1 General

1.1 Introduction and Intended Use (Informative)

This standard defines a uniform multi-pole interface for vehicles for safe and quick installation or exchange of electronic modules (vehicle and function decoder or SUSI module, herein after referred to as decoder) for the purpose of control via Digital Command Control systems.

1.2 References

This standard should be interpreted in the context of the following NMRA Standards, Technical Notes, and Technical Information.

1.2.1 Normative

- S-9.1.1 DCC Interfaces, which specifies general DCC interface requirements

1.2.2 Informative

- TN-9.1.1.3 21MTC Decoder Interface, which provides commentary on the 21MTC decoder interface.
- TI-9.1.1 Sources for Connectors for DCC, which provides a list of manufacturer part numbers for DCC interface connectors.
- TI-9.2.3 Serial User Standard Interface for DCC, which provides information on SUSI
- RCN-121 Decoder Interface 21MTC, with which this standard is intended to be in harmony
- NEM 660 Electrical Interface 21MTC, with which this standard is intended to be in harmony.

1.2.3 Description of the Interface

The interface supports the connection of a motor, and a baseline of 8 function outputs, 2 input sensors and data bus expansion with options allowing up to 12 function outputs. The installation space and the size of the decoder are part of the interface. Vehicles with a factory-installed interface and decoder with the interface according to this standard must be clearly marked with the Logo 21MTC on the packaging.

The interface is defined for plugging the decoder directly into the vehicle. A connection via cable is not provided and such a design does not correspond to this standard.

1.3 Terminology

Term	Definition
Vehicle	Mobile model railroad device. This includes locomotives and other rolling stock.
Decoder	DCC receiver for controlling vehicle animation.
System Board	Electronic circuit board that is considered part of the vehicle which a decoder is intended to be plugged into. Also sometimes called a motherboard.
Train Bus	Serial User Standard Interface (SUSI)

1.4 Requirements

To meet this standard all mechanical and electrical values mentioned must be met and respected, unless otherwise noted. It is not necessary to implement all connections of the interface. The connections belonging to unimplemented features must remain unconnected. This applies to vehicles as well as for other devices that use this interface.

2 Mechanical Properties

On the vehicle side, the interface consists of a 22-pin, two-row strip of pins with a grid dimension of 1.27 mm and on the decoder side of the matching socket strip. To assure proper orientation Pin 11 is omitted and the associated socket is blocked. The pins have a length of 3 mm and either a square profile with an edge length of 0.40 mm or a round profile with a diameter of 0.43 mm. Pins and sockets have a gold-plated contact surface and a contact load capacity of max. 1 A.

2.1 Requirements for the decoder

The dimensions of the decoder are a maximum of 30 (length) x 15.5 (width) x 6.5 (height) mm. The maximum assembly height on the side with the socket strip, hereinafter referred to as the top, is 2.2 mm. On the side opposite the socket strip, hereinafter referred to as the underside, the maximum fitting height is 3.3 mm. The maximum thickness of the board is 1 mm. The center line of the socket strip is 2.8 mm away from the one short edge of the decoder. The socket strip is to be installed symmetrically to the decoder width. Drill holes must be provided in the circuit board, which allow the pin header to be inserted through the circuit board from below. A 4.8 mm wide strip of components must be kept free from the edge of the decoder on the underside where the socket connector is located. At a distance of 5.8 mm from the edge, the equipment height is limited to 2.8 mm. There is no need to drill a hole in the board at position Pin 11 of the socket strip. In order to ensure that there is no mix-up when installing the rotated variant (see Section 4), the position Socket 11 must also be completely sealed.

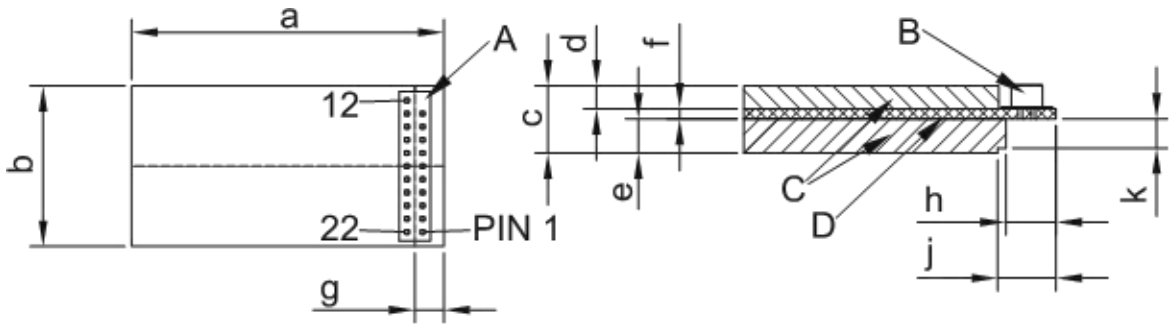


Figure 1: Decoder plan view (top visible) and a side view for compact plug variant.

A = index position Pin 11

C = components on the top and bottom

B = socket

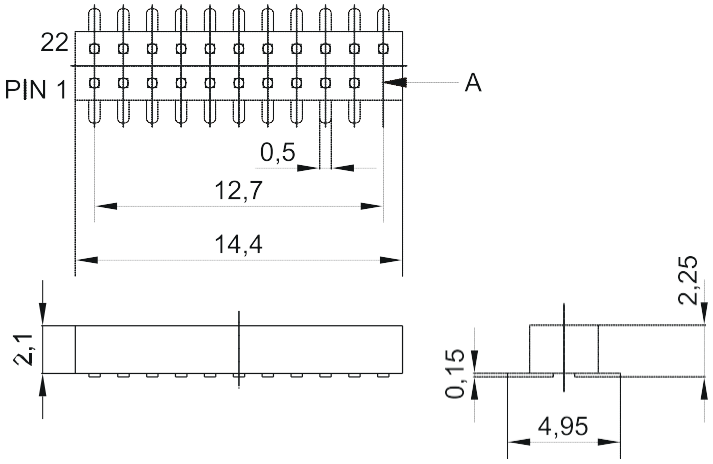
D = decoder board

The lower-case letters in Table 1 correspond to the following dimensions. Unless otherwise stated, all values are maximum dimensions.

#	Description	Measure
a	Length	30.0 mm
b	Width	15.5 mm
c	Total height	6.5 mm
d	Equipment height above	2.2 mm
e	Assembly height below	3.3 mm
f	Thickness of the board	1.0mm
G	Distance between the center of the socket strip and the edge	2.8 mm
H	Area to be kept clear on the underside	4.8 mm
j	Area with reduced equipment height	5.8
k	Reduced assembly height	2.8

Table 1: 21MTC Physical Dimensions

The following picture shows a typical example of a socket connector.



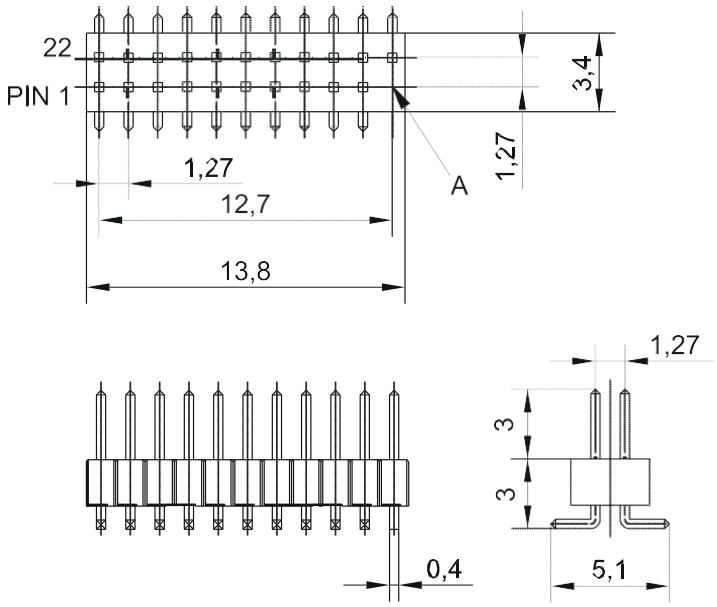
A = Index position Pin 11

Figure 2: Typical socket connections for decoders

2.2 Requirements for the vehicle

The installation space in the vehicle must be such that a decoder with maximum dimensions can be inserted without constraint. There should also be enough space be provided that the decoder can be pulled without tools.

The following image shows a typical example of a pin header.



A = Index position Pin 11

B = Circuit board in the vehicle

C = On the board in the vehicle of components area to be kept clear

Figure 3: Typical pin header for vehicles

Installation in the vehicle is permitted in two variants.

2.3 Compact variant

.The compact variant results in the lowest possible overall height. Here the decoder is inserted with the socket facing up. The pins of the connector are inserted through the board of the decoder. The decoder sits on the board in the vehicle. On the circuit board in the vehicle, the area of the decoder - apart from the pin header - must be kept free of components and be electrically isolated.

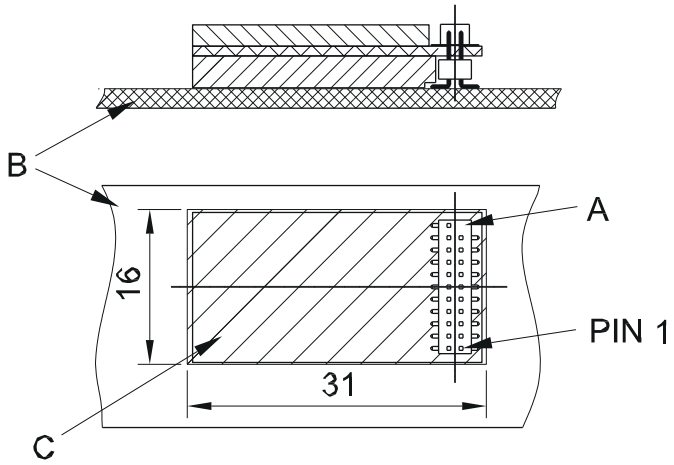
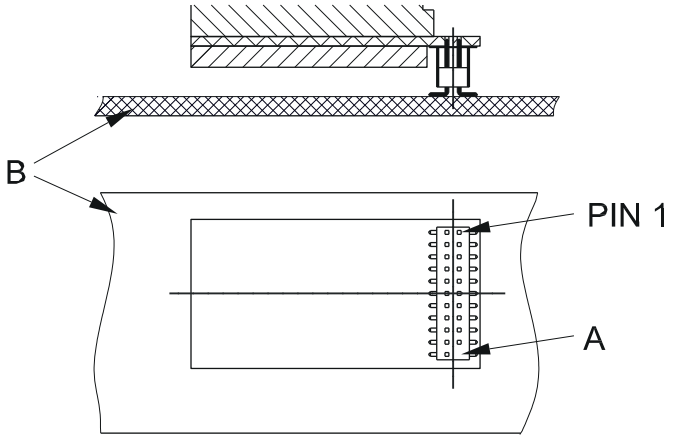


Figure 4: Installation in a compact version

2.4 Rotated variant

If there is enough height, but no space for the free space on the vehicle board, the vehicle manufacturer can use the rotated variant. The decoder is plugged in with the socket facing downwards (towards the vehicle circuit board). The assignment of the connector on the vehicle circuit board must be mirrored in the axis of pin 6/17. The maximum assembly height on the circuit board in the vehicle in the area of the decoder is - apart from the pin header - 3.3 mm and must be electrically isolated from the decoder.



A = Index position Pin 11

B = Circuit board in the vehicle

Figure 5: Installation in a rotated variant

3 Electrical Characteristics

Manufacturer of this decoder must specify the maximum current allowed to be drawn for each output and input. In case the decoder utilizes a flat ribbon cable with a connector at the remote end, following the wire color specification is optional. For standalone extension cables and interface cables, with connectors at both ends, wire color coding is mandatory.

3.1.1 Pin Assignments

The pin assignments for 21MTC are defined in Table 2:

Pin	Name	Description	Group
1	Input1	Sensor-Input 1, alternate AUX7	4
2	Input2	Sensor-Input 2, alternate AUX8	4
3	AUX6	Output 6	8
4	AUX4	Output 4	8
5	ZBCLK	Train Bus Clock, alternate AUX9	7
6	ZBDTA	Train Bus Data (TxD, RxD), alternate AUX 10	7
7	F0r	Light direction rear	5
8	F0f	Light direction forward	5
9	LS/A	Speaker Connection A	6
10	LS/B	Speaker Connection B	6
11	Index	Not used, Orientation	
12	Vcc	Internal Decoder-Voltage 1.8 – 5.7 Volt	2
13	AUX3	Output 3	8
14	AUX2	Output 2	5
15	AUX1	Output 1	5
16	V+	Decoder Plus, referenced at rectifier, port storage capacitors	
17	AUX5	Output 5	8
18	Motor2	Motor-connection #2 minus / direction rear	3
19	Motor1	Motor-connection #1 plus / direction forward	3
20	GND	Decoder GND, Referenced at rectifier	
21	Track left	Track left in direction forward	1
22	Track right	Track right in direction forward	1

Table 2: Contact assignment and function descriptions

3.1.2 Description of Signals

Group 1: When supplied with AC-Motors Pin 21 is connected to the outer rails und Pin 22 to the middle rail.

Group 2: Pin 12 is not mandatory. It is recommended to use this connection only for the access bus interface.

Group 3: Pin 19 is field coil A; Pin 18 is field coil B for AC-Motors.

Group 4: Pin 1 and 2 are open collector inputs and are switched to GND. The input resistance should be approx. 100kΩ. Sensor input 1 should be used for wheel synchronization on steam locomotives. These connections can also be used as function outputs with logic level.

Group 5: When switched on, these outputs are connected to GND on the decoder side. The voltage for the switched load results from the track voltage at V+. If the rear lights are connected separately from the headlights in the vehicle, the rear lights of Driver's Cab 1 are switched with AUX1 (Pin 15) and those of Driver's Cab 2 with AUX2 (Pin 14).

Group 6: The effective impedance of the speaker(s), as observed by the decoder, is 4Ω - 8Ω and must be documented by the decoder manufacturer. Impedance of factory installed speakers must be documented by the vehicle manufacturer.

Group 7: The microcontroller-pins of the train bus are connected through a serial resistor with a maximum of 470 Ohm. The levels correspond to those of the logic level in Group 8 (Table 3). These connections can also be used as function outputs with logic level.

Group 8: Outputs are defined as TTL/LVTTL logic-level according to Table 3, maximum load 0.5 mA

	Voltage Level Decoder Output	Input Load Switch
Function Switched Off	<= 0.4 Volt	<= 0.8 Volt
Function Switched On	>= 2.4 Volt	>= 2.0 Volt

Table 3: Logic Level Values

It should be noted that when the decoder processor is started, uncontrolled states including a high-resistance state at the outputs with logic level can occur for a short time. Critical hardware on the locomotive board must be secured accordingly.

4 Operation without Decoder

When operating without a decoder, a jumper plug must be used, which connects at least the connections of Track 1 (Pin 22) with Motor 1 (Pin 19) and Track 2 (Pin 21) with Motor 2 (Pin 18). If the vehicle lighting is available, F0f (Pin 8) must also be connected to Track 2 (Pin 21) and F0r (Pin 7) to Track 1 (Pin 22). The connection V + (Pin 16) is to be supplied via two diodes from the track connections.

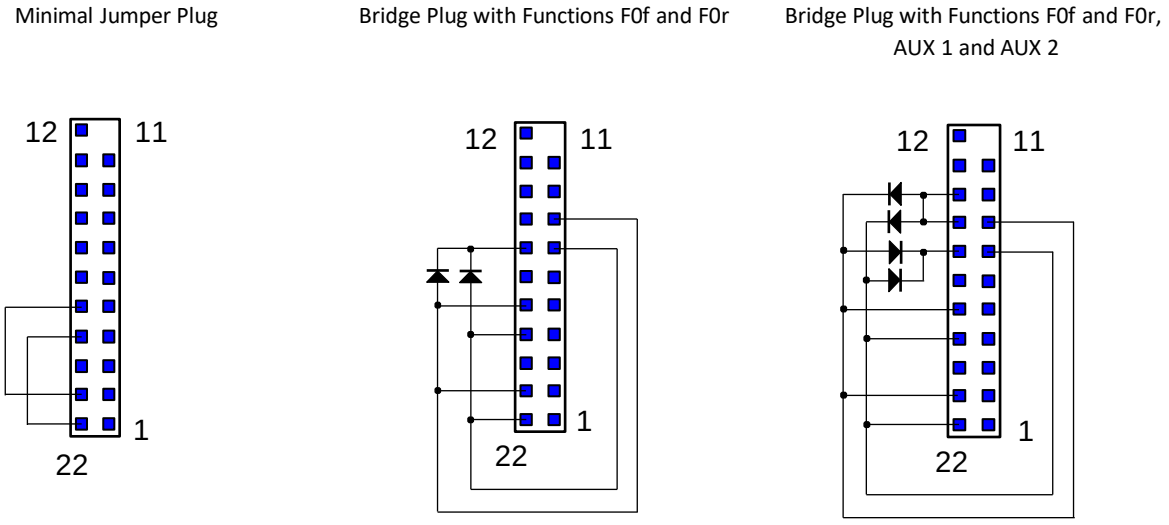


Figure 6: Typical Jumper Plugs

Depending on the wiring of the function outputs in the vehicle, the vehicle manufacturer can produce a jumper plug specific to the vehicle that connects other outputs. In the middle picture the outputs F0f and F0r are controlled depending on the direction; In the right picture, the functions AUX1 and AUX2 are also always switched on.

Use of Interface with SUSI

This interface can also be used as a SUSI interface according to TI-9.2.3. In this case, only four signals may be used:

1. GND (Pin 20)
2. V+ (Pin 16)
3. Train Bus Clock (Pin 5)
4. Train Bus Data (Pin 6)

In particular, the track connections are not to be used when wired as a SUSI interface. All other connections can be used for functions of the SUSI module.

6 Document History

Date	Description
Dec 1, 2020	First Revision of S.9.1.1.3, supporting the latest 21MTC proposed feature additions. Added additional clarifying text for the speaker requirements.
May 6, 2024	Correction, Line 165, GND (Pin 21) corrected to GND (Pin 20).

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