INSTRUCTION MANUAL

MINIATURE - FUNCTION - DECODER
MX681, MX681N
FUNCTION - DECODER
MX685, MX685P16
FUNCTION - DECODER with energy storage circuitry
MX686, MX686D
FUNCTION - DECODER with energy storage circuitry and low-voltage output
MX687V, MX687W, MX687WD
FUNCTION - DECODER with NEXT-18 interface
MX688N18
SOUND-FUNCTIONS-DECODER with energy storage circuitry
MX689, MX689P22

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NOTE:
ZIMO decoders contain an EPROM which stores software that determines its characteristics and functions. The software version can be read out form CV #7 and #9. 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 can add new functions or correct recognized errors. SW updates can be done by the end user for all ZIMO decoders since production date October 2004, see chapter “Software Update!” Software updates are available at no charge if performed by the end user (except for the purchase of a programming module). Updates and/or upgrades performed by ZIMO are not considered warranty repair and are at the expense of the customer. The warranty covers hardware damage exclusively, provided such damage is not caused by the user or other equipment connected to the decoder. For update versions, see www.zimo.at.
**1 Overview**

Function decoders are **locomotive decoders for non-motorized vehicles** and are therefore not equipped with a motor end stage but do offer special features for use in coaches/cars usually belonging to a “block train” pulled by a locomotive.

The hardware of the MX685 function decoder is based on the loco decoder MX630 (board and hardware is almost identical), the MX686 (on the MX631 until 2012) from 2013 onwards on the MX634, the miniature function decoder MX681 on the miniature decoder MX621 and the SOUND-Functions decoder MX689 on the sound decoder MX645. The dimensions and most of their features are therefore identical to the decoder they are based on.

A distinctive feature of all ZIMO function decoders is the **programmable SECOND ADDRESS** (CV #64 to #68), which can be used as an alternative address for the coach containing the function decoder and is commonly set to the same address as the loco pulling the train. If all coaches of a train are equipped with such a decoder using the same (second) address, they can all be controlled simultaneously with a single key stroke (i.e. the interior light of all coaches are turned ON/OFF with a function key of the loco address, if that is the second address). With this, the simplest form of a virtual “**train bus**” becomes reality, which will certainly play a major role in future digital train technology.

### MX681 Family
- **Miniature-Function-Decoder**, with reduced ZIMO features; the software does not contain: MM (Motorola), Servos, SUSI, ZIMO spec. Function mapping.

#### MX681 plug configurations:
- **7 wires (120mm long)** for power pick-up, 4 function outputs. Solder pads are available for further outputs.
- **MX681N**
  - MX681 with **6-pin plug** as per NEM651 and NMRA RP 9.1.1., mounted to the circuit board.
  - (Versions with 8-pin plug as per NEM652 on 70mm wires or 6-pin plug on 70mm wires; special order only).
- **20 x 11 x 3.5 mm**  
  - 1.0 A - 8 Fu-Outputs - 2 Servos - SUSI

### MX685 Family
- **Function-Decoder**, compact design for universal applications.

#### MX685 plug configurations:
- **7 wires (120mm long)** for power pick-up, 4 function outputs. Solder pads are available for further outputs and for 2 servos or SUSI.
- **MX685**
  - MX685 with **16-pin PluX connector** mounted on decoder board.
  - (Versions with 8-pin plug as per NEM652 on 70mm wires or 6-pin plug on 70mm wires; special order only).
- **20.5 x 15.5 x 4mm**  
  - 1.2 A - 8 Fu-Outputs - 2 Servos - SUSI

### MX686 Family
- **High performance Function-Decoder** with built-in energy storage circuitry.

#### MX686 plug configurations:
- **7 wires (120mm long)** for power pick-up, 4 function outputs. Solder pads are available for further outputs as well as for servo or SUSI.
- **MX686D**
  - MX686 with **21-pin “MTC” plug** mounted directly on decoder board.
- **20.5 x 15.5 x 4 mm**  
  - 1.2 A - 8 Fu-Outputs - 2 Servos - SUSI

### MX687 Family
- **High performance Function-Decoder** with built-in energy storage circuitry and **low-voltage output** (1.5 V or 5 V).

#### MX687 plug configurations:
- **10 wires (120mm long)** for power pick-up, 4 function outputs. Solder pads are available for further outputs as well as for servo or SUSI. Low voltage output of 1.5V.
- **MX687W**
  - Same as MX687V but with 5 V low-voltage output.
- **MX687WD**
  - Same as MX687W but with 5 V low-voltage output and **21-pin “MTC” plug** mounted on circuit board.
- **15 x 9.5 x 2.8 mm**  
  - 0.7 A - 8 Fu-Outputs - 2 Servos - SUSI

### MX688
- **Function-Decoder**, only available with Next-18 interface.

#### MX688 plug configurations:
- **30 x 15 x 4 mm**  
  - **SOUND** - 1.2A - 10 Fu-Outputs - 2 Servos - SUSI

### MX689 Family
- **Sound-Function-Decoder** with 10 functions, 3 Watt audio on 4 Ohm (or 2x8 Ohm), with energy storage circuitry.

#### MX689 plug configurations:
- **11 wires (120mm long)** for power pick-up, motor, 4 function outputs, speaker, capacitor. Solder pads for 6 more function outputs as well as for servo or SUSI.
- **MX689**
  - With PluX22 connector, only for vehicles with PluX22 interface and 9 function outputs (+1 additional output outside the norm)
### Technical Information

| Function-Decoder MX681, MX685, MX686, MX687, MX688, MX689 Page 3 |

#### Allowable track voltage **

<table>
<thead>
<tr>
<th>Decoder</th>
<th>** min.</th>
<th>** max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX681</td>
<td>10 V</td>
<td>35 V</td>
</tr>
<tr>
<td>MX685, MX686, MX687, MX688, MX689</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MX686, MX686D, MX687V / W / WD, MX689</td>
<td></td>
<td>35 V</td>
</tr>
</tbody>
</table>

#### Maximum continuous motor current

<table>
<thead>
<tr>
<th>Decoder</th>
<th>** 0.8 A</th>
<th>** 1.0 A</th>
<th>** 1.2 A</th>
</tr>
</thead>
<tbody>
<tr>
<td>MX681, MX681R, MX681N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MX685, MX685R, MX685P16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MX686, MX686D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MX688N18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MX686, MX686D, MX687V / W / WD, MX689</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Operating temperature

-20 to 100 °C

#### Dimensions (L x W x H)

- 12 x 8.5 x 2 mm
- 20 x 11 x 3.5 mm
- 20.5 x 15.5 x 4 mm
- 15 x 9.5 x 2.8 mm
- 25 x 15.5 x 4 mm
- 30 x 15 x 4 mm

*) The short circuit protection is carried out for the total current of all outputs. Use the “soft start” option (i.e. CV #125 = 52) to prevent cold-start problems of light bulbs (in-rush current interpreted as a short circuit, which leads to the output being turned off!)

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**Software - Update:**

ZIMO DCC decoders are equipped to handle software updates by the user. An update device such as the ZIMO decoder update module MXDECUP, from 2011 MXULF, system-cab MX31ZL or command station MX10) is required. The update process is carried out by a USB stick (MXULF, MX31ZL / MX10) or by a PC with Windows operating system and the program “ZIMO Sound Programmer” ZSP or the “ZIMO Rail Center” ZIRC (MXDECUP).

There is no need to remove the decoder or to open up the locomotive. Just set the locomotive on a section of track connected to the update module and start the update with the computer or other equipment mentioned above.
The sound-function decoder is derived from the "normal" sound decoder MX645; therefore:

See the connection diagram in the "Small Decoder" manual (MX618 ... MX649).

Also taken from the locomotive decoders are all sound features, in particular the CVs, so:
consult the "Small Decoder" manual.
### Adressing and Programming

ZIMO decoders can be programmed in
- “Service Mode” (on the programming track) for assigning a new address or reading and writing CV content but also in
- “Operations Mode” (a.k.a. “Programming on the main” or “PoM”), which is done on the main track; programming CV’s “on the main” is always possible in operations mode. However, an acknowledgement of successful programming steps or reading out of CV’s is only possible with a DCC system capable of RailCom.

#### 3.1 Programming in “Service mode” (on programming track)

Before programming is possible, it must be unlocked with CV #144 = 0 or = 128 (the latter allows programming but prevents decoder updating).

This is normally the case but in many sound projects the programming lock is activated to prevent accidental changes. Therefore, it is useful to check that CV, especially when programming attempts have already failed.

The acknowledgments of successful programming steps on the programming track as well as CV read-outs are accomplished by power pulses, which the decoder generates by briefly engaging the motor and/or headlights. If the motor and/or headlights do not draw power (i.e., they are not connected) or don't draw enough power, acknowledgments for successful programming or CV read-outs are not possible.

To make acknowledgments possible in such cases activate CV #112 bit 1, which enables the decoder to use an alternate acknowledgment by sending high frequency pulses from the motor end stage. Whether this method is successful depends on the DCC system used.

#### CV Designation Range Default Description

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#144</td>
<td>Programming and Update Lock Note: The programming lock has no effect on CV #144, which is therefore always accessible for unlocking. Bits 6, 7</td>
<td>0 advertisement lock not active Bit 6 = 1: programming the decoder in “Service Mode” is blocked as a protection against unwanted reprogramming. Note: Programming in “Operations Mode” is not locked because any such programming only applies to the active loco address and reprogramming the wrong locomotive is therefore not possible. Bit 7 = 1: Software updates via MXDECUP, MX31ZL or other means are locked.</td>
<td>255</td>
<td>- 0: programming and update lock not active - 1: programming the decoder in “Service Mode” is blocked as a protection against unwanted reprogramming.</td>
</tr>
</tbody>
</table>
| #112 | Special ZIMO configuration bits    | 0 - 255 | Also Bit 1 = 0 (normal) | Bit 1 = 0: Normal acknowledgment in “Service Mode”; by activating motor and headlight outputs.  
Bit 2 = 0: Loco number ID is OFF (as per CV #17-18) |

#### 3.2 Programming in “Operations mode” (a.k.a. on-the-main, “PoM”)

According to the current NMRA DCC standards it is only possible to program and read CV’s on the main track, but not assigning new vehicle addresses. However, certain DCC systems (among them ZIMO beginning with the system generation MX10/MX32) will allow addresses to be modified on the main track with the help of bidirectional communication.

All ZIMO decoders are equipped with bidirectional communication (“RailCom”) and can therefore (with a corresponding DCC system such as ZIMO MX31ZL and all devices of the new MX10/MX32 generation) read, program and acknowledge successful CV programming steps in operations mode (on the main track). This requires RailCom to be activated, which is the case if the following CV’s are set as:

| CV #29, Bit 3 = 1 AND CV #28 = 3 |

This is usually the default setting, except in certain sound projects or OEM CV sets, in which they need to be set first.

<table>
<thead>
<tr>
<th>CV #28</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#28</td>
<td>RailCom Configuration</td>
<td>0 - 3</td>
<td>3</td>
<td>Bit 0 - RailCom Channel 1 (Broadcast) 0 = OFF 1 = ON Bit 1 - RailCom Channel 2 (Data) 0 = OFF 1 = ON</td>
</tr>
<tr>
<td>#29</td>
<td>Basic settings</td>
<td>0 - 63</td>
<td>14 = 0000 1110 Bit 3 = 1 (&quot;RailCom&quot; is switched on)</td>
<td>Bit 0 - Train direction: 0 = normal, 1 = reversed Bit 1 - Number of speed steps: 0 = 14, 1 = 28 Bit 2 - DC operation (analog): 0 = disabled, 1 = enabled Bit 3 - RailCom (&quot;bidirectional communication&quot;): 0 = deactivated, 1 = activated Bit 4 - Individual speed table: 0 = off, CV #2, 5 and 6 are active, 1 = on, according to CV’s # 67 - 94 Bit 5 - Decoder address: 0 = primary address as per CV #1 1 = ext. address as per CV #17-18</td>
</tr>
</tbody>
</table>
3.3 Decoder-ID, Load -Code, Decoder-Type and SW-Version

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#250,</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>#251,</td>
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<td>#252,</td>
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<td>#253,</td>
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<td>#260,</td>
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<td>#261,</td>
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<tr>
<td>#262,</td>
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<tr>
<td>#263,</td>
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<td></td>
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<tr>
<td>#250,</td>
<td></td>
<td></td>
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<tr>
<td>also contains a code (in CV #250) that identifies the decoder type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read only</td>
<td>-</td>
<td></td>
<td>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 (future function) as well as in conjunction with the &quot;load code&quot; for &quot;coded&quot; sound projects (see CV #260 - 263).</td>
<td></td>
</tr>
</tbody>
</table>

| #65    | SW-Sub-Version Number       | Read only | -                          | This CV indicates a possible sub-version number of a main version noted in CV #7. The entire SW version number is thus composed of CV #7 and #65 (i.e. 28.15). |
| #7     | SW-Version Number            | Read only | -                          | This CV holds the version number of the firmware currently in the decoder. With the help of "Pseudo-programming" it also helps to program decoders with DCC systems of limited range: Ones digit = 1: Subsequent programming value + 100 = 2: ... + 200 Tens digit = 1: Subsequent CV number + 100 = 2: ... + 200 etc. = 9: ... + 900 Hundreds digit = 0: Revaluation applies only once = 1: Revaluation applies until power-off. |
| #8     | Manufacturer ID and          | Read only | -                          | Reading out this CV always result in "145" ("10010001"), the number issued for ZIMO by the NMRA. This CV is also used to reset various events 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 = "8" → HARD RESET (NMRA standard); all CV's reset to the last active CV set, or the default values listed in this CV table if no such set was active. CV #8 = "9" → HARD RESET for old LGB-operation (14 speed steps, pulse chain commands). Further options: see chapter "CV Sets"! |
| #17    | Extended (long) address      | 128    | - 10239 | The long DCC address applies to addresses >127. It is only active if CV #29 Bit5 = 1. |
| #18    |                                 |        |          | |
| #18    |                                 |        |          | |
| #29    | Basic Configuration           | 0 - 63 | 14 - 11100 | Bit 0: Train direction: 0 = normal, 1 = reversed Bit 1: Number of speed steps: 0 = 14, 1 = 28 Bit 2: DCC operation (analogue): 0 = disabled 1 = enabled Bit 3: RailCom (bidirectional communication): 0 = deactivated 1 = activated Bit 4: Individual speed table: 0 = off, CV #2, 5 and 6 are active. T = on, according to CV's #67 - 94 Bit 5: Decoder address selection: G = short address as per CV #1 T = long address as per CV #17+18 |

3.4 The (first) vehicle address

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

The address range in DCC mode exceeds the range of a single CV, in fact, goes up to 10239. Addresses higher than 127 are stored in CV #17 and #18. 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) calculate the value for the CV's involved automatically and also set Bit 5 in CV #29 to the proper value when writing the address, so that the user does not have to deal with the necessary coding.

Decoder-controlled consisting (a.k.a. “Advanced consisting”)

Combined operation of two or more locomotives (consisting) can be organized by:
- the DCC system (common practice with ZIMO systems, without changing any decoder CV's) or
- by the following decoder CV's, which can be programmed manually or managed by the DCC system (often the case with American made systems).

This chapter covers only the latter; the decoder controlled consisting!
### 3.5 The second address in a function decoder

The second address in

CV #64 (short) or CV #67+68 (long)

is used as an alternative address for cars or coaches equipped with a function decoder. The second address is usually the decoder address of a locomotive. If all coaches of a train are equipped with function decoders using the loco address as the second address, the lights of all coaches for example can be turned ON/OFF with a single loco function key.

See chapter “Function mapping”.

The “virtual motor control” follows the commands of the second address, if one is defined (value > 0).

### 3.6 Analog operation

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

To allow analog operation

CV #29, Bit 2 = 1

must be set.

The analog mode in the function decoder affects only the function outputs. Setting options are available for the function outputs similar to loco decoders.
3.7 “Virtual” motor control and momentum

Even though function decoders don’t have an actual motor output, they can still be programmed with parameters for “virtual motor control”, in order to synchronize the actions of the function decoder with the loco decoder, provided the first or second address of the function decoder is identical with the loco decoder. This is especially important during accelerations or decelerations, for example, when activating the direction key without first stopping the train. It makes sense to use the same settings in these CVs as are used in the locomotive decoder.

However, the 28-speed point curve is not available, only the three-point curve, because the relevant CV numbers are used for the second address. For this reason, Bit 4 in CV #29 is also not available. And of course, CV settings that relate to motor feedback are unnecessary.

For many applications though, the motor control CV’s are not important in function decoders and setting CV #3 and #4 to match the CV’s of the loco decoder is sufficient.
### CV Designation | Range | Default | Description
---|---|---|---
#122 | Exponential deceleration | 0 - 99 | 0 | Deceleration time (momentum) can be stretched in the lower speed range. Tens digit: Percentage of speed range to be included (0 to 90%). Ones digit: Exponential curve (0 to 9).

**EXAMPLE:**

CV #122 = 11, 23 or 25 are typical initial test values.

#49 | Signal controlled (HLU) acceleration | 0 - 255 | 0 | Entered value multiplied by .4 equals deceleration time in seconds from stop to full speed when:

- "ZIMO signal controlled speed influence" with ZIMO MX9 track section module or successor
- "asymmetrical DCC signal" method (Lenz ABC) is employed

#50 | Signal controlled (HLU) deceleration | 0 - 255 | 0 | Entered value multiplied by .4 equals deceleration time in seconds from full speed to complete stop when:

- "ZIMO signal controlled speed influence" with ZIMO MX9 track section module or successor
- "asymmetrical DCC signal" method (Lenz ABC) is employed

#51 #52 #53 #54 #55 | Signal controlled (HLU) speed limits | 0 - 255 | 20 40 (U) 70 110 (L) 100 | ZIMO "signal controlled speed influence" method (HLU) using MX9 or successor:

- Defines the internal speed steps for each of the 5 speed limits generated via HLU.

#59 | Signal controlled (HLU) delay | 0 - 255 | 5 | ZIMO signal controlled speed influence (HLU) with ZIMO MX9 track section module or future module or when using the "asymmetrical DCC signal" stopping method (Lenz ABC):

- Time in tenth of a second until the locomotive starts to accelerate after receiving a higher signal controlled speed limit command.

#27 | Direction dependent stops with asymmetrical DCC signal (Lenz "ABC" method) | 0, 1, 2, 3 | 0 | Bit 0 = 1: Stops are initiated if voltage in right rail is higher than left rail (in direction of travel).

**Note:** This setting, CV #27 = 1, IS THE COMMON APPLICATION for this feature (provided the decoder is wired to the rail correctly).

- Bit 1 = 1: Stops are initiated if voltage in left rail is higher than right rail (in direction of travel).

- Stopping is directional if only one of the two bits is set (not both). Traveling in the opposite direction will have no effect. Use the other bit in case the train stops in the wrong direction!

#134 | Asymmetrical threshold for stopping with asymmetrical DCC signal (Lenz ABC method) | 1 - 14, 101 - 114, 201 - 214 | 0.1 - 1.4 V | 106 | Hundredths digit: Sensitivity adjustment, changes the speed with which the asymmetry is being recognized.

- 0: fast recognition (but higher risk of errors, i.e. unreliable stopping).
- 1: normal recognition (@ 0.5 sec.), pretty save results (default).
- 2: slow recognition (@ 1 sec.), very reliable.

- Tenths and ones digit: Asymmetrical threshold in tenths of a volt. The voltage difference between the two half waves of the DCC signal defined here is the minimum required to be recognized as asymmetrical that starts the intended effect (usually braking and stopping of a train).

- 016 (Default) therefore means normal recognition at 0.8 V asymmetry. This value has proven itself to be appropriate under normal conditions; by using 4 diodes to generate the asymmetry.

#29, #124, #112 | Individual bits in these CV's are responsible for the correct reaction to "DC" and "Marklin" brake sections | - | - | Set the following CV's for polarity dependent DC brake sections:

- CV #29, Bit 2 = 0 and CV #124, Bit 5 = 1.

For polarity independent brake sections ("Märklin-Brake sections") set them also to:

- CV #29, Bit 2 = 0 and CV #124, Bit 5 = 1 and additionally CV #112, Bit 6 = 1.

#124 | Shunting key functions: | Bits 0 - 4, 6 | 0 | Select a function 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 a function key for MOMENTUM DEACTIVATION:

- Bit 2 = 0 (and Bit 6 = 0): "MN" key for deactivation.
- Bit 2 = 1 (and Bit 6 = 0): F4 key for deactivation
- Bit 6 = 1 (Bit 2 is irrelevant): F3 for deactivation.

Effect of above key (MN, F3 or F4) on LOW GEAR:

- Bit 1 = 0: no effect on momentum
- Bit 1 = 1: removes momentum of CV #121 + #122
- Bit 1 = 2: removes momentum of CV #121 + #122 + #155
- Bit 1 = 3: removes momentum of CV #121 + #122 + #155 + #156

NOTE:

- Extended shunting key selection in CV’s #155, #156

#155 | Selecting a function key as half-speed key | 0 - 19 | 0 | Expanding on the settings of CV #124, If another key is required than F3 or F7:

- CV #155: Defines a function key for half-speed activation (= top speed cut in half).

If a key is assigned through CV #155, a possible assignment is the following example:

For polarity independent brake sections ("Märklin-Brake sections") set them also to:

- CV #29, Bit 2 = 0 and CV #124, Bit 5 = 1 and additionally CV #112, Bit 6 = 1.
### 3.8 The NMRA-DCC function mapping

ZIMO decoders have between 4 and 12 function outputs (FO). Items connected to these outputs (lights, smoke generator etc.) are switched ON and OFF with the function keys of the cab. Which function is to be controlled by which function key, can be defined with the NMRA function mapping.

**CV’s #33 to #46**

constitute the NMRA function mapping table for the first address; unfortunately, this function mapping also has its restrictions (only one 8-Bit register is available for each function, which leaves only 8 outputs to select from) and the headlight is the only function that can be controlled by direction.

<table>
<thead>
<tr>
<th>NMRA Function</th>
<th>CV</th>
<th>Number key on ZIMO cabs</th>
<th>Function outputs;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>FA6 FA5 FA4 FA3 FA2 FA1</td>
<td>Rear light Front light</td>
</tr>
<tr>
<td>F0</td>
<td>#33</td>
<td>1 (L) fw</td>
<td>7 6 5 4 3 2 1</td>
</tr>
<tr>
<td>F0</td>
<td>#34</td>
<td>1 (L) re</td>
<td>7 6 5 4 3 2 0</td>
</tr>
<tr>
<td>F1</td>
<td>#35</td>
<td>2</td>
<td>7 6 5 4 3 2</td>
</tr>
<tr>
<td>F2</td>
<td>#36</td>
<td>3</td>
<td>7 6 5 4 3 2</td>
</tr>
<tr>
<td>F3</td>
<td>#37</td>
<td>4</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F4</td>
<td>#38</td>
<td>5</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F5</td>
<td>#39</td>
<td>6</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F6</td>
<td>#40</td>
<td>7</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F7</td>
<td>#41</td>
<td>8</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F8</td>
<td>#42</td>
<td>↑ 9</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F9</td>
<td>#43</td>
<td>↑ 1</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F10</td>
<td>#44</td>
<td>↑ 2</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F11</td>
<td>#45</td>
<td>↑ 3</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F12</td>
<td>#46</td>
<td>↑ 4</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
</tbody>
</table>

The black dots in the table above indicate the 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

and so on..
The Function mapping for the Second address is defined in the
CV's #69 to #82

The first address and the second address commands are read separately, and stored according to the respective "function mapping" and the desired function output states.

After power-on (system boot-up, longer track power interruption etc.), the decoder is first waiting for a SECOND ADDRESS command (provided the second address is not 0) and the outputs are set based on this secondary address command. First-address commands are executed only if changes in the function output states between successive first-address commands occur. During continued operation the "principle of the most recent change" between first and second address commands applies.

### Function Outputs

<table>
<thead>
<tr>
<th>NMRA Function</th>
<th>CV</th>
<th>Function Outputs</th>
<th>Function Outputs:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F1 FA6 FA5 FA4 FA3 FA2 FA1 Rear light Front light</td>
<td></td>
</tr>
<tr>
<td>F0</td>
<td>#69</td>
<td>1 (L) fw</td>
<td>7 6 5 4 3 2 1 0</td>
</tr>
<tr>
<td>F0</td>
<td>#70</td>
<td>1 (L) re</td>
<td>7 6 5 4 3 2 1 0</td>
</tr>
<tr>
<td>F1</td>
<td>#71</td>
<td>2</td>
<td>7 6 5 4 3 2 1 0</td>
</tr>
<tr>
<td>F2</td>
<td>#72</td>
<td>3</td>
<td>7 6 5 4 3 2 1 0</td>
</tr>
<tr>
<td>F3</td>
<td>#73</td>
<td>4</td>
<td>4 3 2 3 0 7 6 5</td>
</tr>
<tr>
<td>F4</td>
<td>#74</td>
<td>5</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F5</td>
<td>#75</td>
<td>6</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F6</td>
<td>#76</td>
<td>7</td>
<td>4 3 2 1 0 7 6 5</td>
</tr>
<tr>
<td>F7</td>
<td>#77</td>
<td>8</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F8</td>
<td>#78</td>
<td>9</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F9</td>
<td>#79</td>
<td>0</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F10</td>
<td>#80</td>
<td>1</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F11</td>
<td>#81</td>
<td>2</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
<tr>
<td>F12</td>
<td>#82</td>
<td>3</td>
<td>1 0 7 6 5 4 3 2</td>
</tr>
</tbody>
</table>

### Tip: Directional tailights with the help of special effect CV's:

With the NMRA function mapping it is only possible to have function F0 directional and was intended for the headlights, so they automatically switch between "front" and "rear" when changing direction. All other functions are controlled independent of direction.

The special effect CV's #125 … 132, #159 and #160 (see chapter "Special function output effects"), each assigned to a function output (up to FO8), make it possible to have more direction dependent functions. To utilize only the directional capabilities of these CV's use only the directional Bits 0 and/or 1 without setting the actual effect-bits.

**Example 1:** A couple of red tailights are connected to function outputs FO1 and FO2 (front and rear of engine). Both are to be actuated with F1 but should also change with direction. This requires the following CV settings:

CV #31 = 6 (both white headlights as red tailights in the rear on F1 !)
CV #126 = 1 / CV #127 = 2 (Direction dependence for rear white and red lights by means of “Special Effects” CV)

This can be done as follows:

Connect: White front headlights connected to function output “front headlights”
Red front tailights to function output FO2
White rear headlights to function output FO1
Red rear tailights to function output "rear headlights" (1).

### 3.9 “Unilateral Light Suppression”

This is a another feature, asked for by many users, that makes it possible to switch off all lighting on one side of a locomotive with the push of one function key (usually on the “train side”, i.e. where cars are coupled to the locomotive).

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
</table>
| #107 | Light suppression (i.e. front headlights AND additionally defined function output) at cab side 1 (front) | 0 - 255 | 0       | The value of this CV is calculated as follows:
|     | Number of a function output (FO1…FO28) x 32 + number of a function key (F1, F2…F28) + Value of CV #107 |
|     | Function Key: That key (F1, F2…F28) which should turn off ALL lights on the cab side 1 (front side) AND Function Output: i.e. tailights on the same side. |
| #108 | Cab side 2 (rear)                                                         | 0 - 255 | 0       | Same as CV #107 but for other locomotive side. |
### 3.10 Dimming, Low beam and Direction Bits

Some elements connected to function outputs are often not designed to operate with full track power, as is the case for example with 18V bulbs at 24V track voltage (quite common on large scale model railroads). Other times the brightness needs to be reduced simply because the light is too bright.

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”). Such low-voltage outputs are by the way fully stabilized and the voltage will not fluctuate with changes in track voltage.

Alternatively or in addition to this (the dimming effect is not limited to devices connected to full track power but also works with low voltage), the PWM (pulse with modulation) voltage reduction is also available with CV #60, which defines the PWM duty cycle. Of course, this kind of voltage reduction is also interesting because it is easy to change at any time.

**NOTE:** Bulbs with voltage ratings as low as 12V 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 5V or 1.2V 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”).

LED’s, on the other hand, require a series resistor; if however, the resistor is designed to operate at 5V, the PWM dimming is also sufficient at a track voltage of 25V. (in this case the setting would be CV #60 = 50, so a reduction by one fifth, 1/5th).

CV #60 generally affects all function outputs. The dimming function can be restricted to specific function outputs using the dim mask CV’s (see table).

---

**Low/high beam with the help of the low beam mask**

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

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#119</td>
<td>Low beam mask for F6</td>
<td>Bits 0 - 7</td>
<td>0</td>
<td>Selected function outputs will dim with F6 key, according to dim value in CV #60.</td>
</tr>
<tr>
<td></td>
<td>Output assignment for (example) low/high beam headlights</td>
<td></td>
<td></td>
<td>Typical application: Low/high beam</td>
</tr>
<tr>
<td></td>
<td>ATTENTION: Certain settings in CV #154 (Special output configurations) change the meaning of CV's #119 and #120 and therefore will no longer work as a low-beam mask.</td>
<td></td>
<td></td>
<td>Bit 0 - front headlight.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 1 - rear headlight.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 2 - function output FO1, Bit 3 - FO2.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 4 - function output FO3, Bit 5 - FO4.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 6 - function output FO5, Bit 7 - FO6.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit value = 0: Output will not be dimmed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit value = 1: Output will be dimmed with F6 to value defined in CV #60.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 7 = 0: normal action of F6.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>= 1: inverted action of F6.</td>
</tr>
<tr>
<td></td>
<td>EXAMPLE: CV #119 = 131: Function key F6 toggles headlights between low and high beam.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#120</td>
<td>Low beam mask for F7</td>
<td>Bits 0 - 7</td>
<td>0</td>
<td>Same as CV #119 but with F7 as low beam key.</td>
</tr>
</tbody>
</table>
A "second dim value" with the help of the uncoupler CV

If more function outputs need to be dimmed than CV #60 allows or if some function outputs require a different voltage and the uncoupler function is not needed on the same vehicle then

CV #115
can be used for an alternative low voltage supply. The respective function outputs must be defined as "uncoupler output" in the corresponding

CV's #125…#132, #159 and #160
(see "Special effects for function outputs)."

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#115</td>
<td>Uncoupler control or</td>
<td>0 - 9</td>
<td>0</td>
<td>Only active as uncoupler if &quot;uncoupler&quot; function is selected (value 48) in CV #125 …#132, 159 or 160:</td>
</tr>
<tr>
<td></td>
<td>Second dim value</td>
<td></td>
<td></td>
<td>Tens digit = 0: used for dimming. One digit (0 to 9): PWM – voltage reduction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0 to 90%)</td>
</tr>
<tr>
<td>#127</td>
<td>Effects on FO1, FO2,</td>
<td>0</td>
<td>0</td>
<td>Value = 48 for dimming application</td>
</tr>
<tr>
<td></td>
<td>FO3, FO4, FO5, FO6</td>
<td></td>
<td></td>
<td>#127 → FO1 #128 → FO2</td>
</tr>
<tr>
<td>#159</td>
<td>on FO7</td>
<td></td>
<td></td>
<td>#129 → FO3 #130 → FO4</td>
</tr>
<tr>
<td>#160</td>
<td>on FO8</td>
<td></td>
<td></td>
<td>#131 → FO5 #132 → FO6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#159 → FO7 #160 → FO8</td>
</tr>
</tbody>
</table>

3.11 The Flasher Effect

Flashing is actually a lighting effect just like all the others that are summarized in the CV's starting with #125; but for historical reasons are listed in their own CV's #117 and #118.

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#117</td>
<td>Flasher functions</td>
<td>0 - 99</td>
<td>0</td>
<td>Duty cycle for flasher function:</td>
</tr>
<tr>
<td></td>
<td>Outputs are assigned in</td>
<td></td>
<td></td>
<td>Tens digit = ON time</td>
</tr>
<tr>
<td></td>
<td>CV #118</td>
<td></td>
<td></td>
<td>Ones digit = OFF time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0 = 100msec, 1 = 200msec….9 = 1 sec)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Example:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CV #117 = 55: Flashes evenly at 1 a second interval.</td>
</tr>
<tr>
<td>#118</td>
<td>Flashing mask</td>
<td>Bits 0 - 7</td>
<td>0</td>
<td>Selected function outputs will flash when turned ON.</td>
</tr>
<tr>
<td></td>
<td>Defines which outputs</td>
<td></td>
<td></td>
<td>Bit 0 - front headlights</td>
</tr>
<tr>
<td></td>
<td>operate as flashers</td>
<td></td>
<td></td>
<td>Bit 1 - rear headlights</td>
</tr>
<tr>
<td></td>
<td>according to programmed</td>
<td></td>
<td></td>
<td>Bit 2 - function output FO1,       Bit 3 - …FO2</td>
</tr>
<tr>
<td></td>
<td>in CV #117</td>
<td></td>
<td></td>
<td>Bit 4 - …FO3,       Bit 5 - function output FO4.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit value = 0: No flash</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit value = 1: Output flashes when turned ON.</td>
</tr>
</tbody>
</table>

3.12 F1- Pulse Chains (Only for old LGB products)

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
</table>
| #127 | Special ZIMO configuration| 0 - 255| 4 = | Bit 3 = 0: 12-function mode
|      | Bits                      |       | 00000100 | 8 = Function mode
|      |                           |       | (Bits 4 and 7 = 0) | Bit 4 = 0: Pulse chain recognition OFF
|      |                           |       |          | = T: Pulse chain recognition ON (use with old LGB systems)                 |
|      |                           |       |          | ... Bit 7 = 0: no pulse chain generation
|      |                           |       |          | = 1: Generates pulse chain commands for LGB sound modules.                  |

Bit 6 = 1: FO2 flashes inverse!
Bit 7 = 1: FO4 flashes inverse!
(for alternate flashing, i.e. wig-wag)

Example:
CV #118 = 12: FO1 and FO2 are defined as flashers.
CV #118 = 168: Alternate flashing of FO2 and FO4
3.13 Special Effects for Function Outputs
(US and other lighting effects, Smoke generator, Uncoupler…)

Special effects can be assigned to a total of 10 function outputs with

- CV's #125, #126, #127 … #132, #159, #160
- for F0fr., F0rear, FO1 … FO6 , FO7 , FO8

The values for these special effect CV’s contain the

actual 6-Bit = special effects code and the 2-Bit directions code

Bits 7 ... 2 = 000000xx

- 000001xx Mars light = direction = 4, 5, 6 (bidirectional, forward, reverse)
- 000010xx Random flicker = direction = 8, 9, 10 (dito, dito, dito)
- 000100xx Single pulse strobe = direction = 16, 17, 18
- 000101xx Double pulse strobe = direction = 20, 21, 22
- 000110xx Rotary beacon = direction = 24, 25, 26
- 000111xx Gyralite = direction = 28, 29, 30
- 001000xx Ditch light type 1, right = direction = 32, 33, 34
- 001001xx Ditch light type 1, left = direction = 36, 37, 38
- 001010xx Ditch light type 2, right = direction = 40, 41, 42
- 001011xx Ditch light type 2, left = direction = 44, 45, 46
- 001100xx Uncoupler as defined in CV #115 = 48, 49, 50

- automatic disengagement in CV #116
- 001101xx “Soft start” = slow power-up of function output = 52, 53, 54
- 001110xx Automatic stoplights for street cars, stoplight-off delay, see CV #63. = 56, 57, 58
- 001111xx Function output turns itself off at speed >0 = 60, 61, 62
  (i.e. turns off cab light when driving).
- 010000xx Function output turns itself off after 5 minutes (i.e. to protect smoke generators form overheating).
- 010001xx As above, but after 10 minutes = 66, 68, 70
- 010010xx Speed or load dependent smoke generation = 72, 73, 75
  for steam engines as per CV #137 – 139 (i.e. pre-heating at stand still, heavy smoke at high speed or high load).
  Smoke turns itself off as per CV #353; function key has to be pressed to reactivate smoke.
- 010100xx Driving state-dependent smoke generation for diesel engines = 80, 81, 82
  as per CV’s #137 – 139 (i.e. pre-heating at stand still, heavy smoke during motor start-up sound and acceleration).
  Synchronized control of fan connected to the fan output. Smoke turns itself off as per CV #353; function key must be pressed to reactivate smoke.
- 010101xx Driving state-dependent smoke generator for diesel engines = 80, 81, 82
  as per CV’s #137 – 139 (i.e. pre-heating at stand still, heavy smoke during motor start-up sound and acceleration).

- Bits 1, 0 = 00: bidirectional (active in both directions)
- 01: active in forward direction only (+ 1)
- 10: active in reverse direction only (+ 2)

- Special effects American lighting effects as well as others such as uncoupler, smoke generator and more on

- function output F0 (front headlight)

- Effects can be further adjusted and modified with

- CV's #62 - 64
- and

- CV #115

(for uncoupler).

- Bits 1, 0 = 00: bidirectional (active in both directions)
  - 01: only active in forward direction
  - 10: only 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 = Effekt-Code

EXEMPLES

00001001 = 01000001 – 00000100 = 5

Gyralite independent of direction = 00100000 = 32

Ditch type 1 left, only forward = 00101000 = 32

Uncoupler = 00110000 = 48

Soft start of output = 00101000 = 52

Automatic stop light = 00111000 = 64

Automatic cab light OFF = 00111100 = 65

Auto. smoke OFF after 5 min = 01000000 = 64

Auto. smoke OFF after 10 min = 01001000 = 68

Speed/load depen. smoke - 01010000 = 72

Speed/load depen. diesel smoke = 01010000 = 60

CV  Designation  Range  Default  Description

#125  Special effects  American lighting effects

as well as others such as
uncoupler, smoke
generator and more

on function output F0
(front headlight)

Effects can be further
adjusted and modified
with CV's #62 - 64

and

CV #115

(for uncoupler).

- Bits 1, 0 = 00: bidirectional (active in both directions)
  - 01: only active in forward direction
  - 10: only active in reverse direction

#126  Special effects

rear headlight
(default F0 reverse)

- Bits 1, 0 = 00: bidirectional (active in both directions)
  - 01: only active in forward direction
  - 10: only active in reverse direction

#127  Special effects for

FO1, FO2, FO3,
FO4, FO5, FO6

#132  Special effects

for

FO7, FO8

#159  Special effects for

FO1, FO2, FO3,
FO4, FO5, FO6

#160  Special effects for

FO7, FO8

#62  Effects modifications

0 - 9  0  Change of minimum dimming value

#63  Light effects modifications

or

Stop light OFF delay

0 - 99  51  Tens digit: sets cycle time (0 - 9, default 5), or start-up time during soft start with 001101 (0 - 0.9s).

Ones digit: OFF delay time (range: 0 – 25 sec.). For stop light OFF delay (001101xx in CV #125, 126 or 127); Time in tenths of a second the stop lights remain ON after the street car comes to a full stop.

#83  Effects modifications

0 - 9  5  Ditch light OFF time modification

#353  Automatic smoke generator

shut-down

0 - 255  0

0 - 106 min  0

For special effect codes “010100xx” or “010100xx” (smoke generator); Overheat protection: turns OFF from ½ min – about 2 hours.

0 = Won’t turn off automatically.

1 = 1 … 252. Switches off automatically after 25 seconds/unit. Maximum time therefore is about 6300 sec. 105 min.

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 is 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 #3 = 13 (0001101), CV #4 = 14 (0001110).
3.14 Configuration of Electric Uncouplers

"System KROIS" and "System ROCO"

When one or two of the function outputs F01...F06 (but not F07 or F08) are assigned to the uncoupler function (CV #127 for F01 etc.), the control of the couplers as well as the entire uncoupling process is defined by the settings in CV #115 and CV #116.

These CV's limit the pull-in time (to prevent overheating), define a hold-in voltage if required (i.e. System "Roco") as well as the automated coupler unloading and train disengagement.

It is recommended to use the following settings for the Krois system: CV #115 = 60, 70 or 80; these settings will limit the pull-in voltage (full track power) to 2, 3 or 4 seconds respectively. A hold-in voltage is not required for the Krois coupler and the ones digit can therefore remain at "0".

### Function Outputs

- **CV #115**
  - Uncoupler control
  - "Pull-in" time and "hold" voltage or use CV #115 for an alternative second dim value (dimming 0-90% using ones digit; tens digit must be 0)
  - Range: 0 - 99
  - Default: 0

- **CV #116**
  - Servo outputs: Protocol
  - Range: 0 - 3
  - Default: 0

3.15 SUSI-Interface and Logic-Level Output

All decoders described in this manual (except for the MX681) have outputs that can either be used as a SUSI interface, as logic level outputs or for servo control. These outputs are available at solder pads or on the decoder plug (MTC or PluX), see the various decoder drawings starting on page 5.

These outputs are active by default as SUSI interface. They can be switched for the alternative applications with CV #124 (Bit 7) or CV's #181 and #182 (see next chapter "Servo configuration").

### Susi Interface Outputs

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#124</td>
<td>Shunting key functions: Bits 0 - 4, 6: Shunting key selection and HALF-SPEED ACTIVATION Bit 5 = 1: &quot;DC stopping&quot; Bit 7 = 0: SUSI active instead of normal functions</td>
<td>Bits 0 - 4, 6</td>
<td>0</td>
<td>Shunting key functions: Bits 0 - 4, 6: Shunting key selection and HALF-SPEED ACTIVATION Bit 5 = 1: &quot;DC stopping&quot; Bit 7 = 0: SUSI active instead of normal functions</td>
</tr>
</tbody>
</table>

### Servo Configuration

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#161</td>
<td>Servo outputs: Protocol</td>
<td>0 - 3</td>
<td>0</td>
<td>Note: CV #161 must be set to &quot;2&quot; for Smart Servo RC-11</td>
</tr>
<tr>
<td>#162</td>
<td>Servo 1 - Left stop</td>
<td>0 - 255</td>
<td>49</td>
<td>servos left stop position. &quot;Left&quot; may become the right stop, depending on values used.</td>
</tr>
<tr>
<td>#163</td>
<td>Servo 1 - Right stop</td>
<td>0 - 255</td>
<td>205</td>
<td>Defines the servos right stop position.</td>
</tr>
<tr>
<td>#164</td>
<td>Servo 1 - Center position</td>
<td>0 - 255</td>
<td>127</td>
<td>Defines a center position, if three positions are used.</td>
</tr>
<tr>
<td>#165</td>
<td>Servo 1 - Rotating speed</td>
<td>0 - 255</td>
<td>30</td>
<td>Rotating speed; time between defined end stops in tenths of a second (total range of 25 sec, default 3 sec.).</td>
</tr>
<tr>
<td>#166</td>
<td>As above but for Servo 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bit 0 = 0:** Servo protocol with positive pulses.
- 1: Servo protocol with negative pulses.

**Bit 1 = 0:** Control wire only active during movement
- 1: ... always active (consumes power, vibrates at times but holds position even under mechanical load) – this setting is also required for SmartServo RC-1 (with memory wire)!

**Bit 2 = 0:** Moves to center position, if defined for two-key operation (see CV #181/182), when both function keys are OFF.
- 1: Servo runs only if function keys are pressed when in two-key operating mode (see CV #181/182).

- **CV #181/182**
  - Definition makes no difference.

- **CV #181**
  - Servo 1 - 0 to 28
  - Servo 2 - 90 to 101-114
  - 101-114

- **CV #182**
  - Servo 1 - 0 to 28
  - Servo 2 - 90 to 101-114

- **CV #181/182**
  - 0: Servo not in operation
  - 1: Single-key operation with F1
  - 2: Single-key operation with F2 and so on to
  - 28: Single-key operation with F28
  - 90: Servo action depends on loco direction: forward = turns left; reverse = turns right
  - 91: Servo action depends on loco stop and direction: turns right when stopped and direction is forward, otherwise turns left.
  - 92: Servo action depends on loco stop and direction: turns right when stopped and direction is reverse, otherwise turns left.
  - 93: Servo action depends on loco movement: turns right when loco stopped, left when loco moving; direction makes no difference.
  - 101: Two-key operation F1 + F2
  - 102: Two-key operation F2 + F3 and so on to
  - 127: Two-key operation F27 + F28
  - 111: Two-key operation F11 + F12
Connecting servos to decoder: consult the loco decoder manual!

**Table 1**: CV Designation

<table>
<thead>
<tr>
<th>CV</th>
<th>Designation</th>
<th>Range</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>#28</td>
<td>RailCom Configuration</td>
<td>0 - 3</td>
<td>3</td>
<td>Bit 0 - RailCom Channel 1 (Broadcast)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = OFF, 1 = ON</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 1 - RailCom Channel 2 (Data)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = OFF, 1 = ON</td>
</tr>
<tr>
<td>#29</td>
<td>Grundeinstellungen</td>
<td>0 - 63</td>
<td></td>
<td>Bit 0 - Train direction:</td>
</tr>
<tr>
<td></td>
<td>Configuration data</td>
<td></td>
<td></td>
<td>0 = normal, 1 = reversed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 1 - Number of speed steps:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = 14, 1 = 28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 2 - DC operation (analog):</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = off, 1 = on</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 3 - RailCom (&quot;bidirectional communication&quot;)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = deactivated, 1 = activated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 4 - Individual speed table:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = off, CV # 2, 5, 6, are active</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = on, according to CV’s # 67 – 94</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bit 5 - Decoder address:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 = primary address as per CV #1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 = ext. address as per CV #17+18</td>
</tr>
</tbody>
</table>

With the help of **bidirectional communication** according to RailCom or the alternative future method it will possible that **decoders can acknowledge received commands** -
- which increases operational reliability and the bandwidth of DCC systems because already acknowledged commands don’t need to be sent repeatedly;

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

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

**decoder addresses are recognized by “local” detectors -**

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

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

RailCom in ZIMO Decoders is activated with

\[
\text{CV #29, Bit 3} = 1 \quad \text{AND} \quad \text{CV #28} = 3
\]

These are usually default settings on a new decoder, but RailCom is turned off by default in many sound projects or OEM CV sets and must therefore be activated first with above CV’s.

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5 **Operating with Märklin MOTOROLA Systems**

See loco decoder manual!

6 **ZIMO Decoder - Software Update**

See MXULF manual!