



## Multi-protocol Decoder 76 500 and 76 520

For locomotives with direct current motors for digital operation DCC- and Motorola-data formats. The 76 520 decoder differs from the 76 500 **only** by the fact that it features an 8-pole NEM connector. All other hardware and software features of both decoders are identical.

In the rest of this manual, we'll only mention the 76 500 decoder – meaning both decoders: 76 500 and 76 520.



### Features of the 76 500

- Regulated multi-protocol decoder for DCC and Motorola formats
- Suitable for direct current and coreless motors up to 1A
- Smooth engine control due to a 18.75 kHz PWM frequency
- 14, 27, 28 and 128 speed steps of available, depending upon data format.
- Supports both short (1-127) and long (128-9999) addressing schemes
- Conforms to NMRA specifications
- Minimum, maximum and medium speeds adjustable
- Speed table for 14 and 28 speed step modes
- Main track programming ("operations mode programming") in DCC mode
- Half-speed (switching speed) activated via F3
- Acceleration/deceleration can be enabled/disabled via F4
- Direction dependent lighting and dimming controllable via F0
- 2 additional function outputs available A1 and A2 (controllable through two functions)
- SUSI interface (mini socket) for the connection of sound modules or other modules for the control of adjustable auxiliary functions (f1 to f12)
- Reacts to a DCC brake signal (e.g. Power 3) or to brake sections with DC voltage
- Protected from overheating
- All outputs protected against short-circuits
- Automatic detection of DC or AC current systems (analog operation)
- All CV's can be programmed with Command Stations using either DCC or Motorola formats
- Supports register, CV direct and Paged programming modes (DCC)
- Updateable Flash Memory

### Description

The locomotive decoder 76 500 is a small, efficient multi-purpose decoder. It can be used in DCC and Motorola digital systems and can operate likewise in analog mode with DC voltage or with AC voltage (direction of travel change-over by over-voltage pulse - e.g., Märklin system).

The decoder operates on a frequency of 18.75 kHz (PWM – Pulse Width Modulation) and is therefore not only suitable for direct current motors, but also for "coreless" engines (e.g. Faulhaber, Maxon, Escap) up to a continuous power input of 1A. Short periods of higher current draw can be tolerated.

The regulation of the driving characteristics of the engine is made either by means of the minimum, middle and maximum speed settings (CV's #2, #6 and #5) or, in table mode (CV #29, bit #4=1), through the CV's which regulate each individual speed step. The cruise-control (back EMF, also known as "speed control") regulation can be individually adapted to each type of locomotive engine via control parameters stored in CV's.

The decoder has two direction dependent lighting functions controlled via the f1 and f2 function keys. The f3 and f4 function keys can be used to trigger a low-speed operating range (F3 = on) and turn on/off the locomotive's acceleration/deceleration features (F4 = on). The function outputs - such as lighting, A1 and A2 outputs, low-speed range and adjustable acceleration/deceleration delay - can be assigned to the desired function keys of the digital Command Station or throttle via function mapping.

The decoder is programmable using the Intellibox, all major DCC Command Stations and Märklin controllers. All CV's are accessible, regardless of the programming device used.

Right out of the box, the decoder automatically recognizes DCC and Motorola digital data formats, as well as analog operation and AC or DC voltage. However, the desired mode of operation can, if desired, also be explicitly specified manually.

**Configuration Variable(CV) Table**

<b>CV</b>	<b>Description</b>	<b>Possible Values</b>	<b>Factory Default</b>	
1	Locomotive address	DCC 1-227 Motorola 1-80	3	
2	Minimum speed	1-63	1	
3	Acceleration factor	1-63	2	
4	Deceleration factor	1-63	2	
5	Maximum speed (must be greater than CV 2)	1-63	48	
6	Middle speed (must be greater than CV 2 and less than CV 5)	1-63	24	
7	Software version (read only)	-	3	
8	Manufacturer's Id (read only)	-	85	
17	Long address (CV 17 = high byte, CV 18 = low byte)	1-9999	2000	
18	Long address = (CV 17 – 192) * 256 + CV 18	192-231 / 0-255	199 / 208	
19	Consist address 0 = Consist address is inactive Setting bit 7 (e.g., adding 128 to the address) reverses direction	1-127	0	
29	DCC Configuration Bit 0 = 0 Normal driving direction Bit 0 = 1 Reverse driving direction Bit 1 = 0 14 Speed step operation Bit 1 = 1 28 Speed step operation Bit 2 = 0 Only for digital operation Bit 2 = 1 Auto-detect digital / analog operation Bit 3 Not used Bit 4 = 0 Speeds controlled by CV's 2, 5 and 6 Bit 4 = 1 Speeds controlled by CV's 67 - 94 Bit 5 = 0 Use short address specified in CV 1 Bit 5 = 1 Use long address specified in CV's 17/18 Bit 6/7 Not used	Value 0* 1 0 2* 0 4* - 0* 16 0* 32 -	0-255	6
33	Function mapping for directional-dependent lighting function (F0) when moving forward Bit 0 Forward lights Bit 1 Rear lights Bit 2 Special function A1 Bit 3 Special function A2 Bit 4 Half-speed (switching speed) operation Bit 5 Acceleration / deceleration	Value 1* 2 4 8 16 32	0-63	1
34	Function mapping for directional-dependent lighting function (F0) when moving backward. Bit values follow the same format as CV 33		0-63	2
35	Function mapping for function (F1) Bit values follow the same format as CV 33		0-63	4
36	Function mapping for function (F2) Bit values follow the same format as CV 33		0-63	8
37	Function mapping for function (F3) Bit values follow the same format as CV 33		0-63	16
38	Function mapping for function (F4) Bit values follow the same format as CV 33		0-63	32
39	Function mapping for function (F5) Bit values follow the same format as CV 33		0-63	0
40	Function mapping for function (F6) Bit values follow the same format as CV 33		0-63	0
49	Decoder Configuration Bit 0 = 0 Speed regulation on Bit 0 = 1 Speed regulation off Bit 1 Not used Bit 2 = 0 decelerates to Stop in brake sections Bit 2 = 1 decelerates to speed = CV #52 Bit 3 = 0 Data format DCC and Motorola Bit 3 = 1 Data format DCC only Bit 4 = 0 Data format DCC and Motorola Bit 4 = 1 Data format Motorola only Bit 5 = 0 No dimming on A1 and A2 outputs Bit 5 = 1 Dimming on A1 and A2 is enabled	Value 0* 1 - 0* 4 0* 8 0* 16 0* 32	0-255	32

<b>CV</b>	<b>Description</b>	<b>Possible Values</b>	<b>Factory Default</b>
49 cont'd.	Bit 6 = 0    Do not invert forward/rear light outputs Bit 6 = 1    Invert forward/rear light outputs Bit 7 = 0    Brake only if brake signal Bit 7 = 1    Brake with DC voltage	0* 64 0* 128	
	<i>Warning: If bits 3 and 4 are set to disable both DCC and Motorola, then the decoder does not react to any driving command: it can only be programmed.</i>		
50	Dimming factor for directional lights and for outputs A1 and A2	0-63	32
51	Configuration of analog mode: 1 = only AC operation, 2 = only DC operation 3 = both AC and DC operation (automatically detected)	1-3	3
52	Speed at the end of a braking section (active only if CV #49 Bit #2=1 and Bit #7=1)	0-255	30
53	Frequency of the motor regulation (CV #49 Bit #0 = 1) = = (value of CV #53) * 53 us. TIP: should the locomotive not operate smoothly, you can try and improve it by changing this CV. We suggest trying values from 60 to 255.	0-255	200
54	Motor regulation factor: set higher motor voltage	0-255	2
55	Motor regulation factor: set lower motor voltage	0-255	1
56	A/D converter correction factor (do not change!)	0-255	0
57	Not used	-	-
58	Time interval for the A/D measurement	0-255	25
59	If this CV is programmed to the value 1, then all CV's of the decoder are reset to their original factory settings	0, 1	0
60	Short detection (do not change!). 0=Off, 250=On	0-250	250
61	Maximum temperature (90 °C) 0 = temperature monitoring is turned off	0-255	Varies by decoder
62	Not used	-	-
65	Offset Register for CV programming with a Motorola controller	0-255	
66	Page Register for CV programming with a Motorola controller	0-255	
67	Speed step 1	0-255	5
68	Speed step 2	0-255	7
69	Speed step 3	0-255	10
70	Speed step 4	0-255	12
71	Speed step 5	0-255	15
72	Speed step 6	0-255	32
73	Speed step 7	0-255	20
74	Speed step 8	0-255	22
75	Speed step 9	0-255	25
76	Speed step 10	0-255	27
77	Speed step 11	0-255	30
78	Speed step 12	0-255	32
79	Speed step 13	0-255	35
80	Speed step 14	0-255	37
81	Speed step 15	0-255	42
82	Speed step 16	0-255	50
83	Speed step 17	0-255	55
84	Speed step 18	0-255	60
85	Speed step 19	0-255	65
86	Speed step 20	0-255	70
87	Speed step 21	0-255	75
88	Speed step 22	0-255	80
89	Speed step 23	0-255	85
90	Speed step 24	0-255	90
91	Speed step 25	0-255	95
92	Speed step 26	0-255	100
93	Speed step 27	0-255	105
94	Speed step 28	0-255	110

Defaults (factory setting values) are indicated by \*

## Installation of the locomotive decoder 76 500

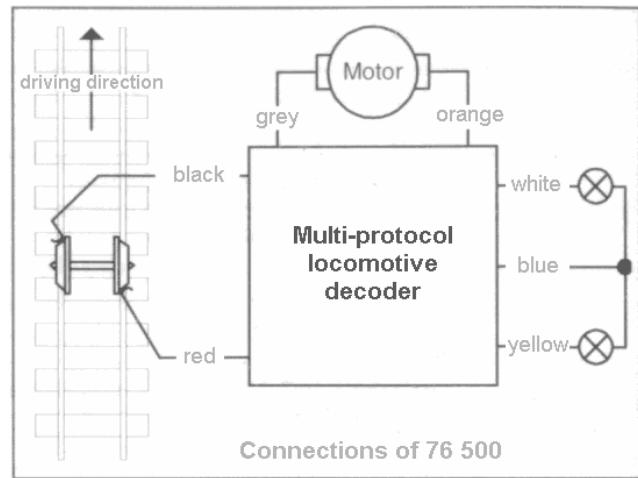
### Connecting the motor

Completely isolate the motor from the rails – this is very important! For 2-rail locomotives, connect the red and black wires, respectively to the right and left electric pickups of the locomotive. For 3-rail locomotives, connect the red wire to the slider and the black wire to a suitable ground (chassis) connection.

For 2-rail locomotives, connect the orange wire to the motor contact which, prior to motor isolation, was connected to the pickup where you now connected the red wire. Connect the grey wire to the other motor contact. For 3-rail locomotives, connect the orange and grey wires to either side of the motor shield (brush plate).

Test whether the locomotive now moves in the correct direction (forward/backward – as indicated on the throttle). If necessary, then you'll have to swap the orange and grey wires.

**Important:** do not remove any noise-suppression device (component) which may be connected to the motor.



### Connecting the directional lights

Connect the white wire to the front light and the yellow wire to the rear light. The ground side of these lamps can be connected to either the blue wire or, with half brightness, to the black or red wire. Please note that this is only possible for lamps (bulbs) with two connections. Bulbs that are connected to the chassis ground (due to the design of the bulb holder) should NOT be connected to any wire other than the white / yellow (hot) wires.

## Installation of the locomotive decoder 76 520

### Connecting the decoder

Remove the cover of the locomotive and, if equipped with a NEM socket, insert the interface plug of the decoder into the free socket (after having removed any eventual "dummy plug" which may be present for analog operation of the locomotive).

If the directional dependent lighting should light up inverted (forward/reverse), then you must rotate the plug by 180 degrees.

Note: If the driving direction of the locomotive does not agree with the display of your digital controller, then you can turn around (invert) the driving direction via CV 29 bit 0.

### Mapping of NEM 652 Connector

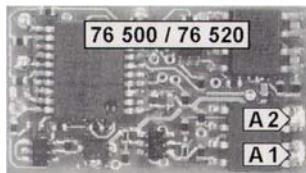
1	●	●	8
2	●	●	7
3	●	●	6
4	●	●	5

1. Motor operation (orange)
2. Lights rear (yellow)
3. Auxiliary lighting (green)
4. Current supply left or ground (black)
5. Motor operation (gray)
- 6..Lights forward (white)
7. Floating / isolated ground (blue)
8. Current supply right / pickup shoe (red)

### Connection of special functions of 76 500 and 76 520

In addition to lights, additional devices (for example, a smoke generator) can be attached to the light circuits. For direction of travel-dependent switching, the two wires (white and yellow) can be connected together.

**Note:** If the driving direction of the locomotive does not agree with the display of your digital controller, you can turn around (invert) the driving direction via CV 29 bit 0. If only the lights are inverted (but not the driving direction), you can swap only the lights by acting on Bit #6 of CV #49.



Additional special functions such as a smoke generator, Telex uncouplers or interior compartment lighting can be attached to special function circuits A1 and A2. The "hot" side of the device should be soldered directly to the decoder plate. The return (ground) is connected either with the blue cable of the decoder or to the locomotive chassis (which normally is connected to one of the two locomotive electric pickups – i.e., to either the black or the red wire).

### Attachment of the decoder in the vehicle

Use the included "sticky pad" to fasten the decoder to any place in the locomotive. The sticky pad protects the decoder against contacting other connections and holds it firmly in place.

### Start-up

Examine the correct installation with a continuity tester or ohmmeter. Make sure that the placement of the decoder in the vehicle will not touch or interfere with any connections! Also make sure that replacing the cover of the locomotive will not cause any wires to get pinched or contact other circuits.

**A short-circuit within the engine, lighting, pickup shoe or wheel sets can possibly destroy the decoder as well as the locomotive's electronics!**

### Digital and analog operation

The decoder can be operated on DCC or Motorola digital layouts. For DCC operation, the default is set to 28 speed steps. If the decoder is used on a conventional (analog) layout, then it can be controlled either with direct current driving equipment or with an AC transformer (Märklin). All modes of operation are recognized automatically by the decoder.

## Programming

The Configuration Variables (CV's) form the basis for controlling and selecting all possible features and functions of the decoder in accordance with the DCC standard. The decoder can be programmed with the Intellibox, DCC Command Stations and Märklin Central Units.

### Programming with the Intellibox

We recommend that, regardless of the format in which the decoder will be ultimately operated, the decoder should be programmed using the programming menu for DCC decoders.

The Intellibox supports the programming of DCC decoders with an easy-to-use input menu. Long addresses do not have to be calculated – they can be entered directly. The Intellibox calculates automatically the values for CV 17 and CV 18. For the exact method to program CV's, please refer to the appropriate chapter in the Intellibox manual.

### Programming with DCC Command Stations

Use the programming menu of your DCC Command Station (or throttle) to select and program decoder CV's by register, direct or Page Programming mode. Some Command Stations/throttles also support the so called "main track programming" (also known as "operations mode programming"). Please refer to the operating manual of your device for specific instructions.

#### Programming long addresses without a menu

If your programming device does not support programming via an input menu, the values for CV 17 and CV 18 must be calculated. Here is an example for the programming the long address 2000:

- Divide the address value by 256:  $2000 / 256 = 7$ , with a remainder of 208.
- Take the integer result (7) and add this to 192.
- The result (199) is the value to be programmed into CV 17.
- The remainder (208) is the value to be programmed into CV 18.
- *Important:* You must remember to set bit 5 in CV 29 to 1 in order for the decoder to use this long address.

Bit	Function in CV 29	Value
0	Normal driving direction Reverse driving direction	0 1
1	14 Speed step operation 28 Speed step operation	0 2
2	Digital operation only (no analog) Auto-detect digital/analog operation	0 4
4	Speeds controlled by CV's 2, 5 and 6 Speeds controlled by CV's 67-94	0 16
5	Short address (CV1) Long address (CV's 17 & 18)	0 32

#### Procedure for configuration variable calculation

CV's 29 and 49 define various operating characteristics of the decoder, where each parameter is identified by a "bit" value. The value which is ultimately entered into the CV is calculated by adding all appropriate "bit" values.

##### Example:

Normal driving direction	value = 0
28 drive positions	value = 2
Auto-detect digital / analog operation	value = 4
Speed curve defined by CV's 2, 5, 6	value = 0
Use short address	value = 0

The sum of all values is 6. This is the preset (default) value set by the factory in CV 29.

### Programming with a Märklin Central Unit

All CV's can be programmed with a Märklin Central Unit, although they cannot be read back.

1. Turn the Central Unit off, and then on.
2. Enter the decoder address and then turn its light "on" (normally by pressing the [function] key).
3. Turn the control knob all the way to the left (direction change position) and hold it there for approx. 10 sec., until the locomotive light turns off.
4. Release the control knob (set it to the speed zero position). The rear light will now flash slowly 4 times.
5. Enter the number of the CV to be programmed (as if you were entering a locomotive address).
6. Turn the control knob all the way to the left (reverse) briefly. Now the rear light will flash 4 times quickly.
7. Enter the desired value for CV.
8. Turn the control knob all the way to the left (reverse) briefly. Now the rear light will flash 4 times slowly. If additional CV's are to be programmed, repeat steps 5-8. To stop programming, press "STOP" on the Central Unit or enter "80" as the CV number and turn the control knob all the way to the left (reverse) briefly.

Since programming with a Märklin Central Unit only allows input values of 01 to 80, the value "0" must be entered as the value of "80".

### Page-Register mode for writing to CV's with a number higher than 79

CV addresses higher than 79 can be programmed only with the help of the PAGE register. This PAGE register is CV 66. When you enter a value (greater than zero) into CV 66, subsequent programming will add 64 to the contents of any entered value. The entered value must lie in the range 1 to 64.

##### Example

You would like to program CV 82 with the value of 15. First, CV 66 must be programmed with the value 1. Next, program CV 18 with a value of 15. This will have the effect of entering the value 15 in CV 82, since the value of 1 (the contents of CV 66) will be multiplied by 64 (and  $1 \times 64 = 64$ , and  $64 + 18 = 82$ ). Finally, CV 66 should be programmed (reset) to zero, so that additional programming will affect the intended CV's.

### **Offset register for writing CV values larger than 79**

Values greater than 79 can be programmed only with help of the offset register. This offset register is CV 65. If one writes a value greater than 0 into CV 65, then all subsequent writes (excluding those to CV 65!) shall add the value of CV 65, multiplied by 4, to any value written to a CV.

**Example** CV 49 is to be programmed with the value the 157. This requires that we first program CV 65 with the value 25. Then we can program CV 49 with the value the 57. This will have the value  $4 * 25 + 57 = 157$  written to CV 49. After having done this, CV 65 should be set again to zero, so that future writes to other CV's do not get "offset".

**Note:** Any write to either CV 65 or CV 66 does **NOT** take into account the values written in either of these CV's.

### **Märklin brake section**

The decoder reacts to Märklin brake sections (brake with a DC voltage applied to the tracks), if CV 29 bits 2 and CV 49 bits 7 to 1 are set (factory setting 1 and 0).

### **Technical data**

Addresses: 1-9999 (supports both short and long DCC addresses)

Max. current draw: 1 A

Function outputs: 1 A each

Total current draw: 1 A

Size: 22 x 12.5 x 5.5 mm

The decoder is preset with address 03, operation with 28 speed steps (for the DCC case) and can be operated and programmed via the DCC- and Motorola data formats.

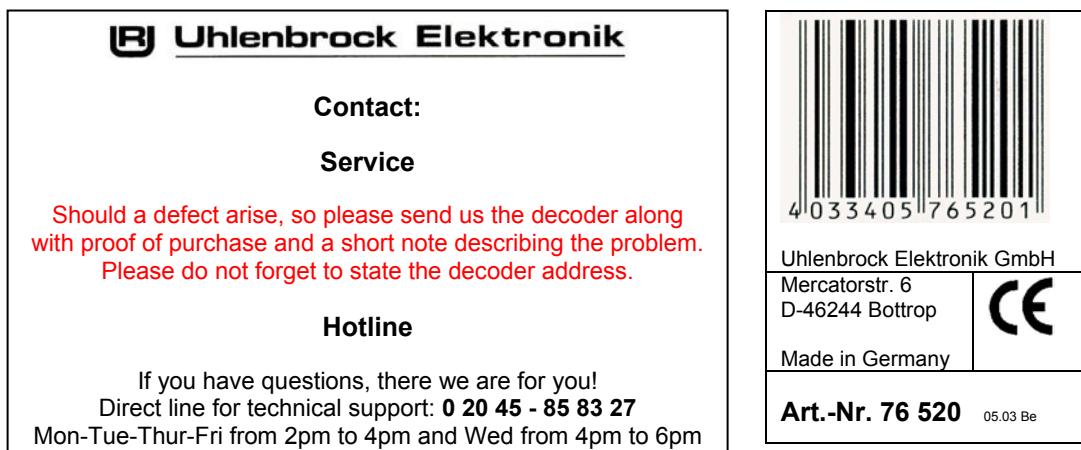
### **Delivery status**

On delivery, the decoder can be controlled via either DCC or Märklin/Motorola operation. It has the ability to switch automatically between both formats. Additionally, the decoder can be operated on conventional (analog) layouts with either a DC transformer or an AC (Märklin) transformer.

### **Declaration of guarantee**

Each component is examined before distribution for proper operation. However, if a problem should arise within the guarantee period of 2 years, then we will repair it for you free of charge upon receipt of your sales invoice. The warranty claim is void, if damage was caused by inappropriate treatment, use or modification. Please note that, according to EMV law, this component may be operated only within vehicles which carry the CE designation.

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Translation by Mr. Robert Frowenfeld with support from Stefano Chiti-Batelli.