 - 255 0 - 255 0 - 255		As delivered, this random generator is not assigned to any sound.
#327 #328 #329	As above but for sound generator Z5	0 - 255 0 - 255 0 - 255		As delivered, this random generator is not assigned to any sound.
#330 #331 #332	As above but for sound generator Z6	0 - 255 0 - 255 0 - 255		As delivered, this random generator is not assigned to any sound.
#333 #334 #335	As above but for sound generator Z7	0 - 255 0 - 255 0 - 255		As delivered, this random generator is not assigned to any sound.
#336 #337 #338	As above but for sound generator Z8	0 - 255 0 - 255 0 - 255		As delivered, this random generator is not assigned to any sound.

CV	Designation	Value range	De-fault	Description
#341	Switch input 1 Playback time	0 - 255 = 0 - 255 sec	0	The sound sample allocated to switch input 1 is played back for the duration defined with this CV. = 0: Play sample back once (as recorded)
# 342	Switch input 2 Playback time	0 - 255 = 0 - 255 sec	0	The sound sample allocated to switch input 2 is played back for the duration defined with this CV. = 0: Play sample back once (as recorded)
# 343	Switch input 3 (if not used for the cam sensor) Playback time	0 - 255 = 0 - 255 sec	0	The sound sample allocated to switch input 3 is played back for the duration defined with this CV. = 0: Play sample back once (as recorded)

Table from CV #299 continues here !!!				
CV	Designation	Value range	De-fault	Description
#344	Run-on time of motor sounds after stops (Cooling fan etc.) for DIESEL and ELECTRIC engines	0 – 255 = 0 – 25 sec.	0	After the engine is stopped some accessories are still operating (i.e. cooling fans) and stop after the time defined here, provided the engine didn't start up again. = 0: Won't run after stop = 1 … 255: Runs for another 1 to 25 seconds.
#345	Quick-select key for the sound of a MULTI-SYSTEM engine	1 - 19	0	Defines a function key (F1 – F19) which switches between two sound types (i.e. between an electro and diesel sound of a multi-system engine). This feature is only intended for certain sound projects (i.e. RhB Gem), where the two sound types are part of the same sound collection.
#350	Delay of switchgear sound after start up for ELECTRIC engines.	0 – 255 = 0 – 25 sec.	0	The switchgear on some engines (i.e. E10) should not be heard immediately after start but rather after some time defined here. = 0: Switchgear is heard immediately after start.
#351	Smoke fan speed at steady speed for DIESEL engines	1 – 255	128	The fan speed is adjusted with PWM; the value in CV #351 defines the speed at steady cruise. = 128: Half of the available voltage is applied to the fan motor.
#352	Smoke fan speed at acceleration and motor start-up for DIESEL engines	1 - 255	255	To generate the puff of smoke at start-up or heavy smoke under hard acceleration, the fan motor is set to a higher speed (usually full speed). = 255: Motor receives full voltage at start-up.
#353	Automatic shut-down of smoke generator	0 – 255 =	0	If the smoke generator is controlled by one of the Special Effects "010010xx" or "010100xx" in CV's 127 – 132 (for one of the function outputs FO1 to FO6), it will turn off automati-

Table from CV #299 continues here !!!				
CV	Designation	Value range	De-fault	Description
	for STEAM and DIESEL engines	0 – 25 sec.		cally after the time defined here (to prevent overheating). = 0: Won't turn off automatically. = 1 … 252: Switches off automatically after 25 seconds/unit. Maximum time therefore is about 6300 sec. = 105 minutes.
#354	Steam chuff frequency at speed step 1	1 - 255	0	CV #354 works only if used together with CV #267! CV #354 compensates for the non-linear speed measurement for the "virtual cam sensor": While the adjustment of CV #267 is done in the vicinity of speed step 10 (slow but not very slow), a correction for speed step 1 can be performed with CV #354 (extremely slow). = 0: no effect = 1…127: more chuff beats in relation to CV #267, = 255…128: less chuff beats.
#365	Fan speed at standstill. For STEAM and DIESEL engines.	1 - 255	0	Supplements to the adjustments in CV #133 und the effects of code "72" (steam engines) or "80" (diesel engine), which covers the fan only during start-up and running. CV #355 on the other hand adjusts the fan speed at standstill, so that a small amount of smoke is being pushed out in those situations.

7. “Bi-directional communication”

The future oriented technology that has been installed (hardware) on all ZIMO decoders since 2004, is functional since 2007 in all current ZIMO decoders including the MX640.

“Bidirectional” means that the information transfer within the DCC protocol is not only flowing towards the decoder but also in the opposite direction; that is not just driving, function and switch commands are being sent to decoders but also messages such as acknowledgements and status information are being received from decoders.

RailCom is defined by the “RailCom working group” (Lenz, Kühn, Tams and ZIMO), before that by the NMRA RP’s 9.3.1 and 9.3.2 for bidirectional communication; with the goal of a uniform platform for “RailCom” applications.

The functionality is based on short cut-outs (max. 500 micro seconds) introduced to the otherwise continuously sent DCC signal by the command station. These cut-outs provide the opportunity and enough time for the decoders to send a few bytes of data to locally mounted detectors.

With the help of RailCom© = bidirectional communication, it will

be possible that the decoder can acknowledge received commands -

- which increases operational reliability and the bandwidth of the DCC system because already acknowledged commands don’t need to be sent repeatedly;

up-to-date information from decoders is sent to the command station (“global detector”) -

- e.g. “real” train speed, motor load, routing and position codes, “fuel reserves”, current CV values on demand from decoders to command station or more precisely, to a **global detector** in the command station;

decoder addresses are recognized by “local” detectors -

- the actual loco positions are determined by local detectors connected to individual track sections (integrated in the future in MX9 track section modules), which has been possible with ZIMO’s own loco number recognition for over two decades without bidirectional communication; but only with ZIMO components.

RailCom will be further developed over the coming years and will bring new applications, which of course require new software updates in decoders and other equipment. ZIMO decoders as of 2009 are able to send their own loco address from an isolated section of track (with a so called broadcast method, very fast, although only for one loco inside that section), send CV content on demand along with some decoder data such as actual speed in km/h, load and decoder temperature.

On the system side, a third party product has been available from the beginning – the address display LRC120, which is a “local” RaiCom detector displaying the loco address of one track section. Since 2007, the MX31ZL became available with an integrated “global” RailCom detector and finally “global” RailCom detectors for the installation into ZIMO command stations MX1EC, MX1, MX1HS as well as MX31 cabs.

The RailCom function is activated with CV #29, Bit 3 and further defined in CV #28 (see chapter 3, CV table); RailCom is fully functional by default (broadcast and data).

„RailCom“ is a trademark of Lenz Elektronik GmbH.

8. Installation and wiring

General information:

There has to be enough **free space inside the engine** so that the decoder can be mounted without exerting mechanical stress. Pay particular attention that no pressure is applied to the decoder when the loco housing is being reinstalled and the wires can’t get caught by movable parts.

All direct connections that are present in the original wiring configuration between the power pick-ups (wheels and wipers) and the motor **must be isolated;** otherwise the decoder end stage may get damaged at power-up.

The same goes for the **headlights and other additional accessories,** which must be completely isolated.

Do noise suppression components on a locomotive motor have a negative affect on motor regulation?

Yes, sometimes . . .

Explanation: Motors of model railroad locomotives are often equipped with choke coils and capacitors, which are supposed to suppress or filter out noise (causing poor TV reception etc.), caused by the sparks arcing across the motor’s brushes.

Such components impair the motor regulation. Compared to others, ZIMO decoders manage quite well and there is hardly a difference in performance with or without those components in place. However, in recent years larger choke coils are being installed in many locomotives than was the case earlier – and these can noticeably compromise drivability.

The potentially “harmful” choke coils are often recognizable by their shape, as they look like a resistor with color bands (in contrast to a wire wound ferrite bar). That doesn’t mean though that these choke coils have a negative effect in all cases.

Lessons learned and accompanying measures…

ROCO, BRAWA, HORNBY – so far present no problems, no action necessary.
FLEISCHMANN H0 with “Round motors” – choke coils are no problem; capacitors should be replaced if needed, especially the ones between frame and motor (may destroy the decoder if left in place)!
Newer Bühler motors present no problems so far.

TRIX H0 – choke coil between track and decoder plug should be removed!

MINITRIX, FLEISCHMANN PICCOLO – very inconsistent; removing of capacitors is often advantageous; choke coils on the other hand presented no problems so far.

Indications of an actual negative effect of such components, besides a general unsatisfactory motor control (jerking…), are:

- weak BEMF compensation: as confirmation, set the decoder for testing purposes to low frequency – CV #9 = 200 – and see whether the control compensation becomes stronger. If that’s the case, the choke coils are most likely to blame for the weak compensation in the high frequency range.

- if a difference in compensation is noticeable between 20 and 40 kHz (selectable in CV #112, Bit 5); if so, it is very possible that the choke coils or capacitors are the cause.

Remedy: **Bypass choke coils** (or replace with wire strap)**! Remove capacitors!** Capacitors are less likely to interfere with motor regulations but cannot be ruled out (see “Round motor” above).

Locomotives with 6 or 8 pin NMRA interface . . .

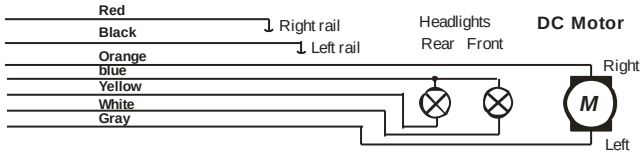
. . . are easy to retrofit with the MX...**R**, MX...**F**, MX...**N** (e.g. MX63R or MX64F) etc. They come with the appropriate 8 (R) or 6 (F, N) pin connector. There is usually enough room provided in such locos. By removing the dummy plug from the loco, all damaging connections mentioned above should be interrupted and the decoder can be plugged in instead. This is unfortunately not always true with some loco manufacturers. It is advisable to use an ohmmeter to confirm that motor connections are isolated from the power pick-ups before plugging in a decoder.

In some cases it is necessary to hardwire some decoder leads besides just plugging in a plug. An example of this is the MX630R that has more outputs available than the standard 8-pin plug has room for. For hard-wiring of decoder leads use the explanations below.

Hard-wiring a locomotive…

… with a DC motor and headlights:

This probably represents the **most common wiring diagram** for HO installations. All other diagrams that follow are modified or extended versions of this one.

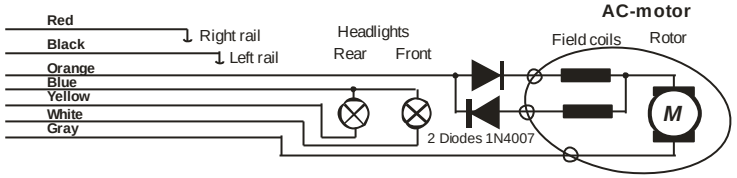


Lights connected as shown on this diagram are direction controlled and switched on/off by the F0 key (1 on Zimo cab). The lights can also be controlled independently with F0 and F1 for example (1 and 2 on Zimo cab), using function mapping CV's #33, 34, 35.

PLEASE NOTE: Body mounted light bulbs that are hard to insulate can be left as is. The body acts as the power supply to the bulb. The blue lead from the decoder must not be connected to the bulbs in such circumstances. The white and yellow leads are connected to the other side of the bulbs. The brightness of the headlights will be reduced with such an application.

. . . with an AC engine:

Two additional 1N4007 diodes (or equivalent) are required as shown in the diagram below when installing a decoder in a loco equipped with an AC motor. They can be obtained at your local electronic store or from ZIMO.



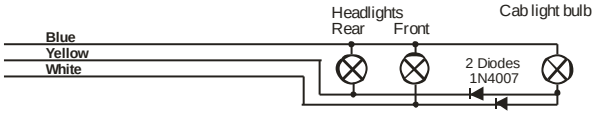
Most locomotives with AC motors get the power supplied by a third rail, which is of no significance as far as the motor hook-up is concerned. The above schematic is therefore valid for AC locomotives running on two or three rail track (instead of "right rail" and "left rail" think "outside rails" and "center rail").

Note: many locomotive manufacturers supply field magnets that can be used in place of the motor's field coil. Using a field magnet turns an AC motor into a DC motor, which is connected as such (see above) and can also utilize the decoders BEMF feature (BEMF does not work with AC motors).

Additional hook-up for cab lighting controlled with F0 key:

This is no longer of much use today; it is a remainder from a time when decoders only had two function outputs, which were used for the headlights and the cab light. Cab lights connected this way can be switched with the F0 key but in contrast to the headlights were non-directional.

This is however a general schematic that can be used in cases where something is to be operated by several different function outputs, but the same outputs used independent of each other. There are 2 diodes required (type 1N4007 or equivalent) available from ZIMO or any electronic parts supply store.

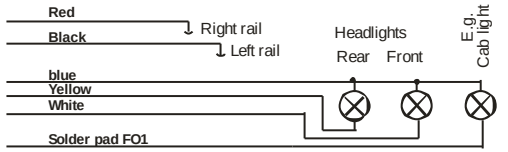


Connecting function outputs FO1, FO2, FO3, FO4…:

Depending on decoder type, function outputs FO1 and higher are available on wires, solder pads or part of a connector (i.e. the MX620 offers FO1 and FO2 on solder pads, the MX630 and MX632 on wires with higher outputs on solder pads) and can be connected in the same fashion as headlights.

For mapping the outputs to function keys, see chapter 5; the function outputs FO1 and FO2 are mapped by default with function keys F1 and F2.

Also see note on MX632 below!



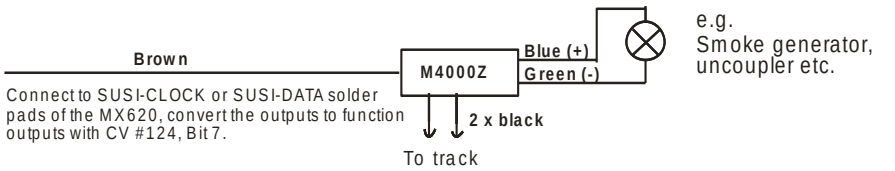
Using logic level outputs:

ZIMO decoders also have so called logic level outputs in addition to the normal function outputs, to which current consuming devices may not be connected directly. Use a ZIMO M4000A amplifier or similar transistor switching device, when connecting logic level outputs with a load.

Some logic level outputs are used alternatively for the "SUSI-CLOCK" and SUSI-DATA" connections and can be switched back to logic level outputs when setting CV #124 Bit 7 = 1 (if SUSI is not required). Furthermore, the same pins can be used for servo control (activated with CV's #181 & 182).

NOTE MX632: The logic level outputs FO5 and FO6 of the MX632 are identical in their function as the amplified outputs FO5 and FO6 (not FO7 and FO8 as was first announced); however, **neither the amplified outputs FO5/FO6 nor the logic level outputs FO5/FO6 are functional, if they are defined for "SUSI" (CV #124, Bit 7) or servo control (CV's #181, 182) are activated!!**

The brown lead of an **amplifier module M4000Z** is connected with the relevant logic level output solder pad of the decoder.



Connecting DIETZ sound modules without "SUSI" / "virtual cam sensor"

See Dietz instruction manual regarding the installation and connection of their sound modules to a ZIMO decoder.

For a good acoustic impression of steam engines, it is important that the chuffs are synchronized to wheel revolutions. Therefore a cam sensor should be installed and connected to the sound module (reed switch, optical or hall-effect sensor), which sends exactly 2 or 4 pulses to the module (depending on loco type).

Sound modules can usually generate their own chuff rate based on speed information (e.g. coming from the SUSI interface of a decoder), if no cam sensor can be installed or installation proves too difficult. The result is often poor with a chuff rate that is too fast at low speeds (the SUSI protocol is not precise enough in that respect).

To improve this situation, ZIMO decoders come with a **"virtual cam sensor".** They use the function output FO4, which is converted to a "virtual cam sensor" function with the help of CV #133 and connected with the cam sensor input of the sound module (e.g. Dietz, reed switch input); naturally in addition to SUSI or other connections.

The virtual cam sensor is of course not capable of synchronizing chuff rates to wheel positions but rather to wheel speed, which is of little difference to the viewer.

The chuff rate of the "virtual cam sensor" can be defined per wheel revolution with CV #267 and CV #354; consult the CV table in ZIMO sound chapter.

Connecting a DIETZ or other sound module to "SUSI":

The SUSI interface developed by Dietz is an NMRA standard and defines the connection between sound modules and loco decoders, provided the sound module is also equipped with such an interface. Due to space restrictions on small decoders, the SUSI interface composed of 4 conductors (2 data, ground and power) is not built as a plug-in connector but instead uses **4 solder pads** (see decoder drawings in the chapter "Technical specifications" in this manual).

Speed and load information (e.g. to change sound intensity when going uphill, downhill, start up etc.), as well as sound-configuration variables (CV's #890…) are sent via the SUSI data lines (CLOCK and DATA) from the decoder to the sound module.

Accessing SUSI CV's in the SUSI module: These CV's are in the 890 range, according to the standard (NMRA DCC Draft RP), which is not accessible with many DCC systems (ZIMO cabs MX2 and MX21 were also limited to 255 - until mid 2004). For this reason, ZIMO decoders allow access to these CV's with numbers in the 190's!

Connecting an electric uncoupler (System "Krois"):

In order to prevent damage to the delicate core of an uncoupler from continuous power, appropriate adjustments can be made with special CV's for one or several function outputs.

First, write the value "48" to the CV that is assigned to the same output the uncoupler is connected to (e.g. CV #127 for output #1, CV #128 for output #2 etc.)

Next define a limit for the uncoupler's activation time in CV #115 (see CV-table):

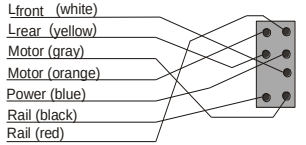
With the **"Krois uncouplers"**, it is recommended to use a value of "60", "70" or "80" for CV #115; this means that the pull-in voltage (full track voltage) is limited to 2, 3 or 4 seconds. A reduced "hold" voltage is not required for Krois, that's why the ones digit is left at 0. Other uncouplers may need a reduced hold voltage though, like the ones from ROCO for example.

Regarding the "automated coupler detachment" and/or "automatic tension release" see CV #116 in the chapter "Additional Notes to…".

MX620R, MX630R, MX640R with NMRA 8-pin interface (NEM 652):

The "R" designated decoders come with an 8-pin plug mounted to the end of its wires, which fits in to the socket of a DCC ready loco. Remove the dummy connector from the socket and plug the decoder in its place, that's all.

All the necessary connections to power, motor and headlights are established with this interface. Other outputs have to be hard wired.

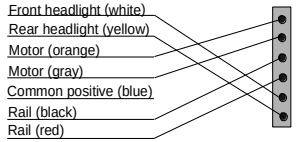


MX620F, MX630F with NMRA 6-pin interface (NEM 651):

The "F" designated decoders come with a 6-pin plug mounted to the end of its wires, which fits into the socket of a DCC ready loco.

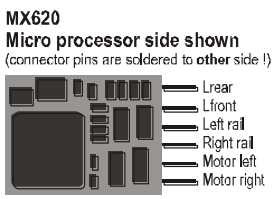
The brightness of the headlight is reduced since the blue wire (common supply) is not part of this interface. The light bulbs get their power directly from the power pick up.

The blue wire is still available at the decoder and can be connected to other bulbs not powered directly from the track, if needed.



MX620N plugs directly into the 6-pin interface (NEM 651):

Many N, HOe, HOm as well as some HO engines have this socket installed with the required minimum space of 14 x 9 mm to accept the decoder.



ATTENTION: Plug the decoder into the socket with the pins down and the **micro processor** on top (visible)!

MX631D, MX632D, MX632VD, MX640D, MX642D – with 21-pin interface:

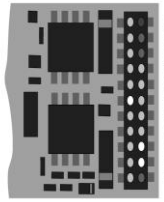
These decoders have a 21-pin female plug on the circuit board (no wires), which allows the decoder to be plugged directly in to the 21-pin male receptacle of locomotives equipped with such interfaces. There are actually 22 pins present but one of those (#11, top right) pins serves as a key to prevent wrong installations. The 21-pin interface is, just like the 6 and 8-pin interface, defined by the NMRA-DCC PR 9.1.1.

Since the original definition of the 21-pin interface was designed for a certain motor configuration, some of the pins are not used for the intended purpose (Hall, motor 3) with “normal” applications and are being used for other functions instead.

Because of this, decoders come with differently configured 21-pin interfaces, depending on feature content. “Empty” pins are only used if the engine is prepared accordingly.

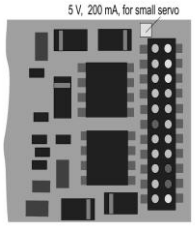
That is why the MX632D for example has function outputs FO4 - FO6 and the low voltage supply available on additional solder pads on the decoder board; see technical drawings in chapter 2.

MX632D, C Top Side
and MX632VD, MX632WD



+ 5 V	Index pin
Function output FO3	n.c.
Function output FO2	n.c.
Function output FO1	Front headlight (= Lfr)
Common positive	Rear headlight (= Lrear)
Low voltage outp (...V, W)	SUSI Data (FO8, Servo 2)
Motor connection 1	SUSI Clock (FO7, Servo 1)
Motor connection 2	Function output FO4
GROUND	Function output FO5
Left rail	Function output FO6
Right rail	n.c. as special order available with capacitor negative (NOT GROUND)

MX640D Top Side
(= side with 21-pin plug !)



+ 5 V, 200 mA max.	Index pin
Function output FO3	Speaker
Function output FO2	Speaker
Function output FO1	Front headlight (= Lfr)
Common positive	Rear headlight (= Lrear)
n.c.(not connected)	SUSI Data
Left motor connection	SUSI Clock
Right motor connection	Function output FO4
GROUND	n.c.
Left rail	n.c.
Right rail	Switch input 1

NOTE: The versions MX631C, MX632C etc. also have a 21-pin interface but are specifically designed for Märklin/Trix engines; see next chapter.

21-pin decoder plugged into loco board, i.e. TRIX
Plugged in right side up, pins of the loco board penetrate through the decoder board into the socket.

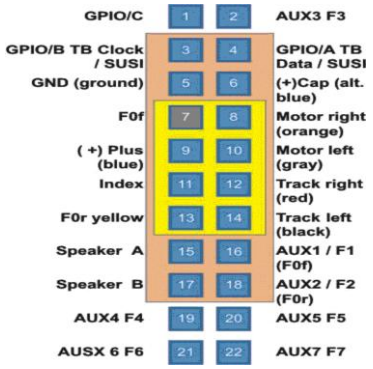
21-pin decoder plugged into loco board, i.e. BRAWA
Decoder is plugged in upside down !

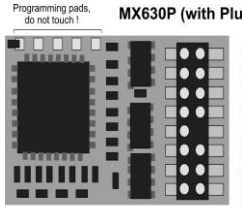
The MX64D can be plugged-in two ways; the board below the connector is perforated, so that **depending on the locomotive**, the decoder can be plugged in from the top or bottom end. **The key pin 11 prevents a wrong installation by not allowing the decoder to be pushed all the way down, provided the installer ensures that the decoder sits firm and level on the plug.**

MX630P – with 16-pinPluX connector:

In contrast to the 21-pin interface (see above), the PluX connection has the male connector mounted on the decoder and the female on the loco board. “PluX” is available with 8, 12, 16 and 22 pin connectors and also use one of the pins for indexing.

The PluX system is defined by the NMRA 9.1.1 and the NEM, including the maximum dimensions to standardize decoders.





MX630P (with PluX16)

SUSI, Servo's (2, 1) or FO6, FO5	
Common (+)	Ground
Motor right	Front headl.
Motor left	Common (+)
Right rail	--- (Index)
Left rail	Rear headl.
Function output	FO1 FO3
Function output	FO2 FO4

The MX630P comes with a 16-pin male plug (15 usable pins, 1 index pin) and can be plugged into engines with 16-pin sockets but also in engines with 22-pin sockets (see drawing at right: brown area accepts 16-pin decoder, total area for 22-pin decoder.

Whether the decoder can be used in engines equipped with 8-pin or 12-pin sockets depends on the available space.

The MX630P, which is not a sound decoder, uses the two pins originally defined for speaker outputs for the additional outputs FO3 and FO4 instead. This will not damage anything even in case the locomotive has a speaker wired to those pins.

Connecting servo and SmartServo motors:

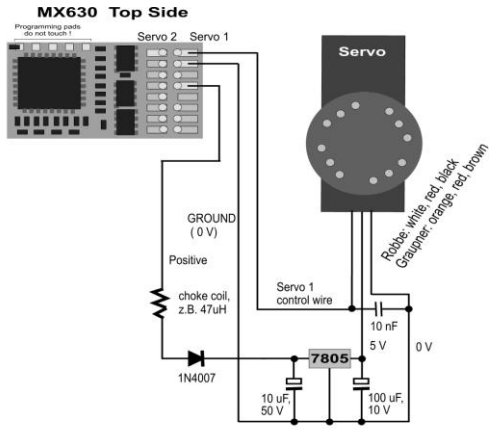
2 servo control outputs are available on the MX620, MX630. MX632 and MX640 decoders for the control of commercially available servo motors or SmartServo RC-1 (Manufactured by TOKO Corp. Japan). The solder pads or pins on the 21-pin or PluX connector the servos connect to, can also be used alternatively for SUSI or as logic level outputs.

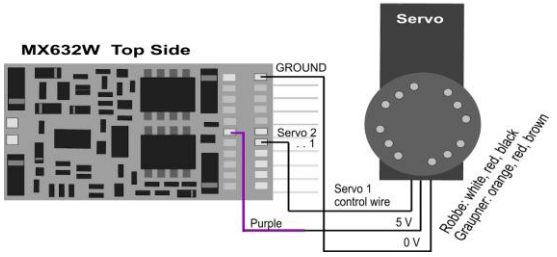
The SUSI and logic level functions are not available if the servo mode is activated (through CV's #181 and 182, see below); this is also true for the function outputs FO5 and FO6 on the MX632.

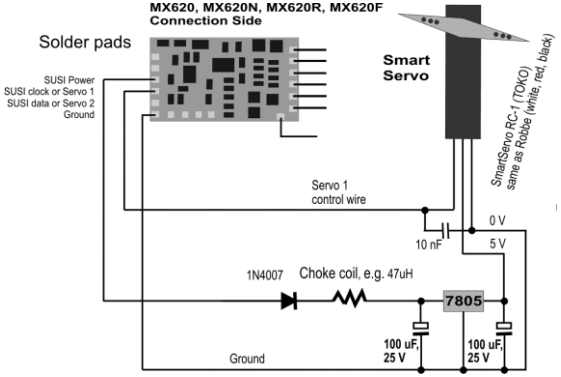
The models **MX632W** and **MX632WD** contain a 5V power supply to power servos directly; the 5V supply on the MX640 is limited to 200mA.
For other decoder types, the 5V must be supplied by an external voltage regulator such as the readily available LM7805; connected as shown in the drawing.

The outputs can be activated for servo control duty with CV's #181 and CV #182 (the value in each must be different than 0).
With the help of CV #181 and #182, the servo functions can be mapped to various function keys (and direction) and selected for control with either one or two function keys.
CV's #161 to #169 define the servos end positions and rotating speed, see CV table.

CV #161 defines the appropriate servo protocol. "Normal" for most servos are positive pulses (which is also the default setting); furthermore a selection can be made whether the servo is powered only while it is being moved or remains powered at all times. The latter should only be used if the servo position can be changed by mechanical influences. However, Bit 1 in CV #161 must always be set for the SmartServo (CV #161 = 2)!







MX640 and MX642 – connecting servo and SmartServo motors.

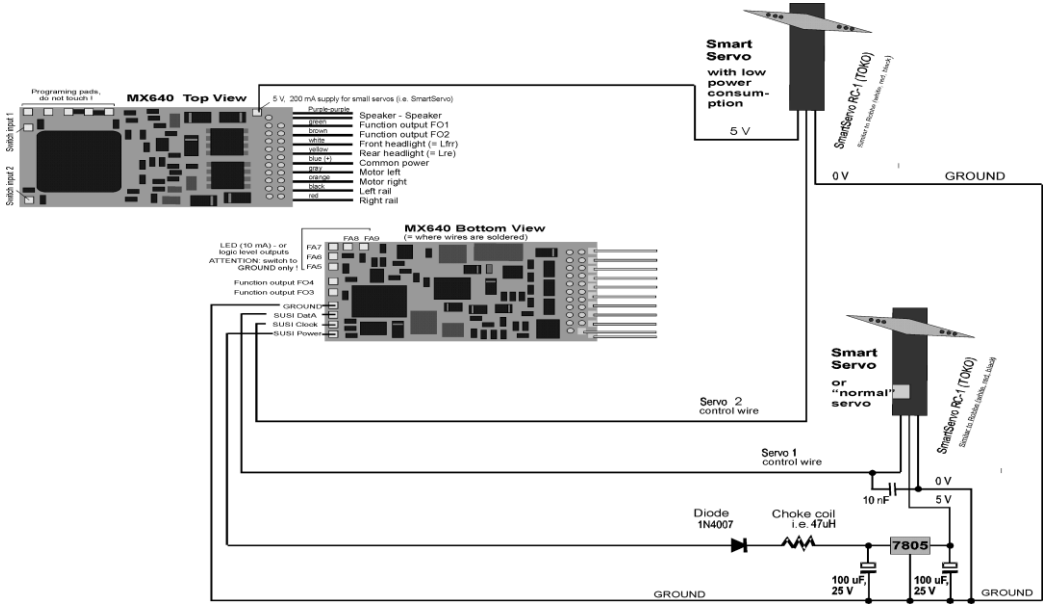
Two servo connections are provided on the MX640 for commercially available servos and SmartServos
RC-1 (Manufacturer: TOKI Corp., Japan). These are normally the **SUSI outputs** but can also be used **as servo outputs** instead. They are in the form of either solder pads or part of the 21-pin socket, depending on the decoder type. Each output can be connected directly with a servo input.

"Energy-saving" servos (max. 200mA) can be powered directly by the MX640!

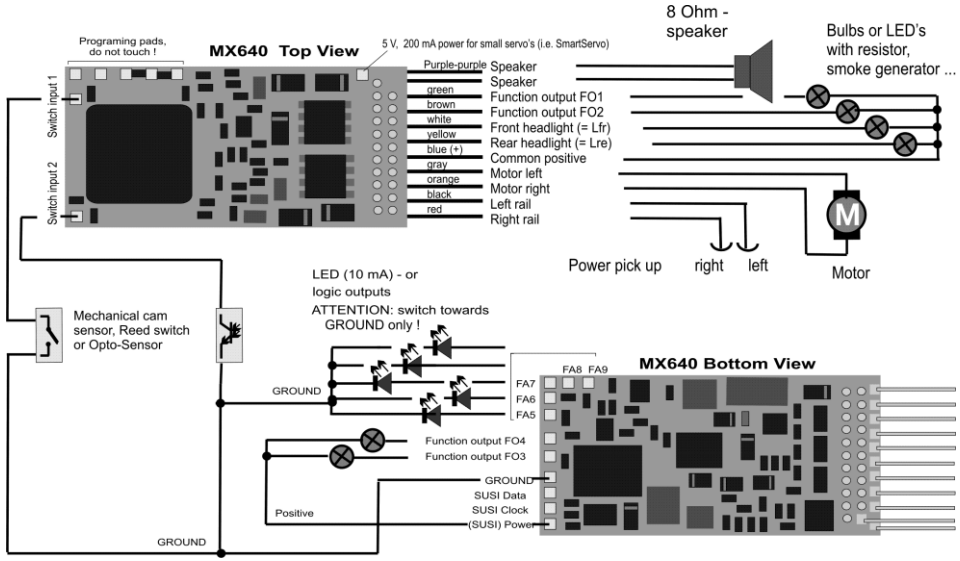
For servos with higher energy consumptions, the 5V operating voltage must be supplied by an external voltage regulator such as the readily available LM7805 as shown in the drawing.

The outputs can be activated for servo control duty with CV's #181 and CV #182 (the value in each must be different than 0). With the help of CV #181 and #182, the servo functions can be mapped to various function keys (and direction) and selected for control with either one or two function keys.
CV's #161 to #169 define the servos end positions and rotating speed, see CV table.

CV #161 is also used to select the appropriate protocol. "Normal" for most servos are positive pulses (which is also the default setting); furthermore a selection can be made whether the servo is powered only while it is being moved or remains powered at all times. The latter should only be used if the servo position can be changed by mechanical influences. For the **SmartServo:** Bit 1 of CV #161 must always be set, that is
CV #161 = 2!



MX640 – Schematic for Sound Connections



MX642…

The (later) sound decoder version MX642 is to be wired the same way, except that

- GROUND, switch input and common power are on solder pads on the top side or common power from the blue wire and
- only 2 LED outputs are available (instead of 5 as on the MX640) on the SUSI pads or alternatively on the top side solder pads.

Also see the decoder schematics on the first pages of this manual.

Connecting speaker, cam sensor:

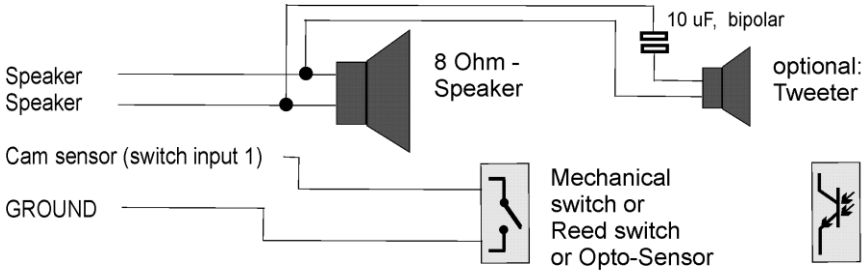
In order to operate the MX640 as a sound decoder, the following items must/may be connected:

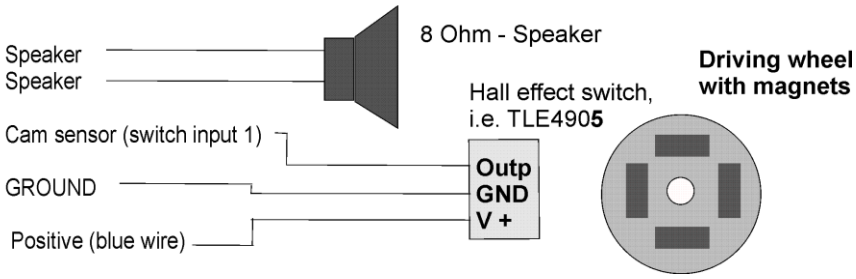
- mandatory – ***SPEAKER –*** Any 8-ohm speaker or two 4 Ohm speakers connected in series can be used. Speaker with higher impedance are also allowed but will result in reduced volume.

An additional tweeter (also 8 ohms or higher) can be connected, if desired; the connection should be made via a bipolar capacitor (10 uF bipolar for 2 kHz frequency).

- optional – ***CAM SENSOR –*** Normally, ZIMO decoders are programmed for the "virtual cam sensor", which can be fine-tuned with CV #267 and CV #354. If a real cam sensor is to be used, the settings of CV #267 must be changed to 0 or 1 depending whether each pulse or every second pulse should trigger a chuff beat. See chapter 6!

Mechanical contacts, Reed switches, optical switches and Hall Effect switches are suitable as cam sensors.





Connecting an external energy source (capacitor) for uninterrupted driving on dead track sections:

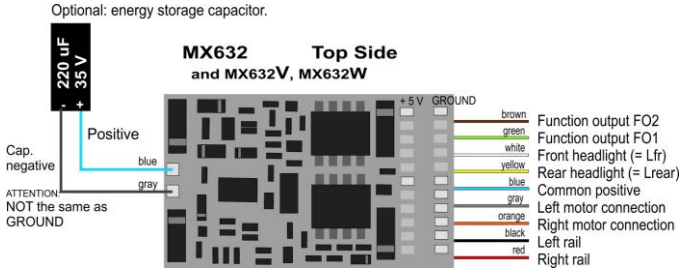
Energy storage devices connected to the decoder have many benefits; even very small capacitors as of 100uF have positive effects, larger ones even more so:

- Prevents stalling and flickering lights on dirty track sections or frogs, especially in conjunction with the ZIMO “smart stopping” feature (requires at least 1000uF to be effective)
- Lowers decoder operating temperature especially with low-impedance motors (at least 100uF)
- when RailCom is used:
  Eliminates the energy loss created by the “RailCom gap”,
  Reduces motor noise caused by RailCom,
  Improves the quality (= legibility) of the RailCom signal
  (at least 100uF)

The required voltage strength of the capacitor is given by the track voltage; 25V is suitable for all cases. Smaller 16V capacitors should only be used if track voltage will never be higher than that.

A simple connection between the decoder and ground is not advisable because of undesired side effects: Software updates, sound installation, programming in Service Mode and the ZIMO loco number identification feature can be negatively influenced or may not work at all.

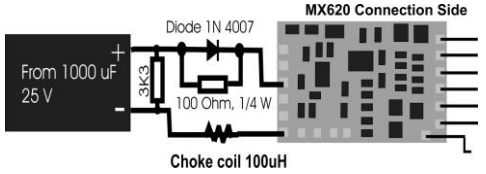
Among the decoders described in this manual, only the **MX631, MX632** and the **sound decoder MX642** have the necessary components on board so that capacitors can be connected directly without the need of additional external components.

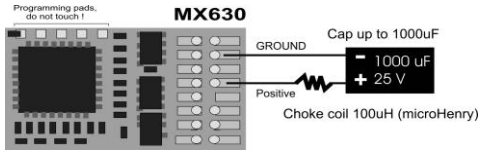


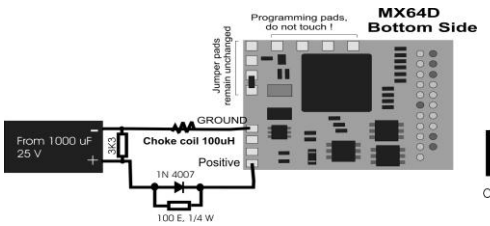
This decoder comes with a small capacitor (220uF) to get you acquainted with the energy storage technique. Larger capacitors of up to 10’000uF are recommended and are readily available (also from ZIMO if necessary) and can simply be connected in parallel. A series of gold caps can also be used (i.e. 8 gold caps at 2.5V each connected in series).

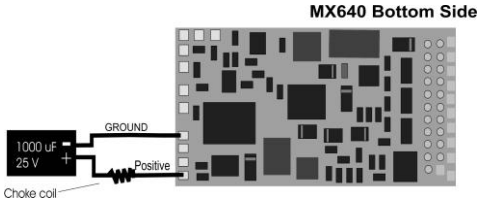
All other decoders such as the **MX620, MX630** and **MX640** require additional external components to be added by the user in order to prevent above mentioned side effects.

For capacitor sizes of up to 220uF (possibly even up to 470uF), adding a choke coil (100mH / 100mA, also available form ZIMO) is sufficient to enable decoder firmware updates with the MXDECUP update module and ZIMO’s loco number identification.





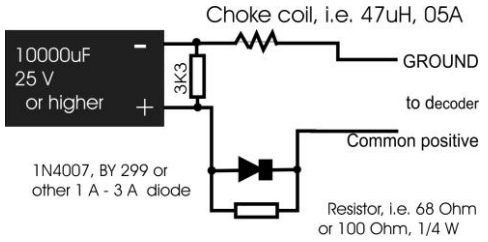




If larger capacitors are used, which is actually a good idea, the circuitry should be expanded. The condenser in these cases is recharged through a 100 ohm resistor. This is necessary so that the command station doesn’t interpret the high in-rush current during boot-up, caused by charging up those capacitors, as a short circuit when a large number of loco’s so equipped are on the layout. The diode (e.g. 1N4007) is required to bypass the resistor when power is needed by the decoder.

NOTE: If signal stops by “asymmetrical DCC signal” (= Lenz ABC, implemented in ZIMO decoders early 2005) is employed, the resistor-diode combination is necessary in any case (even when using small capacitors) to ensure that the decoder can detect the asymmetry of the signal!

Please use the schematic below as a guide when building your own energy storage circuit. The resistor shown (100 Ohm, ¼ W) and the diode (1N4007) are required for the same reasons mentioned above.



The 3300 Ohm resistor shown in the drawing above (not absolutely necessary) serves the following purpose:
Even though a large capacitor supplies the motor and lights for just a few tenths of a second (1000uF) or a few seconds (e.g. 4700uF), the remaining energy keeps the decoder memory alive for several minutes, al-

though the voltage dropped below the level required to drive the motor and/or lights. This is sometimes a rather undesired effect. For example: If a running loco is taken from the track and the speed then set to zero, the loco would briefly run at the previous speed when it is set back on the track within a minute or so. Using the above-mentioned resistor would erase the memory after just a few seconds.

ZIMO offers a collection of components under the part number **SPEIKOMP** that are needed when building a do-it-yourself energy module for ZIMO MX620, MX630 and MX640 decoders. The set contains a diode, resistors, choke coil and a few capacitors (larger capacitors supplied by the user can and should be used if sufficient space is available inside the engine).

Smart stop management on "dead" track sections

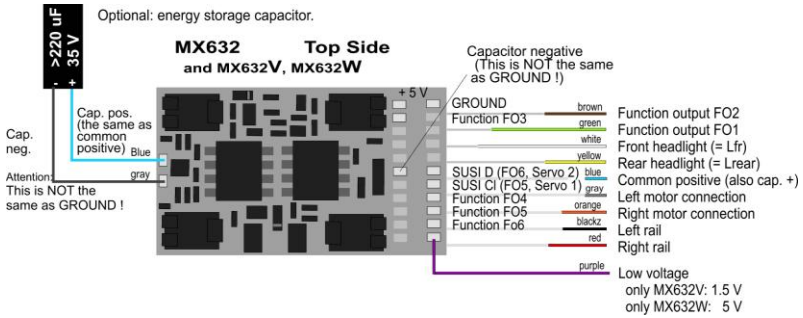
If power to the decoder is interrupted due to dirty rails, wheels or insulated frogs, the decoder automatically keeps the engine going even if the engine is supposed to come to a stop. The engine is allowed to come to a full stop as soon as power to the decoder is restored. With the engine stopped the decoder tests again for track power and if needed moves the engine another very short distance until track power again is restored. Power for the engine during "smart stopping" is of course coming from the capacitor. This prevents a situation where an engine is parked on dirty track and later can't drive away, due to normal internal power loss of capacitors over time.

MX632V, MX632W, MX632VD, MX632WD - the special MX632 design with built-in low voltage supply

These decoders contain an efficient **1.5V or 5V regulator,** which can be directly connected to low voltage bulbs. The low voltage is available at the purple wire and is used for the corresponding loads in place of the "common positive" (blue) wire.

MX632V and MX632VD (1.5V) decoders facilitate the installation considerably especially in high quality brass models (which are often equipped with such bulbs), because it eliminates the installation of an external voltage regulator (that often requires some sort of heat dissipation).

MX632W and MX632WD (5V) decoders are primarily meant for large scale engines (i.e. LGB) that are often equipped with 5V bulbs. The 5V supply can also be used to drive servos, which eliminates the need for an external voltage regulator.



MX640, MX642 – connecting smoke generators of steam and diesel engines:

With a "Seuthe" 18V smoke generator as example:

In addition to a simple ON/OFF function with a function output of your choice, the MX640/MX642 is also capable to adapt the smoke volume to the load (almost no smoke at standstill, little smoke at cruising, heavy smoke at start-up etc.).

This requires the smoke generator to be connected to one of the function outputs FO1 to FO6 and the selected output must be programmed with the associated effect CV (with CV #127 for FO1, CV #128 fir FO2 etc.) for the desired effect; in this case for load dependent smoke for steam engines (effect code "72") or load dependent smoke for diesels (effect code "80").

EXAMPLE: - Steam engine, smoke generator connected to function output FO5: CV #131 = 72.

The selected function output is further defined by CV #137, 138 and 139 ("Definition of smoke generator characteristic"). These CV's must be programmed with appropriate values otherwise the smoke generator will not produce any smoke.

EXAMPLE: - Typical characteristic for a track voltage set around 20V with above smoke generator:

CV #137 = 70…90: little smoke at standstill.

CV #138 = 200: The smoke generator is limited to about 80% of its maximum capacity beginning with speed step 1 (lowest speed step), which produces relative heavy smoke.

CV #139 = 255: The smoke generator is driven to its maximum, which results in thick smoke under heavy acceleration.

Steam chuff synchronized or typical diesel smoke with fan-controlled smoke generators:

Without additional electronic components, the MX640/MX642 can produce steam puffs that are synchronized with the chuff sound or load dependent diesel smoke (i.e. diesel engine smoke at start-up, controlled by the sound project).

The heating element of the smoke generator is connected – as in the example above with the "Seuthe" generator – on FO1…FO6 and configured with the appropriate CV for the desired effect (i.e. "72" for steam or "80" for diesel).

The fan is connected to the function output FO4; the other wire of the fan motor often requires a low voltage (check with the manufacturer) and is therefore connected to an external voltage regulator or to the 5V supply of the decoder, if 5V is suitable for the fan motor.

The CV's must be programmed as follows:

CV #137, #138, #139 = 60, 90, 120 respectively: (IMPORTANT) If the heating element cannot operate at full track voltage, the voltage at the function output must be limited, which is done with suitable values in CV #137, 138 and 139.

CV #133 = 1: (IMPORTANT) this configures output FO4 as a fan output.

CV #353 = …i.e. 10: shuts the smoke generator off automatically to prevent overheating. In this example (10) after 250 seconds).

CV #351, #352 = …: Only for diesel engines when effect code "80" is selected in the applicable CV for FO1…FO6. This defines the fan speed (voltage) for start-up (maximum smoke) and cruising (default: medium smoke); see CV table.

CV #355 =…: For steam and diesel engines. Defines the fan speed (voltage) at standstill (usually for very little smoke output).

9. MX631C, MX632C, MX640C, MX642C for C-Sinus / SoftDrive-Sinus

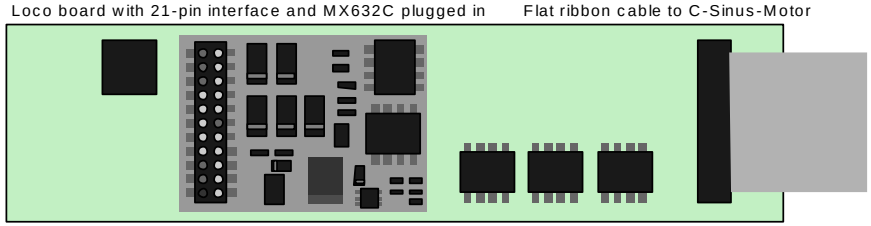
The **MX631C, MX632C, MX640C** and **MX642C** are made especially for Märklin and Trix engines with **C-Sinus motors** provided the locomotive comes with a 21-pin interface. The decoder also **supplies** the necessary **5V** the C-Sinus board needs to operate (which „normal“ decoders are not capable of!).

The C-type decoder can be used independent of the type of motor for Märklin, Trix and Märklin compatible engines, which cannot process normal functions on function output FO3 and FO4 but require logic level outputs instead.

The C-type decoders differ from the normal 21-pin plug (MX631D, MX632D, MX640D, MX642D) in the use of output pins FO3 and FO4. The D version has normal (amplified) outputs on these pins while the C version has logic level outputs. These logic level outputs supply the needed 5V for activating the C-Sinus or Softdrive loco board or for the switchover of front to rear power pick-up, which is installed in many vehicles.

The MX632C (or MX640C) is plugged into the pins of the loco board with the top side of the decoder pointing up, whereby the pins are being pushed through the decoder board in order to make contact with the decoder socket. The position is given by the loco board and is also keyed by the missing pin 11 (on the loco board) and missing hole in the same location on the decoder board.

The picture below shows a sample layout; the loco board may however vary from case to case.



Before plugging in the decoder, check the C-Sinus board whether it contains **0-Ohm resistors; see CAUTION on the next page!!**

MX632C and MX640C are “normal” decoders for “normal” motors, except for the function outputs FO3 and FO4, which can be programmed to operate C-Sinus motors by programming: **CV #145 = 10** if the engine originally came with a Märklin/Trix decoder or **CV #145 = 12** if the original decoder was from ESU (recognizable by a blue circuit board).

With the help of CV #145 the decoder can also be configured for some special versions, which becomes necessary due to different decoder interface layouts on the part of Märklin/Trix, see CV table!

An MX64D equipped C-Sinus locomotive can be operated in the **NMRA-DCC-data format** as well as the **MOTOROLA protocol** but not in analog mode (DC)!

No motor regulation, known as BEMF, takes place when the decoder operates in the C-Sinus mode, since the motor tries to keep the target speed precisely in all situations. The relevant configuration variables, among them CV #9, #56 and #58, are without effect!

CAUTION:

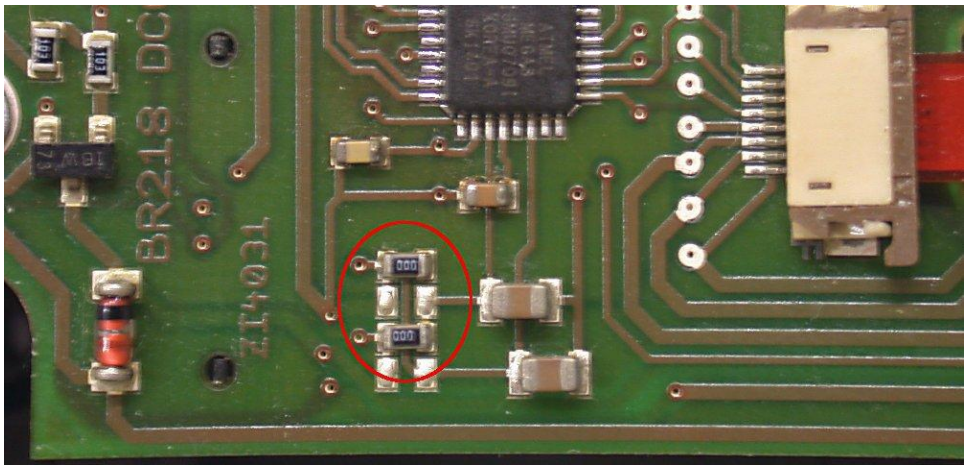
Unfortunately, Märklin/Trix has played a “dirty trick” (although probably not on purpose): Beginning with a specific model or past a certain date, the protective resistors on the loco board input side have been omitted, or more precisely, instead of the 100kO resistors useless **0 Ohm resistors** are being installed. The resulting voltage is too high for the loco board which will not only destroy the board but can also damage the decoder, unless the decoder has been switched to the C-Sinus mode beforehand with CV #145 = 10 or 12.

But even if CV #145 = 10 or 12 is set first, there is no guarantee that the loco board with 0 Ohm resistors will survive in the long run (even though there is no visible problem at the moment)!

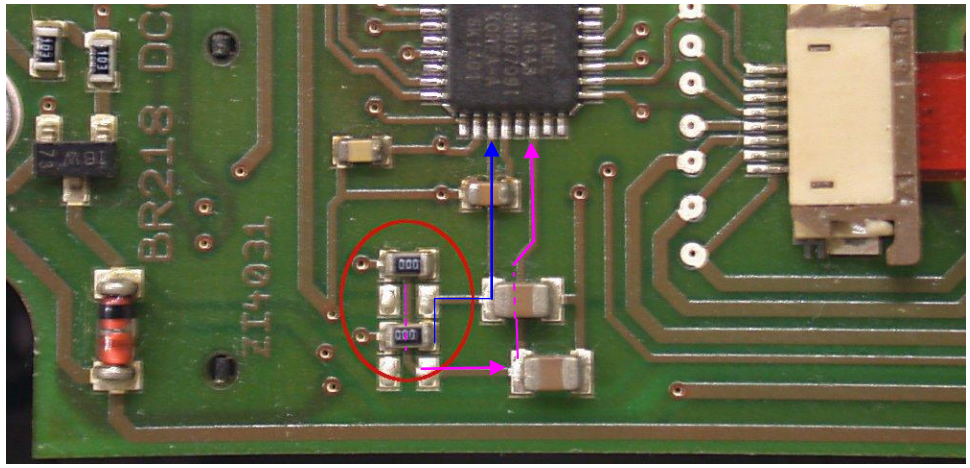
Background information: Although the 21-pin interface in Märklin and Trix locomotives is virtually identical to the standardized NMRA-DCC 21-pin interface, Märklin keeps modifying it whenever the need arises (several versions, “misapplication” of function outputs for motor activation and now the mentioned electrical input changes); their own brand decoder is the only one that is being taken into account through all this. The installation of other brand decoders is, to be sure, undesired…

CORRECTIVE MEASURE: The **MX632C or MX642C must not** be installed if **zero-ohm resistors** (markings **“000”**) are found on the loco board in place of actual protective resistors (markings “104”). It is imperative that these are being replaced with **100KO resistors (“104”)** before installing the decoder. Relevant ZIMO decoders will be shipped with the necessary resistors.

Below is a picture showing a loco board with the useless (“000”) resistors; in such cases it is not allowed to plug in a MX64D / MX64DM decoder!

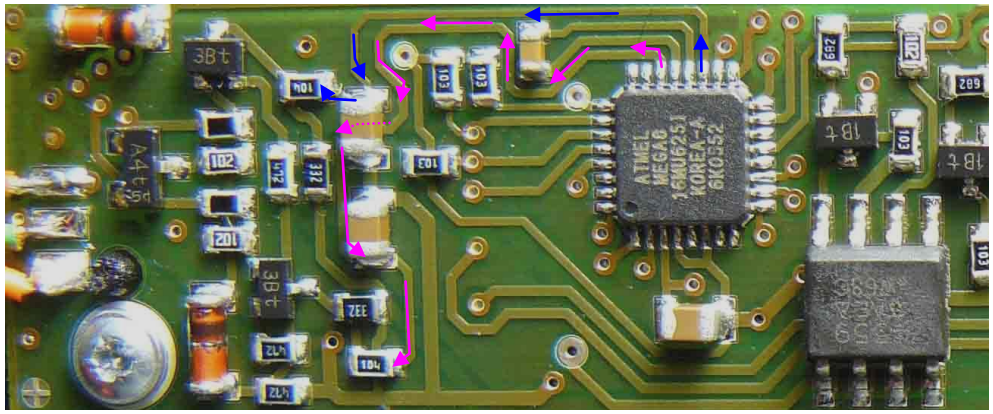


Due to the many different C-Sinus boards that have been produced it is impossible for us to provide precise information about the location of these resistors on each board. Because the resistors may be mounted in different locations on the board in your engine, we would suggest that you find them by following the traces. First study the picture below. The blue and pink arrows are pointing out the traces that connect these resistors with the processor. Note the processor pins those tracers are leading to.



Next find the same pins on the processor of your board and follow those traces carefully. They should lead to resistors marked as either “104” or as “000” (see below). If they are “104” proceed with the decoder installation. If they are marked as “000” they have to be replaced before the decoder is installed.

This picture shows a different Märklin C-Sinus board and how the resistors in question can be located by following the traces back from the controller pins.



CAUTION II – Disclaimer of Liability

Märklin/Trix obviously is not concerned about compatibility of their locomotives with third-party products. The interfaces are being changed often and without notice. ZIMO cannot guarantee that the information given in this manual regarding connection and programming/operating procedures are correct in all instances and cannot assume liability for damages to loco boards and/or decoders as a result of such circumstances.

10. ZIMO decoders and competitor systems

All Zimo decoders comply with NMRA standards and recommended practices and can be used on layouts with other brands of NMRA compliant systems.

What most systems of other manufacturers have in common, in contrast to ZIMO systems, is that track power is not stabilized or only partly stabilized and often relatively weak (in regards to voltage but also amperage). This can lead to uneven speeds and/or limited top speed because Zimo decoders are of course programmed by default to operate on stabilized and regulated track power from a Zimo command station of up to 24V.

It is recommended in such cases to:

- change **CV #57** (reference voltage) from ”0” (automatic regulation based on given track voltage) to a fixed voltage. For example: “140” for a DCC system with a typical track voltage of 16 - 18V. In this case 14V will be used as reference, which leaves a certain safety margin during voltage drops.

Note that the MX62 always uses a fixed voltage.

ZIMO decoder with Lenz “DIGITAL plus” from software version 2.0

This system uses 28 speed steps beginning with version 2.0 and 128 steps with version 3.0 and up. It also programs in direct mode according to NMRA DCC standards and is therefore fully compatible with Zimo decoders.

All Zimo decoders are set to 28 speed steps by default. Make sure the system is also set to 28 steps for the decoder address in question. Incompatibility will be the result if the speed steps between decoder and system do not agree with each other; which is most often noticed by non working headlights. It would only make sense to switch the system from 14 steps to 28 or 128 speed steps rather then setting the decoder back to 14 steps, which would result in unnecessary poor drivability.

All configuration variables are accessible; see the manual for the cab in question. The address is located in the registry’s position **#**1.

The configuration variables #49 to #54 will have no effect, since the signal controlled speed influence is only supported by a Zimo system.

ZIMO decoder with ROCO Lokmaus-2

Although the Lokmaus-2 allows CV programming, its display is limited to two digits only and therefore limits the number of CV’s and their values to 99.

Zimo decoders offer a special pseudo-programming feature with CV #7 (that normally stores the software version number) to allow unrestricted programming. It is called pseudo-programming because the permanently stored value in CV #7 cannot be overwritten but rather holds a temporary value that allows the Lokmouse2 to be used for expanded programming capabilities (see CV table); the engine must not be running during the programming procedure!

Example:

To enter a value of 160 (which is not possible with a Lokmouse-2 because value is >99) to CV #5 (max. speed) proceed as follows:

First program CV #7 to 1, followed immediately by setting CV #5 to 60. No power interruptions between those steps are allowed.

Explanation: The value 1 in CV #7 actually 01 (tens digit=0 and ones digit=1) causes the decoder to add 100 to the CV **value** that will be entered in the next programming step. Therefore, a value of 60 entered to CV #5 with the Lokmouse2 is stored as 160!

Example:

To program CV #122 (exponential deceleration), for example, with a value of 25 do the following:

Again, go to CV #7 and enter a value of 10, then go to CV #22 and enter a value of 25.

Explanation: CV #7 = 10. The 1 in the tens digit causes the decoder to add 100 to the CV **address** in the following programming step. As a result, CV #122 will be programmed instead of CV #22!

ZIMO decoder with DIGITRAX Chief

No problems expected with this system!

The Digitrax system usually operates at 28 or 128 speed steps. If for some reason the headlights don't work, confirm that indeed the system and the decoder are set to the same number of speed steps and if necessary, change the speed steps at your cab to 28 or 128 steps.

There have been some malfunctions in the past during system boot up. For example: locomotives would not start unless the power to the decoder was interrupted briefly (by tipping the locomotive off one rail). It is not quite clear whether the causes have ever been fully identified and eliminated; it may also depend on the command station model (year of manufacture) and the software version in the Digitrax command station.

11. Special - CV - Sets

This feature allows easy programming of a group of predefined values to the decoder's appropriate configuration variables. Such "CV sets" may be part of the decoder software at delivery (as listed and described in the table below) or defined by the user.

Typical applications are: Railroad specific lighting, motor specific data for perfect slow speed behavior, prototypical loco specific acceleration, easy switching between a passenger and goods train or single loco versus consist.

Programming of such CV-sets (either supplied or self defined) is accomplished by a **pseudo-programming sequence of CV #8 in Service Mode programming on the programming track** (CV #8 contains "145", the manufacturer code for ZIMO and cannot really be overwritten, therefore the term pseudo-programming).

At the time this was written (July 2009) there are no ready-made CV sets available for the MX620, MX630 or MX640, only for the MX63 and MX64.

More such sets and the possibilities for self-definition are planned for a future software version.

On the other hand, there are CV settings for the MX640C within SOUND projects, which will be handled similarly during a HARD RESET.

HARD RESETS:

CV #8 = 8 as hard reset will reset all configuration variables to default values according to the CV-table.

CV #8 = 0 as well as the "traditional" ZIMO hard reset – known from ZIMO cabs (MX2, MX21, MX31… by programming a decoder to address 0), will reset a decoder to the last defined "Special CV Set" or to the stored sound project.

12. Converting binary to decimal

If, according to the CV table, a CV calls for setting individual bits (which is the case with CV #29, 112 and 124, for example) proceed as follows:

Each bit has a specific value:

Bit 0 = 1
Bit 1 = 2
Bit 2 = 4
Bit 3 = 8
Bit 4 = 16
Bit 5 = 32
Bit 6 = 64
Bit 7 = 128

The decimal values of all bits of a CV that are supposed to be set are added up (Bit... = 1 in the CV- table). All other bits (Bit....= 0) are ignored. Note that bits are numbered from right to left.

Example:

Bit 0, 2, 4 and 5 are supposed to be set (Bit...=1); but not the others 1, 3, 6 and 7 (Bit…=0).

This results in a bit-set of 00110101and a decimal value of:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	1	1	0	1	0	1

0 + 0 + 32 + 16 + 0 + 4 + 0 + 1 = 53 (decimal value)

The calculation in reverse:

A trial and error method is used to determine individual bits from a decimal figure: start with the largest value. If a number is larger or equal to 128 then Bit 7 = 1. If the remaining number is larger or equal to 64 then Bit 6 = 1 and so on.

Example:
The decimal figure of 53 is neither larger or equal to 128, nor larger/equal to 64 but is larger than 32. Therefore Bit 7 = 0, Bit 6 = 0 but Bit 5 = 1; the rest of 21 (53 - 32 = 21) is larger than 16 (Bit 4 = 1), the remaining 5 (21 - 16 = 5) is not larger than 8 but is larger than 4 (Bit 3 = 0, Bit 2 = 1), and finally 1 (5 - 4 = 1) is not larger/equal to 2 but is equal to 1 (Bit 1 = 0, Bit 0 = 1).

13. Operating with Märklin MOTOROLA systems

Using the MOTOROLA mode only makes sense if the system used is not capable of operating in the DCC format. DCC is substantially more powerful and should to be the preferred protocol with a multi-protocol system.

The MOTOROLA data format is recognized automatically by the decoder.

Addressing and CV programming is possible with the current Mobile Station as well as the Märklin 6021 command station. The update method in the first case is automated and easy to do (see operating manual of the Mobile Station); with older systems however it is very tedious (because this system doesn't provide much help):

Programming CV's with Märklin 6021 central unit:

Start the programming mode by:

1. selecting the address of the engine to be programmed

2. press the "STOP" key at the central unit and wait a few seconds

3. Crank the speed regulator past the left stop and hold (direction switch)

4. press the "START" key

5. release the speed regulator

The front headlight of the engine should now be flashing once per second indicating that the decoder is in the programming mode.

You can now choose between two programming modes:

1. Short mode: programming is limited to CV's 1 – 79 and a value range from 0 – 79

2. Long mode: the values to be used in each case are split and transmitted in two steps (CV 1-799, value range 0-255)

The short mode is always active after entering the programming mode.

To change to the long mode write 80 to CV #80 (enter address 80 and change direction twice to change to the long mode).

Short mode:

Enter the CV to be programmed in the central unit as an address and briefly operate the direction switch.

The headlight now quickly flashes twice.

Now enter the desired value to the selected CV and again operate the direction switch briefly (enter 80 for a value of 0).

The headlight flashes once indicating that you can program the next CV or end the programming by turning power to the track off.

Long mode:

Remember to set address 80 to a value of 0!

Enter the hundreds and tens digit in the central unit of the CV you want to program (for example: for CV 123 enter 12) and operate the direction switch.

The headlight now quickly flashes twice.

Now enter the ones digit of the same CV (for example: for CV 123 enter 03) and operate the direction switch again.

The headlight briefly flashes 3 times.

Enter the hundreds and tens digit in the central unit of the value you want to program and operate the direction switch.

The headlight briefly flashes 4 times.

Now enter the ones digit of the value and operate the direction switch again.

Again, the headlight flashes once indicating that you can program the next CV or end the programming by turning power to the track off.

14. DC - Analog Operation

ZIMO decoders switch automatically to analog when DC voltage is present and CV #29 is set accordingly (Bit 2 = 1, which is the default setting).

Operation is possible with diverse power packs:

- "normal" DC throttles, with poor or no ripple control
- smooth power from a power supply unit
- PWM throttles such as the Roco analog mouse.

The following CV adjustments are possible for analog operation:

⇨ CV #14, Bit 7 = 0: Analog operation without motor regulation

Bit 7 = 1: Analog operation with motor regulation (is of particular value with sound; for example: that the chuff frequency fits the wheel movements)

⇨ CV #14, Bit 6 = 0: Analog operation with momentum as per CV #3 and 4.

Bit 6 = 1: Analog operation without momentum.

⇨ CV #13, CV #14: Select function outputs that should be ON in analog mode.

15. AC - Analog Operation

ATTENTION: **Only the decoders of the MX630, MX631, MX632 and MX642 family** have the dielectric strength to withstand the overvoltage pulses required for direction change in the classic AC operation!

16. ZIMO Decoder Software Update

… and Sound Installation

All current ZIMO decoders can be updated with new firmware by the end user with the help of the update module MXDECUP or MXDECUPU (with USB converter), the MX31ZL or with the new MX10 command station.
New software versions can be downloaded at no charge from ZIMO's web site: www.zimo.at (under "UP-DATE") and add new features, improvements and corrections to the decoder firmware.

First download a so-called **"Decoder Software Collection File"** from the UPDATE pages at the zimo web site: www.zimo.at. , usually the one marked ***aktuell*** (the last line in the update list). It contains the latest firmware **for all ZIMO decoders.** The correct file for the decoder at hand will be automatically selected during the update process.

The update itself can be done in different ways:

⇨ With the **decoder update module MXDECUP** via a **computer,**
using the serial port with the MXDECUP or
the USB-serial convertor with the MXDECUPU.

The MXDECUP(U) is connected with the computer, power supply and a section of track. Set the engine onto this "update" track. Start the program **"ZIMO Rail Center" (ZIRC)** on the computer. ZIRC selects the proper software from the "decoder software collection file" and installs it in to the decoder when prompted to do so.

The **"ZIMO Sound Program" (ZSP)** can also be used instead of ZIRC. As the name implies, this program is used for editing and installing sound files to ZIMO sound decoders but can also be used to update decoder firmware in all ZIMO decoders (sound, non-sound and accessory decoders).

The programs **ZIRC** and **ZSP** can also be downloaded at no charge from www.zimo.at

⇨ With the **system cab MX31ZL** and **a computer**
using the USB interface of the MX31ZL.

The MX31ZL is used in this case just like an MXDECUP (see above) and the procedure is also controlled by the PC with **ZIRC** or **ZSP.**

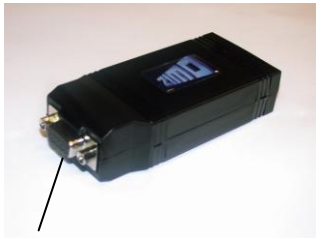
This is of advantage especially to the ZIMO system user, since the cost of a MX31ZL is about the same as a MX31 with MXDECUPU. The MX31ZL can also be used for updates without a computer (see below) and most of all; it is also a complete DCC system.

⇨ From the **USB stick** using a **MX31ZL,**

In this case, the "decoder software collection file" is first loaded onto the USB stick. Plug the stick to the MX31ZL (with the help of the adapter that comes with the MX31ZL) and use the MX31ZL to proceed with updating as many decoders as desired (but of course, only ZIMO decoders). This process doesn't require a computer and no direct connection to one (see MX31ZL instruction manual).

⇨ From the **USB stick** using a **MX10 command station,**

similar procedure as with MX31ZL; more information will follow when the MX10 becomes available.



RS-232 – SUBD-9-socket

To "update track", to power supply control-LED's behind socket

MX31ZL with USB stick

The update module MXDECUP(U) is shipped with a power supply, a RS-232 cable and a USB converter (with MXDECUPU).

Implementation and operation:

A **section of track** is used as "update track" and connected to the 2-pin screw terminal of the MXDECUP(U). Set the engine with the decoder that is to be updated on the track. The decoder can of course be connected with its red and black wires directly to the track connector of the module instead.

In contrast to the CV-programming procedure, the update procedure with the corresponding acknowledgment does not depend on the load connected to the decoder (such loads are neither necessary nor hindering).

Please note...

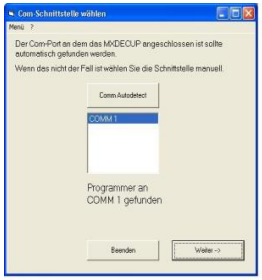
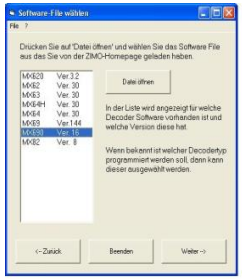
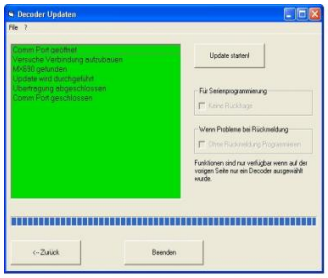
Electrical loads in the loco that are not connected to the decoder may potentially present a problem (since the decoder cannot turn the load off), because of the 150mA power limit of the MXDECUP. The update process may fail in such cases and the relevant loads must first be removed or remove the decoder from the locomotive.

Make sure the choke coil recommended in chapter 17 is actually installed, if **external buffer circuits** (capacitors) are used to maintain power to the decoder on dirty track sections. Acknowledgments from the decoder to the MXDECUP are otherwise not possible.
Although there is a "blind update option" available in ZSP that operates without acknowledgements, its use is not really recommended.

Now, plug-in the ***power supply*** at the MXDECUP. The green LED, visible in the connector recess, should now be lit. Next, connect the MXDECUP with the ***computer*** using either the RS-232 cable or the RS-232 cable with USB converter. The green LED now turns off again (both LED's are dark).

The actual update process is started and controlled with the ***"ZIMO Sound Programmer"*** (***ZSP***, always use the latest version:

We can't offer a detailed description here regarding the update process; since ZST will often be modified and expanded (this software performs a number of other tasks within the ZIMO system). In any case, there is a button on the original ZST main page named: "start with MXDECUP online". English speaking users should start the ZST extension, which opens the COM PORT selection page. All further steps, such as selecting the right COM port, the update software file (one file contains all current software versions for all ZIMO decoders), starting, control and terminating the update process are self-explanatory on screen or can be obtained from the help file.

The two LED's at the MXDECUP are flickering very rapidly during the update process (red and green). This indicates that data packets are sent to and acknowledgments received from the decoder. The LED's remain dark once the update process is finished.

If for any reason the update is unsuccessful (indicated by ZST), another update can be started after a waiting period of 5 seconds!