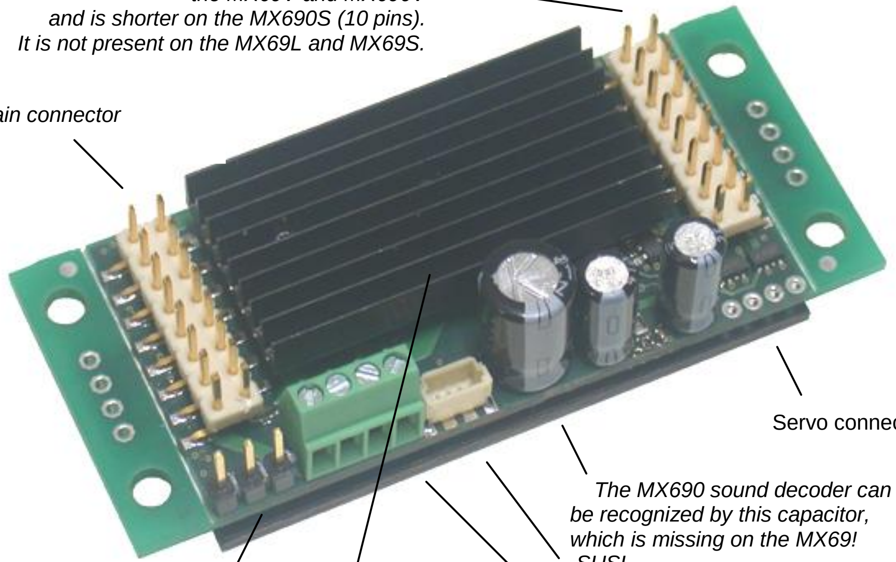
INSTRUCTION MANUAL



LARGE-SCALE - DECODER

MX69L, MX69S, MX69V

LARGE-SCALE - SOUND - DECODER

MX690S, MX690V

+ LARGE SCALE DECODER WITH ENHANCEMENT BOARDS

EDITION

2004 11 20
2004 12 01
2004 12 20
2005 01 25 SW -Version 6: Servo activation
2005 05 15
2005 06 05
2005 07 20 SW-Vers 8: ABC, virtual cam sensor, mph-regulatio
2005 08 18 SW-Version 9: Const. stopping distance, several co
2006 01 03 SW-Version 10: Partly automated motor regulation, (
etc.
2006 05 15 SW-Version 13: Improved motor control, ABC, functi
2006 06 20 Live steam operation, function mapping
2006 08 10 First common instruction manual for MX69 and M

2006 08 20
2006 09 10
2006 09 25
First sound program addition 2006 11 18
2007 01 30
SW-Version 15: first Diesel edition 2007 01 30
New function mapping description 2007 06 21
Decoder with enhancement board 2007 08 10
SW-Version 17 ---- 2007 11 01
2008 01 30
2008 02 15
SW-Version 18 --- 2008 04 04
MX69, 690: SW-Version 20 ---- 2008 07 15
SW-Version 20.104 2008 10 18
2008 11 16
2009 02 20
SW-Version 25.1 --- 2009 08 01
SW-Version 26.0 --- 2009 09 26
CV amendments (sound, chuff frequency, fan) --- 2010 03 01

Included with the decoder: MX69x, .5m flat ribbon cable with unattached connector (use a vice to mount connector to cable); some 3K3 SMD resistors for setting the desired low voltage (MX69V, MX690V only).

Not included with every decoder is this instruction manual; some will be included at no extra cost (about 1 for every 10 decoders) to dealers. Order extra manuals separately (minimum charges may apply) or download manual (PDF) 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 from CV #7.

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.

Software updates are available at no charge if performed by the end user (except for the purchase of a programming module), see chapter 12; 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 service see www.zimo.at !

1. Overview

The MX69 - and MX690 - decoders are for the installation in O, 1, 2 and similar large scale engines (LGB, among others). They are equally suited for locos with standard as well as core less motors (Faulhaber, Maxxon, Escap and others).

The MX69/MX690 operates according to the standardized **NMRA-DCC data format** and can therefore be used within a ZIMO digital system as well as DCC systems of other manufacturers, including Märklin systems under the **MOTOROLA protocol.**

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MX69L	**Economy version,** slightly less powerful when compared to the standard MX69S due to omitted heat sink, only 4 function outputs and no screw terminals (push-in plug only). Identical in functionality to the MX69S (same software). ATTENTION: Requires special care during installation because of unprotected circuit board (the heat sinks on the other decoder type's act as a protective shield on both sides). TYPICAL APPLICATION: O-gauge locos or as replacement for original equipment decoder of LGB locos (plugged together with adapter board).
MX69S	The **Standard MX69, 3 A** total output, **8 function** outputs, connection and control of external power source MXSPEIG possible, 4 special outputs for 4 servos. TYPICAL APPLICATION: all engines that don't require any of the special features of the MX69V.
MX69V	**Top-of-the-line** MX69, up to **5 A** output (if heat transfer to external metal surface is provided), **14 function outputs,** 3 switch inputs (reed switches or similar), low voltage output (6.8V default setting, removal of a resistor drops the voltage to 1.5V) for bulbs and other low voltage equipment, in/outputs for infrared communication with stationary local hardware (most often a ZIMO accessory decoder such as the MX82). TYPICAL APPLICATION: Powerful, current consuming engines or engines equipped with lots of functions, with low voltage bulbs and/or sound modules.
MX690S	Identical to MX69S but with **Sound** added, that is **3 A** motor output, 8 function outputs, 4 special servo outputs etc.
MX690V	Identical to MX69V but with **Sound** added, that is **5 A** motor output (if heat transfer to external metal surface is provided), 14 function outputs, 3 switch inputs, low voltage for functions etc.

For versions with enhancement board see chapter "MX69, MX690 with enhancement board"

2. Technical Information

The MX69x (MX690x) is built on a double layer circuit board. With the exception of the MX69L, all versions are covered with a heat sink on both sides. A 4-pin screw terminal is provided for connections to the track and motor and a 16-pin socket for function outputs. An additional 16-pin socket for further function outputs, special outputs and switch inputs (also for the speaker on the MX690) is provided on the MX69V (MX690V).

TECHNICAL DATA **DRIVING and FUNCTIONS**

Track voltage .... 12 - 24 V***)
Maximum continuous motor output = maximum continuous total output MX69L .... 2 A
MX69S (MX690S) .... 3 A
MX69V (MX690V) .... 4 - 5 A *)
Maximum peak current (Motor only or total) .... 8 A

Number of function outputs……………...MX69L, MX69S, MX690S: 8…..MX69V, MX690V: 14
Maximum continuous total output per function group**) .... 1.5 A
Low voltage range for function outputs (MX69V, MX690V only)………………………1.5 to 15V
Maximum continuous output at low voltage (MX69V, MX690V) .... 0.8 A
Operating temperature .... - 20°C to 100°C
Dimensions (L x W x H including sockets) 2.16 x 1.02 x @.63in (55 x 26 x ca.16 mm)
The MX69L is .55in (14 mm) high, the MX69S .63in (16 mm) and the MX69V .70in (18 mm).
The length given is minus the break-away mounting brackets, which increase the length by 2 x ¼ in.

*) Continuous full load (5 A) of the MX69V requires direct contact to metal parts for heat transfer.

**) The short-circuit protection controls the maximum current per function group. The MX69L and MX69S have one, the MX69V two such function groups.
The soft-start option (see CV #125="52" etc.) can be utilized to prevent possible a cold start-up problems with incandescent light bulbs (peak current of a cold light bulbs may cause decoder to turn off function group)!

***) When used with the DiMAX command station (Massoth): The DiMAX 1200Z, according to its instruction manual, should deliver 24V to the track (which would only by marginally higher than specified by the DCC standard). In reality though (last checked in 2006), the unit powers the track with a varying voltage heavily dependent on load, starting with 30V at idle (depending on line voltage!) all the way down to 20V under heavy load. The ZIMO large-scale decoders (most often….) are able to deal with the 30V (in contrast to many other brand decoders); it is better though to lower the track voltage to an allowable level with a constant load (@ 0.5A).

TECHNICAL DATA **SOUND (MX690 only)**

Storage capacity for sound samples…………………………………………………………16 Mbit
Sample rate, adapting to sound sample characteristic……………………...……......11 or 22 kHz
Number of independent playable sound channels……………………….…..…………………..4
Amplified output…………………………………………………………………………...……...Sinus 1.1W
Impedance of speakers……………………………………………...………………………8 Ohm

OVERLOAD PROTECTION:

The motor and function outputs of the ZIMO large-scale decoders are designed with lots of reserve capacities and are additionally protected against excessive current draw and short circuits. The affected output is turned off once an overload situation exists and subsequent load tests are performed by the decoder, which is often recognized as flashing headlights.

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 after 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. Since the capacity and speed of such circuits is limited, the track voltage should not be selected unnecessarily high; that is not higher than recommended for the rolling stock in question. The full adjustable range of a Zimo command station (up to 24V) should only be utilized in special cases. Although ZIMO decoders are suitable for 24V operation, that may not be the case when interacting with some other equipment.*

THERMAL PROTECTION:

All ZIMO decoders have the ability to measure their own operating temperature. Power to the motor will be turned off once that temperature exceeds 100^{0}C. The headlights start flashing rapidly, at about 10 Hz, to make this state visible to the operator. Motor control will resume automatically after a drop in temperature of about 20^{0}C, typically in 30 to 60 seconds.

As is the case with all modern ZIMO decoders:

D O – I T – Y O U R S E L F S O F T W A R E U P D A T E

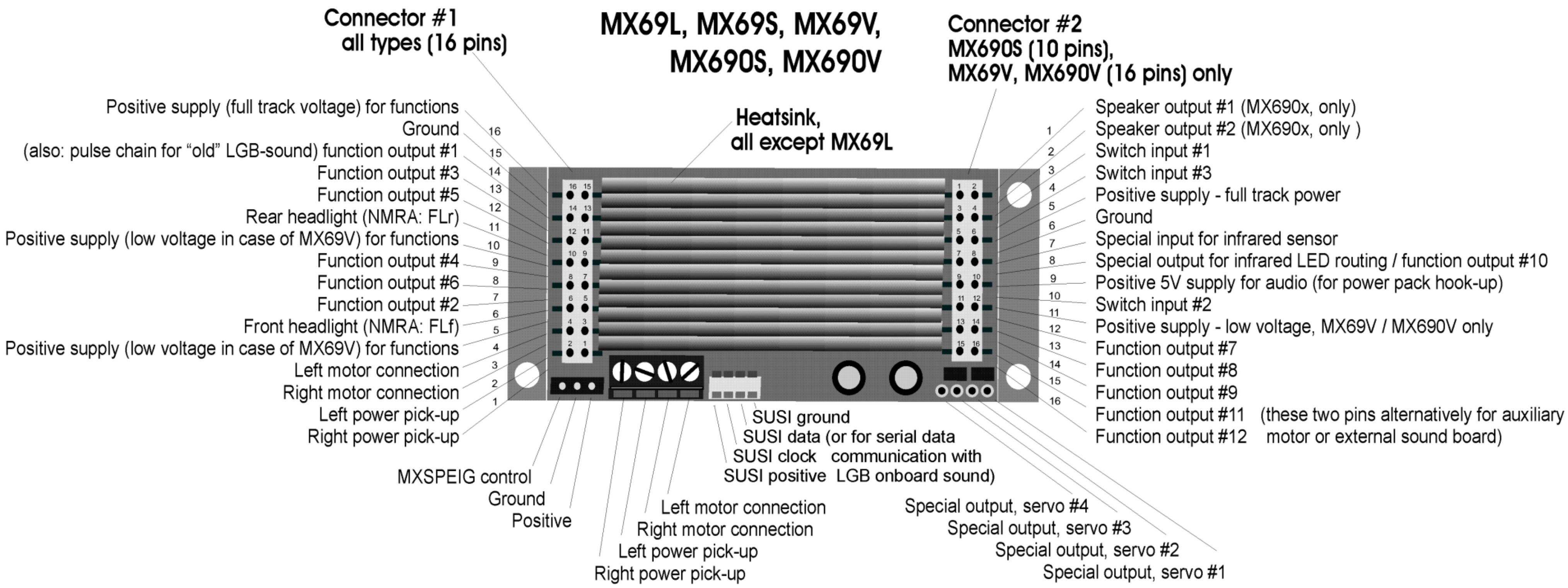
ZIMO DCC decoder firmware can be updated by the user. This requires a device with update function (ZIMO decoder update module **MXDECUP,** system cab **MX31ZL** or command station **MX10**). The update itself is carried out via a USB stick / SD card (MX31ZL / MX10) or via a PC with the program “ZIMO Sound Programmer” (**ZSP**) or “ZIMO Rail Center” (**ZIRC**).

There is **no need to remove the decoder**; the loco is set on the update-track (which is connected to the update module) as is and the whole update procedure is handled by the PC.

NOTE: Engine accessories that are not controlled by the decoder may interfere with the update; the same goes for power back-up capacitors if the steps mentioned in the chapter “Installation” are not followed (choke coil installation).

For more information regarding decoder update go to: the **last chapter** in this manual and www.zimo.at!

ZIMO or ZIMO dealers also offer a SW update as a customer service.



3. Decoder programming

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.**

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 ADDRESS AND PROGRAMMING PROCEDURE:

The **procedure** for programming and reading 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 a decoder with a cab or computer, every successful programming step will be made visible by the decoder. The same acknowledgment method is used when reading the configuration variables.

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. 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!

On the following pages:

▲ **CV table** for **configuration variables #1 to #255,** valid for large-scale decoder families MX69 and MX690 (CV's above #265 are in the Sound chapter)

followed by (chapter 4 and 5):

▲ **SUPPLEMENTAL NOTES and function mapping** for the application of configuration variables **(CV's) #1 to #255**

followed by (chapter 6):

▲ **Sound sample selection and definition;** description of basic functionality, operating procedures and CV table for **CV's #256 to #511** for all MX690 sound decoders.

▲ Understanding **Bits and Bytes** when calculating single-bit CV values is important. **Go to the chapter "Converting binary to decimal"** for more on this subject. There is also a NMRA function mapping calculator available at www.zimo.at, follow the links "PRODUCTS" and "Decoder".

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 clearly suggests any value from 1 to 252. The higher the value the faster the engine runs at speed step 1 and vice versa.

Another similar CV is the "dimming" 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 suggests using a value between 1 and 255 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 the value of each Bit you want to turn ON and enter the total to the CV.

One such CV is CV #29:

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	Note: 128 speed steps are always active if corresponding information is received! 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 commands are received. Bit 2 - DC operation (analog): 0 = off 1 = on 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 3, 6, 7 are to remain 0!

You can only change the setting of Bit 0, 1, 2, 4 and 5. Bits 3, 6 and 7 have to remain OFF 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. This 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 for MX69 and MX690:

Configuration Variables can be defined within the programming procedures to improve the driving characteristics of a locomotive 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.

NOTE: CV's #265 and up for MX690 sound decoders are located in the SOUND chapter!

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 chapter "Additional notes on…")	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.
#3	Acceleration rate	0 - 255	MX69: 2 MX690: 12	Multiplied by 0.9 equals' acceleration time in seconds from stop to full speed.
#4	Deceleration rate	0 - 255	MX69: 2 MX690: 12	Multiplied by 0.9 equals' deceleration time in seconds from full speed to complete stop.
#5	Vhigh	0 – 252 (See chapter "Additional notes on…")	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, ¼ to ½ of the value in CV #5 (See chapter 4)	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 if CV #5 = 255, otherwise lower). The three point speed curve resulting from the CV's #2, 5 and 6 are automatically smoothed out, no center hiccup noticeable ! Bit 4 in CV #29 has to be 0, otherwise speed table is active.

CV	Designation	Range	Default	Description
#7	Software version and Temporary register when programming with a "Lokmouse2" and similar low level systems. See section "Operation within other systems" at the end of this manual! and for temporary register when programming higher CV numbers with "medium-level systems" such as Intellibox or Lenz; especially for sound sample selection and sound CV's. E.g. CV #300 = 100 IMPORTANT: ---------------------------- Also check CV #65 for sub-version number ----------------------------	This CV is read only read out always shows version number Pseudo-programming for Lokmouse 2 to values of: 1, 2, 10, 11, 12, 20, 21, 22 and sound programming: 110, 120, 130, 210, 220, 230 (see chapter 6)		This CV normally displays the decoder software version. The **sub-version Number** is stored in **CV #65** and must be read-out separately. For Lokmaus-2 users: **Pseudo-programming** (because programmed value is not really stored) as an initial step for programming or read-out of a higher CV (>99) and/or a higher value (>99) with systems not capable of handling higher numbers: Ones digit = 1: The entered CV value will be increased by 100 during the actual programming. Ones digit = 2: ….increases by 200. Tens digit = 1: The entered CV number will be increased by 100 during the actual programming. Tens digit = 2: …increases by 200. Tens digit = 3: …increases by 300 Hundreds digit = 1: Changed CV number is retained until power-down. Hundreds digit = 2: …retained until cancelled with CV #7 = 0. **Lokmaus-2 application: see chapter 9!**
#8	Manufacturer ID and HARD RESET with CV #8 = „8", CV #8 = "0" or LOADING of special CV sets	Read only all additional programming is pseudo only; read-out always shows "145", which is ZIMO's assigned number	145 (= ZIMO)	NMRA assigned manufacturer ID for Zimo is: 145 ("100101001") **Pseudo-Programming** ("Pseudo" = programmed value is not really stored): **CV #8 = "8" -> HARD RESET** (NMRA standard reset). All CV's return to default values, independent of possibly activated CV sets or sound projects. The state is the same as a decoder at time of delivery without active CV set or sound project. ATTENTION: Sound may not play back properly, which requires a reset using CV #8 = 0. MX690 sound decoder only: **CV #8 = "0" -> HARD RESET** (ZIMO special): all CV's reset to the currently stored sound project. **CV #8 = "xx" -> Load CV set,** if one is present in the decoder (usually country or model specific values as sometimes sold by certain manufacturers) **CV #8 = "9" ->** HARD RESET for LGB-operation with14 speed steps and pulse chain commands; otherwise the same as CV #8 = 8.

CV	Designation	Range	Default	Description
#9	Motor control frequency and EMF sampling rate / time **Recommendation for coreless motors, i.e. MAXXON, FAULHABER:** **CV #9 = 22 or 21** usually with CV #56 = 100	55 High frequency, mid-range sampling algorithm 1- 99 High frequency, modified sampling algorithm 255-176 Low frequency (See chapter "Additional notes on…")	55 High frequen-cy, mid-range sampling algorithm. (earlier SW versions: Default 0 with the same effect as 55)	= 55: Default motor control with high fre-uency (20 / 40 kHz) and an EMF-sampling rate that automatically adjusts between 200Hz (low speed) and 50Hz. <> 55: Modification of automated adjustments, with separate settings for frequency (tens digit) and sampling time (ones digit). 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 (for core less motors; 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: 255 = frequency of 30 Hz, 208 = frequency of 80 Hz, 192 = frequency of 120 Hz.
#10	EMF Feedback cut-off NOTE: This CV is seldom required.	0 – 252 (See chapter "Additional notes on…")	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. If either CV #10 or #113 is set to 0 a default curve is valid.
#13	Analog functions	0 - 255	0	Selects function outputs, F1 to F8, which should be "on" in analog mode. Each bit equals one function; Bit 0 = F1, Bit 1 = F2 … Bit 6 = F7, Bit 7 = F8.
#14	Analog functions Acceleration, deceleration and motor control in analog operation.	0 - 127	64 (Bit 6 = 1)	Bits 5 to 0: Choose function outputs F12 to F9 as well as FLr and FLf 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 applying CV #3 and CV #4 defined momentum. Bit 6 = 0: Analog operation with CV #3 and CV
				#4 defined momentum. Bit 7 = 0: unregulated DC operation Bit 7 = 1: regulated DC operation
#17 + #18	Extended address	128 - 10239	0	The long 5-digit primary address. This address is only active when Bit 5 in CV #29=1. Otherwise address entered in CV #1 is active.
#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 F1 – F8	0 - 255	0	Selected functions (F1 – F8) 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 "short" or "long" primary address. Applicable Bits set to 1 = function controlled by consist address.
#22	Consist address active for headlights	0 - 3	0	Select whether the headlights are controlled with the consist address or single address (Bit 0 for front headlight, Bit 1 for rear headlight) Respective Bit = 0: function output controlled with single address Respective Bit = 1: function output controlled with consist address
#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: value added. = 1: value subtracted.
#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: value added. = 1: value subtracted.
#27 from SW Vers. 8	Position dependent stops with asymmetrical DCC signal (Lenz "ABC" me-	0, 1, 2, 3	0	This CV activates the position 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)

CV	Designation	Range	Default	Description
	thod)			THIS IS THE COMMON APPLICTION for this feature (provided the decoder is wired to the correct rail). Bit 1 = 1: Stops are initiated if voltage in left rail is higher than right rail (in direction of travel). Stopping is directional only if 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 1 = 1 (value = 3): Stops in both directions. 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.
#28	RailCom Configuration	0 – 3	3	Bit 0 – RailCom channel 1 (broadcast) 0 = OFF <u>1</u> = ON Bit 1 – RailCom channel 2 (data) 0 = OFF <u>1</u> = ON NOTE: **CV #28 was deleted** by the RailCom working group and later reinstated again in a slightly modified form!
#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	**14 =** 0000 1110	Bit 0 - Train direction: <u>0</u> = normal, 1 = reversed Bit 1 - Number of speed steps: 0 = 14, <u>1</u> = 28 Note: 128 speed steps are always active if corresponding commands are received. Bit 2 - DC operation (analog) *: 0 = off <u>1</u> = on Bit 3 - RailCom („bidirectional communication") 0 = off **<u>1</u>** = activated Bit 4 - Individual speed table: <u>0</u> = off, CV # 2, 5, 6, are active. 1 = on, according to CV 's # 67 – 94 Bit 5 - Decoder address: <u>0</u> = primary address as per CV #1 1 = ext. address as per CV #17+18 NOTE: Bit 5 is usually set automatically during address programming. <u>Example:</u> #29 = 2: normal direction, 28 speed steps, no DC operation, speed table according to CV #2, 5, 6, primary address as in CV #1. #29 = <u>14:</u> DC mode and RailCom added. #29 = 22: DC mode and individual speed table added according to CVs #67 – 94. #29 = 0: 14 (instead of 28) speed steps,

CV	Designation	Range	Default	Description
				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"!** *) If DC braking is used (e.g. **Märklin brake module**), also set CV #29, Bit 2 = "0" and Bit 5 of CV 124 = "1" but additionally CV #112, Bit 6 = 1!
#33 #34 #35 #36 #37 #38 #39 #40 #41 #42 #43 #44 #45 #46	Function mapping	(See chapter "Additional notes on…")	1 2 4 8 2 4 8 16 4 8 16 32 64 128	Function mapping according to NMRA: #33 - 46 = 1, 2, 4... Outputs are mapped to F0 - F12 by default. Example: Headlight switches with direction and can be turned on/off with F0 key, Function output FO1 switches with F1, Function output FO2 switches with F2, Function output FO3 switches with F3, and so on. Also see NMRA function mapping table at the end of this chapter.
#49	Signal controlled acceleration	0 - 255	0	Entered value multiplied by .4 equals acceleration time in seconds from stop to full speed when: "ZIMO signal controlled speed influence" (with ZIMO MX9 track section module) or "asymmetrical DCC signal" method (Lenz ABC) is employed.
#50	Signal controlled deceleration	0 - 255	0	Entered value multiplied by .4 equals acceleration time in seconds from full speed to complete stop when: "ZIMO signal controlled speed influence" (with ZIMO MX9 track section module) or "asymmetrical DCC signal" method (Lenz ABC) is employed.
#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	Defines the internal speed step for each of the 5 speed limits (CV's #51 – 55) that can be applied with the: ZIMO "signal controlled speed influence" method (HLU) using MX9 or future track section modules.

CV	Designation	Range	Default	Description
#56	Back-EMF control P and I value **Recommendation for coreless motors, i.e. MAXXON, FAULHABER:** **CV #56 = 100** (Default value "55" is not suitable) **most often used together with CV #9 = 22 or 21**	55 High frequency with medium sampling algorithm. 0 – 199 modified settings. (See chapter "Additional notes on…")	55 High frequency with medium sampling algorithm. (earlier SW versions: Default 0 with the same effect as 55)	Back-EMF compensation is calculated by PID algorithm (Proportional/Integral - Differential). = 55: Decoder adjusts itself automatically; it may be useful in certain cases to optimize the BEMF compensation with these values. = 0 - 99: modifications for „normal" DC motors = 100 - 199: modifications for coreless motors (MAXXON, Faulhaber, etc...) Tens digit: Proportional (P) value; set by default (0) to a mid value and automatic adjustment with the goal of jerk free running ("0" equals "5"). 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 ("0" equals "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 chapter "Additional notes on…")	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 chapter "Additional notes on…")	255	Intensity of back-EMF control for lowest speed step. Example: # 58 = 0: no back-EMF # 58 = 150: medium compensation, # 58 = 255: maximum Compensation. If required, an "intensity curve" can be achieved using CV #10, 58 and 113 to reduce load regulation at higher speeds.

CV	Designation	Range	Default	Description
#59	Signal dependent reaction time	0 - 255	5	This value multiplied by 10 is the time in seconds it takes to start a signal controlled acceleration after receiving a higher speed limit command with: "ZIMO signal controlled speed influence" (requires ZIMO MX9 or MX900 track section module) or "asymmetrical DCC signal" method (Lenz ABC).
#60	Reduced function output voltage (Dimming) Affects all function outputs. If only certain outputs should be affected use the dimming mask in CV #114, #152 additionally.	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. 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 MX690V are capable of providing.
#61	Special ZIMO function mapping	0 - 7, 97, 98, 99 (See chapter "Additional notes on…")	0	For applications not covered by NMRA function mapping (CV #33 - #46), for example: "Swiss lighting". = 97: Alternative function mapping without "left-shift". = 98: starts a flexible function mapping for directional function control. See "function mapping – ZIMO extensions".
#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 chapter "Additional notes on…")	**)	User programmable speed table. Only active if Bit 4 in CV #29 is set to 1. 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).
#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

CV	Designation	Range	Default	Description
#105 #106	User data	0 – 255 0 - 255	0 0	Free memory space to store user supplied data.
#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	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: Loco number recognition on (Turning the loco number recognition off prevents a possible ticking sound if this feature is not used). Bit 3 = 0: reacts only to the (new) NMRA-MAN-Bit=**12 function mode** = 1: also reacts to old MAN bit, **8 function mode** Bit 4 = 0: Pulse chain recognition off = 1: Pulse chain recognition on (used with LGB systems) Bit 5 = 0: 20 kHz motor control frequency = 1: 40 kHz frequency Bit 6 = 0: normal (also see CV #129) = 1: non-directional DC braking („Märklin-Brake mode") Bit 7 = 0: Pulse chain generation off = 1: generates pulse chain commands for LGB sound modules at function output FO1. Only in MOTOROLA format: Bit 3 = 0: normal (4 functions per address = 1: next address is used to control 4 more functions, for a total of 8 functions, which is otherwise not possible within a MOTOROLA system.
#113	BEMF reduction Note: This CV is rarely necessary	0 – 255 (See chapter "Additional notes on…")	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.

CV	Designation	Range	Default	Description
#114	Dimming mask 1 Excludes certain function outputs from dimming per CV #60. See dimming mask 2 for higher function outputs in CV #152	Bits 0 - 5	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) "Pull-in" time and "hold" voltage CV #115 alternatively used for additional dim value (0-90% according to ones digit; set tens digit to 0)	0 – 99 (See chapter "Additional notes on…")	0	Active if "uncoupling" is selected (value 48) in CV #125......132: Tens digit = 0 - 9, pull-in time in seconds of applied full voltage: Value: 0 1 2 3 4 5 6 7 8 9 Seconds: 0 .1 .2 .4 .8 1 2 3 4 5 Ones digit = 0 to 9, hold power in percent of track voltage, 0 - 90%. Applied after the pull-in time elapsed (ROCO uncoupler).
#116	Automated uncoupling procedure	0 – 99 100 – 199 (See chapter "Additional notes on…")	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 uncoupling. 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 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 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.
#120	Low beam mask for F7	Bits 0 - 7		Same as in CV #119 but for F7 key.
#121	Exponential acceleration	0 – 99 (See chapter "Additional notes on…")	00	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 chapter "Additional notes on…")	00	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 chapter "Additional notes on…")	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).	(See chapter "Additional notes on…")	0	Select 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 Select shunting key for MOMENTUM DEACTIVATION: Bit 2 = 0 (Bit 6 = 0): "MN" key for shunting, Bit 2 = 1 (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 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] contin- ues on next page!	Special effects American lighting effects or Uncoupler, automatic ON/OFF of function otuputs according to various criteria's, "Soft start" of function outputs. Operates with F0 in forward direction by default, unless assigned different through function mapping. Effects can be modified with CV#62 - 64 and #115 for uncoupling...		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 and 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 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. See CV #133 for synchronized fan control through FO10 (See Tips in chapter "Installation…). = 010100xx Load dependent **smoke generation** for **diesel engines** as per CV's #137 – 139 (i.e. pre-heating at stand still, heavy smoke at start-up, high speed or high load). Smoke turns itself off as per CV #353.See CV #133 for synchronized fan control through FO10. (See Tips
				in chapter "Installation…). <u>EXAMPLES</u> You want : Program CV #125 to: Mars light forward only - 00000101 = 5 Gyralite independent of direct.- 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 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 = 0: independent of direction = 1: active in forward direction = 2: active in reverse direction ATTENTION: change CV #33, #34… if direction is wrong. see CV #125 for details
#127	Special effects for function output #1 (default F1)		0	See CV #125 for details.
#128	Special effects for output #2 (default F2)		0	See CV #125 for details.
#129 - #132	Special effects For outputs #3, #4, #5 and #6 (default F3, F4, F5, F6)		0	see CV # 125
#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 If stop light is activated with value 56 in CV #125, 126 or 127: Time in tenths of a second (range: 0 – 25 sec.) the stop lights remain ON after the street car comes to a full stop.
#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 FO 10 for fan control from SW version 20.	Function output 10 as simulated exhaust cam sensor for external sound modules or FO10 as output for a fan of a smoke generator	0, 1 DIESEL engine: Define fan speed for cruising and accelera-tion with CV's #351 and 352.	0	= 0: (default) FO10 is used as normal function output, not as simulated exhaust cam. = 1: (typical setting): FO10 sends cam sensor signals, either virtual signals or signals of a real cam sensor. See CV's #267 and 268! FO10 is often used to run a smoke generator fan (i.e. USA-Trains USAR22-454). In such cases, the heating element of the smoke gene-rator must be connected to one of the function outputs FO1 … FO6 with the correct Effect CV (#127 … 132) programmed to "72" for steam engines or "80" for diesel engines. See chapter "Installation and wiring of the MX69".
#134	Asymmetrical thre-shold 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 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 0.6 V. This value has proven itself to be appropriate under normal conditions; by using 4 diodes to gener-ate the asymmetry!
#135	km/h – Speed regulation - Activating, control and range definition	2 – 20 (See chapter "Additional notes on…")	0	= 0: km/h – Regulation turned off; the "normal" speed regulation is in effect. Pseudo-Programming („Pseudo" = pro-grammed value is not being stored): CV #135 = 1 -> Initiates a calibration run (see chapter 4, "km/h – speed control") Continue with "normal" programming of CV #135 (programmed value will be stored): = 2 to 20: speed steps / km/h – factor; for example: = 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;

CV	Designation	Range	Default	Description
				step 1 = 2 km/h, step 2 = 4km/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.
#136	km/h – Speed regulation - Control number read-out	(See chapter "Additional notes on…")	-	A numeric value can be read-out after a suc-cessful calibration run, which was used to cal-culate the speed. This value is interesting be-cause it is (almost) independent from the se-lected speed during the calibration run. The uniformity of the resulting values from several calibration runs may be an indication of the ca-libration quality. See chapter 4!
 #137 #138 #139	Characteristics for smoke generators connected to FO1…FO6 (if the effect "smoke" is selected in the appropriate CV #127 – 132). PWM at stand still PWM at cruising PWM during acceleration	 0 - 255 0 - 255 0 - 255	 0 0 0	The values in CV #137 – 139 define a smoke characteristic for the function outputs (FO1, FO2, FO3, FO4, FO5 or FO6; referred to be-low 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). CV #137: PWM of FOx at standstill CV #138: PWM of FOx at cruising speed CV #139: PWM of FOx at acceleration (PWM = Pulse With Modulation)
#140	Distance controlled stopping (constant stopping distance) Select start of brak-ing and braking process	0, 1, 2, 3, 11, 12, 13	0	Activates distance controlled stopping as per CV #141 in place of time-constant braking ac-cording to CV #4. = 1: automatic stops with "signal controlled speed influence" or "asymmetrical DCC signal". = 2: manual stops using the cab. = 3: automatic <u>and</u> manual stops. If the train travels at less than full speed the start of braking is delayed in above cases (= 1, 2, 3), to prevent an unnecessary long "creep-ing" (recommended). On the other hand: = 11, 12, 13: selection as above, but braking starts always immediately after entering the brake section.
#141	Distance controlled stopping (constant stopping distance) Setting the distance	0 - 255	0	This CV defines the "constant stopping" dis-tance. The right value for the existing stop sec-tions has to be determined by trial. Use these figures as a starting point: CV #141 = 255 is about 500m (6m in H0), CV #141 = 50 about 100m (1.2m in H0)

CV	Designation	Range	Default	Description
#142	Distance controlled stopping (constant stopping distance) High-speed correction using the ABC method	0 - 255	12	The delayed recognition (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.
#143	… Compensation using the HLU method	0 - 255	0	Since the HLU method is more reliable than the ABC method, no recognition delay is usually required in CV #134; therefore this CV can also remain at default setting 0.
#144	Programming and update lock	Bits 6, 7	0 or 255 (255 = „FF“, which for “old” decoders is the same as 0)	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, 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 etc.) = 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.

CV	Designation	Range	Default	Description
				=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	A certain backlash 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. Also, soon after it starts spinning it may enter the acceleration 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 #146. = 0: no effect = 1 to 255: the motor spins at minimum rpm (according to CV #2) for a specific time. Acceleration starts after that time has elapsed. This comes only in effect when a direction change has been performed previously. 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 at 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		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

CV	Designation	Range	Default	Description
	settings have a negative effect on motor control. The CV's #147 – 149 will be removed again from future decoder software.			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 braking (reaches full braking over 1, 2 … 8 seconds by applying both motor end stages). =9: Applies full motor brake immediately when speed 0 is reached by applying 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: 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

CV	Designation	Range	Default	Description
				Bit #6 = 1) Bit #7 = 0: FO9 can be mapped with normal NMRA function mapping (CV #33…) = 1: Active direction Bit for FO9: FO9 is turned ON in reverse. (NOTE: FO9 can no longer be mapped with regular NMRA function mapping if Bit #7 = 1)
#161	Protocol for all servo outputs	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 only active during servo movements. = 1: … always active (consumes power, vibrates at times but holds position even under mechanical load). This setting must be selected when a **SmartServo** (with memory wire) is being controlled! 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 while function keys are pressed when in two-key operating mode (see CV #181/182).
#162	Servo 1 Left stop	0 - 255	49 = 1ms pulse	Defines the servos left stop position. "Left" may become the right stop, depending on values used.
#163	Servo 1 Right stop	0 - 255	205	Defines the servos 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., default = 3 sec.).
#166 to #169	As above, for Servo 2			
#170 to #173	As above, for Servo 3			
#174 to #177	As above for Servo 4			

CV	Designation	Range	Default	Description
#181 #182 #183 #184	Servo 1 Servo 2 Servo 3 Servo 4 Function assignment	0 – 114 90 - 93	0 0 0 0	= 0: Servo not in operation = 1: Single-key operation with F1 = 2: Single-key operation with F2 = 3: Single-key operation with F3 etc. = 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 etc. = 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)
#185	Special assignment for live steam engines		0	= 1: Steam engine operated with single servo; speed and direction controlled with speed regulator, stop is in center position. = 2: Servo 1 proportional speed regulator, Servo 2 for direction. = 3: as in 2, but: direction-servo is automatically in "neutral" if speed is 0 and F1 is ON; If speed step > 0: direction-servo is engaged. NOTE to CV #185 = 2 or 3: Servo 1 is adjustable with CV #162, #163 (end stops); with appropriate values the direction can be switched as well. Servo 2 is adjustable with CV #166, #167.

CV	Designation	Range	Default	Description
#250 to #253	Decoder ID SW version 26 or higher	Read only	-	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 placed 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 . . .

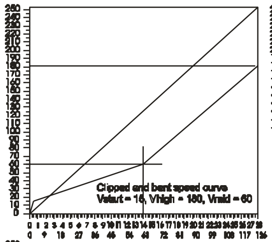
Two ways of programming speed curves:

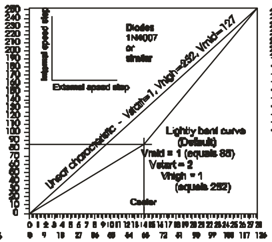
Programmable speed curves can often optimize the driving characteristics of an engine. These curves alter the relationship between the cab's speed regulator settings and the engines speed (that is between 14, 28 or 128 external speed steps of the cab and the 252 internal speed steps of the decoder).

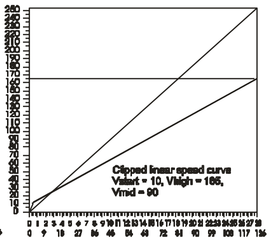
Which one of the two speed curves the decoder applies is determined by Bit 4 of Configuration Variable #29: "0" assigns the first type - Three Step Programming, defined by just three CV's and "1" assigns the second type - Programmable Speed Table, defined by 28 individual CV's.

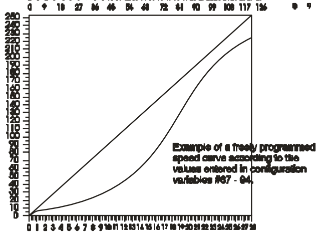
Three step programming: by using the Configuration Variables #2 for Vstart, #5 for Vhigh and #6 for Vmid.
Vstart defines one internal speed step out of a total of 252 to the first speed step of the cab, Vhigh to the highest speed step and Vmid to the center speed step of the cab. In this way a simple 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 limited 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.









In case of ***Faulhaber*, *Maxxon or similar*** motors (core less):
First program to special setting ***CV # 9 = 12*** *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 20 kHz in default mode or when a value of "0" is entered in CV #9, can be raised to 40 kHz 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 and more noise. This sampling frequency varies automatically in the default mode (CV #9 = 0) between 200Hz at low speed and 50 Hz at maximum speed (this is a new feature of the MX69!). The sampling rate and time can be set individually with CV #9;

* For MAXXON, Faulhaber or similar core less motors with CV #56 programmed to 100 , it is recommended in most cases where an improvement is still required to select a lower sample frequency and a minimal sampling time such as **CV #9 = 11, 21, 31** etc;

* for **older type motors** 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 and is the force (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 refrence" 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.

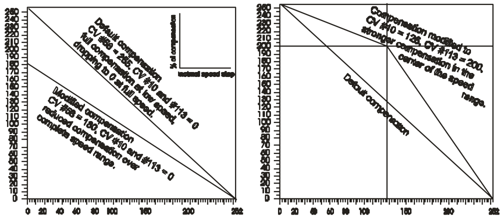
The relative reference is suitable as long as a constant voltage is present (which is the case with all Zimo systems but not all competitor systems) and the resistance along the track is kept to a minimum.

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 values) see CV table and the following chapter on "Step by step…..!

Acceleration / 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 smaller figures).

Step by step CV adjustment procedure to optimize engine performance:

It is recommended to systematically program a decoder since setting the CV's for load compensation and momentum can result in a certain interaction with each other (ATTENTION: VALID FROM SW-VERSION 10; for older versions use appropriate manual):

***** To begin, select the highest possible number of speed steps the system can operate in, that would be 128 for Zimo (select the number of speed steps at the cab for the decoder address in question). All Zimo decoders are set by default to 28 /128 speed steps. If used with systems that are restricted to 14 steps set Bit 1 in CV #29 to 0 (only necessary with older non-ZIMO systems such as "Lokmouse1" or LGB MZS).

***** Next set the engine to the lowest speed step, recognizable on the Zimo MX2 cab when the bottom LED next to the speed slider changes color from red to green (if not done so already, change the cab to 128 speed steps first!). MX21 and newer cabs show the current speed step number in the display.

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 is not only critical for smooth even low speed behavior but also for quiet motor performance (see previous page but also CV #56!), which can be modified with CV #9. This CV is also used to set the decoder to low frequency motor control, which is used only rarely with older AC motors.

By default, CV #9 (=0) is set to high frequency at 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. Further fine-tuning is possible with the help of CV #9 and CV #56, if drivability is not flawless or too much motor noise is audible.

In case of a **coreless motor design** such as **Faulhaber, MAXXON or similar**, start by setting **CV #56 = 100** (in place of the default value of 0 (zero) for "normal" motors); the "1" in the hundred digit causes among others the mid-range setting to match high-efficient motors, which is similar to a value of "11" but with further adjustment possibilities in both directions using the tens and ones digit.

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 the engine's speed is still fluctuating after the above adjustments have been carried out, 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 fluctuate also. 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 the current 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. Sometimes it's even better to keep this value about 20% lower to compensate for a slight internal voltage drop in the decoder.

***** Next, we check to see whether the loco starts up 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.).

The "direction-change jolt" can 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).

***** If a locomotive starts up too fast or comes to a stop too quickly, which is often the case even though the momentum is set to your liking, use **CV #121 and #122** to add an exponential acceleration and deceleration curve. This in effect will stretch the time the locomotive spends in the lower speed range. Often used values for these CV's are in the range of 25 to 55. Tens digits define the percentage of the speed table to be included in this curve (20% - 50% in this example). Ones digits define the curvature.

Notes on acceleration behavior versus speed steps:

An acceleration or deceleration sequence, 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 can not 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 decoder controlled acceleration or deceleration event can only be influenced by 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)!

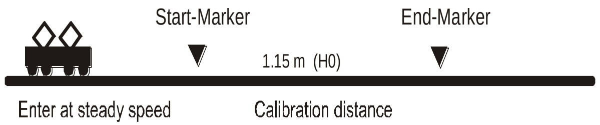
Km/h – speed regulation – CALIBRATION and operation

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 precisely).

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 readjusts itself.

A CALIBRATION RUN; should 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 length before and after, for acceleration and deceleration), 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 length of track before the calibration marker needs to be increased accordingly.

* The calibration mode is now activated by programming **CV #135 = 1** (operational 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 in 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"

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.

* 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.

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, especially in terms of their length and consistency everywhere on the layout. 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.

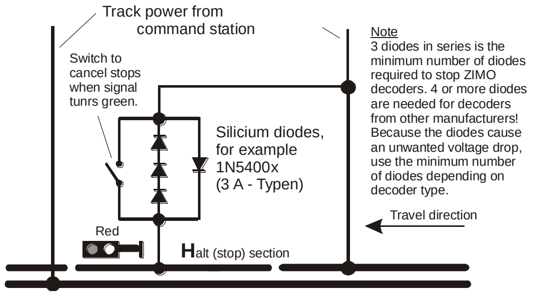
Settings for stopping with "asymmetrical DCC signal" (Lenz ABC)

From SW-Version 8

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 commercially available diodes.

3 diodes in series and one in 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.

If Schottky diodes are used (that cause a smaller voltage drop), the diode ratio needs to be increased to at least 4:1!



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 (default = .4V) can be modified with CV #134 if necessary. At the time of writing, the "asymmetrical DCC signal" has not been standardized and many DCC systems pay no attention to this feature!

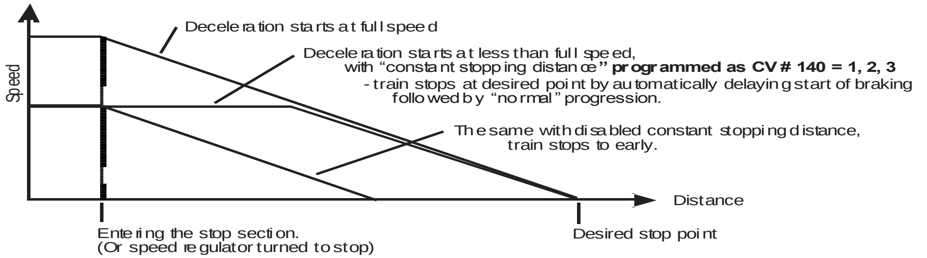
Distance controlled stopping – Constant stopping distance

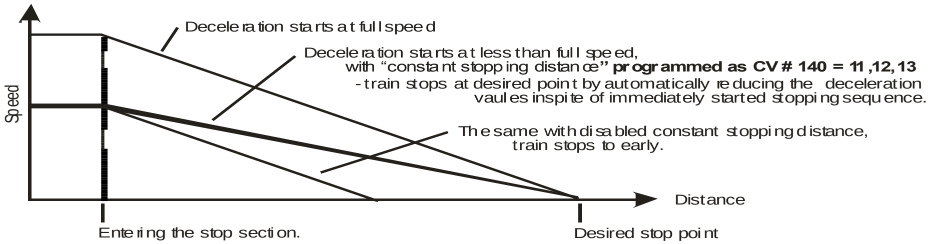
from SW-Version 9

This feature is activated with CV #140 (= 1, 2, 3, 11, 12, 13) and keeps the stopping distance as close as possible to the one defined in CV #141, independent of how fast the train enters the stop section.

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 order of events; see diagram above: **The first** is the **recommended method (CV #140 = 1, etc.),** where the train entering at less than full speed continues at first at the same speed 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, 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 this capability 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 = 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. Reductions in speed or acceleration events are not affected by this (still handled by CV #3, 4 etc.).

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.

Example programming . . .

TYPICAL LGB LOCOMOTIVES (with one or two Bühler motors in typical LGB fashion):

CV #9 = 0 (Default)
CV #56 = 0 (Default, synonymous with „55", that is center settings for proportional and integral regulation).

BRAWA G 4/5 RhB (equipped with MAXXON motor)

CV # 9 = 11 (low sampling frequency and time)
CV # 56 = 100 (basic setting for MAXXON)

Automated uncoupling procedure; with coupler tension relieve and loco/train separation:

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

With the help of CV #116 the decoder can be programmed so that the engine automatically moves away from the train after opening the couplers without moving 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).

<u>EXAMPLE:</u>

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 procedure is activated if the tens digit in CV #166 is other than 0; if desired (and CV #116 > 100), the loco pushes first automatically against the coupler in the opposite direction!

- The procedure (acceleration) 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 procedure starts as soon as the loco comes to a full stop provided the button for this function is still being activated.

- The procedure ends when the function is turned off (by releasing the key if in momentary mode or by pressing the key again if in latched mode), or when the programmed time limits have been reached (CV #115 for the coupler and CV #116 for the loco detachment phase).

- Moving the speed slider during an automated uncoupling procedure stops the process 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, the MAN key (only on Zimo cabs), the F4 or F3 key can be assigned as a shunting 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 throttle is used for half the decoder's full 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):

In addition to being programmed on the programming track, configuration variables can also be programmed on the main track 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 only be possible with RailCom (bidirectional communication).

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 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 operating manual for on-the-fly programming steps!

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

The MX69/MX690 decoders have between 8 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 on the cab. Which key controls which function 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, which at the same time also restricts free allocation and only the headlight function is intended for directional control.

Additional possibilities are offered by ZIMO through configuration variable #61:

Extended flexibility, more directional functions,
and automated time-controlled light switch-off with CV #61:

CV #61 on the one hand offers fixed allocations, especially liked for the Swiss lighting system (CV #61 = 6 or 7) and on the other hand flexible allocations (new for MX69) through a special programming procedure (CV #61 = 98). With the latter, each function/direction combination can be assigned to specific function outputs and in addition allows the definition of an automated turn-off feature that turns designated function outputs off after the loco comes to a stop.

Please consult the next 3 pages!

An alternative method for directional functions:

According to the NMRA function mapping (see table on the right), only function F0 is influenced by directional changes, which switches headlights according to direction. All other functions F1 – F12 (and higher) are not influenced by direction.

The directional bits (0,1) in the “Special Effects” CV #125 to #132 (later: possibly more CV’s in a special CV block) allow for more directional functions (i.e. F1, F2, F3…), if at the same time the actual “Effects” bits 2 – 7 remain at “0”.

Example 1: The **red taillights** on the front and rear end of a locomotive are connected to FO1 and FO2; both are to be switched with F1 and should change with direction. In order to do that set CV #35 to “12” (Bit 2 for FO1 and Bit 3 for FO2), CV **#**127 to “1” and CV **#**128 to “2” - thus function output 1 is turned on in forward direction only and output 2 in reverse. Special effect codes in bit 2 - 7 all remain at 0.

Example 2: The taillights <u>should not</u> be switched individually and independent from the headlights as in the example above but rather **the two loco ends** should be properly lighted (white and red lights) and switched on/off with F0 (front) and F1 (rear). This allows turning all lights off on the appropriate loco end, if cars are coupled to the loco.

This can be achieved as follows: Connect the front white headlights to function output “Front headlight” and front red taillights to function output 2; rear white headlights on function output 1 and rear red taillights on function output “Rear headlights”.

CV #33 = 1 (= default, front white light on F0 “front headlights), CV **#**34 **=** 8 (front red lights when F0 “rear headlights”!), CV #35 = 6 (both rear white and red lights on F1 !), CV #126 = 1 and CV #127 = 2 (Directional change of rear white and red lights with “Effect”-CV’s).

Alternative method: Use the function mapping procedure CV #61 = 98; see later 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 of the cab; the single bits to the function outputs of the MX69/MX690 loco decoder. The function keys are matched to the function outputs by setting the appropriate bits. Multiple assignments are permissible.

According to NMRA standard:

NMRA Function	CV	Numerical keys of ZIMO 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	#37	4				7	6	5	4	3	2	1●	0			
F4	#38	5				7	6	5	4	3	2●	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	(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						

The above table shows the <u>default settings</u>; 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.

#36	3							7	6	5●	4	3●	2	1	0
#37	4				7	6	5●	4	3	2	1	0			
#38	5				7	6●	5	4	3	2	1	0			

EXAMPLE: The output #5 should be switched in addition to output #3 with the F2 key (#3 key). Outputs #7 and #8 should be switched (not additionally but instead) with the F3 and F4 keys (this could be a whistle and a bell of a sound module, for example). The new values need to be entered as follows: CV36=40; #37=32; #38=64.

ZIMO – Special function mapping

The relevant allocations can be activated by programming the desired number to configuration variable #61. Function F1 along with some others can be mapped with specific function outputs, with the help of the NMRA function mapping. For example, function output FO1 can be allocated to function F2 (CV #35 = 4) or special shunting lighting can be realized with CV #35 = 3 (both headlights on).

CV #61 = 1 or 2

NMRA Function	CV	Numerical keys of ZIMO 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, F5 (FO8): Bell, F2 (FO7): Whistle when actuating an external (usually older) sound board with an MX69V.

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

CV #61 = 11 or 12

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

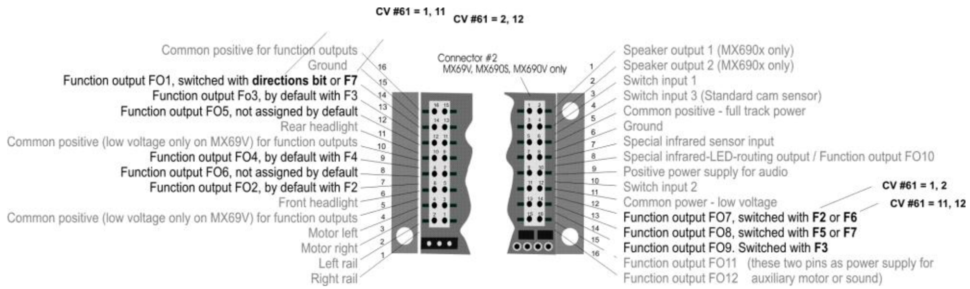
…for many applications desired: actuation of **FO1** by the driving direction, that is by the **"directional bit"** (when CV #61 =1) or by **F7** (when CV #61 = 2).

…only relevant for MX69V/MX690V (S and L type decoders don't have these outputs): Assigning functions F2, F3 and F5 to function outputs FO7, FO8 and FO9 was a common way of accessing **older external sound boards** (with whistle, bell and ON/OFF inputs). These function allocations were taken over from the predecessors MX65 and MX66.

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),

…only relevant for MX69V/MX690V: Functions F7, F3 and F6 are herewith assigned to outputs FO7, FO9 and FO8, which corresponds to another common way of accessing **older external sound boards** (again similar to the case CV #61 = 1 or 2).



CV #61 = 3 or 4

NMRA Function	CV	Numerical keys of ZIMO 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 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 = 13 or 14

NMRA Function	CV	Numerical keys of ZIMO 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 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														●		

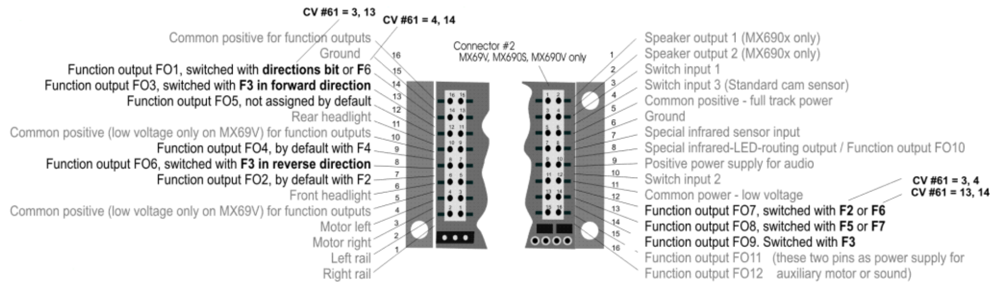
CV61 = 13 CV61 = 14

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

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	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 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

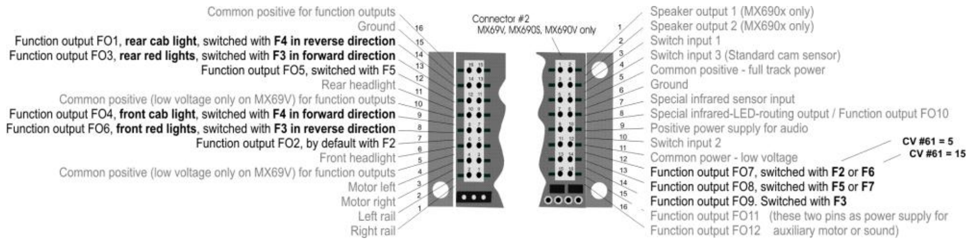
CV #61 = 5 or 15: For electric and diesel locos where **headlights and taillights as well as cab lights** are to be actuated by one function key each (F3 and F4) independent of direction. Also included in this assignment are the functions F2 and F5 (if CV #61 = 5) or F6 and F7 (if CV #61 = 15) on outputs 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 = 97

Alternative function mapping without "left shift" for MX69/MX690:

*The "left shift" of higher CV's (from CV #37) can be suppressed with **CV #61 = 97**, which allows higher function output's to be assigned to lower function keys (i.e. it is possible to switch FO1 with F4 using this feature, which would not be possible with the NMRA mapping method, but with the disadvantage that FO7 and FO8 become inaccessible!).*

				FO6	FO5	FO4	FO3	FO2	FO1	Rear Light	Front Light
F0	#33	1 (L) fr		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	2	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



CV #61 = 6

NMRA Function	CV	Numerical keys of ZIMO 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											●			●
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														●		

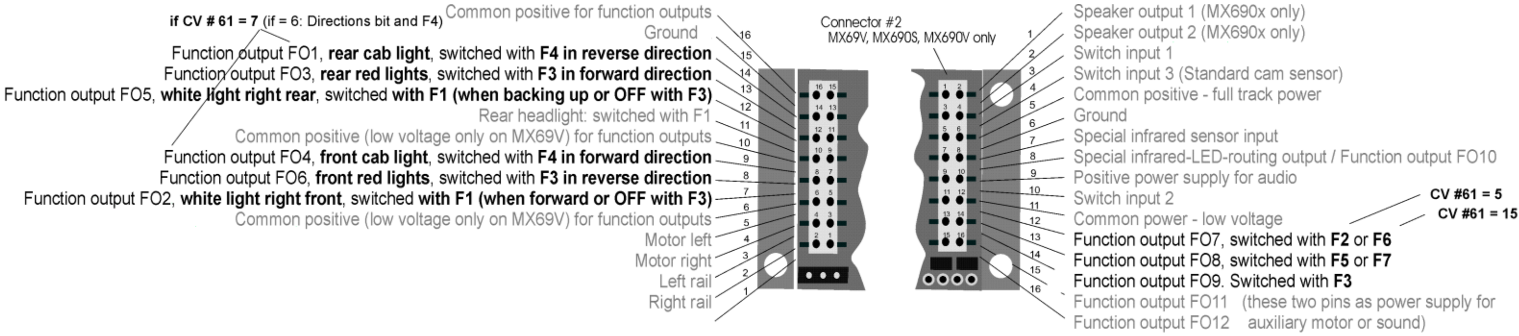
CV #61 = 7

NMRA Function	CV	Numerical keys of ZIMO 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											●			●
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.



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) that 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:** Set the loco direction to “forward”, all functions off; the loco must be on the main track (not on the programming track); the whole procedure is performed with operations mode programming.

*** CV #61 = 98** Writing 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 (as many as desired) to be assigned to F0 in forward direction, are now actuated with the corresponding function keys (i.e. FLf, FLr, F1…F12).

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.

Confirm again by actuating **the direction key.**

***** After confirmation, 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.

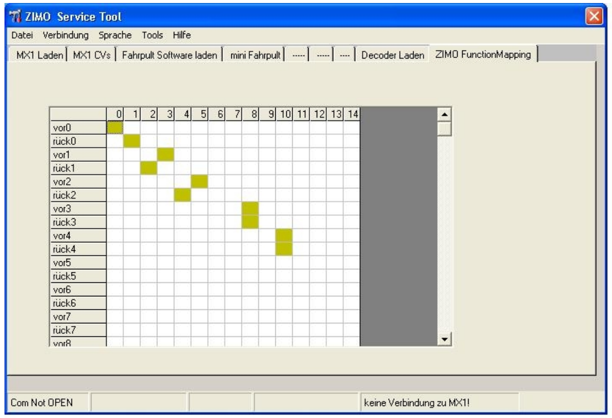
NOTE:

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 re-activate several function output allocations with the help of the “CV-set” feature!

For a better understanding, the function keys are listed here in the sequence they are 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 that replaces the “CV #61 = 98” procedure will become available as part of the ***“ZIMO Service Tool” ZST,*** 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

Only MX690S, MX690V and the versions with enhancement board!

▶ 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 engine types 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 available 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.

Loco type selection with CV #265 – current layout for MX690 with SW version 18.

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

CV	Designation	Range	Default	Description
#265	Loco type selection	1, 2… 101, 102…	1 (steam) or 101 (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... Includes chuff sounds as well as other sounds (whistle, compressor, bell…) = 101, 102 … 132: Select among various diesel types (if the collection holds several diesels).

Attention: For now, only one diesel sound can be installed (CV #265 = 101).

Operating the sound decoder for the first time (European steam edition):

As delivered, the MX690 comes with typical engine sound activated and function-sounds allocated to function keys:

Function F8 – turns engine sounds on/off,

sounds activated by function keys remain active regardless (an on/off key can be assigned for these as well with CV #311, which could also be F8).

The sound in case of the MX690 with **"European steam sound"** 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 functional 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 (also comes on with F0)
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 up to #255, to #127 or even worse to #99.

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

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

which increases the CV numbers about to be accessed by 100, 200 or 300. For example:

If programming CV #266 = 45 is not possible, programming CV #7 = 110 followed by CV #66 = 45 executes the desired programming of CV #266 = 45

or

if neither CV #266 = 45 nor CV #166 = 45 is possible, 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.

The 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!

Also see CV #7 for systems that are not capable of programming high values (>99).

Selecting a new or replacing the current chuff set:

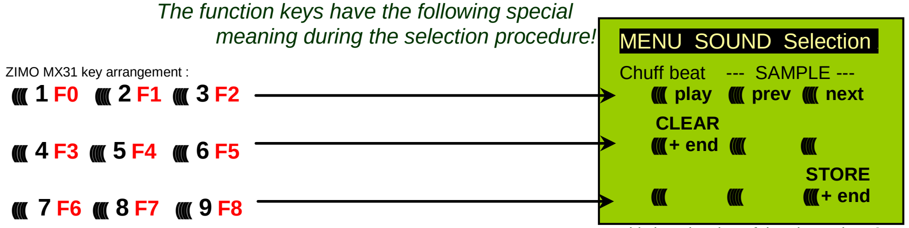
The following procedures are always used in the same way in spite of the flexible decoder layout with different sound sample compilations. It is also worth mentioning that the sound samples can be listened to and evaluated under actual operating conditions (with the engine running), not just on the computer.

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 in a different layout.

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 **sound 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,
…. play-back 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.

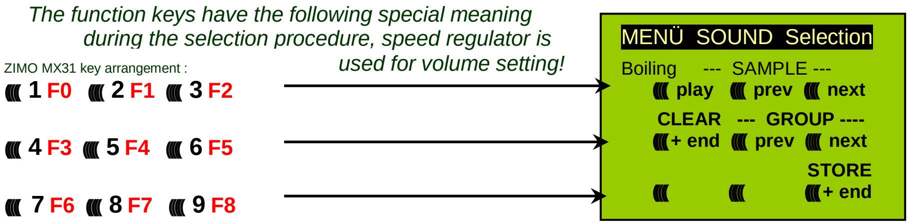
Selecting boiling, whistle, blow-off and brake squeal sounds

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.



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.

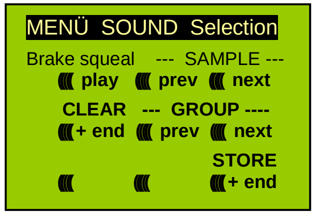
F4, F5 = prev., next: switches between sound groups.

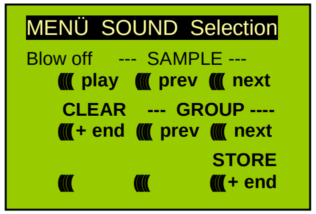
The **speed regulator** acts as volume control for the background sound during selection procedure.

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 also be **ended** by any other programming procedure or by removing power.

Normal function outputs cannot be activated as long as the selection procedure is active.





A simplified procedure (w/o CV #300) is available with MX31 (SW1.22 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 absolutely 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.

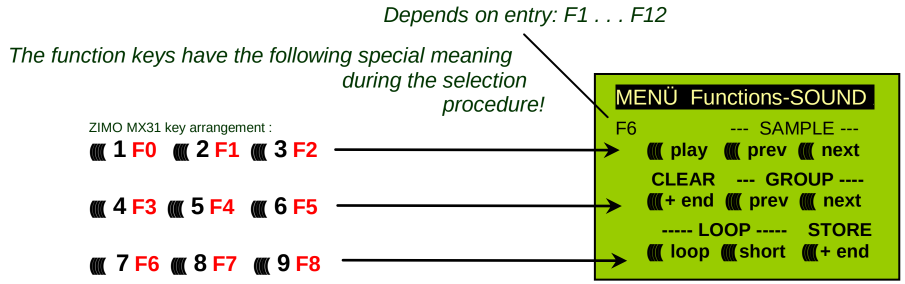
The **allocation procedure** for function sounds are initiated with a "Pseudo-Programming" in operations mode programming:
CV #300 = 1 for function F1
CV #300 = 2 for function F2
CV #300 = 3 for function F3
etc.
CV # 300 = 20 for function F0

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!



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 markers are included in the sample; basic settings are also saved; changes take effect only if F6 or F7 is actuated.

If F6 or F7 are not actuated, the sound sample then is always played back in the 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 that group is reached; use the key to scroll in the opposite direction (F1, F2) to listen to the other stored sounds,

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

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

…. a wrong key is pressed.

The **“confirmations jingle”** is played after ending the allocation procedure with F3 or F8.

Simplified procedure (without using CV #300) with MX31, SW1.2 or MX31ZL, SW3.06

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

The MX690 decoders provide 8 simultaneously playing random generators who’s timing is determined by CV’s; see “CV table” from CV #315.

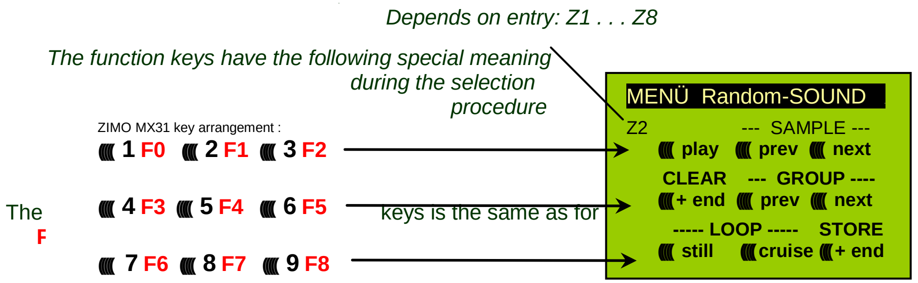
The **allocation procedure** for random sound is initiated with a “Pseudo-Programming” in operations mode programming

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.



Drawing of an MX31 display, not a photo!

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!

Simplified procedure (without using CV #300) with MX31, SW1.2 or MX31ZL, SW3.06

Allocation of sound samples to switch inputs S1, S2, S3:

The MX690 has 3 switch inputs available on connector #2. Input 1 and 2 are free for any function input while the third input is most often used for the cam sensor. If no cam sensor is available, that output can of course also be used for another function. These inputs can accept reed switches, optical or hall-effect sensors and similar; see chapter 8.

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.

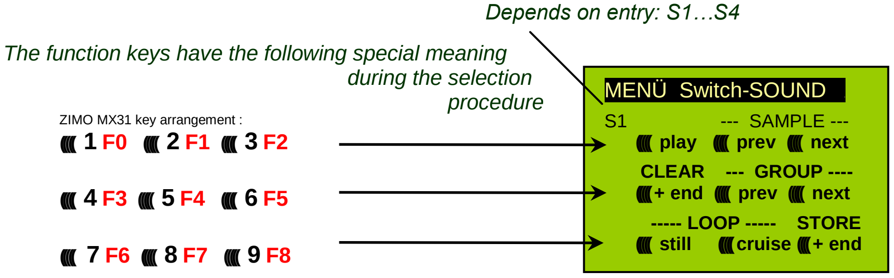
The switch input **allocation procedure** is initiated with the operations mode Pseudo-Programming

CV #300 = 111 for switch input S1

CV #300 = 112 for switch input S2

CV #300 = 113 for switch input S3

and so on…



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 recording of 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, also known as BEMF. 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, 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.

Simplified procedure (without using CV #300) with MX31, SW1.2 or MX31ZL, SW3.06

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 or 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).

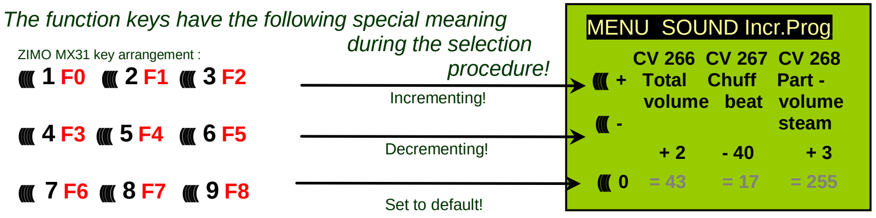
The function keys of the cab temporarily serve as instruments for the incremental programming during which they cannot be used to actuate function outputs. The function keys are assigned to this with the "Pseudo-Programming"

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 is not only the leading CV #266 assigned for incremental programming but CV #266, #267 and #268 as well.

This is again shown here by means of the ZIMO cab (with the planned 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 or 10; 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!

The value of a particular CV can only be determined by reading it out on the programming track as long as the bidirectional communication is not available (which is of course implemented hardware wise on the MX690 and requires only a software update to be fully implemented). 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 tables 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 during the "incremental programming" procedure.

CV	Designation	Value range	INC steps	Default	Description
LEAD - CV **#266**	Total volume	0 - 255	5	65	The value "65" results (mathematically) in the highest possible distortion-free play back 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	0 - 255	1	70	CV #267 active only 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 chuff's 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 reason 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 3 of the MX690, see chapter 8); each positive rise results in a chuff beat. = 2, 3, 4 … real cam sensor, several triggers in sequence (2, 3, 4 …) result in a 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 out of a group of 4 or 6 steam chuffs, one of them always is more accentuated; this effect is in itself already part of the chuff sample set but can be amplified with CV #269.
#270	PROJEKT not functional yet: Longer chuff length at very low speeds	0 - 255	10	?	PROJECT (not functional yet): 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.

CV	Designation	Value range	INC steps	Default	Description
#271	Overlapping effect at high speed For STEAM engines	0 – 255 (useful up to about 30)	1	16	The individual steam chuffs should overlap each other at high speed like on a real engine. Because the frequency of the chuffs increase 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 chuffs 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 (on F4 as delivered, 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 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 can be achieved by actuating the function key that

CV	Designation	Value range	INC steps	De-fault	Description
					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!* *Adjusting sound 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 about 1/10 of full speed. Note: For practical purposes (but not absolutely necessary), CV #275 is set to the proper value by trial 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 "unloaded 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 (or muted) on declines. 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).
#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 <u>for DIESEL engines</u>	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. =<u>1</u>: 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 every speed increase (even if increased by just 1 step).

CV	Designation	Value range	INC steps	Default	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 doubled already at “medium speed”.

CV	Designation	Value range	INC steps	Default	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 doubled 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 engine	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, where 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 18	0 – 19 Or 101 - 119	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. =1 … 19: Assigned function key = 101 … 119: Assigned function key, inverted action.

CV	Designation	Value range	De-fault	Description
#314	Fade in/out time from SW version 18	0 – 255	0	Time in tenth of a second 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.
#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.

CV	Designation	Value range	De-fault	Description
#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.
#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 for STEAM and DIESEL engines	0 – 255 = 0 – 106 minutes	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 automatically after the time defined here (to prevent overheating). = 0: Won't turn off automatically. = 1 … 255: 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 of 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. Bidirectional communication = "RailCom"

The future oriented technology for which all ZIMO decoders have been prepared since 2004 (hardware), has been installed since February 2008 with SW version 18 in the MX69 and MX690 decoder family.

"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 transmitted by the decoders.

The definitions for RailCom are determined 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,

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

global information from decoders is sent to the command station

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

decoder addresses are recognized by "local" detectors

- from isolated track sections connected to MX900 track section modules (successor to the MX9), which also facilitates the engines location. This however has been possible with ZIMO's own loco number recognition for over a decade without bidirectional communication, but only with ZIMO components.

Starting in 2007, 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. In the first phase - 2008, SW version 18 – ZIMO decoders will be 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), CV content on demand and some decoder data such as actual speed, load and decoder temperature.

On the system side, a third party product is available from the beginning – the address display LRC120, which is a "local" RailCom detector displaying the loco address of one track section. In the course of 2007, the MX31ZL will become 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 is also the default setting (see CV list in chapter 3)

„RailCom" is a trademark of Lenz Elektronik GmbH.

8. Installation and wiring of the MX69

General information:

There has to be enough **free space inside the engine** for a proper decoder installation. Pay particular attention that no pressure is exerted on the decoder when the loco shell is being reinstalled. Use the **plug-in cables (MX65KAB)** to connect the decoder to the loco, don't solder directly to the pins!

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

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

Connector #1 (16-pin socket – all decoder types):

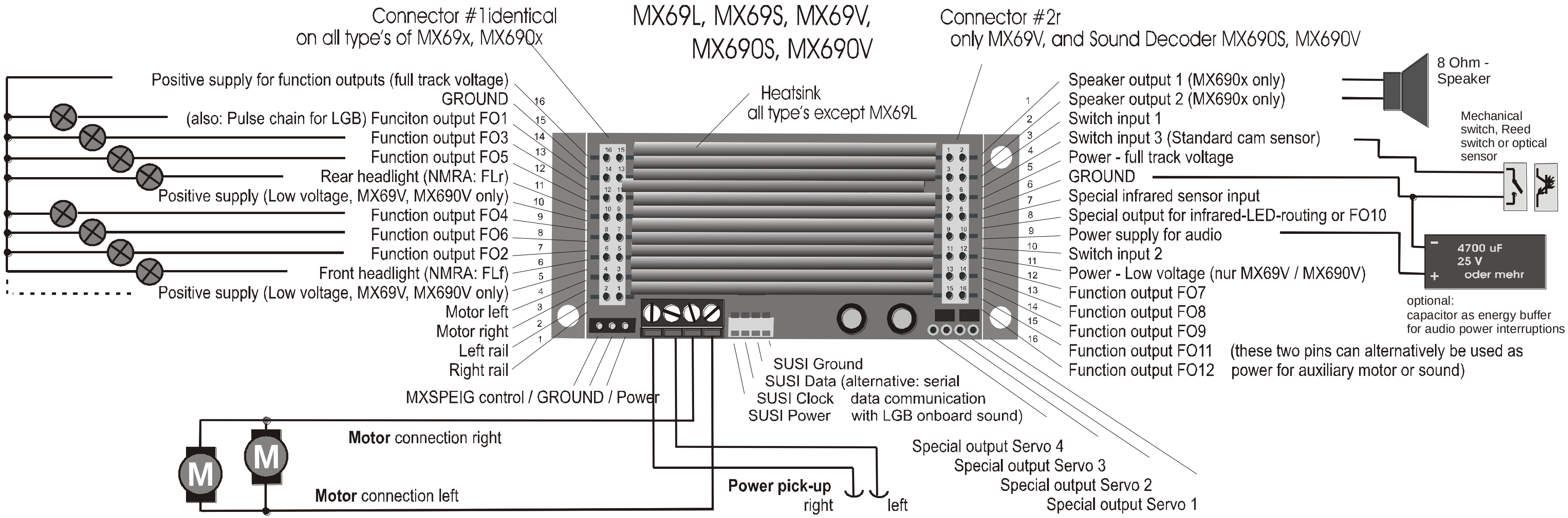
The pins of this socket connect the decoder to the track, motor and 8 functions (headlight and F1 to F6).

Additional equipment (functions) is always connected between one of the positive leads and the applicable function output lead (negative). NMRA function mapping and/or ZIMO extended function mapping (see previous pages) is used to map function outputs to function keys.

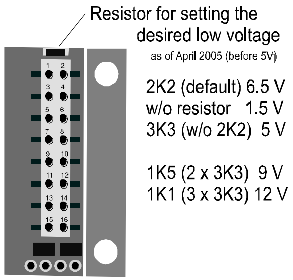
The positive supply from the MX69L and MX69S (MX690S) is rectified track voltage (at pin 5, 10, 16), which is somewhere between 12 and 24V. Headlights, smoke generators etc. have to match the track voltage! However, a certain voltage reduction is possible with configuration variable #60, to lower a 20V track voltage to the 12V a light bulb may require for example (Dimming - see CV list in chapter 3).

An alternative method is to use the low voltage output of the MX69V (MX690V) at pin 5 and 10. The voltage is selectable between 1.5V (resistor removed) and full track voltage with the help of a resistor. Regardless of which low voltage is selected, additionally pin 16 always supplies rectified track voltage.

A further possibility (independent of the MX69 type) is the use of an external power supply (e.g. by installing a rectifier and a LM317 voltage regulator in to the engine).



Adjustable low voltage output (MX69V and MX690V only):



MX69V/MX690V provides a way for setting the output voltage anywhere from 1.5V to track voltage, which allows the direct connection of low voltage bulbs (and other accessories) to the decoder output. The low voltage is available at two pins of connector #1 (MX69V/MX690V only).

Low voltage settings at delivery: 6.5V; increase the low voltage by soldering one or several of the supplied SMD resistors (value 3K3 is marked as “332”) on top of the already installed 2K2 resistor; reduce the voltage down to 5V by replacing the installed 2K2 with a 3K3 resistor; reduce the voltage down to 1.5V by removing the 2K2 resistor (without installing another one).

NOTE: *The dimming function of CV #60 is not recommended for low voltage consumers; use the low voltage supply instead. Dimming is accomplished by PWM of the full track voltage, which can be damaging to small bulbs; even more so during programming on the programming track due to the acknowledgment pulses.*

The 4-pin screw terminal:

MX69S, MX69V, MX690S and MX690V all have an additional 4-pin screw terminal for the connection of power and motor leads; the terminal is good for 5A and must be used in place of the corresponding pins of the #1 16-pin connector, if the power consumption exceeds 1A.

Connector #2 (16-pin socket - MX69V, MX690V):

This connector is designed for connecting further accessories (function outputs FO 7 - 12), switch inputs (reed switches, infrared sensors and more) and for speakers and cam sensors (in MX690x sound decoders).

INFORMATION ABOUT THE USE OF SWITCH INPUTS WILL BE ADDED LATER.

Connecting DIETZ sound modules / virtual wheel speed sensor:

See Dietz instruction manual for wiring (the MX65/MX66 manual can also be consulted). For sound boards with SUSI, see below!

IMPORTANT: **Large scale sound modules** should ALWAYS be connected **directly to the track.** Although the SUSI interface delivers power to the connected sound module, it is often too weak for larger power consumption, which may lead to malfunctions of the sound modules (uncontrolled sound actuation etc.).

For a good acoustic impression it is important that the chuffs of a steam loco 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 could 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, the MX69 comes with a **“virtual cam sensor”.** Connect the MX69 function output FO10 with the cam sensor input of the sound decoder together with the SUSI or other necessary connections. The virtual wheel speed sensor is of course not capable of synchronizing chuff rates to wheel <u>positions</u> but rather to wheel <u>speed</u>, which makes little difference to the viewer.

The chuff rate of the “virtual wheel speed sensor” can be defined per wheel revolution with CV #133; consult CV table in chapter 3.

The “SUSI” interface:

The SUSI interface developed by Dietz (submitted to the NMRA as a new standard) defines the connection between sound modules and loco decoders, provided the sound module is also equipped with such an interface. SUSI simplifies the installation of decoders and sound modules in locos greatly - even swapping the same sound module with different locos is possible without difficulties.

Speed and load information (e.g. to change sound intensity when going uphill, downhill, start up etc.), as well as sound-configuration variables from the decoder are sent by SUSI to the sound module.

Accessing SUSI CV’s: 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!

IMPORTANT: Large-scale sound modules should ALWAYS be connected **directly to the track.** Although the SUSI interface delivers power to the connected sound module, it is often too weak or unstable for large consumers.

Connecting an analog sound board to function output FO12 (MX69V only):

Analog sound is primarily used in conventional DC layouts and is powered and controlled by direct track voltage (not through a digital interface like “SUSI” or LGB “onboard”). The term analog sound has neither to do with how the sound is generated (most often digital as well) nor whether function outputs are present.

Function output FO12 emulates “PWM-sound-supply” including a separate speed curve for the control of a sound board, if CV’s #137, 138 and 139 are defined accordingly. FO12 and if required a ground wire from the MX69V is connected to the motor input pins of the sound board (according to the instructions supplied), which either power the complete board or are just used as control input (depending on sound board design).

Function output FO12 generates a pulse with modulated signal (PWM) according to the sound curve defined in CV #137, 138 and 139 that is changed into a DC signal, usually through input filters of the sound board.

The sound curve can be defined with CV #112 Bit 0 as either speed dependent (Bit 0 = 0, default) or load dependent. The sound in the first case is similar to a sound module connected directly to the motor in a DC system except that sound is also available with the loco stopped (e.g. idle sound of a diesel). In the load dependent case, the sound reacts prototypically to accelerations, inclines etc. Check the CV table for programming CV #137, 138 and 139!

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 the function output(s) at connector #1 (output #1 - #6).

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

Next define the uncoupler activation 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.

Replacing an LGB “on-board” decoder with a ZIMO MX69 and connecting it with the original LGB on-board sound module

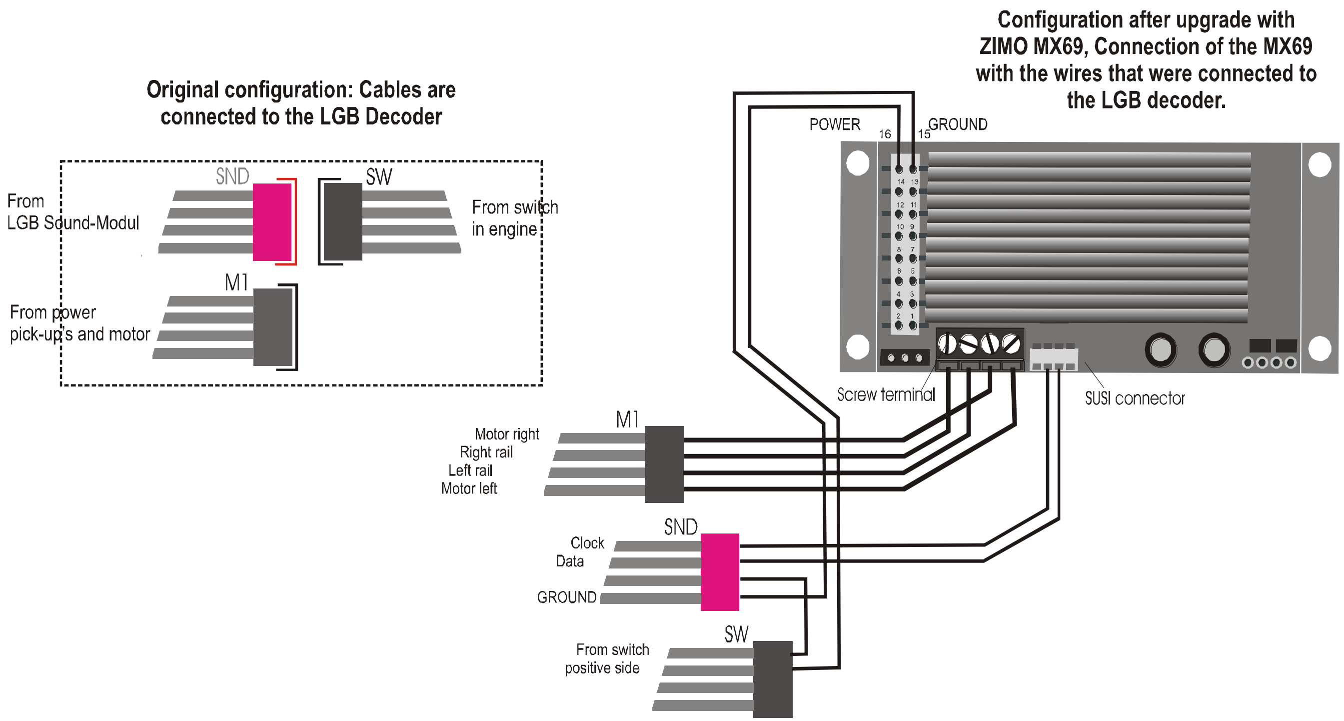
The decoder and sound module in the “on-board” set up, as used by LGB since 2004, communicates with each other via a special serial data bus (as opposed to the earlier “direct decoder” technique that used the pulse chain method).

The MX69 allows the direct connection to and control of the LGB on-board sound module using the LGB on-board protocol, thereby fully replacing the LGB on-board decoder (and of course adding the typical ZIMO features).

The two data cables of the on-board sound module are connected to the MX69 SUSI connector since the actual SUSI interface is not needed with this application. The SUSI connector itself needs to be redefined from a SUSI interface to “LGB on-board” using Bit 7 of CV #124; in the simplest case: CV #124 = 128 (if shunting key functions are not used).

The drawing below illustrates all the connections that are required when a loco with original LGB on-board equipment is converted to a ZIMO MX69 decoder. The schematic is based on the conversion of an LGB RhB Ge4/4 III, part #27422 (with “100 Jahre Albula und Ruinaulta” livery) and should be generally valid but can unfortunately not be guaranteed by ZIMO since changes without notice in LGB’s production cannot be ruled out.

Easier still is the conversion with an “Onboard Decoder Adaptor” (manufactured by Arnold Hübsch), which is not covered in this manual but in a separate manual supplied with the adapter.



Installing MX69 in older LGB locos (before “on-board”)

All LGB locos that are equipped with an original LGB decoder can relatively easily be converted to a ZIMO MX69 decoder (an MX69S is usually sufficient).

All other locos (without decoder) can of course also be converted but would have to be hard wired, since the locos won’t have any decoder connectors.

In contrast to LGB decoders, only one decoder is required for locos with two motors when converting to ZIMO MX69. The two motors are connected in parallel to the decoder!

There are many differences among LGB-DCC ready locos: some come with and some without a DCC interface on the central power supply board.

POWER and MOTOR:

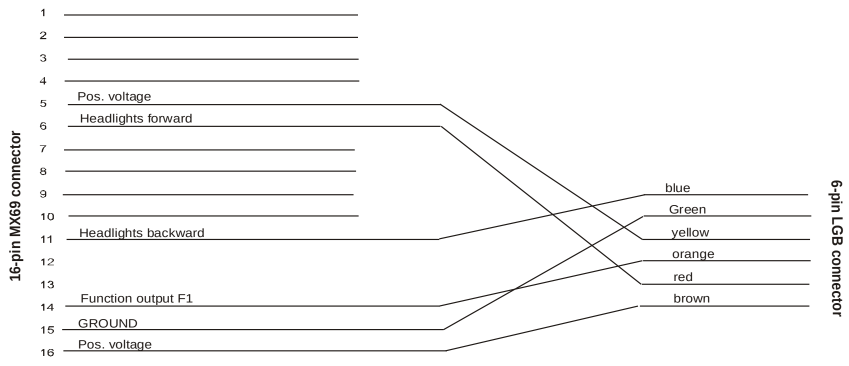
On locos without a DCC interface, connect the electrical pins of the gearbox (or both gearboxes) with the screw terminals of the MX69. The two inner pins (wire colors white and brown) connect to the POWER PICK-UP terminals and the two outer pins (wire colors yellow and green) to the MOTOR terminals.

Locos with a DCC interface get the respective pins of the central power supply board (marked with gn, br, ws and ge) connect with the MX69 4-pin screw terminal. Here again, the inner pins (br and ws) are connected to POWER and the outer pins to the MOTOR pins of the 4-pin screw terminal. Switch to DCC mode with the help of the DIP switches.

HEADLIGHTS and FUNCTIONS:

For locos without a DCC interface, connect the headlights and other functions to the MX69 decoder as described in the previous pages. If the loco is equipped with low voltage bulbs (5V) and you want to retain them, either lower the voltage with the help of CV #60 (often used value: 60) or use an MX69V with low voltage supply.

For locos with a DCC interface connect the 16 pin socket of the MX69 with the 6-pin interface socket. A connecting cable can be made out of the ZIMO MX65KAB and the LGB “extra” decoder cable. A finished connecting cable is also available from ZIMO under the order #**MX65LGBK.** The decoder does not have to be programmed for low voltage output because with this hook-up the 5V regulator of the central power supply board remains functional and the lights remain connected to that board.



CONVENIENT CONTROL OVER LGB SOUND:

Some older LGB models require that the function key F1 be pressed repeatedly (between 1 and 8 times) to activate single functions. The MX69 replaces this necessity by generating pulse chain commands. To activate this feature set Bit 7 to “1” in CV #112 (add 128 to the value in this CV). The desired number of pulses will then be generated and with that the corresponding function turned on or off, with a single push of a function key between F1 and F8.

The other function outputs of the MX69 are no longer accessible with this configuration but there are no other functions provided, beyond the ones controlled with pulse chain commands, in such rolling stock anyway.

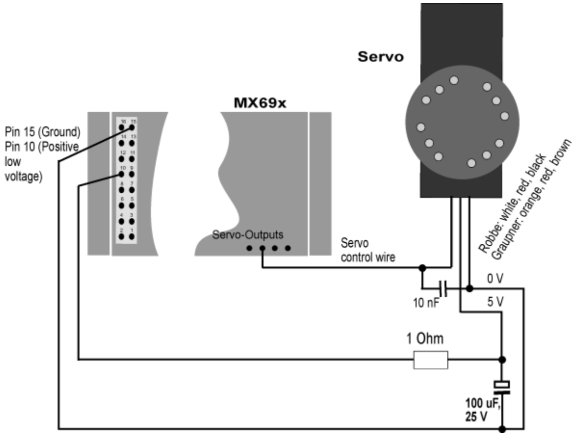
FURTHER INFORMATION NEEDED?

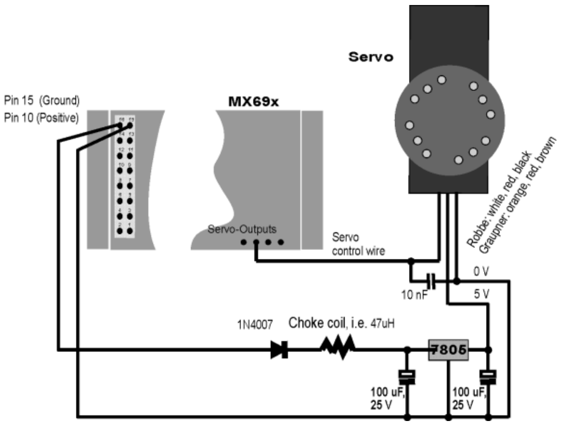
There are a number of conversion examples shown from ZIMO users at the ZIMO web site: www.zimo.at that might be helpful! Follow the links “APPLICATIONS”, and “Application tips”.

Connecting servo motors:

All MX69 (MX690) have 4 servo outputs (either as solder pads or pins, depending on decoder type) to individually control as many commercially available servo motors.

The 5V required by the servo(s) can be supplied by the low voltage outputs (connector #2 pin 11, ground at pin 6; or connector #1 pins 5 or 10; ground at pin 15) of the MX69**V** / MX690**V** (see drawing below), provided the outputs are set to 5V and the capacity is sufficient.





For **SmartServo**: CV #161 = 2

ATTENTION: The low voltage output of the MX69V is by default set to about 6.5V and should be reduced to 5V for servo operation (see “Adjustable low voltage”, solder 2K2 in place of 3K3 resistor)!

To protect the servo from voltage spikes, install the resistor (1 Ohm) and 100uF capacitor in the 5V supply circuit as shown to the left. To suppress noise in the control wire it is recommended to install the 10nF capacitor as shown.

Both precautions mentioned above are probably not necessary for most commercially available servo motors but are certainly recommendable.

The 5V supply has to be provided by external means for the MX69**S**, MX690**S** or MX69**L.** This is, by the way, also necessary with the MX69V if the low voltage is set different than 5V, the power consumption limit is already reached or the servos themselves draw more power than the decoder can supply.

The allocation of the servo outputs to the function keys is done with CV #181 – 184, the remaining definition with CV #161 to 177. CV #185 is especially provided for live steam engines. See CV table in chapter 3! ATTENTION: This CV range might later be moved with a newer SW version due to future NMRA standardization.

To suppress noise in the control wire it is again recommended to install the 10nF capacitor as shown.

Connection and control of an external energy source (capacitor) for uninterrupted driving on dead track sections:

With the help of an electrolytic capacitor or a battery the

- driving performance on dirty track sections (or wheels) can be improved
- flickering of lights is reduced
- and stalling of trains, especially when crawling, can be eliminated.

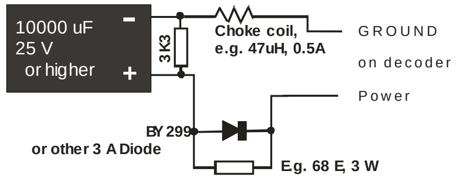
From SW version 8:

Smart stop management

In cases where power to the decoder is interrupted due to dirty rails, wheels or insulated frogs, the decoder prevents the engine from stopping even though a currently active brake application should bring the train to a stop. Only when power to the decoder is restored is the loco allowed to stop, with subsequent testing to ensure power to the decoder is still available after the engine stopped (if not, the engine is moved again a short distance).

The energy storage increases with the capacity of a condenser and from 1000uF (Microfarad) on an effect will be noticed. 100’000uF are recommended for large scale if the necessary space is available. Gold caps with several Farads would of course be even better.

The capacitor is connected between a ground and positive pin of the decoder. Note polarity!



Use the above schematic if you want to build this circuit yourself. The 100 ohm resistor is required to prevent a short circuit when booting up the system, due to the large in-rush current caused by a large number of capacitor-equipped locos on the track. The diode (e.g. 1N4007) allows the resistor to be bypassed when a quick discharge is required.

NOTE: The above resistor-diode combination is definitely required if the “asymmetrical DCC signal stop” feature is used (=Lenz ABC) to ensure that the decoder can detect the asymmetry of the signal!

The purpose of the resistor 3K3 shown in the drawing above (not necessarily required) is:
Even though a large condenser supplies the motor and lights for just a few tenths of a second (1000uF) or a few seconds (e.g. 10,000uF) the remaining power, although at a voltage level below what is required by the motor and lights, is sufficient power to keep the decoders memory alive for quite some time. 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 after about a minute. Using the above-mentioned resistor would erase the memory after just a few seconds.

Tips for connecting smoke generators:

Using the "Seuthe" 18V smoke generator as an example:

Besides a simple ON/OFF function using any function output, the MX69/MX690 offers a simple solution for **changing smoke intensity** from a **stand still to full load.**

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.

Synchronized steam chuff or typical diesel smoke with "USA Trains USAR22-454":

Without additional electronic components, the MX690V can produce steam puffs that are synchronized with the chuff sounds 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 **FO10;** the other wire of the fan motor is connected to the low voltage power pin (i.e. pin 9 on connector #2) because the fan motor of the USA Trains smoke generator is designed to operate on 6V. The low voltage supply of the decoder must be set to the voltage required by the fan motor, which is the case at delivery of the MX690V for the USA Trains generator (@6.5V).

The CV's must be programmed as follows:

CV #137, #138, #139 = 60, 90, 120 respectively: (IMPORTANT) the heating element of the USA Trains smoke generator is designed for maximum 9V, which requires that the voltage of that function output is limited. This is done with suitable values in CV #137, 138 and 139.

CV #133 = 1: (IMPORTANT) this configures output FO10 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).

Connecting speaker, cam sensor, audio-energy storage:
(only MX690S, MX690V)

In order to operate the MX690 as a sound decoder, the following items must/may be connected:

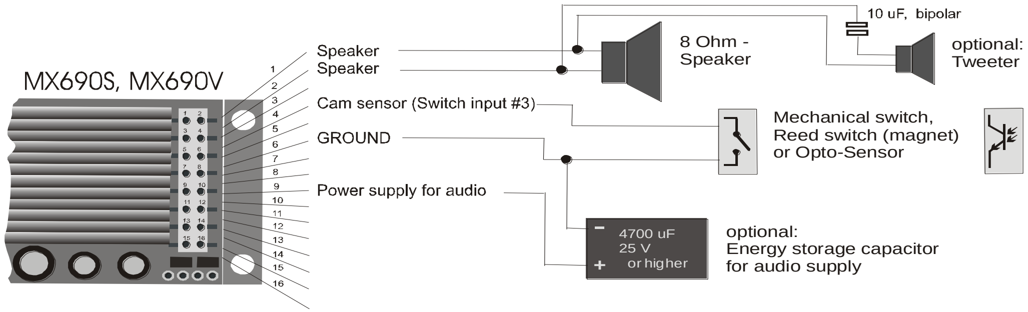
- mandatory – ***SPEAKER*** – Any 8 ohm speaker can be used or two 4 Ohm speakers wired in series. Speakers with higher impedance are allowed as well but will result in reduced volume.

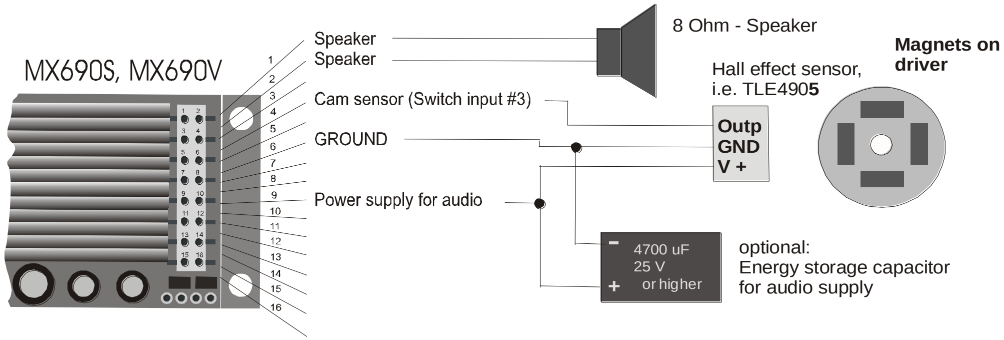
If desired, a tweeter (also 8 ohms or higher) can be added but should be wired with a bipolar capacitor (10 uF bipolar for 2 kHz frequency).

- 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.
Mechanical contacts, Reed switches, optical switches and Hall Effect switches are suitable as cam sensors. The switch input #3 of the MX690 is fitted internally with a pull-up resistor, which means that the cam sensor should switch this input to ground to trigger a chuff beat.

- optional - ***AUDIO-ENERGY-BUFFER*** – An electrolytic capacitor connected according to these instructions (see drawing) will prevent sound interruptions when track and wheel contact is lost for brief periods. The capacitor connected to the pin "power supply for audio" works independently form the energy buffer for the motor (see above) that is, it will not be drained by the motor but is reserved for uninterrupted sound only.

The capacitor must be of 25V, its capacity must be at least 1000uF (for about .2 second of power), better still a 4700uF capacitor good for about 1 second.





9. MX69, MX690 with enhancement board

All large scale (sound) decoders with permanently attached or plugged-in enhancement boards have the same characteristics and functions as the "normal" MX69S, MX69V, MX690S and MX690V, which includes servos, SUSI, inputs etc, BUT ADDITIONALLY:

* Energy storage capacitors to combat light flicker and engine stutter (for a few tenths of a second), with provisions for attaching additional (larger) external capacitors (for several seconds of back-up),
* Decoder connections with screw terminals or plug-in sockets (with pin configurations found in most gauge1 locomotive boards),
* As type "W" or "X" (for MX690S and MX690V sound decoders): With 10W sinus audio amplifier, adjustable to different speakers (4 Ohm or higher) and special circuitry to suppress switch-off noise.

The different decoder / enhancement board combinations turn into many different decoder types that are suitable for diverse applications:

Note: The pictures below always show the V-type decoder MX69V or MX690V (i.e. MX69VEL, MX690VEK…); the S-type decoders MX69S or MX690S (i.e. MX69SEL, MX690SEK…) are the same in appearance but lack the two smaller capacitors in the front center. The largest of the 3 caps on the other hand is always present.

 ***MX69SEL, MX69VEL***	„Enhanced non-sound" with plug-in sockets **MX69S** or **MX69V** with mounted enhancement board. Two 12-pin plug-in sockets for decoder connections, matching the usual gauge 1 loco boards.
 ***MX69SEK,***	„Enhanced non-sound" with screw terminals **MX69S** or **MX69V** with mounted enhancement board. 32 Screw terminals for decoder connections.
MX69VEK	
 ***MX690SEL, MX690VEL***	„Enhanced sound" with plug-in sockets and 1.1W amplifier **MX690S** or **MX690V** with mounted enhancement board. Two 12-pin plug-in sockets for decoder connection, matching the usual gauge 1 loco boards. 1.1W audio output like the "normal" sound decoder.
 ***MX690SEK, MX690VEK***	„Enhanced sound" with screw terminals and 1.1W amplifier **MX690S** or **MX690V** with mounted enhancement board. 32 screw terminals for decoder connection. 1.1W audio output like the "normal" sound decoder.
 ***MX690SEW, MX690VEW***	„Enhanced sound" with plug-in sockets and 10W amplifier **MX690S** or **MX690V** with mounted enhancement board. Two 12-pin plug-in sockets for decoder connection, matching the usual gauge 1 loco boards. 10W audio output, volume and mute controls.

 ***MX690SEX, MX690VEX***	„Enhanced sound“ with screw terminals and 10W amplifier **MX690S** or **MX690V** with mounted enhancement board. 32 screw terminals for decoder connection. 10W audio output, volume and mute controls.
 ***MXEHPW***	Enhance existing decoders with plug-in sockets and 10W amplifier Plugs onto “normal” **MX690S** or **MX690V** decod-er. Two 12-pin plug-in sockets for decoder connec-tion, matching the usual gauge 1 loco boards. 10W audio output, volume and mute controls.
NOTE: The actual enhancement board may have less screw terminals than shown here, since many connections are in duplicate.	
 ***MXEHPX***	Enhance existing decoders with screw terminals and 10W amplifier Plugs onto “normal” **MX690S** or **MX690V** decod-er. 32 screw terminals for decoder connection. 10W audio output, volume and mute controls.

TECHNICAL INFORMATION

Dimensions (L x W x H) MX690 with permanently mounted enhancement board .. 60 x 40 x 24 mm
plugged-in .... 60 x 40 x 32 mm

Maximum motor current = maximum continuous total current .... 3 A
peak current .... 5 A

Audio amplifier of the MX690SEW, -VEW, -SEX, -VEX .... 10 Watt
minimum speaker impedance .... 4 Ohm

Other technical data’s are identical to the standard decoders (MX690S or MX690V).

Most of the connections on the enhancement board are a direct extension from the decoder and can therefore be used in the same way.

Speaker, cam sensor … on the MX690SEW, -VEW, -SEX, -VEX:

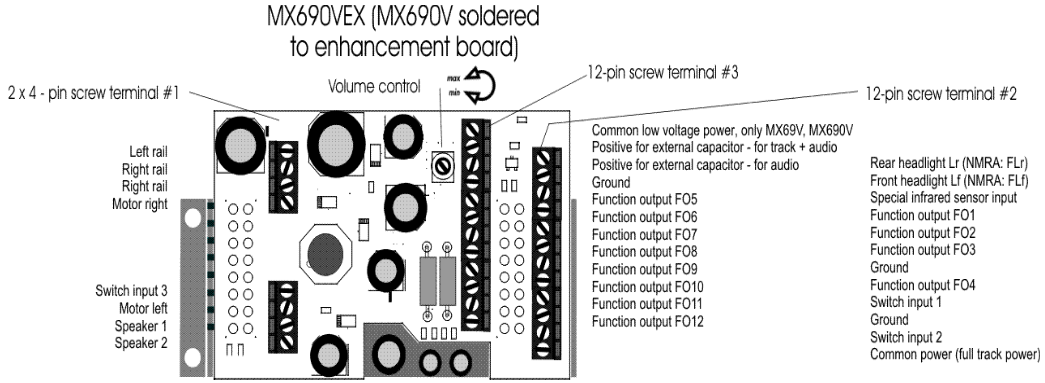
Speakers are connected to the speaker pins on connector #1 (bottom left).

The 10 Watt versions can be fitted with one 4 Ohm or two 8 Ohm speakers. The amplifier can drive an additional tweeter, which must be electrically isolated by a capacitor.

The kind of cam sensor and its connection is covered in the previous chapter. Switch input 3 is pre-ferred for this (also on connector #1, same as speaker).

Below is a wiring diagram with the example of a MX690VEX,

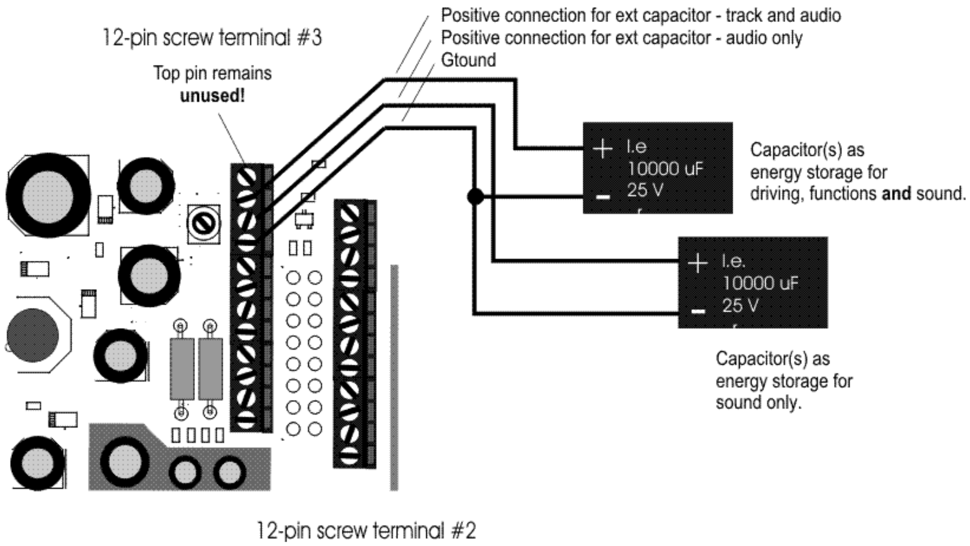
Some of the other types have a few less pins and the versions with plug-in sockets only have the two outer rows (Row 1 and 2) available; row 3 however is electrically functional and is accessible at the board pin holes (solder connection).



External capacitors on MX69/MX690 with enhancement board:

Using **external capacitors as energy storage** for overcoming dead track sections is a lot easier with the enhancement board, because there are no other components required; besides the capacitor itself (or capacitors). All other electronic components - as recommended in the previous chapter for decoders without enhancement board - are already installed on this board.

Two separate connections are available for connecting external capacitors for track and audio power. The capacitor for track power also supports the audio part, whereas the audio capacitor adds additional power to the audio section only.



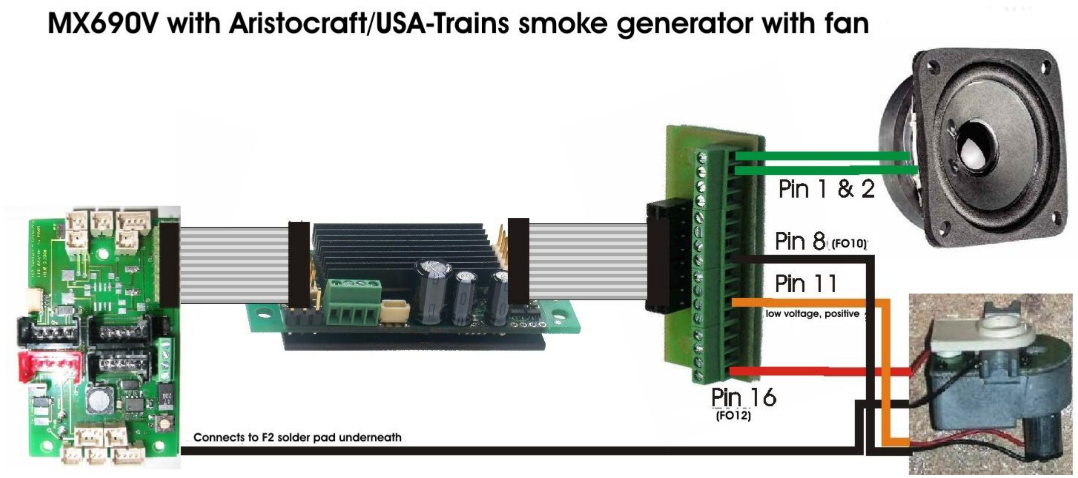
A high output energy module MXSPEIG (using gold caps) is in preparation.

10. ZIMO EASY-LINE

Under the name „EASY-LINE", complete **ZIMO large-scale sound decoder** kits will be offered that contain all necessary items needed for a simple installation, especially for LGB engines, which are equipped by the manufacturer with LGB Onboard decoders. The kit contains:

- ZIMO MX690V large scale sound decoder,
- LGB-Adapter from MANHART, with LGB Onboard decoder compatible connector,
- Screw terminal adapter LGB-SCHR16, from Arnold Hübsch,
- Smoke generator with fan, from USA-Trains,
- necessary cable and connectors.

The MX690V comes equipped with a **Sound project** recording (steam or diesel), which takes into account the specifics of the partner products.



Example: The sound project "EASY-STEAM":

The smoke generator is switched ON/OFF with F2.

The following CV's come configured as:

CV #133 = 40, for synchronized steam chuffs (fan connected to FO10 and pin 11 for low voltage)

CV #137 = 70, CV #138 = 100, CV #139 = 130, for load dependent smoke (smoke generator connected to FO12 and FO2).

!!! Based on 20V track voltage !!!

For adapter details go to: http://www.beathis.ch/lgb/shop/lgbadapt/lgbadapt.html

11. MX69 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.

Most systems of other manufacturers, in contrast to ZIMO systems, do not stabilize their track voltage at all or only in a limited way and is often relatively week (Voltage and Amps). This can lead to uneven speeds and/or limited top speed because Zimo decoders are of course programmed to operate on stabilized power of up to 24V from a Zimo command station.

It is recommended if necessary to:

- change **CV #57** (reference voltage) from "0", which causes the decoder to use track voltage as a reference for BEMF, to a fixed voltage. For example: "140" for a DCC system with a typical track voltage of 16 - 18V. In this example 14V will be used as reference, which leaves a certain safety margin during voltage drops.

MX69, MX690 with Lenz "DIGITAL plus" SW version 2.0 or higher

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. 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.

MX69, MX690 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!

Examples:

To enter a value of 160 to CV #5 (max. speed) with the Lokmouse2 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.

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.

MX69 with LGB MZS System

Operation and programming is limited to system capabilities, which are:

Only 23 loco addresses, available configuration variables and maximum values limited to 99 (with "Universal-Handy, with "Lok-Handy" even less), 14 speed steps only and function outputs can only be operated using the pulse-chain method with F1 function key.

To adapt the MX69 the following CV's have to be set to: CV **#**29 Bit 1 =0 (14 speed steps) and CV #112 Bit 4 = 1 (enable pulse-chain commands).

With the help of pseudo-programming CV **#**8 **=** 9 ("pseudo" because the entered value is only used temporarily and not permanently stored), the decoder will be reset to CV #29 = 4 (14 speed steps and analog on) and CV #112 = 16 (pulse-chain commands enabled). This in fact is a modified HARD RESET for LGB. This reset is also possible with an LGB system, where direct access to programming of CV #112 is impossible!

The Lokmaus-2 pseudo-programming feature may be used for programming the decoder (see previous section) to overcome the programming limits (range limited to 99), or another full-featured DCC system.

MX69 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.

12. 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 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 (CV #8 contains "145", the manufacturer code for ZIMO and cannot really be overwritten, therefore the term pseudo-programming).

In contrast to MX63 and MX64 HO decoders, there are **no special CV sets available for large-scale decoders at this time (SW version 17, 18…).** Because the relevant CV's of sound decoders are stored within the sound project has also a lot to do with it.

The possibility of using self-defined CV sets is planned for future software versions.

Note to hard resets (are identical for CV-sets and sound projects):

CV #8 = 8 the common hard reset, will reset all configuration variables to default values according to the CV-table in chapter 3.

CV #8 = 0 the "traditional" hard reset – a procedure known from ZIMO cabs (MX2, MX21, MX31…by programming an address to "0") – will on the other hand reset the decoder to the last defined "special CV set" or the lastly installed sound project!

13. 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).

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).

14. MX69 and Märklin MOTOROLA System

The only time it makes sense to use the MX69 in the MOTOROLA mode is when one is forced to use a system that is not capable of operating in DCC. DCC is much more efficient and is therefore the preferred mode in multi-protocol systems.

The MOTOROLA format is automatically recognized by the decoder.

Address and CV programming is possible with a Märklin system although very tedious (little support from the system):

PROVISIONAL INSTRUCTIONS:

Programming MX69 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

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 1 – 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 enter address 80 for 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.

15. Software Update with MXDECUP

… 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 "UPDATE") 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 of 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 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 projects 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.

MXDECUP(U) MX31ZL with USB stick

RS-232 – DSUB-9-socket Connect to "update track", connect to power supply control-LED's behind socket

The update module comes with a power supply, an RS-232 connecting cable and a USB converter (in case of MXDECUPU). Power supplies (12V DC, 300mA minimum, unregulated), serial cable with two 9-pin sub-D connectors (1:1) and commercially available USB converters (USB to serial) can also be acquired locally if necessary.

Implementation and operation:

A **section of track** is used as "update track" and connected to the 2-pin screw terminal of the MXDECUP. Set the engine with the decoder that is to be updated on the track. The decoder can of course be connected 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).

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 ZST that operates without acknowledgements, its use is not really recommended.

First, 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 Service Tool"*** (***ZST***, always use the latest version. For English applications use the **ZST extension**, see explanation on previous page):

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!