1 General

1.1 Introduction and Intended Use (Informative)

This standard defines a multi-pin interface for vehicles with limited installation volume for electronic components. It is suitable for N and TT gauges, as well as smaller vehicle installations in HO gauge. In addition to vehicles, this interface may be utilized with function-only decoders or SUSI modules.

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 requirements for DCC interfaces
- S-9.2.3 DCC Service Mode, which specifies requirements for service mode programming

1.2.2 Informative

- TN-9.1.1.6 E24 Decoder Interface, which provides commentary on the E24 decoder interface.
- TI-9.1.1 Sources for Connectors for DCC, which provides a list of manufacturers and part numbers for DCC interface connectors
- TI-9.2.3 Serial User Standard Interface for DCC, which provides information on SUSI
- RCD-124 Decoder Interface E24, with which this standard is intended to be in harmony[i]

1.2.3 Description of the Interface

The interface supports the connection of a motor, directional lighting and a baseline of 12 function outputs. The installation space requirements and the size of the decoder as outlined below are part of the interface. The interface consists of 28 pins, 24 being normal contacts and 4 guide pins which are used for power pickup as noted in Table 3, Section 3.1. This interface is designed for direct insertion of a decoder into a vehicle.

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 into which a decoder is intended to be inserted. Also sometimes referred to as 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 or features of the interface. Connections belonging to unimplemented features must remain unconnected. This applies to both vehicles and other devices that may use this interface.

2 Mechanical Properties

The interface consists of an encapsulated 28-pin plug connector on the system board of the vehicle (Figure 1) and an encapsulated 28-pin socket connector on the decoder board (Figure 2). Examples shown are for visual reference only, as they do not display the full 28 pins of the actual devices.

Figure 1: Vehicle Connector

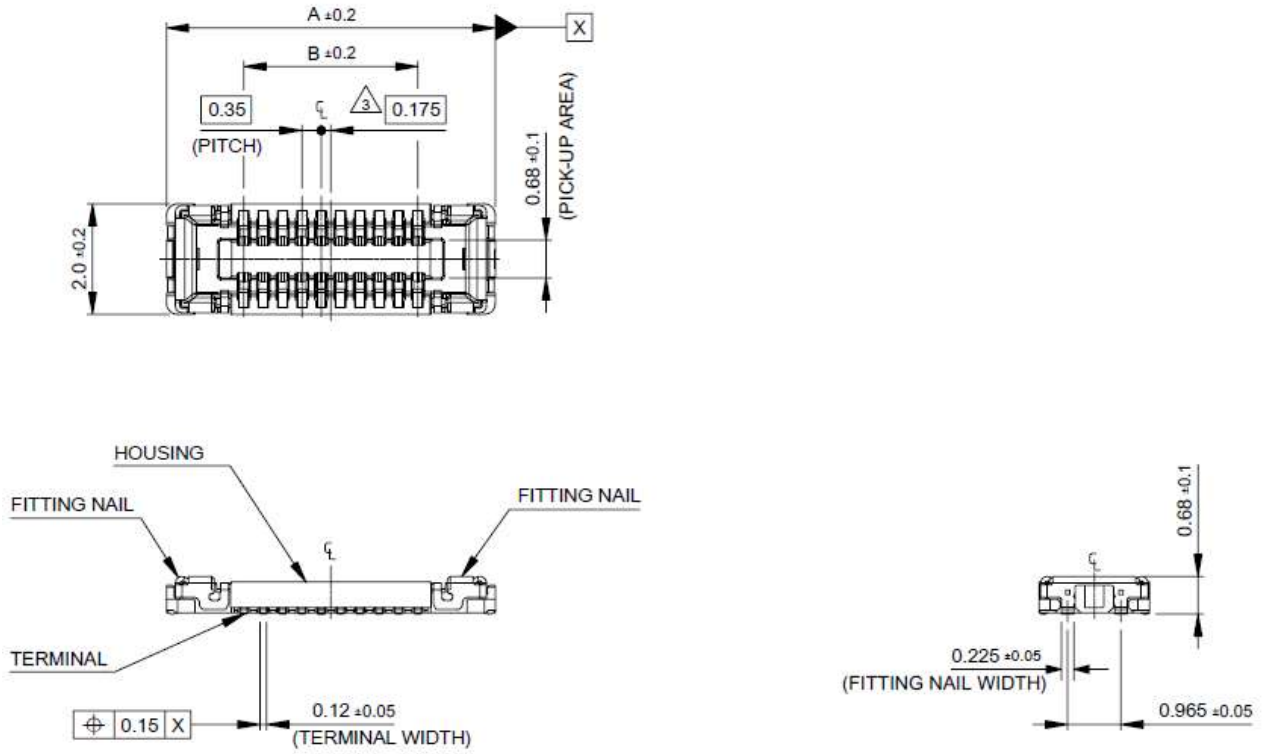
Figure 2: Decoder Socket

The MOLEX connectors as utilized by this standard are completely described in the following MOLEX technical documents, and references cited therein. For the decoder connector (Figure 2), see: https://www.molex.com/en-us/products/part-detail/5052702412?display=pdf, For the vehicle side connector (Figure 1), see: https://www.molex.com/en-us/products/part-detail/5050702422?display=pdf.

PLEASE NOTE that this interface is physically symmetrical but is not keyed or otherwise protected from improper orientation upon decoder installation. The physical design of the system board of the vehicle or module must include external precautions (such as barriers or blocking components) to ensure that the decoder is not inserted incorrectly, in order to prevent electrical or physical damage.

2.1 Dimensional Requirements

2.1.1 Decoder



Molex Part No.	Contacts	Dimension A (mm)	Dimension B (mm)
505270-2412	24	6.65	3.85

Figure 3: Molex Decoder Socket Generalized Layout

Based on the interface dimensions provided above, the Dimensional Requirements of the decoder board are specified as follows.

Dimension No.	Description	E24
a	Decoder length maximum	19.5 mm
b	Decoder width maximum	8.4 mm
c	Decoder height without socket and components on the bottom	2.6 mm
d	Distance decoder edge to center socket	1.6 mm
e	Distance between decoder edge and bottom of the assembly	3.2 mm
f	Maximum height of the components on the underside	0.7 mm

Table 1: Primary Dimensional Requirements, E24 Decoder

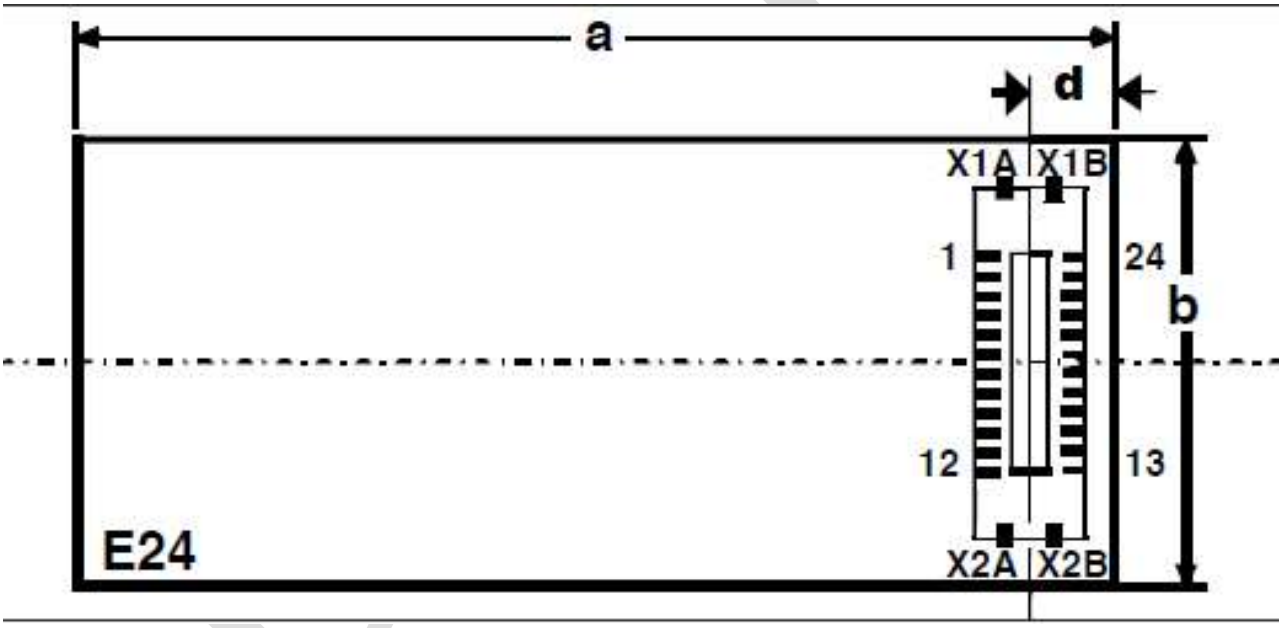


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Figure 4: View of the decoder from below, component side of the socket

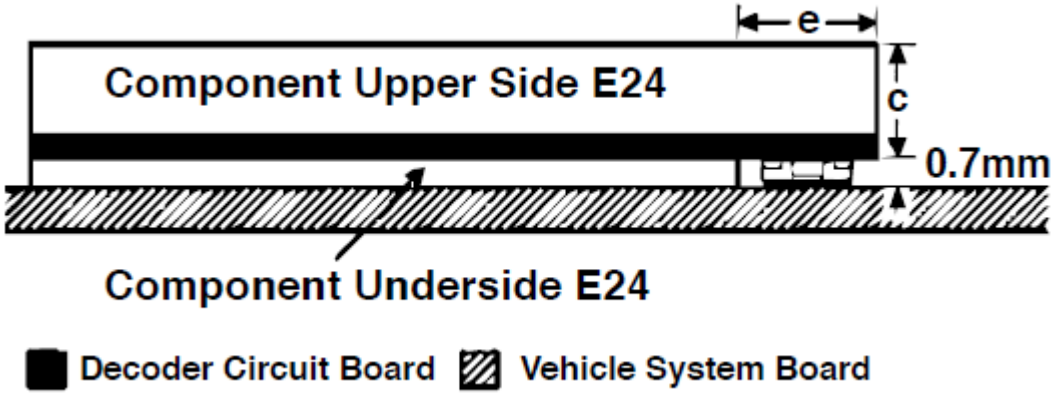
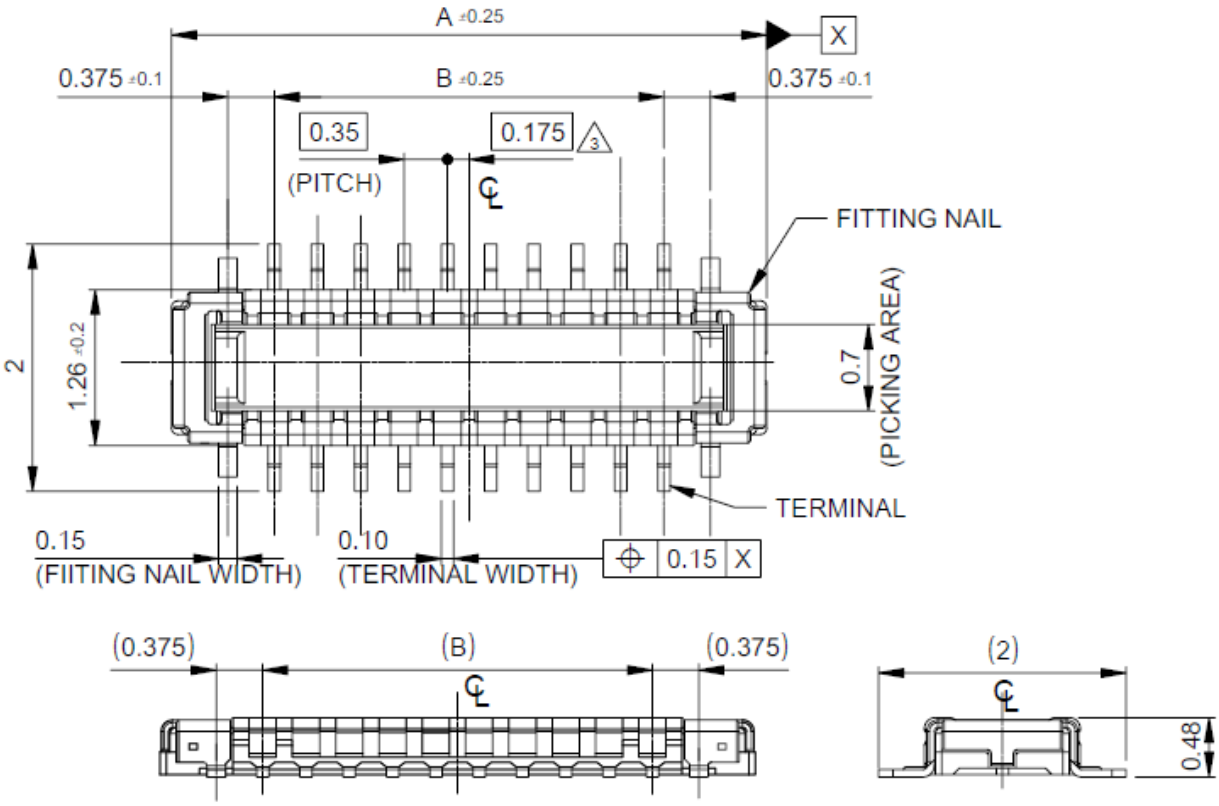


Figure 5: View of Decoder and System Board Connectivity

Components may be installed on the decoder board to a maximum height of 0.7 mm on the underside with the socket. The highest components on the underside should not have any electrically conductive surfaces on their upper side to prevent short circuits to vehicle parts.

2.1.2 Vehicle

The installation space required in the vehicle or module must be such that a decoder of maximum dimensions specified above may be inserted without undue constraint. There should also be sufficient space provided that the decoder may be removed without tools. Due to the physical symmetry of the interface, however, the vehicle system board, module or vehicle itself must incorporate features to prohibit the decoder from being inserted in an improper orientation.



Molex Part No.	Contacts	Dimension A (mm)	Dimension B (mm)
505070-2422	24	5.51	3.85

Figure 6: Molex Vehicle Connector Generalized Layout

3 Electrical Characteristics

The electrical specifications for the decoder socket and system board connector are described fully in the MOLEX documentation (decoder side: https://www.molex.com/en-us/products/part-detail/5052702412?display=pdf, vehicle side: https://www.molex.com/en-us/products/part-detail/5050702422?display=pdf.) Table 2 below summarizes several key values:

Maximum Voltage	50 V AC(rms) / DC
Contact Load Capacity	0.3A Maximum, pins 1-24 (“Terminal”) 3.0A Maximum, Guide Pins (“Nail”)
Insulation Resistance	100 M Ohm, Minimum @ 250V DC
Dielectric Strength	250 V rms AC @ 0.5 mA for 1 minute
Contact Resistance	80 mOhm max, pins 1-24 (“Terminal”) 30 mOhm max, Guide Pins (“Nail”)

Table 2: Electrical Specifications of Connectors

The contact load capacity of the connections numbered 1 to 24 is 0.3 A, and the 4 guide pins (X1A, X1B, X2A, X2B) are 3.0 A. The track connections use the higher load capacity of the guide pins. The motor connections and GND (decoder minus after rectifier) are each designed with two contacts. The load capacity of these connections is therefore 0.6 A.

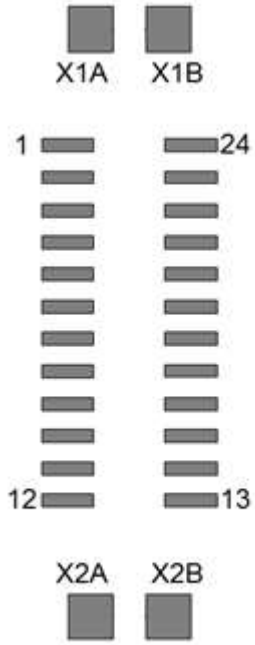


Figure 7: Pin Arrangement for E24 Interface

3.1 Pin Assignments

Pin	Name	Description	Group
X1A, X1B	Track Power (Left)	Left Rail Power Pickup (in forward direction of travel)	1
1	LS_B	Speaker Connection B	5
2	LS_A	Speaker Connection A	5
3	GND	Decoder negative, referenced at rectifier	
4	Motor (-)	Motor connection (-)	2
5	Motor (-)	Motor connection (-)	2
6	Motor (+)	Motor connection (+)	2
7	Motor (+)	Motor connection (+)	2
8	Cap. (+)	Storage Capacitor Connection	6
9	F0_f	Headlight Forward	3
10	F0_r	Headlight Reverse	3
11	AUX_1	Output 1	3
12	AUX_2	Output 2	3
13	AUX_8	Output 8	3
14	AUX_7	Output 7	3
15	AUX_6	Output 6	3
16	AUX_5	Output 5	3
17	V+	Decoder positive, referenced at rectifier	
18	Vcc	Internal decoder voltage, 1.8-5.7V	
19	AUX_10 / GPIO_C	Output 10, alternate GPIO_C	4
20	AUX_4	Output 4	4
21	AUX_3	Output 3	4
22	GND	Decoder negative, referenced at rectifier	
23	TBCLK / AUX_12 / GPIO_A	Train Bus Clock, alternate Output 12, alternate GPIO_A	4
24	TBDATA / AUX_11 / GPIO_B	Train Bus Data, alternate Output 11, alternate GPIO_B	4
X2A, X2B	Track Power (Right)	Right Rail Power Pickup (in forward direction of travel)	1

Table 3: Pin Assignments, E24 Connector

Connections that are not used on the vehicle side must be routed to soldering points on the vehicle circuit board.

3.2 Description of Signal Assignments

Group 1: Track Power Right (X2A and X2B) and Track Power Left (X1A and X1B) are connected to the vehicle wheels for the incoming power supply.

Group 2: Motor + (pins 6 and 7) is connected such that the vehicle moves forwards when a +ve potential is applied to Motor +. This is normally connected to the right rail for DC operation. Motor – (pins 4 and 5) is similarly connected to the left rail if no decoder is present / DC operation.

Group 3: These outputs are (amplified) open collector/drain switched against ground on the decoder side. The voltage for the load comes from the decoder positive at V+ (pin 17). Maximum load capacity is 100 mA per output. In the case where taillights are connected separately from the headlights, the taillights in the forward direction are connected to AUX1 (pin 11) and the taillights in the reverse direction are connected to AUX2 (pin 12).

Group 4: Outputs are defined as TTL/LVTTL logic-level according to Table 4 and are suitable for switching external load switches on the system board of the vehicle. The maximum load is 0.5 mA. During startup, these decoder outputs may be briefly undefined or exhibit high-impedance conditions. If this brief undefined state is critical to the system board operation, then appropriate precautions should be implemented on the system board.

If Train Bus is supported, the decoder must include a 470Ω series resistor on TBCLK / AUX_12 / GPIO_A (pin 23) and TBDATA / AUX_11 / GPIO_B (pin 24) and must have a 15KΩ (or greater) pull-up on TBDATA (pin 24) before the 470Ω series resistor.

GPIO_A, B, and C may also be used as digital inputs, which are switched externally to GND. When used as inputs, a pull-up resistor in the range of 10k-50kΩ must be used. GPIO_A and GPIO_B are preferred for servo control and should always be used by Serial buses.

GPIO_C may also be used as an analog input, provided the static input resistance must be over 100 k Ω and the control from the vehicle in this case must not exceed 3.3V. GPIO_C should preferably be used for wheel synchronization in steam locomotives.

Group 5: The effective impedance of the speaker(s), as observed by the decoder, is 4Ω - 8Ω and must be specified and documented by the decoder manufacturer. Impedance of factory installed speakers in a vehicle must be documented by the vehicle manufacturer.

Group 6: This output is designed for connecting storage capacitors. This must NOT be supplied with voltage from the vehicle side or connected to V+ (pin 17). The connection must be switchable in both current directions and the charging current must be limited to a maximum voltage of 15V. For capacitors used in the vehicle, electrolytic capacitors must have a nominal voltage of at least 16V, and tantalum capacitors must have a nominal voltage of at least 25V.

NOTE: If a voltage V+ is independently generated on the vehicle system board, it must not be connected to V+ (pin 17) of this interface.

	Decoder Output Voltage Level	System Board Input Voltage Level
Function switched off	<= 0.4V	<= 0.8V
Function switched on	>= 2.4V	>= 2.0V

Table 4: TTL/LVTTL voltage levels

3.2.1 Functional Support Minimal Requirements

Functions F0_f, F0_r, AUX_1 and AUX_2 are the minimal requirements to be supported by an E24 decoder implementation. In vehicles, implemented function outputs must not require the presence of additional higher function outputs or special buses that are not standardized for operation of any implemented functions.

3.3 Vehicle Operation Without Decoder

When operating an E24 connector-equipped vehicle without a decoder, a jumper plug must be installed which at a minimum connects current pickup on the right (pins X2A and X2B) with Motor+ (pins 6 and 7), and current pickup on the left (pins X1A and X1B) with Motor − (pins 4 and 5), as shown in the first panel of Figure 8 below.

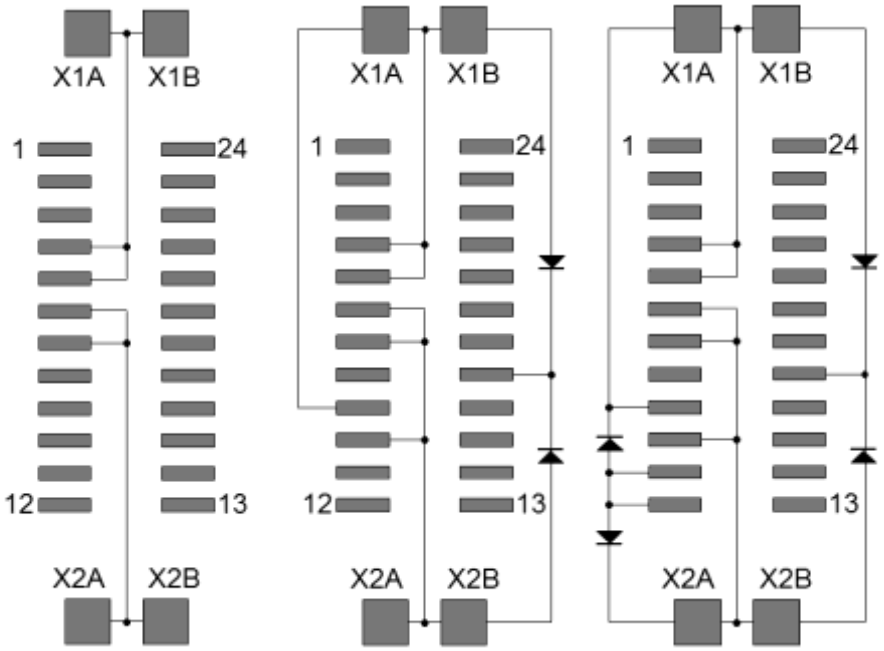


Figure 8: Typical Jumper Plugs

Depending on the wiring of the function outputs in the vehicle, a vehicle manufacturer may produce a vehicle-specific jumper plug that connects additional outputs beyond the minimum. For example, in the middle panel of Figure 7, the outputs F0_f and F0_r are enabled and directionally controlled; in the right panel, the functions AUX1 and AUX2 are also enabled and permanently active (on). This is similar to a case where wiring for constant lighting would be desired, such as for car interiors. In the event of using these outputs for tail lighting as noted previously, AUX1 will be connected to F0_r and AUX2 to F0_f.

The connection V+ (pin 17) is to be supplied via two diodes from the track connections.

3.4 Additional Interface Use Cases (Electrical)

3.4.1 Use of the Interface as a Function Only Decoder

This interface can be used in vehicles without a motor (e.g. control cars). Since the motor connections are not connected in this case, the decoder must have an internal means of generating the required service mode acknowledgement as defined in S-9.2.3.

3.4.2 Use of the Interface with SUSI

This interface can also be used as a SUSI interface as defined in TI-9.2.3. Only the four signals may be used:

1. GND (pins 3 and 22)
2. V+ (pin 17)
3. Train Bus clock (pin 23)
4. Train Bus data (pin 24)

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

4 Document History

Date	Description
Jan 14, 2026	First Draft

[i] RCN stands for RailCommunity Normen. The direct German to English translation of Normen is Norms and in this context is intended to have an equivalent meaning to Standards. RCD stands for RailCommunity Documentation and is intended to have an equivalent meaning to NMRA Recommended Practices (RP). RailCommunity is an organization of manufacturers that creates German language standards for model railway electronics.

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