PIKO #97442 SmartDecoder XP 5.1 Sound

ML4000 Diesel Locomotive (North American version) Reference Guide

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Decoder overview:

The PIKO SmartDecoder XP 5.1 Sound inside the ML4000 is a powerful, NMRA DCC-Conformant, load-regulated, multiprotocol *PluX22* sound decoder. It features high fidelity, 12 bit 8-channel sound with 2.5 watts of output that ensures distortion-free sound at all levels. The decoder can be used on DCC layouts as well as traditional DC analog layouts. It will automatically detect what control mode is used on your layout. The decoder is RailCom® and RailCom Plus®-compatible for nearly instant registration on DCC systems with RailCom technology.

It features an abundance of user-programmable sound and lighting functions along with multiple unit consisting and programmable motor speed curves. The two directional lighting outputs and seven additional function outputs can be activated individually on keys F0 to F68. A slow-speed switching gear/mode, three starting and braking delays, and a plethora of locomotive sounds can also be activated via any of the function keys. The decoder's sound module controls function outputs like fade-in / fade-out headlight effects. Sophisticated circuitry keeps the decoder functioning in the event of short-term power loss like on dirty track. The Smart Decoder XP 5.1 Sound can be programmed with most DCC systems, but we strongly recommend the PIKO SmartProgrammer device (PIKO item #56415) for advanced programming projects like Extended Function Mapping.

Decoder attributes:

- NMRA DCC-Conformant
- Automatic detection of conventional DC operating mode
- Nearly silent operation thanks to auto-adaptive motor control
- 14, 28, and 128 speed steps
- Short (1-127) and long (128-9999) DCC addressing
- RailCom® and RailCom Plus®-compatible
- mfx® (Marklin DCC system) compatible
- DCC Programming on the Main (POM)
- Programmable via register, CV direct, or page programming
- Adjustable minimum, medium, and maximum speed levels
- Adjustable extended speed curve
- Switching gear/mode (1/2 normal locomotive speed).
- 3 adjustable acceleration and braking delays
- F0 - F12 can be programmed to operate while on analog layouts
- 7 special function outputs; direction-dependent and dimmable
- Directional light outputs; dimmable
- Marker lights can be switched on or off
- Four adjustable flashing patterns for outputs like Mars lights
- Adjustable headlight illumination time: light starts dim and then reaches full brightness
- Two adjustable light dimming settings for outputs A1 to A7
- Simple function mapping for lighting functions in F0 - F12 and A1 to A7
- Extended function mapping in F0 - F68 for switching multiple function outputs at the same time (linked functions)
- Adjustable braking distances
- Recognizes automated DCC brake sections on your layout
- Speed-dependent activation / deactivation of function outputs
- Automatic shuttle train operation with adjustable halt times for automated train routing (computer-controlled train operation)
- Function icons can be displayed or hidden on DCC throttle's screen
- Suitable for 1.2 Amp DC and AC motors
- Overload protection for each function output
- Error memory for motor and function outputs
- Temperature overload protection
- Decoder programming lock

Decoder sound module:

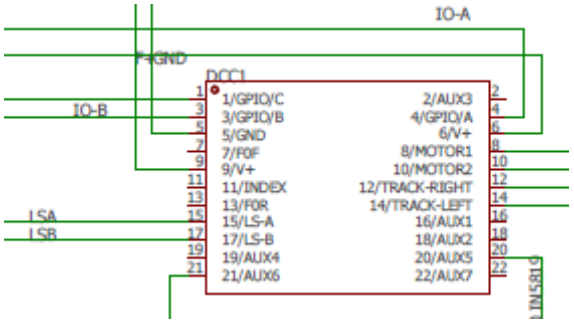
- 12 bit resolution
- 8-channel sound
- 128 MBit sound storage for up to 495 seconds of digitized original sound
- 22.05 kHz audio sampling rate
- Powerful digital amplifier with 2.5 watt output
- Locomotive start-up / shutdown sequences
- Up to 32 switchable sounds accessed via function keys F0 to F68
- Load-dependent sound change (starting, uphill, downhill, braking, stationary, etc.)
- Adjustable volumes for overall sound *and* individual sounds
- Sound fader function
- Random sounds like cooling fans or air compressor; adjustable to speed thresholds
- Automatic brake squeal with adjustable speed threshold
- Automatic flange squeal with adjustable speed threshold
- Ability to upload locomotive sound files via the PIKO SmartProgrammer / SmartTester
- and much more!

Installing the decoder in an analog model:

First, remove the locomotive shell as shown on page 1 of the locomotive instruction manual. Next remove the jumper plug from the locomotive's PluX22 interface; located on the main circuit board of your model. Insert the sound decoder into the PluX22 interface as shown on page 1 of the locomotive instruction manual. Make sure the decoder is oriented correctly. Note the location of PIN 11, which is blank/missing. Next, remove the plastic engine room insert located under the circuit board and place the speaker in it's recess located in the chassis. Replace the engine room insert and circuit board, taking care to thread the speaker's wires up through the insert, as shown on page 1 of the locomotive instruction manual. Carefully solder the speaker's wire leads to the solder pads located at the rear of the main circuit board. Make sure that no wires are crossed when you put the shell back on the chassis.

Below are a couple of graphics showing what each pin on the decoder controls. **If installing a decoder from another manufacturer, take note of which pin corresponds with which socket in the ML4000's DCC interface!**

PluX22 Interface ML 4000 #97442



Name	Pin Nr.	Pin Nr.	Name
GPIO_C	1	2	AUX3
ZBCLK / AUX8 / GPIO_A	3	4	ZBDATA / AUX9 / GPIO_B
GND	5	6	Cap. +
F0_f	7	8	Motor +
U+	9	10	Motor -
Index (not used)	11	12	right wheel pick-up
F0_r	13	14	left wheel pick-up
LS_A	15	16	AUX1
LS_B	17	18	AUX2
AUX4	19	20	AUX5
AUX6	21	22	AUX7

Pin	Description
1	GPIOC -> not used
2	AUX3 -> not used
3	GPIOA -> LightController control (SUSI Clock (ZBCLK))
4	GPIOB -> LightController control (SUSI Data (ZBDATA))
5	GND -> Ground (SUSI GND / capacitor -)
6	V+ CAP -> capacitor + (optional)
7	F0F -> not used
8	Motor +
9	F+ -> SUSI + / capacitor +
10	Motor -
11	Index (No pin on the decoder, no contact hole in the circuit board)
12	Right rail
13	F0R -> not used
14	Left rail
15	LSA -> Speaker A
16	AUX1 -> not used
17	LSA -> Speaker B
18	AUX2 -> not used
19	AUX4 -> not used
20	AUX5 -> not used (reserved for FAN Motor)
21	AUX6 -> not used (reserved for FAN Motor)
22	AUX7 -> not used

First time use:

The model's first start-up should be on a programming track, with your control system's programming mode activated. When reading or programming, very small currents will flow through the decoder, which are entirely normal and do not damage the decoder. The decoder is factory-set to DCC address 3, which you can now change if you desire. If you are using a RailCom Plus®-compatible digital control center (i.e. PIKO SmartControl) or an mfx®-compatible digital control center (Marklin), the decoder will log on automatically and can be used immediately. If the decoder is used on conventional analog layouts, it can be operated with an analog DC throttle. The decoder will automatically recognize the operating mode.

ML4000 Decoder Function List

F#	Function	Notes
0	Headlights On/Off	Toggle on/off. (Only controls front & rear headlights, not other lights)
1	Bell On/Off	Toggle on/off
2	Horn - Playable	Momentary (as long as button is pressed)
3	Horn - Short	Toggle. Each press gives one short blast
4	Dynamic Brakes	Toggle on/off (notches up diesel motor sound if not already notched-up)
5	Manual Notch Up	Multi-press. If on, holds diesel motor notch. If off, allows automatic notching to work.
6	Manual Notch Down	Multi-press. If on, holds diesel motor notch. If off, allows automatic notching to work.
7	Headlight Dimmer On/Off	Toggle On for dim/Off for full brightness. (Only controls headlights)
8	Motor Sounds On/Off & Mute	Multi-Press. Press 1x to start Motor 2. 2x to start Motor 1. 3x to shut down both. 4x to mute all sounds
9	Markers & Classification Lights	Multi-Press. 1x = Marker Boards On (& Stay On), 2x= White Class Lights On, 3x = Green, 4x = Red (Only in Reverse), 5x = All Off. Automatically directional
10	White Gyralite	Toggle on/off. Automatically directional
11	Red Emergency Gyralite	Toggle on/off. (When on, deactivates other front lights)
12	NOT USED	(Only for extra lights on German Test versions of the ML 4000)
13	Cab Interior Light	Toggle on/off
14	Engine Room Light	Toggle on/off
15	Consist Lighting Override	Multi-Press. Used to turn front or rear lights off when running in a consist. 1x = Front lights off, 2x = rear light off, 3x, both front & rear lights off, 4x = Initial state, all directional lights can be activated.
16	Volume Control (4 Steps)	Multi-Press. Each press steps overall sound volume down about 20%.
17	Couple/Uncouple	Toggle. Alternates between coupling and uncoupling sounds
18	Brake Squeal/Brake Release	Toggle. On starts squeal. Off stops squeal and makes air release sound
19	Curve Squeal	Toggle on/off
20	Radiator Fan	Toggle on/off
21	Sander Valve	Toggle on/off.
22	Cab Chatter #1	Multi-Press. Each press plays one of three different long sequences.
23	Cab Chatter #2	Multi-Press. Each press plays one of three different long sequences.
24	Air Compressor	Toggle on/off. When on, compressor runs randomly, stops, and runs again
25	Control Stand Light	Toggle on/off
26	Grade Crossing Horn	Momentary. 3 different lengths of automatic grade crossing pattern, depending on whether loco is running at slow, medium or high speed
27	NOT USED	(Open slot for future use.)
28	Switching Mode	Toggle on/off. On reduces speed range by about half

DC Analog operation

The sound decoder can be operated on conventional DC analog layouts, and it will automatically recognize that it is being used on a conventional analog layout. Not all the decoder's sound and light functions will be available in analog operation. Note that on a DC analog layout, your model will not begin to move until the voltage is turned up higher than what you are used to with DC analog models. This is because decoder-equipped models only begin to function at a higher voltage than analog models. Please also note that analog layouts operated with Pulse Width Modulation (PWM) throttles may cause erratic performance of DCC decoder-equipped locomotives.

You can set the decoder so that functions F0 - F12 work in analog mode. To do this, CVs 13 & 14 must first be programmed to operate in analog mode. Their values are found in the CV table on pages 9-13.

Programming

CAUTION: Before programming, remove all other models from the programming track!

You are likely to want to change the settings of your ML4000 over the years, and the following several pages give you instructions on how to do that. The ML4000's Smart Decoder XP 5.1 Sound is, like all other DCC decoders, controlled by Configuration Variables, or *CVs*. CV programming can be done via a few methods: Placing the model on a programming track and calling up the programming menu of your throttle, removing the Smart Decoder and inserting it into the SmartProgrammer (PIKO # 56415), and programming the decoder using a PC, or by using the Java Model Railroad Interface (JMRI) where a dedicated decoder profile is available (as of April 2024) for easy programming of all CVs on the decoder.

CVs form the basis of all decoder settings. The value to enter when programming a CV is calculated from the CV tables on pages 10-16 by adding up the values for each desired function. In addition to it's DCC address, *configuration CVs* are the most important CVs in a decoder. These are CVs 12 and 29. A configuration CV normally contains settings which are represented in bits. On a programming screen like the PIKO SmartControl, bits are displayed underneath the CV that has been called up on the screen. The two tables below illustrate how a configuration CV is configured:

Bit	CV12 operational state	value
0	DC analog off DC analog on	0 1
2	DCC format off DCC format on	0 4
4	AC analog off AC analog on	0 16
5	Motorola® format off Motorola® format on	0 32
6	mfx® format off mfx® format on	0 64

Bit	CV29 operational state	value
0	Normal direction of travel Opposite direction of travel	0 1
1	14/27 speed steps 28/128 speed steps	0 2
2	Digital operation only Automatic analog/digital switchover	0 4
3	RailCom® switched off RailCom® switched on	0 8
4	Speed steps via CV 2, 5 and 6 Speed steps via CV 67-94	0 16
5	Short address (CV 1) Long address (CV 17 and 18)	0 32

Here is an example of how to calculate a value for CV 29:

Normal direction of travel	Value = 0
28 speed steps	Value = 2
Analog or digital operation	Value = 4
RailCom® activated	Value = 8
Speed steps via CV 2, 5, 6	Value = 0
Short DCC addressing	Value = 0

The sum of all values is 14. CV 29 is already factory set to 14.

Programming with DCC throttles:

The SmartDecoder XP 5.1 Sound can be programmed for short (1-127) or long (128 – 9999) addressing. Use the programming menu of your DCC throttle to read and program the decoder's CVs. This can be done by register programming, page programming, or by directly accessing each CV on your DCC throttle. The decoder can be programmed using **P**rogramming **O**n the **M**ain (**POM**). Consult your DCC system owner's manual for more information on POM.

Programming long addresses (128 – 9999) *without* using a programming menu like the SmartProgrammer:
If you want to program the decoder using long addresses yet your DCC system does not support long addressing, you can *still* program the decoder through CVs 17 and 18. **First** you need to calculate the value for CVs 17 and 18. The following example shows how to calculate the values of CVs 17 and 18, for a decoder with an address of 2000:

- Divide the address value by 256: (2000 ÷ 256 = 7 with a remainder of 208).
- Take the result (7) and add 192 to it.
- Enter that sum (199) as a value in CV 17.
- Enter the remainder (208) as a value in CV 18.
- **NOTE**: Set bit 5 of CV 29 to 1 so the decoder also uses the long address.

Programming lock (decoder programming lock):

The SmartDecoder XP 5.1 Sound has a programming lock in case you install the decoder in a model where you can add additional function decoders. Although rare nowadays, it used to be common to install a main decoder for the motor of a model and additional decoders for light or sound functions. The entire set of decoders had a common DCC address. A decoder lock means that the decoders can only be programmed if the value of CV15 matches the value of CV16 (index). To achieve this, CV 16 must be programmed to a different number in each additional decoder before it is installed in the model. To change or read the value of a CV in a decoder, first program the corresponding index number of CV16, i.e. the value in CV16, into CV 15. The respective decoder compares the values in CV 15 and CV 16 and if both values match, access to the CVs is enabled. If the comparison fails, it is not possible to access the CVs of the decoder. CV16 can always be read, even if the decoder lock is active.

The SmartDecoder XP 5.1 Sound has a programming lock in the event you install the decoder in a model where you may add additional function decoders. While rare these days, at one time it was common to install a main decoder for a model's motor and additional decoders for light or sound functions. The whole set of decoders shared a common DCC address. A decoder lock causes the main decoder to transfer CVs to only one auxiliary decoder that has the same short (CV 1) or long (CVs 17 and 18) DCC address. To activate this, CV 16 must be programmed to a different number in each auxiliary decoder before it is installed in the model. To change or read the value of a CV in an auxiliary decoder, first program the corresponding index number in CV 15 and then program the CVs of the selected decoder. The Smart Decoder compares the values in CV 15 and CV 16 and if both values match, access to the CVs is enabled. If the comparison fails, then there is no way to access the CVs of the decoder.

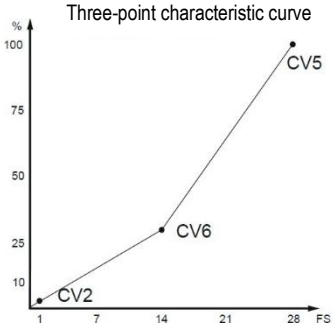
Functions A1 to A7:

Function outputs A1 to A7 can only be used if the devices attached to outputs A1 to A7 are already connected to the decoder via it's DCC socket or there are solder pads for the devices on the model's circuit board. The SmartDecoder XP 5.1 Sound only controls the rear light (F0r), the engine room lights (A3) and the fans (A5/A6). The model's other lighting functions are controlled via modules on the circuit board which are controlled by the SUSI interface of the SmartDecoder.

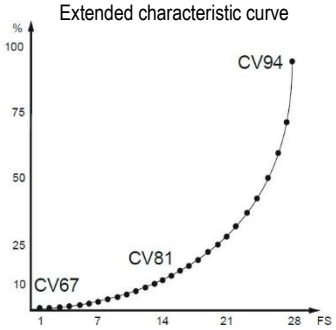
Multiple unit operation, Consisting, Speed matching

Modelers typically like to run several locomotives as part of a "lash-up," which is also called a "locomotive consist." To do this you will need to match the participating locomotives' speed settings. The ML4000's decoder is factory set to a simple 3-point speed curve, where the minimum speed is set in CV 2, the medium speed is set in CV 6, and the maximum speed is set in CV 5. You can change the factory settings to a customized, 28-step extended speed curve by going to CV 29 and entering a value of 1 into Bit 4. This will allow you to define the speed for each one of the 28 speed steps. The 28 individual steps are controlled by CVs 67-94, which control steps 1 to 28 respectively. For example, to change speed step 1, you would enter a value into CV 67. To change speed step 28, you would enter a value into CV 94. For modelers who run the ML4000 on a 128-speed step setting, the 28-step extended speed curve automatically adjusts to 128 speed steps

Three-point characteristic curve



Extended characteristic curve



Multiple-unit operation (Consisting)

The XP 5.1 SmartSound decoder is easily programmed for locomotive consisting by accessing its *multiple-unit address*. This address is stored in CV 19 in a value range from 1 - 127. When this address is activated on your throttle, the decoder no longer reacts to the locomotive's original DCC address. To reverse the model's direction of travel while it is included in a consist, change Bit 7 of CV 19 to 1. This gives the address a value of 128. The factory setting of Bit 7 in CV 19 is 0.

Function outputs for including the ML4000 in a locomotive consist are set via CV 21 (F1 - F8) and CV 22 (F0, F9 - F12).

CV 21 determines whether functions F1 - F8 are controlled via the locomotive consist address in CV 19. For each bit, a value of 1 means that the corresponding function is addressed via the locomotive consist address. A value of 0 defines that the function is only addressed via the individual ML4000's address, which has been set in CV1 or CVs 17 & 18. Bit 0 - bit 7 correspond to function keys F1 to F8.

CV 22 determines whether functions F0 and F9 - F12 are controlled via the address of the locomotive consist in CV19. For each bit, a value of 1 means that the corresponding function is addressed via the locomotive consist address. A value of 0 defines that the function is only addressed via the individual ML4000's address, which has been set in CV1 or CVs 17 & 18. Bit 0 corresponds to F0 while the consist is moving forward while bit 1 corresponds to F0 while the consist is moving in reverse. Bit 2 - bit 5 correspond to function keys F9 - F12.

Other programming options

Trim speed

The motor speed curves for forward direction and backward direction can be trimmed separately from each other. For example, the forward speed curve of a locomotive can be set to match the exact acceleration of its prototype. The same can be done for the reverse speed curve. So, the model could travel at different speeds (depending on the direction it is going) even though the throttle is set to the same speed step. The forward trim speed is set in CV 66 while the backward trim speed is set in CV 95, with both CVs using a value range from 1 - 255 (0 = off). The factory setting of both CVs is a value of 128.

RailCom®, RailCom Plus®

RailCom® is a decoder technology developed by LENZ® that allows for the transfer of data from the decoder via a special "CutOut" DCC digital signal to whatever track the model is on. Obviously, the track must have detectors installed that evaluate this data and, if necessary, forward it to the DCC command station. This system allows for easier train identification on a throttle's screen and makes Programming On the Main simpler. RailCom® is activated or deactivated in CV 29, Bit 3. Additional RailCom® settings are made in CV 28. There, for example, you can activate RailCom Plus® in Bit 7. If RailCom Plus® is activated, the decoder will automatically send it's address, locomotive symbol, and function icons to a RailCom Plus®-compatible DCC command center and its function symbols will appear on the control screen within a few seconds.

Acceleration and Braking Delay (ABV)

The PIKO XP 5.1 SmartDecoder can be programmed to use three different acceleration and braking delays (ABV - ABV1 - ABV2); each selected from a range of 0 - 255. To prevent jump starts, the decoder has a "soft start" feature that can be set in CV 53. Once the "soft start" takes place, the respective ABV delay kicks-in. The first ABV is set in CV 3 (start-up delay) and CV 4 (braking delay). ABV1 and ABV2 are set in CVs 150 - 153. If simple function mapping is used (CV 96 = 1), then you can determine from CV 156 which function key (F0 - F68) should turn off the ABV. ABV1 and ABV2 are mapped to any function key from F0 - F68 by using CVs 154 and 155.

Switching gear/mode

The switching gear/mode function (locomotive runs at half speed, like when it is switching) can be mapped to any key between F0 - F68 by using CV 157.

Fault memory

If the decoder detects a motor malfunction or overheated component, it responds by flashing the model's headlights on both ends. If the lights flash quickly (approx. 4x per second), the decoder has detected a motor fault. If the lights flash slowly (approx. 2x per second), the decoder detects that something has overheated. When the decoder detects a fault, CV 30 (error memory) will show what the fault is.

CV30 -> 1 = motor fault, 2 = overheated decoder, 4 = function output error

Once the fault has been corrected, the error memory (CV 30) should be reset to a value of 0.

Function mapping

NOTE: These function outputs are NOT USED by default on the ML4000. More information is on Page 8.

Simple function mapping (switched off at the factory)

The following table shows decoder settings in simple function mapping. Simple function mapping is only active when CV 96 is set to 1. **The factory default setting is Extended function mapping, where CV 96 is set to 6.**

In simple function mapping, you can assign "switchable" functions like lighting, sound, or other outputs to function keys F0 to F12. CVs 33 to 46 control the settings of these keys. Their CV values determine whether the function can be switched on or off, as is shown in the table below. Keep in mind that the SmartDecoder XP 5.1 Sound only has 7 function outputs, of which the higher ones are highlighted in gray in the table below:

CV / F-key	Bit 7 (128)	Bit 6 (64)	Bit 5 (32)	Bit 4 (16)	Bit 3 (8)	Bit 2 (4)	Bit 1 (2)	Bit 0 (1)	Value
33 / F0v	A6	A5	A4	A3	A2	A1	F0h	F0v	1
34 / F0r	A6	A5	A4	A3	A2	A1	F0h	F0v	2
35 / F1	A6	A5	A4	A3	A2	A1	F0h	F0v	4
36 / F2	A6	A5	A4	A3	A2	A1	F0h	F0v	8
37 / F3	A6	A5	A4	A3	A2	A1	F0h	F0v	16
38 / F4	A9	A8	A7	A6	A5	A4	A3	A2	4
39 / F5	A9	A8	A7	A6	A5	A4	A3	A2	8
40 / F6	A9	A8	A7	A6	A5	A4	A3	A2	16
41 / F7	A9	A8	A7	A6	A5	A4	A3	A2	32
42 / F8	A9	A8	A7	A6	A5	A4	A3	A2	64
43 / F9	A12	A11	A10	A9	A8	A7	A6	A5	16
44 / F10	A12	A11	A10	A9	A8	A7	A6	A5	32
45 / F11	A12	A11	A10	A9	A8	A7	A6	A5	64
46 / F12	A12	A11	A10	A9	A8	A7	A6	A5	128

Here is an example of simple function mapping: You want function key F3 to be the only key that switches the rear light output (F0h) on or off.
The CV to program for F3 is CV 37. A value of 2 (F0h, rear light output) is programmed into CV 37. To keep F0 from causing the rear light output from illuminating when the locomotive switches direction, program CV 34 (for function key F0) to a value of 0.

Function outputs are switched off depending on the direction of travel when CV 96 has a value of 1)

In CV 97 (forward direction of travel) and CV 98 (backward direction of travel) you can specify which function outputs A1 - A7 should be switched off. If any of functions A1 - A7 are switched on via a function key, they are automatically switched off in the desired direction of travel.

CV 97:		Value	CV 98:		Value
Bit 0	A1 forward off	1	Bit 0	A1 backwards off	1
Bit 1	A2 forward off	2	Bit 1	A2 backwards off	2
Bit 2	A3 forward off	4	Bit 2	A3 backwards off	4
Bit 3	A4 forward off	8	Bit 3	A4 backwards off	8
Bit 4	A5 forward off	16	Bit 4	A5 backwards off	16
Bit 5	A6 forward off	32	Bit 5	A6 backwards off	32
Bit 6	A7 forward off	64	Bit 6	A7 backwards off	64

A combination (sum of the individual values) is possible in each case.

Pointer CVs 31 and 32

To expand the number of usable CVs, the CV range from 257 - 512 was configured for block-by-block addressing. Block-by-block addressing means there are several blocks (banks) in the decoder with a CV range of 257-512. To program a specific CV bank, CV 31 and CV 32 must first be programmed as "pointer CVs" to the respective block.

Volume settings:

The master volume of the XP 5.1 SmartDecoder is changed in a special CV block. To access this bank, "pointer" CV 31 must be set to 16 and "pointer" CV 32 must equal 0. Then CV 257 can be set to the desired volume. This CV block also allows you to set individual sound options like flange squeal and their five different volume levels. Please refer to the CV table for each respective CV.

Function Mapping Sound

Function key assignment for individual sounds can only be done with extended function mapping and cannot be programmed using individual CVs.

Custom sound files

To load a custom PIKO sound file onto the decoder, you will need the PIKO SmartProgrammer (# 56415) and (optional) the PIKO SmartTester (# 56416).

Factory reset

To restore the sound decoder to factory settings, please program CV 8 to a value of 8:

Simple and Extended Function Mapping

The following decoder settings are possible with simple (CV 96 = 1) *or* extended (CV 96 = 6) function mapping. Keep in mind that the decoder is factory set to Extended function mapping (CV 96 = 6).

Setting options for function output intensity *(for DCC experts only!)*

The settings for each function output intensity are stored in a separate CV block in CVs 257 - 512. To reach this CV block for programming, two "pointer CVs "(CV 31 and CV 32) must be set beforehand.

CV31 = 18
CV32 = 0

A variety of settings can be assigned to each function output of the SmartDecoder XP 5.1 via ten defined CVs. A list of each CV and its associated output is found in the CV table. Basically, there are two *parameter sets* (A & B), each with five CVs, that are structured according to the following scheme (the example is the front light function output F0v):

CV 257, output F0v effect A -> effect number according to the list below
CV 258, output F0v PWM A -> 1st light intensity setting (dimming)
CV 259, output F0v flags A -> additional automatic switch-off options including fade-in and -out
CV 260, output F0v parameter 1 A -> additional setting parameter if required
CV 261, output F0v parameter 2 A -> additional setting parameter if required
CV 262, output F0v effect B -> effect number according to the list below
CV 263, output F0v PWM B -> 2nd light intensity setting (dimming)
CV 264, output F0v flags B -> additional automatic switch-off options including fade-in and -out
CV 265, output F0v parameter 1 B -> additional setting parameter if required
CV 266, output F0v parameter 2 B -> additional setting parameter if required

These output parameter settings can be assigned to specific function keys by function mapping.

Effects:
The following table lists numbered effects used for programming the various function outputs. The respective effect number is required for assigning the effect to the function output and if necessary, to be programmed into the first CV of the respective parameter set. There are additional settings listed below the table, for effects shown in italics.

0: no effect	10: Mars light	30: Single flash	40: *Load-regulated smoke output*	60: Front coupler activation
1: *Flash pattern 1*	11: Gyra light	31: Multiple flashes	41: *Speed-regulated smoke output*	61: Rear coupler activation
2: *Flash pattern 2*	12: Blinking headlight	32: Switching gear/mode light	42: *Smoke permanently on*	
3: *Flash pattern 3*	13: Stepped blinking pattern	33: Random linear	50: *Servo1 configuration*	
4: *Flash pattern 4*	14: Reduced intensity	34: Fire box	51: *Servo2 configuration*	
	15: Rotating beacon	35: *Fluorescent lamp*	52: *Servo3 configuration*	80: Motor
	16: Repeating single flash	36: *Malfunctioning Fluorescent lamp*	53: *Servo4 configuration*	
	17: Repeating double flash	37: *Energy saver lamp*	54: *Servo5 configuration*	
	18: Repeating multi flash	38: TV screen	55: *Servo6 configuration*	255: Output/effect shut off

Dimming (PWM):
Light and function outputs A1 - A7 can be set to any dimming level between 0 - 64. The factory setting for each function output is 64.

Flags:

Flags are programming options that enable an output to be switched off automatically or displayed or hidden under certain conditions.

Here is an example:

Bit	Value	Bit	Value
0: Auto-off backwards	1	4: Auto-off fast	16
1: Auto-off forward	2	5: Auto-on	32
2: Auto-off STOP	4	6: Fade in	64
3: Auto-off Slow	8	7: Fade out	128

Bit 0 and/or Bit 1 must be set and Bit 2 and/or Bit 3 and/or Bit4 must be set.

The speed threshold for "Auto-Off Slow" or "Auto-Off Fast" can be set in CV 179 "Speed Threshold" from a range of 0-255.

Fade-in and fade-out times are set via CVs 177 (fade-in time) and CV 178 (fade-out time) in steps of 20 milliseconds from a range of 0 to 255.

If an output has been switched off via an "Auto-Off" configuration, then Bit 5 "Auto-On" can be used to decide whether this output should be automatically switched on again when the switch-off condition is no longer met.

Fade-in and fade-out function outputs:

When an output is switched on or off, it gradually fades-in or fades-out.

CV 177 -> fade-in time in 20 millisecond steps
CV 178 -> fade-out time in 20 millesecond steps
An output that is selected to receive the fade-in / fade-out function is set with the flags described above, in its associated parameter set.

Flash patterns for light and function outputs:

The locomotive decoder has four flash patterns that can be assigned to the outputs. The respective flash interval can be set in CVs 173 (flash pattern 1) - 176 (flash pattern 4), in 20 milli-second steps. If an output uses one of these flash patterns, the effect is assigned to the desired output using effect numbers 1 - 4.

Fluorescent lamp, defective fluorescent lamp effect:

The switch-on effect of a fluorescent lamp (multiple flashes before the light is fully turned on) or a defective fluorescent lamp (light does not illuminate consistently) can be assigned to the light or function outputs. The duration of the switch-on effect (start time) can be set in CV 172 in 100 millisecond steps. The flash interval for a defective fluorescent lamp is fixed. The

fluorescent lamp switch-on effect is assigned to an output using effect numbers 35 (normal fluorescent lamp) or 36 (defective fluorescent lamp).

Energy-efficient lamp effect:

When an energy-efficient lamp is switched on, it takes a while to reach full brightness. This effect's initial brightness level can be set in CV 170 from a range of 0 - 64. The fade-in time to maximum brightness can be set in 100 millisecond steps in CV 171.

Servo control:

Connecting a servo to the decoder requires advanced knowledge of electronics and should not be attempted by those unfamiliar with such procedures.

A maximum of six servo circuits can be connected to the SmartDecoder XP 5.1. Settings for the two stop positions and the speed of the servo movement can be set in three CVs that control the function output to which the servo is connected. A list of the CVs associated with each servo is found in the CV table. Whichever servo configuration number (1 - 6) is used for an output is entered into the parameter set of the associated output using the effect numbers 50 (servo configuration 1) - 55 (servo configuration 6).

Configuration CVs using the example of servo 1:
CV 202 -> Servo1 speed in a value range from 0 -255. The larger the value, the higher the speed.
CV 203 -> Servo1 left stop, value 128 = 1 millisecond servo pulse
CV 204 -> Servo1 right stop, value 128 = 2 millisecond servo pulse

Timer-controlled shutoffs for function outputs:

The headlight (F0v) and taillight (F0h) function outputs as well as outputs A1 - A7 can shut off automatically after an adjustable time. This adjustable time can be individually set in half-second increments from a range of 0 - 255 with the following CVs:

CV180 -> Automatic shut-off time for F0v	CV183 -> Automatic shut-off time for A2	CV186 -> Automatic shut-off time for A5
CV181 -> Automatic shut-off time for F0h	CV184 -> Automatic shut-off time for A3	CV187 -> Automatic shut-off time for A6
CV182 -> Automatic shut-off time for A1	CV185 -> Automatic shut-off time for A4	CV188 -> Automatic shut-off time for A7

The flags of a parameter set can be used to set the conditions under which the respective output should shut off automatically following an assigned time.

At least one flag connected with direction of travel and one speed flag must be set.

If an output is to switch off following a set time from when it was switched on, then all five flags must be set.

Example:

The headlight function output (F0v) should shut off after 5 seconds:

CV 180 = 10 (time for automatic shut off of F0v = 5s)
CV 31 = 18
CV 32 = 0
After the light shuts off:

CV 257 = 0 (no effect)
CV 259 = 31 (all direction and speed flags are set)

Programming lighting functions using the lighting board:
You may note that the decoder diagram on page 2 shows that none of the auxiliary function output pins on the decoder are being used in the ML4000. The lights are being controlled through a separate lighting board that communicates with the decoder through a SUSI interface on pins 3 and 4 . To change the lighting effects on your ML4000, you will need to program the CVs on the LightController, which can be done from a programming track like you would with any other decoder equipped locomotive. This is best done through a program like JMRI (Java Model Railroad Interface), the decoder profile for the ML4000 includes all CVs for the LightController. Any DCC system that can program CVs 1 – 1024 will also work. More information on the LightController is available along with a full CV chart. This is available to download on the PIKO America website on all ML4000 pages, www.piko-america.com
CAUTION: THIS IS FOR DCC EXPERTS ONLY! Do not attempt to adjust CVs without confidence in your skill with DCC programming.

SUSI (Serial User Standard Interface):

The SmartDecoder XP 5.1 Sound has a SUSI interface that controls output modules on the model's circuit board. SUSI modules are electronic modules that control multiple sound outputs at the same time, based on the model's speed or the amount of effort the locomotive is exerting based on train weight. The SUSI modules react to what information the SmartDecoder is feeding them, and they in turn, control more digital functions than would be possible using a single sound decoder. CV 47 controls what outputs the SUSI interface will be used for. Please refer to the CV table for the value to be programmed into CV 47.

CAUTION: Soldering on the decoder or the circuit board should only be carried out by experienced modelers using the appropriate tools. Decoders that have been damaged from improper handling are not covered under the warranty.

CVs 115 and 116 contain settings that determine which commands are passed on from the decoder to SUSI modules/outputs. The SmartDecoder XP 5.1 can pass on the following commands if the corresponding bits in CVs 115 and 116 are set to 1:

CV115, Bit 0 -> actual speed, Bit 1 -> setpoint speed, Bit 2 -> relative load and Bit 7 -> function group 1 (F0 - F4)

CV116, Bit 0 - Bit 7, function groups 2 - 9, also functions F5 - F68 in blocks of eight ascending per bit.

Technical specifications:

Addresses:	1-9999 (long DCC address)
Max. Motor current / total load:	1.2 A * Short-term up to 2 A
Function outputs:	0.4 Amps each
Sound resolution:	12 bit
Number of sound channels:	8
Audio sampling rate:	22.05 kHz
Output power:	2.5 watts
Size:	28.5 x 16 x 4 mm (1.1 in. x 0.6 in. by 0.2 in.)

* Continuous load, can vary depending on the installation situation

CV Tables:

The next few pages of this guide contain CV tables for the XP5.1 sound decoder installed in the ML4000. To make navigating the CV tables easier, important CVs have their rows marked with a light grey background. These highlighted CVs are for controlling the basics that most modelers would want to customize to their liking. Things like the locomotive address, speed control, and sound volume slots are common items to be adjusted. **DO NOT adjust CVs without understanding their function(s) fully first.**

CV Table for the Smart Decoder XP 5.1 Sound

CV	Description	Range	Factory Setting*
1	**Short decoder address**	1-127	3
2	**Minimum speed** (speed setting for when model starts moving at speed step 1)	0-255	0
3	**Start-up delay**	0-255	50
4	**Braking delay**	0-255	60
5	**Maximum speed** (must be greater than CV 2)	0-255	195
6	**Medium speed** (must be greater than CV 2 and less than CV 5)	0-255	135
7	**Software version** (can be updated)	-	varies
8	**Manufacturer ID,** decoder reset via CV 8 =8	-	162
12	**Operating modes** Bit 0=1 DC (analog operation, direct current) 1* Bit 2=1 DCC data format on 4* Bit 4=1 AC (analog operation, alternating current) 16* Bit 5=1 Motorola® data format on 32* Bit 6=1 mfx® data format on 64* *Please note: If all the above data formats are switched off, the decoder can only be programmed in digital mode.*	0-117	117
13	**Function key activation in analog mode** Bit 0-7 -> F1 to F8; When a Bit = 0, the function is off. When a Bit = 1, the function is on	0-255	0
14	**Function key activation in analog mode** Bit 0 - 5 -> F0v, F0r and F9 to F12; When a Bit = 0, the function is off. When a Bit = 1, the function is on	0-63	3
15	**Decoder programming lock**	0-255	1
16	**Decoder programming lock index number**	0-255	1
17 18	**Long decoder address** 17 = Higher value byte 18 = Lower value byte	128 - 9999 192 - 231 0 - 255	1000 195 232
19	**Consisting address (locomotive consisting)** A value of 0 means the consisting address (CADR) is not active. When Bit 7 = 1, the direction of travel is reversed. So, the CADR + 128 reverses the direction of travel	1-127	0
21	**Function control for a Locomotive Consist** Bits 0-7 => F1 to F8, Bit = 0 function off, Bit = 1 function on	0-255	0
22	**Function control for a Locomotive Consist** Bits 0-5 => F0v, F0r and F9 to F12, Bit = 0 function off, Bit = 1 function on	0-63	0
27	**Brake signal settings (train stops before red signal)** Bit 0 = 1 -> ABC right rail more 1* Bit 1 = 1 -> ABC left rail more 2* Bit 4 = 1 -> DC with opposite direction 16* Bit 5 = 1 -> DC with the same direction of travel 32*	0-51	0
28	**RailCom® configuration** Bit 0 = 1 -> channel 1 is on 1* Bit 1 = 1 -> channel 2 is on 2* Bit 2 = 1 -> channel 1 is automatically off 4* Bit 4 = 1 -> broadcast 16* Bit 7 = 1 -> RailCom Plus® is on 128*	0-151	151
29	**DCC standard configuration** Bit 0=0 Normal direction of travel 0* Bit 0=1 Opposite direction of travel 1* Bit 1=0 14 speed steps 0* Bit 1=1 28 speed steps 2* Bit 2=0 Digital only operation 0* Bit 2=1 Automatic analog / digital switchover 4* Bit 3=0 RailCom® switched off 0* Bit 3=1 RailCom® switched on 8* Bit 4=0 Speed steps via CV 2, 5, and 6 0* Bit 4=1 Use motor speed table from CVs 67 - 94 16* Bit 5=0 Short address (CV 1) 0* Bit 5=1 Long address (CV 17/18) 32*	0-63	14
30	**Error memory for function outputs, motor, and thermal overload protector** 1 = Motor error, 2 = Thermal overload, 4 = Function output error	0-7	0
31	**1st pointer CV for CV banks** (set to desired value before configuring CVs in relevant bank)	0, 1, 2, 4	0
32	**2nd pointer CV for CV banks** (set to desired value before configuring CVs in relevant bank)	0, 1	0
33-46	**Simple function mapping** (see “Simple Function Mapping” table for value assignment) **Assignment of function outputs to CVs** CV 33 Light function key (F0) when moving forward 1 CV 34 Light function key (F0) when moving backward 2 CV 35 Function key F1 4 CV 36 Function key F2 8 CV 37 Function key F3 16 CV 38 Function key F4 4 CV 39 Function key F5 8 CV 40 Function key F6 16 CV 41 Function key F7 32 CV 42 Function key F8 64 CV 43 Function key F9 16 CV 44 Function key F10 32 CV 45 Function key F11 64 CV 46 Function key F12 128	0-255	

CV	Description	Range	Factory Setting*
47	**Special function assignment** Bit 0=0 SUSI = Logic1 and Logic2 0* Bit 0=1 SUSI = SUSI 1* Bit 1=0 When Bit 0 = 0, then SUSI = Logic1 and Logic2 0* Bit 1=1 When Bit 0 = 1, then SUSI = Servo1 and Servo2 2* Bit 2=1 A4 for digital coupler 4* Bit 3=1 A5 for digital coupler 8* Bit 4=1 Digital coupler outputs A4 and A5 are reversed 16* Bit 5=1 Use wheel sensor 32*	0-63	1
48	**ABC braking voltage difference** The voltage difference between both rails of an ABC braking track has an approximate CV value of * 0,1V + 1,6V	0-255	0
49	**ABC braking track: special configurations** Bit 0 = 1 -> ABC-reduced speed section; right rail more positive 1* Bit 1 = 1 -> ABC-reduced speed section; left rail more positive 2* Bit 2 = 1 -> Reduced train speed in dedicated slow speed zone (like a shuttle route) 4* Bit 3 = 1 -> ABC-shuttle train operation on 8* Bit 4 = 1 -> ABV1 in ABC-braking track 16* Bit 5 = 1 -> ABV2 in ABC-braking track 32*	0-63	0
50	**ABC braking track; maximum slow speed**	0-255	50
51	**ABC Stop time when changing direction in shuttle operation** Value * 100 milliseconds	0-255	30
52	**General stop time when changing direction** Value * 100 milliseconds	0-255	50
53	**Initial "soft" start and braking ramp** (takes effect before Start-up delay or after Braking delay)	0-255	255
54	**Load detection threshold** (Sensitivity of the load detector for sound and smoke unit outputs)	0-255	128
55	**Zero load hysteresis** (lag time from when decoder detects no load until it plays the correct sounds)	0-255	5
56	**Load gradient** (factor for load detection)	0-255	112
58	**Peak operational load**	0-255	50
61	**Motorola configuration** (number of additional Motorola addresses for F5 - F16)	0-3	0
62	**Throttle configuration for motor control** Bit 0=1 for lower quality motors / bell armature motors 1* Bit 2=1 for lower quality motors without a flywheel 4* Bit 3=1 min./max. adaptive 8*	0-15	2
63	**Overall sound volume** for mfx® command stations (auxiliary CV)	0-255	255
66	**Forward speed trim**	0-255	128
67-94	**Extended speed step characteristic for speed steps 1 - 28**	each 0-255	varies
95	**Reverse speed trim**	0-255	128
96	**Type of function mapping** 1 = simple function mapping, 6 = extended function mapping	1, 6	6
97	**Function outputs „Off" in forward direction** (simple function mapping) Bit 0-7 -> A1 to A8; Bit = 1 output off	0-255	0
98	**Function outputs „Off" in reverse direction (**simple function mapping) Bit 0-7 -> A1 to A8; Bit = 1 output off	0-255	0
101	**Hysteresis analog operation** 100 corresponds to a 1V voltage change for internal speed step changes	0-255	100
102	**Analog voltage threshold for Sound operation** values * 100mV	0-255	10
103	**Analog voltage threshold for motor operation** values * 100mV	0-255	10
104	**Analog voltage for maximum speed** values * 100mV	0-255	150
115	**SUSI send option 1** Bit 0=1 Send actual speed via SUSI 1* Bit 1=1 Send setpoint speed via SUSI 2* Bit 2=1 Send relative load via SUSI 4* Bit 7=1 Send function group 1 (F0 - F4) via SUSI 128*	0-135	135
116	**SUSI send option 2** Bit 0-7 -> function groups 2 - 9 (F5 - F68) in groups of eight ascending functions	0-255	0
120	**SUSI clock rate** values * 1µs + 10µs	0-255	0
130	**Activation period for digital couplers in A4 & A5**, value * 100 milliseconds (if activated in CV47)	0-255	30
131	**Switching (shunting) scenario speed level** (0 = no coupler activation)	0-255	0
132	**Switching (shunting) scenario forward travel time T1** (coupler is free) value * 100 milliseconds	0-255	15
133	**Switching (shunting) scenario forward travel time T2 with coupler activation** value * 100 milliseconds	0-255	40
134	**Switching (shunting) scenario reverse travel time T2 when uncoupling** value * 100 milliseconds	0-255	30
135	**PWM hold time for digital couplers A4 & A5**	0-255	0
140	**Constant braking distance in cm**, A reduced speed value of 255 corresponds to approximately 11% of the maximum possible highest speed	0-255	128
141	**Constant braking distance in cm**, braking distance in cm	0-255	30
142	**Constant braking distance in cm**, function key for test function (0 = off)	0-68	0
143	**Constant braking distance in cm**, calibration for high speed	0-255	100
144	**Constant braking distance in cm**, calibration for low speed	0-255	10
145	**Constant braking distance in cm**, activation by (0 = off): Bit 0 = 1 -> ABC braking 1* Bit 1 = 1 -> DC analog braking 2* Bit 2 = 1 -> DCC brake signal (broadcast) 4* Bit 3 = 1 -> Targeted speed level = 0 (DCC address) 8*	0-63	0
147	**Alternative maximum forward speed**	0-255	0
148	**Alternative maximum reverse speed**	0-255	0
149	**Function key alternative maximum speed** (255 = off)	0-68, 255	255
150	**Alternative acceleration delay 1** (as a replacement for CV 3)	0-255	50
151	**Alternative braking delay 1**, (as a replacement for CV 4)	0-255	50
152	**Alternative acceleration delay 2** (as a replacement for CV 3)	0-255	80

CV	Description		Range	Factory Setting*
153	**Alternative braking delay 2**, (as a replacement for CV 4)		0-255	80
154	**Function key number for ABV 1** (255=aus)		0-68	255
155	**Function key number for ABV 2** (255=aus)		0-68	255
156	**Deactivate function key number for ABV** (255=off)		0-68	255
157	**Function key number for switching (shunting) mode** (255=off)		0-127	255
160	**Chuff rate calibration per wheel revolutions** (Sound)		0-255	160
162	**Engine RPM sound change calibration per locomotive speed** (good for diesels, electrics, and cab cars)		0-255	0
163	**Number of cylinders of a steam locomotive** (used to determine chuffs for either 2- or 3-cylinder steam locomotives)		0-255	0
170	**Energy-efficient lamp;** starting brightness		0-255	30
171	**Energy-efficient lamp** fade-in time in 100ms		0-255	100
172	**Fluorescent lamp** switch-on time *activation in 100ms		0-255	20
173	**Flash generator 1** flash interval value * 20ms		0-255	50
174	**Flash generator 2** flash interval value * 20ms		0-255	100
175	**Flash generator 3** flash interval value * 20ms		0-255	150
176	**Flash generator 4** flash interval value * 20ms		0-255	200
177	**Fade-in for function outputs** fade-in time in * 20ms		0-255	30
178	**Fade-out for function outputs** fade-out time in * 20ms		0-255	30
179	**Speed threshold for automatic switch-off of function outputs**		0-255	50
180	**Time period for automatic shut-off of F0v** value * 500ms		0-255	6
181	**Time period for automatic shut-off of F0r** value * 500ms		0-255	6
182	**Time period for automatic shut-off of A1** value * 500ms		0-63	6
183	**Time period for automatic shut-off of A2** value * 500ms		0-255	6
184	**Time period for automatic shut-off of A3** value * 500ms		0-255	6
185	**Time period for automatic shut-off of A4** value * 500ms		0-255	6
186	**Time period for automatic shut-off of A5** value * 500ms		0-255	6
187	**Time period for automatic shut-off of A6** value * 500ms		0-255	6
188	**Time period for automatic shut-off of A7** value * 500ms		0-255	6
202	**Servo 1 speed**		0-255	20
203	**Servo 1 adjustment for position 1**		0-255	128
204	**Servo 1 adjustment for position 2**		0-255	128
208	**Servo 2 speed**		0-255	20
209	**Servo 2 adjustment for position 1**		0-255	128
210	**Servo 2 adjustment for position 2**		0-255	128
214	**Servo 3 speed**		0-255	20
215	**Servo 3 adjustment for position 1**		0-255	128
216	**Servo 3 adjustment for position 2**		0-255	128
220	**Servo 4 speed**		0-255	20
221	**Servo 4 adjustment for position 1**		0-255	128
222	**Servo 4 adjustment for position 2**		0-255	128
226	**Servo 5 speed**		0-255	20
227	**Servo 5 adjustment for position 1**		0-255	128
228	**Servo 5 adjustment for position 2**		0-255	128
232	**Servo 6 speed**		0-255	20
233	**Servo 6 adjustment for position 1**		0-255	128
234	**Servo 6 adjustment for position 2**		0-255	128
240	**Measurement gap CV** (measurement of BEMF motor offset)		0-32	12
241	**Control factor digital / DC** Increasing proportionally Limit digital / DC		0-255	160
242	**Control factor digital / DC** Increasing proportionally Limit AC analog		0-255	2
243	**Minimum control package width,** offset throttle, control		0-50	12
244	**Control factor digital / DC** proportionally decreasing Limit digital / DC		0-255	200
245	**Control factor digital / DC** DC decreasing proportionally Limit AC analog		0-255	128
250	**Compatibility with various DCC systems** Bit0 = 1 Functions are retained if no more data can be recognized Bit1 = 1 STOPP only 28 speed steps Bit2 = 1 Only accept 1x prog. command (e.g. Intellibox1) Bit3 = 1 Functions on with RESET Bit5 = 1 Linear conversion between DCC28 and DCC128	1* 2* 4* 8* 32*	0-47	35

* factory set values

CV Table for programming function output effects (CV31 = 18, CV32 = 0, Bank 1024)

CV	Description	Range	Factory Setting*
257	Output F0v Effect A	0 - 255	0
258	Output F0v PWM A	0 - 64	64
259	Output F0v Flags A	0 - 255	0
260	Output F0v Parameter 1 A	0 - 255	0
261	Output F0v Parameter 2 A	0 - 255	0
262	Output F0v Effect B	0 - 255	0
263	Output F0v PWM B	0 - 64	10
264	Output F0v Flags B	0 - 255	0
265	Output F0v Parameter 1 B	0 - 255	0
266	Output F0v Parameter 2 B	0 - 255	0
267	Output F0h Effect A	0 - 255	0
268	Output F0h PWM A	0 - 64	64
269	Output F0h Flags A	0 - 255	0
270	Output F0h Parameter 1 A	0 - 255	0
271	Output F0h Parameter 2 A	0 - 255	0
272	Output F0h Effect B	0 - 255	0
273	Output F0h PWM B	0 - 64	10
274	Output F0h Flags B	0 - 255	0
275	Output F0h Parameter 1 B	0 - 255	0
276	Output F0h Parameter 2 B	0 - 255	0
277	Output A1 Effect A	0 - 255	0
278	Output A1 PWM A	0 - 64	64
279	Output A1 Flags A	0 - 255	0
280	Output A1 Parameter 1 A	0 - 255	0
281	Output A1 Parameter 2 A	0 - 255	0
282	Output A1 Effect B	0 - 255	0
283	Output A1 PWM B	0 - 64	10
284	Output A1 Flags B	0 - 255	0
285	Output A1 Parameter 1 B	0 - 255	0
286	Output A1 Parameter 2 B	0 - 255	0
287	Output A2 Effect A	0 - 255	0
288	Output A2 PWM A	0 - 64	64
289	Output A2 Flags A	0 - 255	0
290	Output A2 Parameter 1 A	0 - 255	0
291	Output A2 Parameter 2 A	0 - 255	0
292	Output A2 Effect B	0 - 255	0
293	Output A2 PWM B	0 - 64	10
294	Output A2 Flags B	0 - 255	0
295	Output A2 Parameter 1 B	0 - 255	0
296	Output A2 Parameter 2 B	0 - 255	0
297	Output A3 Effect A	0 - 255	0
298	Output A3 PWM A	0 - 64	64
299	Output A3 Flags A	0 - 255	0
300	Output A3 Parameter 1 A	0 - 255	0
301	Output A3 Parameter 2 A	0 - 255	0
302	Output A3 Effect B	0 - 255	0
303	Output A3 PWM B	0 - 64	10
304	Output A3 Flags B	0 - 255	0
305	Output A3 Parameter 1 B	0 - 255	0
306	Output A3 Parameter 2 B	0 - 255	0
307	Output A4 Effect A	0 - 255	0
308	Output A4 PWM A	0 - 64	64
309	Output A4 Flags A	0 - 255	0
310	Output A4 Parameter 1 A	0 - 255	0
311	Output A4 Parameter 2 A	0 - 255	0
312	Output A4 Effect B	0 - 255	0
313	Output A4 PWM B	0 - 64	10
314	Output A4 Flags B	0 - 255	0
315	Output A4 Parameter 1 B	0 - 255	0
316	Output A4 Parameter 2 B	0 - 255	0
317	Output A5 Effect A	0 - 255	80
318	Output A5 PWM A	0 - 64	14
319	Output A5 Flags A	0 - 255	128
320	Output A5 Parameter 1 A	0 - 255	255
321	Output A5 Parameter 2 A	0 - 255	45
322	Output A5 Effect B	0 - 255	0
323	Output A5 PWM B	0 - 64	10
324	Output A5 Flags B	0 - 255	0
325	Output A5 Parameter 1 B	0 - 255	0
326	Output A5 Parameter 2 B	0 - 255	0

CV	Description	Range	Factory Setting*
327	Output A6 Effect A	0 - 255	80
328	Output A6 PWM A	0 - 64	14
329	Output A6 Flags A	0 - 255	128
330	Output A6 Parameter 1 A	0 - 255	255
331	Output A6 Parameter 2 A	0 - 255	45
332	Output A6 Effect B	0 - 255	0
333	Output A6 PWM B	0 - 64	10
334	Output A6 Flags B	0 - 255	0
335	Output A6 Parameter 1 B	0 - 255	0
336	Output A6 Parameter 2 B	0 - 255	0
337	Output A7 Effect A	0 - 255	0
338	Output A7 PWM A	0 - 64	64
339	Output A7 Flags A	0 - 255	0
340	Output A7 Parameter 1 A	0 - 255	0
341	Output A7 Parameter 2 A	0 - 255	0
342	Output A7 Effect B	0 - 255	0
343	Output A7 PWM B	0 - 64	10
344	Output A7 Flags B	0 - 255	0
345	Output A7 Parameter 1 B	0 - 255	0
346	Output A7 Parameter 2 B	0 - 255	0

CV Table for programming sound settings (CV31 = 16, CV32 = 0, Bank 512)

CV	Description	Range	Factory Setting*
257	Overall volume	0 - 255	200
258	Volume tunnel mode	0 - 255	0
259	Volume control level 3	0 - 255	196
260	Volume control level 2	0 - 255	128
261	Volume control level 1	0 - 255	64
270	**Sound Option1** (switching sound flags on/off) Bit0 = 1 Drive-Stop Bit1 = 1 Drive-Slow Bit2 = 1 Drive-Hold Bit3 = 1 Drive-Lock Bit4 = 1 Coupler sound activates digital coupler Bit5 = 1 Drive-Lock switched off in analog mode	0-63	15
273	**Flange squeal** Speed threshold above which activates flange squeal	0 - 255	10
274	**Brake squeal** Speed threshold below which activates brake squeal	0 - 255	30
289	Volume Sound Slot 1 **Prime Movers**	0 - 255	180
290	Volume Sound Slot 2 **Horn**	0 - 255	200
291	Volume Sound Slot 3 **Bell**	0 - 255	60
292	Volume Sound Slot 4 **Sander Valve**	0 - 255	30
293	Volume Sound Slot 5 **Cab Chatter #1**	0 - 255	30
294	Volume Sound Slot 6 **-**	0 - 255	200
295	Volume Sound Slot 7 **Short Horn**	0 - 255	200
296	Volume Sound Slot 8 **Curve Squeal**	0 - 255	50
297	Volume Sound Slot 9 **-**	0 - 255	100
298	Volume Sound Slot 10 **Coupler**	0 - 255	60
299	Volume Sound Slot 11 G**rade Crossing Horn**	0 - 255	200
300	Volume Sound Slot 12 **-**	0 - 255	200
301	Volume Sound Slot 13 **-**	0 - 255	200
302	Volume Sound Slot 14 **Brake Squeal**	0 - 255	50
303	Volume Sound Slot 15 **-**	0 - 255	200
304	Volume Sound Slot 16 **Air Compressor**	0 - 255	30
305	Volume Sound Slot 17 **Radiator Fan**	0 - 255	40
306	Volume Sound Slot 18 **Air Release**	0 - 255	200
307	Volume Sound Slot 19 **-**	0 - 255	200
308	Volume Sound Slot 20 **Cab Chatter #2**	0 - 255	30
310	Volume Sound Slot 22 **Dynamic brake**	0 - 255	150
311	Volume Sound Slot 23 **Direction turner**	0 - 255	100
312	Volume Sound Slot 24 **Double horn**	0 - 255	255

* factory set values

Function key assignment

F0	Headlights	F10	Dual White Gyralite	F20	Radiator Fan
F1	Bell	F11	Red Gyralite	F21	Sander Valve
F2	Horn - Playable	F12	-	F22	Cab Chatter #1
F3	Short Horn	F13	Cab Interior Light	F23	Cab Chatter #2
F4	Dynamic Brake Sound	F14	Engine Room Light	F24	Air Compressor
F5	Manual Notch Up	F15**	Multiple Unit Consist Lighting	F25	Control Stand Light
F6	Manual Notch Down	F16	Volume Stepper - 4 Steps	F26	Grade Crossing Horn
F7	Headlight Dimmer	F17	Couple/Uncouple	F27	-
F8**	Motor Sounds	F18	Brake Squeal/Release	F28	Switching Mode/Half Speed
F9**	Number Boards & Marker Lights	F19	Flange Squeal		

**Note: This sound decoder features several “multi-step“ functions. Each successive press of the button activates a different condition of that function, as noted below:

F8 Motor Sounds

1x 1 Motor
2x 2 Motors
3x Motors off
4x Sound off

F9 Number Boards & Marker Lights

1x Loco ID boards on in forward mode
2x Loco IDs and white classification on in forward mode 3x Loco IDs and green classification on in forward mode 4x red classification on in reverse mode
5x reset F9 sequencer to 0

F15 Multiple Unit Consist Lighting

1x all front lights off
2x all rear lights off
3x both sides off
4x reset F15 sequencer to 0; all lights on

NOTE: This product is not a toy and is not meant for children under 14 years of age. PIKO is not liable for any damage caused by improper handling and/or failure to follow these instructions.

Service:

If you have any questions, please contact us through the internet or e-mail
Internet: piko-america.com
E-mail: support@piko-america.com

In the unlikely event you should find your model defective, please send us the model along with a proof of purchase, a short note describing the problem, and the model’s decoder address.

Warranty Statement

Every PIKO model is tested for functionality and reliability before leaving the factory. This model is covered under warranty for two years. Should your model need service after the warranty period has expired, we may repair the model free of charge on submission of proof of purchase.
This warranty does not cover damage caused by improper handling. Please note that according to the German EMC (electromagnetic interference) law, this decoder can only be installed in models bearing the CE mark.

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