Preliminary
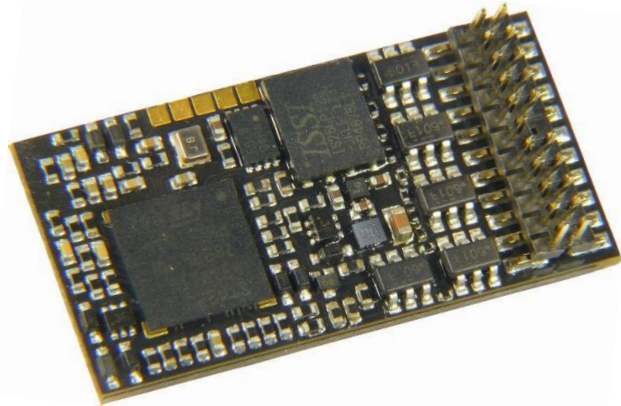
INSTRUCTION MANUAL

Sound decoders MS450P22 f

*) "mfx" is a registered trademark of Fa. Gebr. Märklinf & Cie GmbH.

Editions

Contents

1 Overview

30 x 15 x 4mm   **SOUND**   -   *1.2 A*   -   *9 Fu-Outputs* - *2 Servos* -   *SUSI* - **DCC**, **MM**, **mfx**,
DC, **AC**

MS450P22	**HO-Sound-Decoder** with **9 function outputs, 3 Watt audio on 4 Ohm speaker (or 2 x 8 Ohm),** with **energy storage circuitry, PluX-22 interface** TYPICAL APPLICATION: HO, O and similar gauges.

2   Technical Data, Notes, mfx-operation

Allowable track voltage .... min. 10 V
    MS450.. AC analog .... max. pulse... 35 V

max. continuous motor current:
    MS450 .... 1.2 A

Peak motor current
    MS450 for about 20 sec .... 2.5 A

Maximum total function output, continuous
    MS450 .... 0.8 A

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

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

Sound sample memory .... 128 Mbit (= 360 sec at 16 bit / 22kHz)
Number of independent sound channels 16
Sound amplifier output (Sinus) .... 3 Watt
Speaker impedance .... min. 4 Ohm

Dimensions (L x W x H)
    MS450 .... 30 x 15 x 4 mm

*) The short circuit protection is carried out for the total current of all function outputs.

The decoder type can be read out in CVs #250-252:
CV#250=6, CV#251=4, CV#252=50 = MS450

Software Update:

You need a device that is able to update: **ZIMO MXULF/A** (Decoder update-and-sound-loading-device), **ZIMO central command station MX10** or **Roco digital command station Z21**. The new SW version is downloaded from www.zimo.at, loaded into a flash drive or sent to the updating device via USB-connection to a computer and ZSP.

This is also how a sound project is loaded into a ZIMO decoder.

Overload and Thermal Protection:

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

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

Wrong decoder contact: *if, for example, the motor leads have contact to track power or an overload connection between the motor brushes and rail pick-ups, this is not always recognized by the overload protection circuit and could lead to damage of the motor power amplifier or even a total destruction of the decoder.*

Unfit or defective motors: *e.g. coil or commutator shorts are not always recognized by their high current consumption, because these are often just short current spikes. So, they can lead to decoder damage including damage to power amplifiers due to long-term exposure.*

*The power amplifiers of loco decoders (motor as well as function outputs) are not only at risk of overcurrent 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. This is why the running voltage shall not be too high, i.e. not higher than intended by the corresponding vehicle.*

ZIMO decoders are equipped with temperature sensors to measure their own operating temperature. Power to the motor will be turned off once that temperature exceeds 100°C. The headlights start flashing rapidly, at about 5 Hz, to make this state visible to the operator. Motor control will resume automatically after a drop in temperature of about 20°C (i.e. to about 80°C), typically in about 30 seconds.

Mapping of the PluX-22 interface of the MS450P22:

Fu-Ausgang FA3	Schalteingang IN1
SUSI(Data)/Servo2/FA10/IN3	SUSI(Clock) /Servo1/FA9/IN2
ELKO Plus	MASSE (= ELKO Minus)
Motor rechts	Licht vorne Lf
Motor links	+ Gem. Pluspol
Schiene rechts	Kein Pin (Index, FA8)
Schiene links	Licht hinten Lr
Fu-Ausgang FA1	Lautsprecher
Fu-Ausgang FA2	Lautsprecher
Fu-Ausgang FA5	Fu-Ausgang FA4
Fu-Ausgang FA7	Fu-Ausgang FA6

Mfx operation:

The following pictures are **screenshots of the Märklin central station CS3**, showing procedures as addressing and operating the Roco BR85 (equipped with ZIMO decoder MS450P22):

Pictures on this page: the loco with the mfx-capable decoder is put on the layout where various other vehicles (picture 2) are already registered. The usual **addressing procedure** is handled for the new vehicle (BR85) in the mfx system; with small differences depending on the system used (CS2, Mobile Station, CS3,...).

Pictures on the next page: After selecting **"Lok bearbeiten"** (edit loco) the "blocks" of vehicle data are read and listed. Within the blocks, the parameters can be controlled and modified.

After completing loco editing (by X), the **driving operation** is started (or continued).
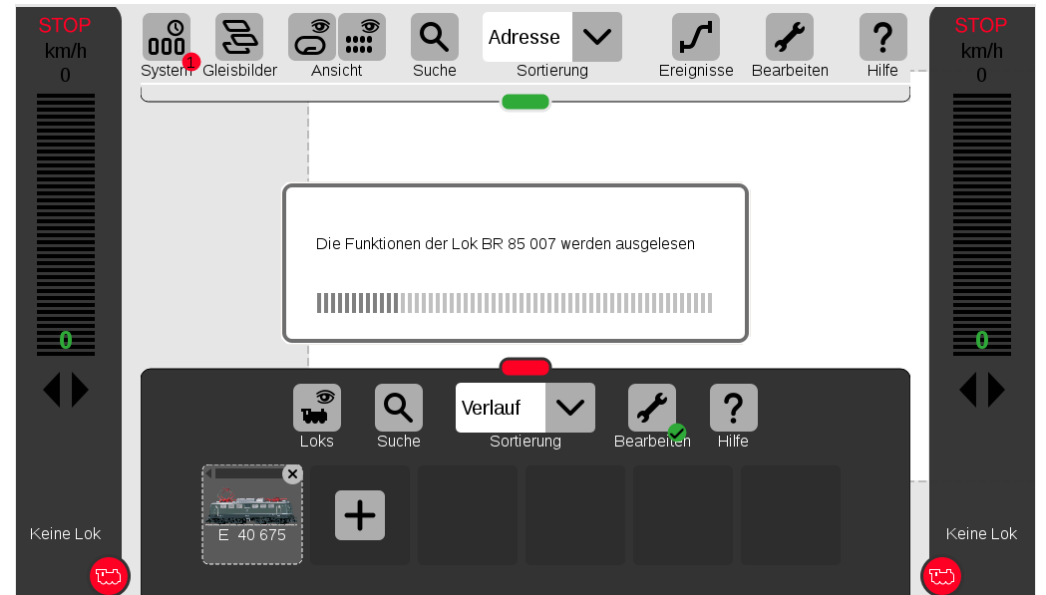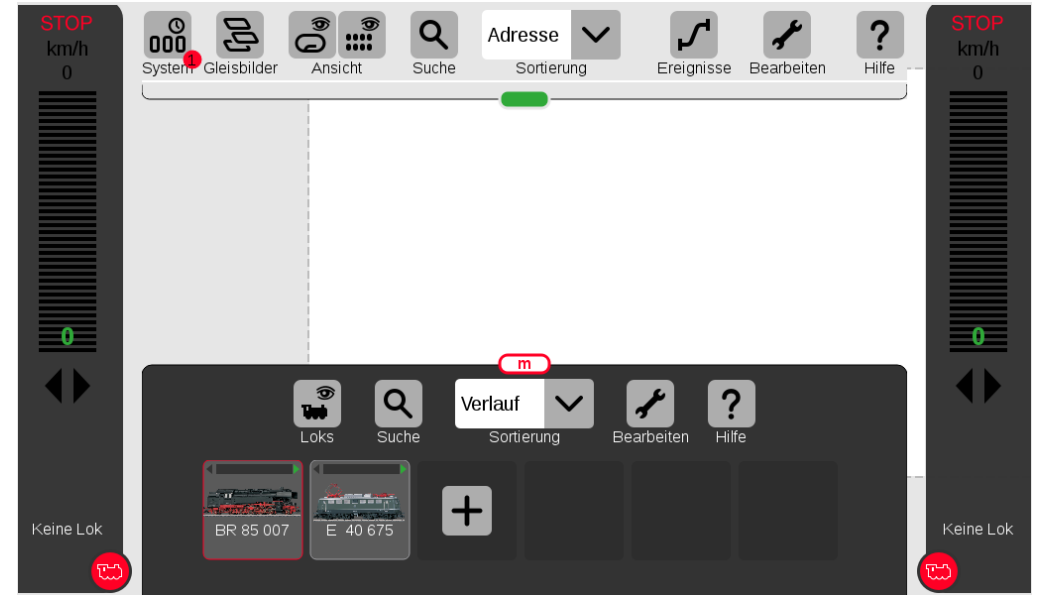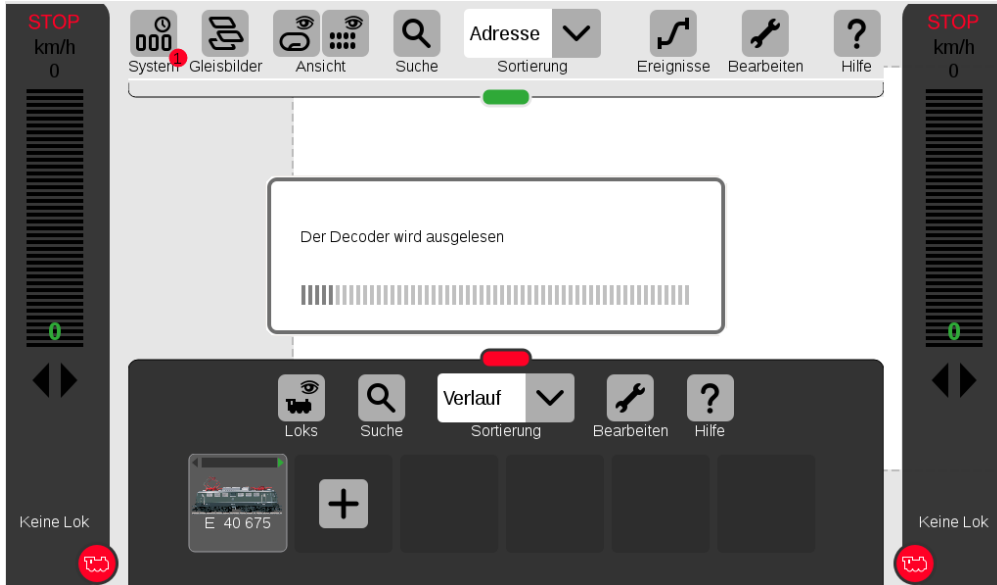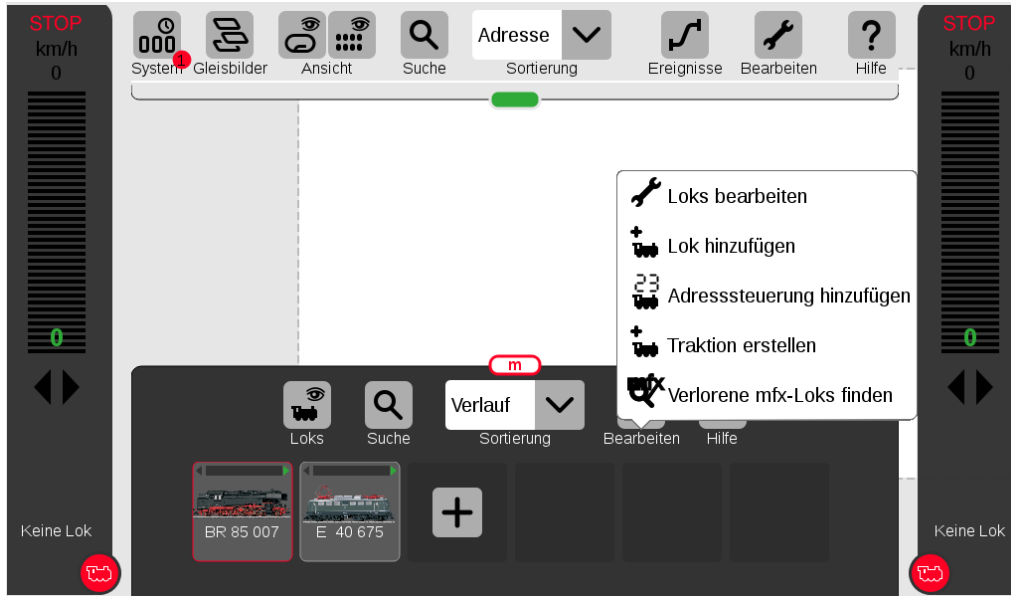
3   CVs in DCC operation

3.1   Basic Configuration

CV	Denomination	Range	Default	Description
#12	Operating modes		117	Bit 0 - DC analog 0 = disabled <u>1</u> = enabled Bit 4 - AC analog 0 = disabled <u>1</u> = enabled Bit 5 - MM 0 = disabled <u>1</u> = enabled Bit 6 - mfx 0 = disabled <u>1</u> = enabled Value 0 = all modes enabled

#27	Automatic stopping		21	Bit 4 - DC braking section, if polarity
				     is reversed
				     0 = disabled <u>1</u> = enabled
				
				Bit 5 - DC braking section, if polarity
				     is equal to direction of travel
				     <u>0</u> = disabled 1 = enabled

#28	RailCom Configuration
	planned in
	SW version 2.00
		0 - 3	3	Bit 0 - RailCom Channel 1 (Broadcast)
				     0 = OFF **1 = ON**
				
				Bit 1 - RailCom Channel 2 (Data)
				     0 = OFF **1 = ON**

#29	Basic Configuration	0 - 63	14 =
			
			0000 **1**110
			
			Bit 3 = 1
			("RailCom"
			on)
			
			and
			
			Bits1 & 2 = 1
			(28 or 128
			speed steps
			and automat-
			ic analog op-
			eration ena-
			bled)
				Bit 0 - Train direction:
				     <u>0</u> = normal, 1 = reversed
				Bit 1 - Number of speed steps:
				     0 = 14, <u>1</u> = 28/128 speed steps
				Bit 2 - automatic change to analog operation
				     0 = disabled <u>1</u> = enabled
				Bit 3 - RailCom („bi-directional communication")
				     0 = deactivated **1 = activated**
				     SW version 2.00 and later!
				Bit 4 - Individual speed table:
				     <u>0</u> = off, CVs #2, 5 and 6 are active.
				     1 = on, according to CVs #67 – 94
				Bit 5 - Decoder address:
				     <u>0</u> = primary address as per CV #1
				     1 = ext. address as per CVs #17 & 18

3.2   Decoder-ID, Load-Code

CV	Denomination	Range	Default	Description
#250, #251, #252, #253	**Decoder-Type** (see chapter 1, Overview)	Read only	-	CV #250 = decoder-class (1=function decoder, 2=decoder, 6=sound-decoder) CV #251 = Hundredths digit of type classification CV #252 = Tens and ones digit of type classification CV #253 = hardware revision

3.3   ManufacturerID, SW version

CV	Denomination	Range	Default	Description
#8	Manufacturer ID and HARD RESET with CV #8 = "8" or CV #8 = 0	Read only always shows "145" for ZIMO ID Pseudo-programming see explanation to the right-	145 (= ZIMO)	Reading out this CV always result in "145" ("10010001"), the number issued for ZIMO by the NMRA. This CV is also used for various resetting processes with the help of Pseudo-Programming. Pseudo-Programming means that the entered value is not really stored, but rather used to start a defined action. CV #8 = "3" → changing 21MTC type D to type C **CV #8 = "4"** → changing 21MTC type C to type D **CV #8 = "8"** → **HARD RESET** (NMRA standard); all CVs return to the last active **CV set or sound project,** or the default values listed in this CV table if no such set was active before.
#7	SW version number Also see CV #65 Sub-Version number	Read only	-	This CV holds the firmware version number currently in the decoder. CV #7 = number of "main" version CV #65 = Sub-version number
#65	SW- Sub-Version Number Also see CV #7 for Version number	Read only	-	If there are subversions to the SW version in CV #7, it is read out in CV #65. The entire SW version number is thus composed of CVs #7 and #65 (i.e. 28.15).

3.4 The vehicle address(es) in DCC mode

Decoders are usually delivered with default **address 3** (**CV #1 = 3**), for the DCC as well as the MM (Märklin Motorola) format. All aspects of operations are possible with this address but it is recommended to change to a different address as soon as possible.

The address space required for DCC exceeds the range of a single CV, up to 10239 in fact. For addresses higher than 127, CVs #17 & #18 are used. Bit 5 in CV #29 is used to select between the short address in CV #1 and the long address in CV's #17/18.

☞ Most digital systems (with the possible exception of very old or simple products) automatically calculate the value for the CVs involved, and also set CV #29 Bit 5 to the proper value when writing the address, so that the user does not have to deal with the necessary coding.

CV	Denomination	Range	Default	Description
#1	Locomotive address	DCC: 1 - 127 MM: 1 - 255	3	The "small" (or "short") vehicle address (DCC, MM) In case of DCC operation: Primary address as per CV #1 is only valid, if CV #29 (basic configuration), Bit 5 = 0. Otherwise, the address per CVs #17 & #18 is valid, i.e. if CV #29, Bit 5 = 1.
#17 & #18	Extended (long) address	128 - 10239	0	The long ("extended") DCC address applies to addresses >127. The loco address per CVs #17 & #18 is valid, if CV #29 (basic configuration), Bit 5 = 1.
#29	Basic configuration	0 - 63	14 = 0000 1110 Bit 5 = 0 ("small" address)	Bit 0 - Train direction: 0 = normal, 1 = reversed Bit 1 - Number of speed steps: 0 = 14, 1 = 28/128 speed steps Bit 2 - automatic change to analog operation 0 = disabled 1 = enabled Bit 3 - RailCom („bidirectional communication") 0 = deactivated 1 = activated Bit 4 - Individual speed table: 0 = off, CVs #2, 5 and 6 are active. 1 = on, according to CVs # 67 – 94 Bit 5 - Decoder address: 0 = primary address as per CV #1 1 = "extended" address per CVs #17 & #18

The combined operation of two or more locomotives (in consist function) with the same speed can be managed by

- the DCC system (common practice with ZIMO systems, without changing any decoder CVs) or
- by programming the following decoder CVs individually, but can also be managed by some DCC systems (often the case with American made systems).

This chapter only covers the decoder-controlled consisting!

CV	Denomination	Range	Default	Description
#19	Consist address planned in SW version 3.00	0, 1 – 127 129 - 255 (= 1 - 127 with inverted Direction)	0	Alternate loco address for consist function: If CV #19 > 0: Speed and direction is governed by this consist address (not the individual address in CV #1 or #17&18); functions are controlled by either consist address or individual address, see CVs #21 & 22. Bit 7 = 1: Driving direction of this loco reversed
#20	Extended consist address planned in SW version 3.00	0 - 102	0	"Extended" consist address: the value defined in CV #20 is multiplied by 100 and added to the value in CV #19, which then results in the address in consist operation. E.g. CV#20 = 12, CV#19=34 equals addr. 1234; CV#20=100, CV#19=00 equals addr. 10000
#21	Functions F1 - F8 consist functions planned in SW version 3.00	0 - 255	0	Functions defined here will be controlled by the consist address. Bit 0 = 0: F1 controlled by individual address = 1: …. by consist address Bit 1 = 0: F2 controlled by individual address = 1: …. by consist address ………. F3, F4, F5, F6, F7 Bit 7 = 0: F8 controlled by individual address = 1: …. by consist address
#22	Functions F0 forw. rev. in consist function planned in SW version 3.00	0 - 255	0	Select whether the headlights are controlled with consist or individual address. Bit 0 = 0: F0 (forw.) controlled by individual address = 1: …. by consist address Bit 1 = 0: F0 (rev.) controlled by individual address = 1: …. by consist address Bit 2 = 0: F9 (forw.) controlled by individual address = 1: …. by consist address Bit 3 = 0: F10 (forw.) controlled by individual address = 1: …. by consist address Bit 4 = 0: F11 (forw.) controlled by individual address = 1: …. by consist address Bit 5 = 0: F12 (forw.) controlled by individual address = 1: …. by consist address Bit 7 = 1: F13 – F27 (all!) ….by consist address Bit 6 = 1: Auto consist: The system changes automatically between individual and consist address, if one of the two addresses has speed 0 and the other has speed >0.

3.5   Analog operation

All ZIMO decoders are capable of operating on conventional layouts with DC power packs, including PWM throttles, in **analog DC** as well as in **analog AC** (Märklin transformers with high voltage pulse for direction change).

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**With the first SW version only AC analog is active,
DC-analog is planned in later software versions.**

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To allow analog operation,

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CV #29, Bit 2 = 1 must be set.

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This is usually the case by default (CV #29 = 14, which includes Bit 2 = 1), but analog operation may be turned off in many sound projects (sound decoders).

The actual behavior during analog operation, however, is strongly influenced by the locomotive controller (power pack). Especially in combination with a weak transformer, it is easily possible that the track voltage collapses when the decoder (motor) starts to draw power which, in the worst case, may lead to intermittent performance.

In the analog operation, it is possible to adjust the acceleration momentum (CV #14, Bit 6) and function outputs (CV #13 & #14).

Note: Actual decoder settings may differ from the default values if a sound project is on the decoder.

CV	Denomination	Range	Default	Description
#29	Basic Configuration	0 - 63	14 = 0000 11**1**0 so Bit 2 = 1 Analog operation	Bit 1 - Number of speed steps: 0 = 14, 1 = 28/128 speed steps Bit 2 - automatic change to analog operation 0 = disabled 1 = enabled and so on..
#13	Functions F1 - F8 Functions F0 forw. rev. F9 - F12 in analog operation (= observation mode) , and Acceleration/ Deceleration, control in analog operation	(CV #13) 0 - 255 (CV #14) 0 - 255	(CV #13) 0 (CV #14) 64 so Bit 6 = 1:	Bit 0 = 0: F1 is OFF in analog mode = 1: …ON in analog mode Bit 1 = 0: F2 is OFF in analog mode = 1: …ON in analog mode .... F3, F4, F5, F6, F7 Bit 7 = 0: F8 is OFF in analog mode = 1: …ON in analog mode
#14				Bit 0 = 0: F0 (forw) is OFF in analog mode = 1: …ON in analog mode Bit 1 = 0: F0 (rev) is OFF in analog mode = 1: …ON in analog mode .... F9, F10, F11 Bit 5 = 0: F12 is OFF in analog mode = 1: …ON in analog mode Bit 6 = 0: Analog operation with acceleration and deceleration according to CVs #3 and #4; useful for sound = 1: unregulated DC operation i.e. without acceleration and deceleration according to CV #3 and #4. This is similar to a classical analog operation.

3.6   Motor regulation

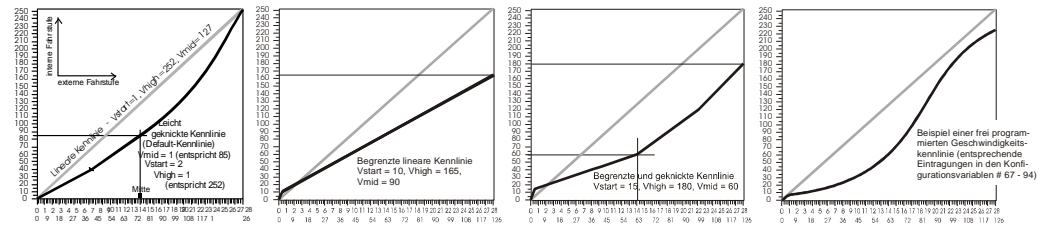*The speed table*

There are two types of speed curves, which are selected with

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CV #29, Bit 4 = 0: 3-point characteristic (defined by 3 CVs)

… = 1: 28-step curve (defined by 28 CVs)

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3-point speed table: the lowest, highest and medium speed is defined by the Configuration Variables #2 (Vstart), #5 (Vhigh) and #6 (Vmid) (=external speed step defined by slider position). This is a simple way to quickly establish a speed range and its curvature.

28-point speed table (a.k.a. "free programmable speed table"): with the help of CVs #67 - 94, all 28 external speed steps can be assigned freely to the internal speed steps (0-255). These 28 CVs apply to all speed step modes (14, 28 and 128). If 128 external speed steps are used, the decoder adds the missing intermediate values by interpolation.

CV	Denomination	Range	Default	Description
#29	Basic configuration	0 - 63	14 = 0000 1110 so Bit 4 = 0 (3-point speed table)	Bit 0 - Train direction: 0 = normal, 1 = reversed Bit 1 - Number of speed steps: 0 = 14, 1 = 28/128 Bit 2 - automatic change to analog operation 0 = disabled 1 = enabled **Bit 4 - Individual speed table:** 0 = off, CVs #2, 5 and 6 are active. 1 = on, according to CVs # 67 – 94 Bit 5 - Decoder address: 0 = primary address as per CV #1 1 = ext. address as per CVs #17 & 18
#2	Start Voltage Vstart	1 - 255	1	Internal speed step (1 … 255) applied as **lowest** external speed step (= 1) (applies to 14, 28, or 128 speed step modes) = 1: lowest possible speed
#5	Top Speed Vhigh	0 - 255	0, 1 equals 255	Internal speed step (1 … 255) applied as **highest** external speed step (that is, speed step 14, 28 or 128 depending on the speed step mode selected in CV #29, Bit 1). =0 = 1 (same as 255): fastest speed possible

CV	Denomination	Range	Default	Description
#6	Medium speed Vmid with 3-point table if CV #29, Bit 4 = 0	1 - 255	1 (= about 1/4 of top speed)	Internal speed step (1 … 255) for **medium** external speed step (that is, speed step 7, 14 or 64 depending on the speed step mode selected in CV #29, Bit 1) "1" = default (Medium speed is set to one fourth of top speed. I.e., if CV #5 = 255 the curve is the same as if CV #6 would be programmed to 64). The speed curve resulting from CVs #2, 5 and 6 is automatically smoothed out.
#67 ...... #94	Free (28-point) speed table if CV #29, Bit 4 = 1	0 - 255	*)	internal speed steps (each 1-255) for each of the 28 external steps. Additionally CV #2 and CV #5. *) The 28-point default curve is also bent in the lower speed range.

The reference voltage for motor regulation

CV #57 specifies the base voltage used for motor regulation. For example: if 14V is selected (CV value: 140) the decoder tries to send the exact fraction of this voltage, determined 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 default value "0" in CV #57 selects the "relative reference", which automatically adjusts the reference voltage to the available track voltage. This setting is only useful if the system can keep the track voltage constant at all times (stabilized track output) and the resistance along the track kept to a minimum. All ZIMO systems keep the track voltage stable, even older systems, but not every system from other manufacturers do, especially relatively cheap systems built before 2005. It is not recommended to set CV #57 to "0" with systems that don't keep track voltage stabilized. Instead set this CV about 2V below track voltage (i.e. 140 for 16V).

☞ CV #57 can also be used as an alternative to CV #5 (top speed), which has the advantage that the full resolution of the 255 speed steps remains available.

CV	Denomination	Range	Default	Description
#57	Voltage reference	0, 100 - 255	0	Absolute voltage in tenth of a volt applied to the motor at full speed (max. throttle setting). A useful (and well functioning) range is 10 to 24 V (i.e. 100-240), and lower than the expected track voltage. Example: A system from another manufacturer is set to 22V at idle but drops to 16V under load: A good setting would be CV #57 = 140…150. CV #57 = 0: automatically adjusts to the track voltage (relative reference); only useful with stabilized track voltage.

Tweaking the motor regulation

Simplified version from SW version 2.5

The motor's performance, especially at crawling speeds (as judder-free as possible), can be fine-tuned with the following CVs:

CV #9 – Motor control frequency and EMF sampling rate

The motor is controlled by pulse width modulation that can take place at either low or high frequency. Low frequency (30 – 159 Hz) is only useful for very few locomotives with very old motors (i.e. AC motors with field coils instead of permanent magnets). **High frequency** (**20 kHz** by default, up to 40 kHz as per CV #112) on the other hand is **quiet** and **easy on the motor.**

Power to the motor is interrupted periodically (50 – 200 times/sec.), even when operating at high frequency, in order to determine the current speed by measuring back-EMF (voltage generated by the motor). The more frequent this interruption takes place (sampling rate), the better; but that also causes power loss and increased noise. By default, the sampling frequency varies automatically between 200 Hz at low speed and 50 Hz at maximum speed.

CV #9 allows the adjustment of the sampling frequency (tens digits) as well as the sampling time (ones digits). The default value of 55 represents a medium setting.

CV # 56 – The PID regulation

The motor regulation can be tailored to motor type, vehicle weight and so on, by using different *P*roportional-*I*ntegral-*D*ifferential values. In reality, changing the differential value can be omitted.

CV #56 allows the proportional value (tens digit) as well as the integral value (ones digit) to be set individually. The default value of 55 represents a medium setting.

CV	Denomination	Range	Default	Description
#9	*Motor control period or frequency* and EMK sampling rate	55 High frequency, medium sampling rate 01 - 99 High frequency with modified sampling rate 255-176 Low frequency	55 High frequency medium Sampling rate	Default motor control with high frequency (20/40kHz), medium EMF sampling rate that automatically adjusts between 200 Hz (low speed) and 5 Hz and medium EMF sampling time. <> 55: Modification of automatic adjustments, each divided in: tens digit for sampling rate and ones digit for sampling time. Tens digit 1 - 4: Lower sampling rate than default (less noise!) Tens digit 6 - 9: Higher sampling rate than default (to combat juddering!) Ones digit 6 - 4: Shorter EMF sampling time (good for coreless motors, less noise, more power) Ones digit 6 - 9: Longer EMF sampling time (may be needed for round motors or similar). Typical test values against jerky driving: CV #9 = 55 (default) → 83, 85, 87, ... CV #9 = 55 (default) → 44, 33, 22, … = 255 - 176: Low frequency (for old motors only!) – 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: CV #9 = 255: frequency at 30 Hz, CV #9 = 208: frequency at 80 Hz, CV #9 = 192: frequency at 120 Hz.

#112	Special ZIMO configuration bits	0 - 255	4 = 00000100	Bit 0 = value-dependent (0) load dependent sound table (1), characteristic defined in CVs #137 - #139. Bit 1 = 0: Normal acknowledgement. = 1: High frequency acknowledgement Bit 2 = 0: ZIMO loco number recognition OFF = 1: ZIMO loco number recognition ON Bit 3 = 0: **12-Function Mode** = 1: **8-Function Mode** Bit 4 = 0: Pulse chain recognition OFF = 1: Pulse chain recognition (for old LGB) **Bit 5 = 0: motor control with 20 kHz = 1: 40 kHz motor control frequency** Bit 6 = 0: normal (also see CV #29) = 1: "Märklin brake section"
#56	P and I value for EMK-load balance control	55 medium PID setting 01 - 199 modified settings	55	= 55: default setting using medium PID parameters. = 0 - 99: Modified settings for "normal" DC motors. = 100 - 199: Modified settings for coreless motors (Faulhaber, Maxxon etc.) Tens digit 1 - 4: Lower proportional value than default Tens digit 6 - 9: Higher proportional value than default Ones digit 1 - 4: Lower integral than default Ones digit 6 - 9: Higher integral than default Typical test values against jerky driving: CV #56 = 55 (default) → 33, 77, 73, 71, ..
#147	EMK – sampling time extended range	0 - 255	0	Useful value to start: 20 For Fleischmann motors to avoid stuttering; values too big worsens the regulation. Slowly elevate the value until the stuttering is gone.

Tips on how to find the optimal CV #56 settings:

Start with an initial setting of CV #56 = **1**1; set the engine at low speed while holding it back with one hand. The motor regulation should compensate for the higher load within half a second. If it takes longer than that, increase the ones digit gradually: CV #56 = 1**2**, 1**3**, 1**4**...

With the locomotive still running at a low speed, increase the tens digit in CV #56. For example: (if the test above resulted in CV #56 = 1**3**) start increasing the tens digit CV #56 = **2**3, **3**3 ,**4**3…as soon as juddering is detected, revert back to the previous digit → this would be the final setting.

Load Compensation, Compensation Curve and Experimental CVs

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 engine stalls or run-away under light load. Load compensation should be reduced as speed increases, so that at full speed the motor actually receives full power. Also, a slight grade-dependent speed change is often considered more prototypical.

Locomotives operated in consists should never run at 100% load compensation in any part of the speed range, because it causes the locomotives to fight each other and could even lead to derailments.
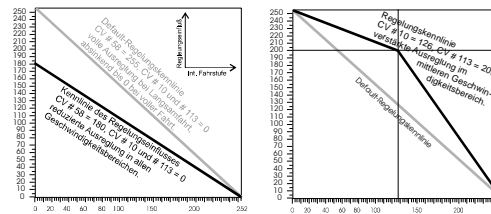
The overall intensity of load compensation can be defined with *CV #58* from no compensation (value 0) to full compensation (value 255). Useful values range from 100 to 200.

For a more precise or more complete load compensation over the full speed range use CV #10 and CV #113 together with CV #58 to define a 3-point curve.

CV	Denomination	Range	Default	Description
#58	BEMF intensity	0 - 255	255	Intensity of back-EMF control at the lowest speed step. If needed - usually not - an additional BEMF control can be defined by CV #10 and CV #113 - together those three (#58, #10, #113) form a three-point curve for the control. Example: # 58 = 0: no back-EMF (like unregulated decoders) # 58 = 150: medium compensation, # 58 = 255: maximum compensation.
#10	Compensation cut-off This CV is rarely required	0 - 252	0	Assigns an internal speed step where back EMF intensity is reduced to the level defined in CV #113. CV #10, #58 and #113 together define a back-EMF curve. = 0: default curve is valid (as in CV #58).
#113	Compensation cut-off This CV is rarely required	0 - 255	0	The BEMF intensity is reduced to this value at the speed step defined in CV #10. CV #113 together with CVs #58 and #10 forms a 3-point BEMF curve. = 0: actual cut-off at speed step in CV #10. Usually CV #10 is also set to 0.
#145 #147 #148 #149 #150	Experimental CVs for test purposes, to find out whether certain automatic settings have a negative effect on motor regulation. Using these experimental CVs will deactivate the automatic settings.		0 0 0 0 0	--- CV #145 = 1: Special setting for Fleischmann motor. --- CV #147 Sampling time --- Useful initial 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 initial value: Too small a value leads to poor regulation (regulates too little, too slow, engine judders (rather slowly)); if the value is too high, it over-regulates, loco will tremble.

CV	Denomination	Range	Default	Description
	CVs #147 – 149 will likely be removed again from the decoder SW at some time. **CV #145 = 10,11,12,13 for C-Sinus motors** see chapter 6			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 Load compensation at top speed --- Load compensation at top speed normally is always 0. This can be changed with CV #150. Example: CV #58 = 200, CV #10 = 100, CV #113 = 80, CV #150 = 40 -> Result: Regulation at speed step 1 is 200 (of 255, almost 100%), at speed step 100 it is 80 (@1/3 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!**

The Motor Brake

This brake is useful for vehicles without worm gears to prevent them from rolling away on inclines, picking up speed on declines as well as to prevent a heavy train from pushing a standing engine downhill.

CV	Denomination	Range	Default	Description
#151	Motor brake	0 - 99	0	= 0: brake not active = 1 - 9: The motor brake is gradually actuated (over a period of 1, 2 … 8 seconds, up to full braking power by shorting both motor power amplifier) if target speed is not reached (not slowing down) after cutting power to the motor (zero PWM to the motor). The higher the value, the faster and harder the brake is being applied. = Tens digit 1 - 9: Reduction of the motor regulation if consist-key is active. The values 1 - 9 reduce the control to 10% - 90% of the value set in CV #58.

3.7   Acceleration and deceleration momentum:

The basic acceleration and deceleration times (momentum) are set with

CVs #3 and #4 according to the

relevant NMRA standard, which demands a linear progression (the time between speed step changes remains constant over the whole speed range). For simple smooth drivability use values 3 or higher but for really slow starts and stops start with a value of 5; values higher than "30" are rarely useful, except in combination with the "braking key".

Important note regarding acceleration behavior - difference to ZIMO decoders of the MX-series:

The acceleration and deceleration behavior according to CVs #3 & #4, refers to the speed steps that are established by the speed table (including interpolation states), both with 3-point and 28 point-speed table. This means, an exponential - not linear - speed table also triggers a corresponding acceleration and deceleration behavior. Usually (also default) such a non-linear speed table is defined.

MX-decoders adjust acceleration and deceleration in 255 equidistant speed steps, regardless of the speed table. Therefore the MX-decoders have special CVs #121 and #122 to change the speed table to an exponential rate, which is not needed with the MS-decoders.

The sound project in sound decoders always comes with different values in CVs #3 and #4 (as well as many other CVs) than what is listed in the CV charts. Often the sound can only be played back correctly in conjunction with the acceleration times provided by the sound project (or certain minimum values), so the sound project's default values should therefore not be changed too much.

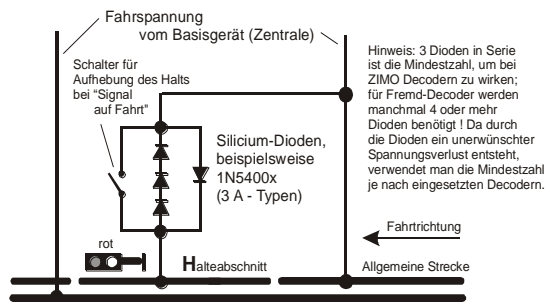| CV	Denomination	Range	Default	Description
#3	Acceleration time	0 - 255	(2)	The value multiplied by 0.9 equals acceleration time in seconds from stop to full speed. The effective default value for sound decoders is usually not the value given here, but is determined by the loaded sound project.
#4	Deceleration time (deceleration)	0 - 255	(1)	The value multiplied by 0.9 equals deceleration time in seconds from full speed to a complete stop. The effective default value for sound decoders is usually not the value given here, but is determined by the loaded sound project.
#23	Acceleration variation	0 - 255	0	For a temporary elevation/decrease (Bit 7 = 0/1) of the acceleration time defined in CV #3.
#24	Deceleration variation	0 - 255	0	For a temporary elevation/decrease (Bit 7 = 0/1) of the deceleration time defined in CV #3.

3.8   Special Operating Mode

Planned in SW-Version 3.0 and later!

3.9   The ZIMO "signal controlled speed influence" (HLU)

Planned in SW version "2.5" (= not yet in 2.0, probably an intermittent version before 3.0)

3.10   Stop in front of a red signal and driving slowly by asymmetrical DCC-signal stops (Lenz ABC)

The "asymmetrical DCC signal" is an alternative method for stopping trains at a "red" signal. A simple circuit made up of 4 or 5 commercially available diodes is all that is required.

Fahrspannung vom Basisgerät (Zentrale)

Schalter für Aufhebung des Halts bei "Signal auf Fahrt"

Hinweis: 3 Dioden in Serie ist die Mindestzahl, um bei ZIMO Decodern zu wirken; für Fremd-Decoder werden manchmal 4 oder mehr Dioden benötigt ! Da durch die Dioden ein unerwünschter Spannungsverlust entsteht, verwendet man die Mindestzahl je nach eingesetzten Decodern.

Silicium-Dioden, beispielsweise 1N5400x (3 A - Typen)

rot

Halteabschnitt

Fahrtrichtung

Allgemeine Strecke

Usually, the stop section contains 3 to 5 silicon diodes in series and one diode in parallel in the opposite direction is the usual arrangement. The different voltage drops across the diodes results in an asymmetry of about 1 to 2V. The direction in which the diodes are mounted determines the polarity of the asymmetry and with it the driving direction a signal stop is initiated.

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

CV	Denomination	Range	Default	Description
#27	Position-dependent stopping ("in front of a red signal") or driving slowly by "Asymmetrical DCC signal" (ABC) planned in SW version 2.00	0, 1, 2, 3	0	Bit 0 = 1: stop, if voltage is higher in the right rail (in driving direction) than in the left. This, i.e. CV #27 = 1 is the USUAL APPLICATION if decoder is correctly wired according to current collector. Bit 1 = 1: stop, if voltage is higher in the left rail (in driving direction) than in the right. Traveling in the opposite direction will have no effect. Use the other bit in case the train stops in the wrong direction! Bit 0 and Bit 1 = 1 (CV #27 = 3): stopping independently of direction of travel.
#49, #50	Acceleration, deceleration time	0 - 255	0	See chapter HLU. planned in SW version 2.00
#53	Slow speed planned in SW version 2.00	0 - 255	70	Internal speed steps for the ABC slow speed

3.11   DC Brake Sections, "Märklin brake mode"

See CV #27 (chapter "basic configuration")

3.12   Distance controlled stopping - constant braking distance

Planned in SW-Version 3.0 and later!

3.13   Shunting, halfspeed, MAN functions

On the one hand, defining the different Configuration Variables (#3, #4, #23, #24) offers prototypical acceleration and deceleration behavior, but is, on the other hand, often obstructive to quick and easy shunting.

This is why the momentum can temporarily be reduced or eliminated altogether with a dedicated function key. Also, during shunting maneuvers it is sometimes helpful to have the speed range of the throttle cut in half.

#155	Selecting a function key for half speed	0 - 19	0	Defines a function key for half-speed activation (= top speed cut in half).
#156	Selecting a function key for deactivating momentum	0 - 19	0	Selecting a function key for deactivating acceleration and deceleration times.
#157	Selecting a function key for the MAN function Only for non-ZIMO cabs that don't have the dedicated MN key. planned in SW version 2.00	0 - 19	0	The MAN function (or MAN key on ZIMO cabs) was originally designed for ZIMO applications only, in order to cancel stop and speed limit commands applied by the "signal controlled speed influence" system (HLU). This function was expanded in later software versions to include "asymmetrical DCC signal stops" (Lenz ABC). If ZIMO decoders are used with non-ZIMO systems that don't have this key, a function key can now be assigned with CV #157 to cancel a signal controlled speed limit or stop command.

3.14 The NMRA-DCC function mapping
SW version 2.0 and later

ZIMO small-scale decoders have between 4 and 12 function outputs (FO). Things connected to these outputs (lights, smoke generator etc.) are switched ON and OFF with the function keys of the controller. Which function key controls which function output can be defined with the NMRA's function mapping.

CVs #33 to #46

Unfortunately, this function mapping also has its limitations (only one 8-bit register is available for each function, which leaves only 8 outputs to select from) and only the headlight function is intended to change with direction.

Function key on the controller	Numeric key on the ZIMO controller	CV	FA12	FA11	FA10	FA9	FA8	FA7	FA6	FA5	FA4	FA3	FA2	FA1	Rear light	Front light
F0	1 (L) fw	#33							7	6	5	4	3	2	1	0●
F0	1 (L) re	#34							7	6	5	4	3	2	1●	0
F1	2	#35							7	6	5	4	3	2●	1	0
F2	3	#36							7	6	5	4	3●	2	1	0
F3	4	#37				7	6	5	4	3	2	1●	0			
F4	5	#38				7	6	5	4	3	2●	1	0			
F5	6	#39				7	6	5	4	3●	2	1	0			
F6	7	#40				7	6	5	4●	3	2	1	0			
F7	8	#41	7	6	5	4	3	2●	1	0						
F8	9	#42	7	6	5	4	3●	2	1	0						
F9	0	#43	7	6	5	4●	3	2	1	0						
F10	↑1	#44	7	6	5●	4	3	2	1	0						
F11	↑2	#45	7	6●	5	4	3	2	1	0						
F12	↑3	#46	7●	6	5	4	3	2	1	0						

The black dots in the table above indicate the underlined default settings at the time of delivery, where each function key corresponds to the same numbered function output. Therefore, the following values were written to these CV's by default:

CV #33 = 1
CV #34 = 2
CV #35 = 4
CV #36 = 8
CV #37 = 2
CV #38 = 4
CV #39 = 8
CV #40 = 16
CV # 41 = 4
and so on..

EXAMPLE of a modification: The F2 key (ZIMO #3 key) should switch output FO4 in addition to output FO2. Moreover, F3 and F4 should NOT switch FO3 and FO4 but rather FO7 and FO8 (couplers, for example). New values are to be entered into the relevant configuration variables as follows:

CV #36=40
CV #37 = 32
CV #38 = 64

			FA9	FA8	FA7	FA6	FA5	FA4	FA3	FA2	FA1	Rear	Front
F2	3	#36				7	6	5●	4	3●	2	1	0
F3	4	#37		7	6	5●	4	3	2	1	0		
F4	5	#38		7	6●	5	4	3	2	1	0		

3.15 The ZIMO extended function mapping
Planned in SW-Version 3.0 and later
Out of the original configurations of CV #61, only CV #61 = 97 is realised

3.16 "Unilateral Light Suppression"
Planned in SW-Version 3.0 and later!

3.17 The "Swiss Mapping"

Planned in SW-Version 2.0 and later (17 groups, like MX645 and other sound decoders)

The "Swiss mapping" is a function mapping that allows the **loco lighting** to be used as is required by Swiss locomotives, which is of course also useful for locos of other countries.

The purpose of the "Swiss mapping" is to switch the various states of the locomotive lighting (turning on and dimming individually) with different function keys, i.e. for situations like driving a single loco-motive, cars coupled on driver's cab 1, or at the driver's cab 2, push-pull, shunting, etc.
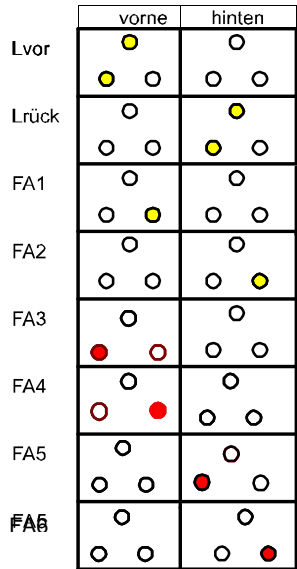
Using this relatively complex method is, of course, only worthwhile if the vehicle is equipped with many independently connected lights (or LED's) and the decoder offers as many function outputs, at least 6. ZIMO decoders offer indeed between 6 and 10 function outputs (with the exception of a few miniature decoders), large-scale decoders even more.

The desired lighting states are defined by **a total of 17 CV groups, each group containing 6 CVs.** (i.e. 102 CVs; CV #430 - #507 + #800 - #823). The principle is simple in itself, in that the first CV of each group contains the number (1 to 28) for a function key F1 .. F28, and the other CVs define which function outputs are to be switched on with this key, each dependent on the direction of travel.

CV	Denomination	Range	Default	Description
#430	Swiss Mapping Group 1 "F-key"	0 - 28, 29 (for F0) 129 - 157	0	With the F-key defined here, the function outputs defined in A1 (forw. and rev.) and A2 (forw. and rev.) are tuned on. Bit 7 = 1: invert function on F-key
#431	Swiss Mapping Group 1 "M-key" or Special setting "full beam"	Bit 0 - 6: 0 - 28, 29 (for F0) and bit 7 or 255	0	The "normal function mapping" of the M-key defined here shall be deactivated (i.e. the corresponding out-puts like headlights are turned off), if the F-key is turned on. Bit 7 = 1: additionally, the outputs listed under A1 and A2 should only switch ON if F and M key are ON. Bit 6 = 1: The M-key outputs shall not be turned OFF if the F-key is ON and driving forward. Bit 5 = 1: The M-key outputs shall not be turned OFF if the F-key is ON and driving backwards. = 157: is an often used value for CV #431, because F0 (= 29) is usually selected as the "M-key" with Bit 7 = 1. F0 then acts as a general ON/OFF key. = 255 (Special **high-beam** setting!): the Fu-Outputs defined in the following four CVs are switched to full intensity, provided that they are controlled via the "normal function mapping", and dimmed with CV #60; this function is used, for example, to switch the headlights of a Swiss locomotive to high-beam, without switching the white taillight to high-beam. Dependency of CV #399: High beam is only switched on if the speed is higher than the value given in this CV (in 255 speed step mode).

#432	Swiss Mapping Group 1 "A1" forward	Bits 0…3: 1 - 12 14 (FO0f) 15 (FO0r) Bits 5…7: 0 - 7	0	Bits 0…3: Function output to be switched ON in forward direction provided that both the "F" and "M"-keys are ON (if bit #7 for the M-key = 1, otherwise F-key ON is sufficient). Bits 7, 6, 5 (7 possible values or zero): Number of the applicable dimming CV. For example: Bit 5 = 1 means dimming according to CV #508 etc.
#433	Swiss Mapping Group 1 "A2" forward	Bits 0…3: 1 - 12 14 (FO0f) 15 (FO0r) Bits 5…7: 0 - 7	0	Bits 0…3: Additional function output to be switched ON in forward direction provided that both the "F" and "M"-keys are ON (if Bit #7 for the M-key CV is = 1, otherwise F-key ON is sufficient). Bits 7, 6, 5 (7 possible values or zero): Number of the applicable dimming CV. For example: Bit 5 = 1 means dimming according to CV #508 etc.
#434	Swiss Mapping Group 1 "A1" reverse	Bits 0…3: 1 - 12 14 (FO0f) 15 (FO0r) Bits 5…7: 0 - 7	0	Bits 0…3: Function output to be switched ON in reversed direc-tion provided that both the "F" and "M"-keys are ON (if bit #7 for the M-key = 1, otherwise F-key ON is suffi-cient). Bits 7, 6, 5 (7 possible values or zero): Number of the applicable dimming CV. For example: Bit 5 = 1 means dimming according to CV #508 etc.
#435	Swiss Mapping Group 1 "A2" reverse	Bits 0…3: 1 - 12 14 (FO0f) 15 (FO0r) Bits 5…7: 0 - 7	0	Bits 0…3: Additional function output to be switched ON in re-versed direction provided that both the "F" and "M"-keys are ON (if bit #7 for the M-key = 1, otherwise F-key ON is sufficient). Bits 7, 6, 5 (7 possible values or zero): Number of the applicable dimming CV. For example: Bit 5 = 1 means dimming according to CV #508 etc.
#436 - #441	. . . Group 2.	. . .	0	All 6 CVs in group 2 are defined the same way as the 6 CVs in group 1.
#442 - 447	. . . Group 3.	. . .	0	All 6 CVs of the following groups are defined the same way is the 6 CVs in group 1.
#448 - #453	. . . Group 4.	. . .	0	. . .
#454 - #459	. . . Group 5.	. . .	0	. . .
#460 - #465	. . . Group 6.	. . .	0	. . .
#466 - #471	. . . Group 7.	. . .	0	. . .
#472 - #477	. . . Group 8.	. . .	0	. . .
#478 - #483	. . . Group 9.	. . .	0	. . .
#484 - #489	. . . Group 10.	. . .	0	. . .
#490 - #495	. . . Group 11.	. . .	0	. . .

#496 - #501	. . . Group 12.	. . .	0	. . .
#502 - #507	. . . Group 13.	. . .	0	. . .
#800 - #805	. . . Group 14.	. . .	0	. . .
#806 - #811	. . . Group 15.	. . .	0	. . .
#812 - #817	. . . Group 16.	. . .	0	. . .
#818 - #823	. . . Group 17.	. . .	0	. . .
#508 #509 #510 #511 #512	Dimming values for "Swiss Mapping" Special configurations	(0- 31)*8 (only bits 7…3 are used) Bits 0 - 2	0	Each group-CV (i.e. #432, #433, #434, #435) can be linked to one of these five dimming CVs. This means that the function outputs shall be dimmed accordingly when switched on. Usable only with function outputs FO0 to FO13. Bit 0 = 1: suppresses the lighting effect (later software) Bit 1 = 1: flashing (later software) Bit 2 = 1: inverted flashing (later software)
#399	Speed dependent high beam (**Rule 17**)	0 - 255	0	In conjunction with the "Swiss Mapping" special "high-beam" setting, see CV #431 = 255; applies to each of the 13 CV-groups (CV #437, 443..): Switches to high-beam only when the speed exceeds the value in this CV; based on the decoder internal 255 speed steps. EXAMPLE and SPECIAL CASES: = 0: High-beam at any speed (incl. stand-still), controlled only by the F-key (i.e. as per CV #430). =1: High-beam only while driving (not at stand-still), provided the defined F-key is ON. = 128: Switches to high-beam when reaching medium speed.

	vorne	hinten
Lvor	● ● ○	○ ○ ○
Lrück	○ ○ ○	● ● ○
FA1	○ ○ ● ○	○ ○ ○
FA2	○ ○ ○	○ ○ ●
FA3	○ ● ○	○ ○ ○
FA4	○ ○ ●	○ ○ ○
FA5	○ ○ ○	○ ● ○
FA6	○ ○ ○	○ ○ ●

The application of the "Swiss Mapping" is shown here with the *example* of an SBB Re422 engine. The function outputs together with the connected.

◀ Lights or groups of lights are shown here as they exist in a typical SBB (Swiss) electric locomotive.

Task of the Swiss mapping here is to

show all possible operating states concerning the lighting (in both directions) correctly, using:
F0 (general ON/OFF), and

F15, F16, F17, F18, F19, F20.

This results in a table, as you can see on the right ▶ wherefore for the "Swiss Mapping" in configured as follows:

#33 = 133	#34 = 42				
#430 = 15	#431 = 157	#432 = 14	#433 = 1	#434 = 15	#435 = 1
#436 = 15	#437 = 157	#438 = 2 .	#439 = 0	#440 = 2 .	#441 = 0
#442 = 16	#443 = 157	#444 = 14	#445 = 1	#446 = 3 .	#447 = 4
#448 = 17	#449 = 157	#450 = 5	#451 = 6	#452 = 15	#453 = 2
#454 = 18	#455 = 157	#456 = 6	#457 = 0	#458 = 4	#459 = 0
#460 = 19	#461 = 157	#462 = 2	#463 = 0	#464 = 1	#465 = 0
#466 = 20	#467 = 157	#468 = 0	#469 = 0	#470 = 0	#471 = 0

Explanation:

The normal NMRA function mapping in CVs #33 and CV #34 (front and rear headlight) determines the lighting in case F0 is ON and function keys F15 – F20 are OFF: CV #33 = 133 (= Lfor, FO1, FO6) and CV #34 = 42 (= Lrev, FO2, FO4).

The following CVs groups (1. Group: CV #430 – 435, 2. Group: CV #436 – 441 etc.), each group shown on one line, contain in the first CV the number of the "F-key" F15, F16, F17, F18, F19, F20, followed by the CVs for the "M-key" and function outputs to be switched.

Note that there are two groups for F15 (CV #430… and #436…) because F15 should switch 3 function outputs simultaneously, but only 2 can be entered per group (A1, A2 for each direction); one group is sufficient for all other "F-Keys".

All "M-Keys" (the second CV in each group) are all set to "157"; this means that "F0" **and** the condition of Bit 7 must be met, which means that the selected outputs are only activated if the F- and M-keys are ON.

The third to sixth CVs in each group contain the numbers of the function outputs to be actuated (where the headlights are coded with "14" and "15", for all other outputs just use the digit in FO1, FO2…).

Functions, Keys	Outputs		Front	Rear
F0, forward (Cab 1 forward)	Lfor FO1 FO6	Locomotive only	● ● ●	○ ○ ●
F0, reverse (Cab 2 forward)	Lrev FO2 FO4	Locomotive only	○ ○ ●	● ● ●
F0 + F15, forward (Cab 1 forward)	Lfor FO1 FO2	Train, cars coupled at cab 2, standard train without pilot car.	● ● ●	○ ○ ●
F0 + F15, reverse (Cab 2 forward)	Lrev FO1 FO2	Train, cars coupled at cab 1, standard train without pilot car.	○ ○ ●	● ● ●
F0 + F16, forward (Cab 1 forward)	Lvor FO1	Train, cars coupled at cab 2, standard train with pilot car or first engine in a double header.	● ● ●	○ ○ ○
F0 + F16, reverse (Cab 2 forward)	FO3 FO4	Loco pushing, cars coupled to cab 2, with pilot car or first engine in a double header. (prototypical since 2000)	○ ● ●	○ ○ ○
F0 + F17, reverse (Cab 2 forward)	Lrev FO2	Loco pulling, cars coupled to cab 1, train with pilot car or first engine in a double header.	○ ○ ●	● ● ●
F0 + F17, forward (Cab 1 forward)	FO5 FO6	Loco pushing, cars coupled to cab 1, with pilot car (prototypical since 2000).	○ ○ ○	○ ● ●
F0 + F18, forward, (Cab 1 forward)	FO6	Loco pushing, cars coupled to cab 1, with pilot car or last engine in a double header. (prototypical up to 2000)	○ ○ ○	○ ○ ●
F0 + F18, reverse (Cab 2 forward)	FO4	Loco pushing, cars coupled to cab 2, with pilot car or last engine in a double header. (prototypical up to 2000)	○ ● ○	○ ○ ○
F0 + F19, forward (Cab 1 forward)	FO2	Loco pulling as last engine in consist, cars coupled to cab 2.	○ ○ ○	○ ○ ●
F0 + F19, reverse (Cab 2 forward)	FO1	Loco pulling as last engine in consist, cars coupled to cab 1.	○ ● ○	○ ○ ○
F0 + F20, forward/reverse	---	Engine(s) inside a consist	○ ○ ○	○ ○ ○

3.18 ZIMO "Input Mapping"
Planned in SW-Version 3.0 and later!

3.19 Dimming, Low beam and Direction Bits
Planned inSW version 2.0 and later!

Some things connected to function outputs may sometimes require less than full track voltage, as is the case for example with 18V bulbs when having 24V on the track (quite common on large scale model railroads). Sometimes only the brightness shall be reduced.

The best solution in such cases is to connect the positive side of such devices to the low voltage supply of the decoder (see chapter "Installation and wiring"). Those are stabilised, i.e. they do not fluctuate with the track voltage (load, etc.).

Alternatively or in addition to this, the PWM voltage reduction is also available with CV #60, which defines the PWM duty cycle (Pulse Width Modulation; the dimming is also effective when connected to the positive terminal of a low-voltage function output).

Of course, this kind of voltage reduction is interesting because it is easy to change at any time by changing the value in CV #60.

☞ ATTENTION: Bulbs with voltage ratings as low as 12 V can be dimmed with this PWM dimming function without damage even if track voltages are considerably higher; but **not** bulbs rated below that, such as 5 V or 1.2 V bulbs. These must be connected to one of the decoder's low voltage supply pins instead of a "normal" positive pin (see chapter "Installation and Wiring").

☞ LEDs, on the other hand, always require a series resistor; if however, a resistor is selected that lowers the voltage to 5 V, the PWM dimming can also be used even at a track voltage of 25 V (in this case the setting would be CV #60 = 50, so a reduction to one fifth).

Generally, CV #60 applies to all function outputs. Specific outputs can be excluded from the dimming function, using the dim mask CVs (see table).

CV	Denomination	Range	Default	Description
#60	Reduced function output voltage (Dimming per PWM). Affects all function outputs.	0 - 255	0	Reduction of function output voltage with PWM (pulse-width modulation), to reduce the light's brightness, for example. EXAMPLES: CV #60 = 0 or 255: full voltage CV #60 = 170: 2/3 of full voltage CV #60 = 204: 80 percent of full voltage
#114	Dim Mask 1 = Excludes specific function outputs from dimming as per CV #60 Also see	Bits 0 - 7	0	Enter function outputs that are **not** to be **dimmed** by CV #60. These outputs will receive the full voltage from the pin they are connected to that is, either full track voltage or low voltage from a low-voltage pin. Bit 0 - front headlights Bit 1 - rear headlights Bit 2 - function output FO1, Bit 3 - FO2, Bit 4 - function output FO3, Bit 5 - FO4, Bit 6 - function output FO5, Bit 7 - FO6, Respective Bit = 0: Output will, if switched on, be dimmed with voltage according to CV #60.

CV	Denomination	Range	Default	Description
	CV #152			Respective Bit = 1: Output will not be dimmed, i.e. it will be supplied with full voltage when switched on. Example: CV #114 = 60: FO1, FO2, FO3, FO4 will **not** be dimmed; i.e. only the headlights are reduced in brightness.
#152	Dim Mask 2 (Excludes specific function outputs from dimming as per CV #60) Addition to CV #114 and FA3, FA4 as direction outputs	Bits 0 - 5 and Bit 6, Bit 7	0 0	... Addition to CV #114. 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. Bit 6 = 0: "normal" = 1: Direction bits on FO3, FO4, i.e. FO3 is switched on when driving backwards, FO4 is switched on when driving forward. (for Märklin switch type C) Bit 7 = 1: direction bit for FO9 when driving forward

Low/high beam mask with the low beam mask

One of the function keys F6 (CV #119) or F7 (CV #120) can be defined as a low beam key. Selected function outputs can be dimmed as required with the function turned ON or OFF (inverted action with Bit 7).

CV	Denomination	Range	Default	Description
#119	Low beam mask for F6 = Allocation of function outputs as (for example) low/high beam ATTENTION: In certain setting in CV #154 ("special output configuration" for OEM projects) the meaning of CVs #119, 120 changes, i.e. they are not low beam mask anymore.	Bits 0 - 7	0	Defines function outputs, which shall be switched to low beam if F6 is active (i.e. dimmed according to CV #60). Typical application: Low/high beam Bit 0 - front headlights Bit 1 - rear headlights Bit 2 - function output FO1, Bit 3 - function output FO2, Bit 4 - function output FO3, Bit 5 - function output FO4. Respective Bit = 0: Output will not be dimmed, Respective Bit = 1: Output will be dimmed with F6 to value defined in CV #60. Bit 7 = 0: normal action of F6. = 1: inverted action of F6. Example: CV #119 = 131: Headlights shall be switched between high and low beam with F6 (F6 = 1).
#120	Low beam mask for F7	Bits 0 - 7		Same as CV #119 but with F7 as low beam key.

3.20 Flasher Effect

Planned in SW-Version 3.0 and later!

3.21 F1 Pulse Chain

Planned for later SW-versions

3.22 Special Effects for function outputs

Planned in SW-Version 3.0 and later!

3.23 Configuration of Smoke Generators

Smoke generator without fan (example: Seuthe 18V):

In addition to a simple ON/OFF function via a function output of your choice, the smoke intensity can also be programmed to change between **standstill, or cruising** and **acceleration**.

This requires the smoke generator to be connected to one of the function outputs **FO1…FO8** and the selected output must be programmed for the desired effect with the associated "effect CV" (with CV #127 for FO1, CV #128 for FO2 etc.); in this case for load dependent smoke of steam engines (effect code "72") or load dependent smoke of diesels (effect code "80").

The smoke generator characteristic as defined by CVs #137, #138 and #139 is used for the relevant function output.
These CVs <u>must</u> be programmed (with appropriate values) otherwise the smoke generator will not produce any smoke.

EXAMPLE: - Typical characteristic for a track voltage set around 20 V with above smoke generator (18 V):

CV #137 = 70 .. 90 Little smoke at standstill
CV #138 = 200: The smoke intensity is increased to about 80% of its maximum capacity beginning
                with speed step 1 (at very low speed), which produces relatively heavy smoke.
CV #139 = 255: The smoke generator is driven to its maximum under acceleration, which results in thick smoke.

Synchronized steam chuffs or typical diesel smoke (with exhaust fan):

The heating element of the smoke generator is connected – as in the example above with the "Seuthe" generator – on **FO1…FO8.** The fan is connected to the function output **FO4** (in some decoders on **FO2**). See chapter "Installation and wiring".

CV	Denomination	Range	Default	Description
#133	Using FO4 as cam-sensor output for the module of your choice or FO4 as output for steam fan of the smoke generator of steam locos	0, 1	0	= <u>0</u> (Default): FO4 is used as a normal function output and controlled by a function key, not a cam sensor. = 1: FO4 is triggered by a cam sensor (synchronously to wheel rotation), usually for driving an exhaust fan. This is achieved with either the "virtual" or a real cam sensor. Also see CVs #267, #268! NOTE: The fan operation is also determined by the sound project. NOTE: large-scale decoders (which are not subject of this manual) have special outputs which offer more setting options for fans.
#137 #138 #139	Definitions of smoke generator characteristic, connected to FO1 – FO6. PWM at stand still PWM at steady speed PWM during acceleration	0 - 255 0 - 255 0 - 255	0 0 0	This is valid, if in one of the CVs #127 - #132 has set on of the function effects "smoke generation" (i.e. "72" or "80"): The values in CVs #137 – #139 define a characteristic for the function outputs (FO1 - FO8; referred to below as FOx). CV #137: PWM of FOx at standstill CV #138: PWM of FOx at steady speed CV #139: PWM of FOx at acceleration

3.24 Configuration of Electric Uncouplers
Planned in SW-Version 3.0 and later!

3.25 SUSI-Interface and Logic-Level Outputs, Reed-Inputs
Planned in SW-Version 3.0 and later!

3.26 Servo Configuration
Planned in SW-Version 3.0 and later!

3.27 SOUND: Basic settings independent of powertrain

The CVs in the following table have the same meaning for all types of power (steam, diesel, electric):

NOTE: The **default values** of individual CVs are **NOT decoder-specific,** but rather depend on the decoder's **sound project.** This means that a HARD RESET with CV #8 = 8 returns the decoder to the state defined by the sound project. The default values in the following table refer to the values defined in THIS sound project for Roco BR85.

CV	Denomination	Range	Default	Description
#266	Total volume (Multiplier)	0 - 255 = 0 - 400 %	64 = 100 %	The default value "64" results in the (mathematically) highest possible distortion-free playback volume; but values of up to 100 may nonetheless be practical. **Recommended: CV #266 = 40 - 90**
#310	ON/OFF key for Driving sound volume and Random Sounds	0 - 28, 255	1	Function key to turn ON/OFF driving sounds (steam chuffs, boiling, blow-off, brake squeal, or diesel motor, thyristor sounds, etc.) as well as random sounds (air brake pump, coal shoveling, ...). = 8: F8 key switches driving sound ON or OFF. Note: this is the default key for ZIMO original sound projects; OEM projects (i.e. ROCO) often use other settings. Mostly 1 for the F1 key. = 0 - 28 as ON/OFF-key for driving noise. = 255: engine and random sounds are always ON.
#311	ON/OFF key for Function sounds planned in SW version 2.00	0 - 28	0	Function key assigned as ON/OFF key of function sounds (i.e. F2 – whistle, F6 – bell etc.). = 0: does not mean that F0 is assigned for this task but rather that the function sounds are always active. = if the same value is entered here as in CV #310, the key defined in #310 turns all sound ON/OFF. = 1 - 28: Separate ON/OFF key for function sound.
#312	Blow-off key	0 - 28	13	See chapter 5.4 "Basic steam engine settings" (does not belong in this chapter, despite the correct number sequence)
#313	"Mute key" fade in/out time Key	0 - 28 101 - 128	114	This CV assigns a function key with which the driving sounds can be faded in and out, i.e. when the train disappears behind scenery. In many sound projects, CV #313 = CV #310, i.e. the same value in both CVs, therefore all sounds are faded in/ot. = 0: No mute key or mute function. = 1 – 28: Corresponding function key F1 - F28. = 101 – 128: Assigned function key with inverted action.
#314	Mute – fade in/out time	0 - 255 = 0 - 25 sec	0	Time in tenths of a second for sound fading in/out when mute button is pressed. Total range is 25 seconds. = 0 (to 10): minimum time setting of 1 sec. = 11 - 255: longer "Mute"-processes
#376	Driving sound volume (Multiplier) planned in SW version 2.00	0 - 255 = 0 - 100 %	255 = 100 %	To reduce the driving sound volume (e.g. Diesel motor with related sounds such as turbo charger) compared to the function sounds.

CV	Denomination	Range	Default	Description
LEAD - CV #287	Threshold for brake squeal	0 - 255	50	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	Brake squeal minimum drive time	0 - 255 = 0 - 25 sec	50	The braking squeal is to be suppressed when an engine is driven for a short time only, which is usually a shunting run and often without any cars (in reality it is mostly the cars that are squealing not the loco itself!). Note: Brake squeal sounds can also be assigned to a function key (see allocation procedure CV #300 = …), with which the brake squeal can be started or stopped manually!
#307	Cornering squeals-order Reed configuration planned in SW version 3.00			Bit0 - Reed1 activates cornering squeal Bit1 - Reed2 activates braking squeal Bit2 - Reed3 activates cornering squeal Bit3 - Reed4 activates braking squeal Bit 7 - 0 = key defined in CV #308 suppresses cornering squeal of Reed inputs if this key is ON 1 = key defined in CV #308 activates cornering squeal independent of Reed inputs
#308	Brake squeal-key planned in SW version 2.00	0-28	25	0: No key defined. Reed inputs always active. 1-28 = key F1 to F28.
#133	Reed configuration Planned for large-scale locos			Bit 4 – inverts the polarity of Reed input 1 Bit 3 – inverts the polarity of Reed input 2 Bit 2 – inverts the polarity of Reed input 3 Bit 5 – inverts the polarity of Reed input 4

With the first SW version only a few CVs are active:
(the first version is designed especially for BR 85);
with **SW version 3.00** the expansion to **general sound projects for steam locos** is planned

Background sounds - Volume adjustments:

#574	"Simmering"	0 - 255	0	Volume driving sound "simmering"
	Planned for later SW versions			
#578	"Brake squeal"	0 - 255	0	Brake squeal volume
	Planned for later SW versions			
	Planned for later SW versions			
#584	Blow-off	0 - 255	0	Blow-off volume (STEAM engine)
	Planned for later SW versions			
	Planned for later SW versions			
	Planned for later SW versions			
	Planned for later SW versions			
	Planned for later SW versions			
	Planned for later SW versions			

Function sounds - Volume adjustments:

#571	Function sound F0	0 - 255 = 100, 1-100 %	0	Sound volume operated with function key F0 = 0: full volume, original sound sample volume (same as 255) = 1 - 254: reduced volume 1 - 99,5 % = 255: full volume
#514 #517 #520 #523 … #565 #568	Function sound F1 Function sound F2 Function sound F3 Function sound F4 … Function sound F18 Function sound F19	0 - 255	0	Sound volume operated with function key F1 Sound volume operated with function key F2 Sound volume operated with function key F3 Sound volume operated with function key F4 … Sound volume operated with function key F18 Sound volume operated with function key F19
#674 … #698	Function sound F20 … Function sound F28	0 - 255	0	Sound volume operated with function key F20 … Sound volume operated with function key F28

Note: The CVs between the above (#570, #572, #513, #515, #516, #518 etc.) hold information for the relevant sound samples (sample numbers, loop parameters etc.), which can also be modified if needed, usually with the CV #300 procedures.

Switch input sounds - Volume adjustments:

#739	Switch input sound S1	0 - 255 = 100, 1-100 %	0	Volume setting for the sound activated with switch input S1 = 0: full volume, original sound sample volume (same as 255) = 1 - 254: reduced volume 1 - 99,5 % = 255: full volume
#741	Switch input sound S2	0 - 255	0	Volume setting for the sound activated with switch input S2
#743	Switch input sound S3	0 - 255	0	Volume setting for the sound activated with switch input S3
#671	Switch input sound S4	0 - 255	0	Number of sound sample for input S4
#672	Switch input sound S4	0 - 255	0	Volume setting for the sound activated with switch input S4

Note: The CV immediately ahead of the CVs listed (#740, #742) contains the sound sample numbers to be played.

Random sounds - Volume adjustments:

#745	Random Sound Z1		0	Volume setting for sound activated by random generator Z1
#748	Random Sound Z2		0	Volume setting for sound activated by random generator Z2
#751	Random Sound Z3		0	Volume setting for sound activated by random generator Z3
#754	Random Sound Z4		0	Volume setting for sound activated by random generator Z4
#757	Random Sound Z5		0	Volume setting for sound activated by random generator Z5
#760	Random Sound Z6		0	Volume setting for sound activated by random generator Z6
#763	Random Sound Z7		0	Volume setting for sound activated by random generator Z7
#766	Random Sound Z8		0	Volume setting for sound activated by random generator Z8

Note: The CV immediately ahead of the CVs listed (#744, #747 etc.) contain the sound sample numbers to be played. Possibility to adjust via ZCS (ZIMO CV Setting) tool.

Connection between sounds and function output:

#726	Connection 1 sound		0	Sound number which shall be valid for connection 1
#727	Connection 1 FO		0	Function output which shall be valid for connection 1. 1=FO0v, 2=FO0r, 3=FO1,….
#728	Connection 2 sound		0	Sound number which shall be valid for connection 2
#729	Connection 2 FO		0	Function output which shall be valid for connection 2. 1=FO0v, 2=FO0r, 3=FO1,….
#730 … #735	…		0	…
#736	Connection 6 sound		0	Sound number which shall be valid for connection 6
#737	Connection 6 FO		0	Function output which shall be valid for connection 6. 1=FO0v, 2=FO0r, 3=FO1,….

3.28 SOUND: Steam engine → sound basic configuration

CV	Denomination	Range	Default		Description
#266	Total volume	0 - 255	60		See chapter 5.4 "Basic settings independent of powertrain"
#267	Chuff sound frequency with virtual cam sensor also see CV #354 in this table (chuff sound frequency at speed step 1)	0 - 255	63		CV #267 is only active if **CV #268 = 0:** Chuff beats follow the "virtual cam sensor"; an actual cam sensor is not needed in this case. The basic configuration "70" results in about 4 to 6 to 8 chuffs per rotation, depending on the selected chuff-set. 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 exact chuff frequency; therefore, CV #267 is used: The lower the value, the higher the chuff frequency and vice versa. The setting should be performed at a low speed (around speed step 10), but not at the lowest speed step 1.
#272	Blow-off duration also see CV #312 in this table (Blow-off key)	0 - 255 = 0 - 25 sec	80		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 tenths of a second! Note: If the blow-off sound is also allocated to a function key (as delivered on F4, see CV #312), the automated blow-off sound can be shortened or extended with the relevant function key. Automated blow-off and function key blow-off are inevitably the same (as per selection/allocation). **= 0**: no blow-off sound playback
#274	Blow-off-Standstill and Starting whistle Standstill	0 - 255 = 0 - 25 sec	30		Constant opening and closing of the cylinder valves in real shunting operations, which often requires many short trips with associated idle times, is usually omitted. 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 tenth of a second! The same stop-time is also used for the start-up whistle!
#312	Blow-off key	0 - 28	-		Defines function key which activates blow-off noise; e.g. for shunting with "open valves".
#354	Chuff-frequency at Speed step 1	1 - 255	11		CV #354 works only if used together with CV #267! CV #354 compensates for the non-linear speed measurements 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),

CV	Denomination	Range	Default		Description
	also see CV #267 in this table				a correction for speed step 1 can be performed with CV #354 (extremely slow). = 0: no effect = 1 - 127: Steam chuffs at speed step = 1 (and extremely slow speed) more common than CV #267 = 255 ... 128: less chuff beats.
#154	Various special bits In first version only Bit 4; further Bits planned for later SW-versions		16		Bit 1 = 1: DIESEL, ELECTRO: Drive off immediately even if playback of idle sound has not yet finished. Bit 2 = 1: DIESEL, ELECTRO: After short stops, wait for idle sound before driving off. Bit 4 = 1: STEAM: Two stage compressor (Z1 for fast refill after coming to a stop, Z2 for slow pressure loss compensation during longer stops). Bit 7 = 1: STEAM: Delay start until playback of start-up whistle has finished. Other Bits: OEM special features (Loco with panto, etc.)

3.29 SOUND: Steam engine → Load and acceleration dependency

The load dependency of the sound is based on the current engine load and acceleration/deceleration.

NOTE: The CVs in this chapter affect the sound volume according to load (that is, by how much the volume should increase at higher loads or decrease at lesser loads, all the way down to mute if necessary). A possible exchange of sound samples at load increase or decrease is however a matter of the sound project.

NOTE: The **default values** of the single CVs are typical benchmarks, because the real values are defined by the loaded **sound-project**; i.e. a HARD RESET with CV #8 = 8 reinstalls the values defined by the sound project.

CV	Denomination	Range	Default		Description
LEAD - CV **#275**	Volume at slow speed without load	0 - 255	220		With this CV, the chuff volume can be adjusted for low speed and "basic load" (same conditions as during the "automated recording run"). Here, the engine is driven by about 1/10 of its full speed, adhering to the exact speed is, however, not important. During this adjustment CV #277 is to be left at "0" (default), so that the setting for "no-load driving" is not influenced by load factors.
#276	Volume at high speed without load	0 - 255	220		Like CV #275 (see above) but for driving fast. CV #276 defines the "basic-load" chuff sound volume at full speed. Set the speed regulator to maximum during this set-up.
#282	Duration of acceleration sound	0 - 255 = 0 - 25 sec	30		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 tenth of a second!
#283	Driving noise-chuff volume for full acceleration noise	0 - 255	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 one speed step), the volume defined here is applied with each speed increase, even if it's just one step.
LEAD - CV **#284**	Decelerations-threshold for reduced volume during deceleration	0 -255 (internal speed steps)	1		Steam chuffs should be played back at less volume (or muted) 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 a 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 reduction of noise at deceleration	0 - 255 = 0 - 25 sec	30		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 tenth of a second!
#286	Volume of reduced driving noise at deceleration	0 - 255	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).