Scott A. Gothe

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 2, 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.

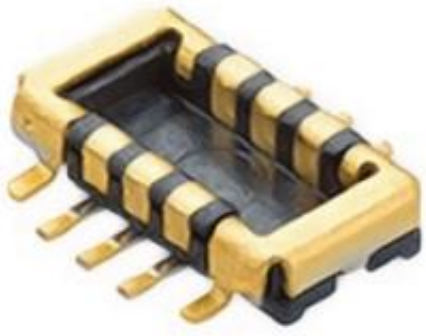


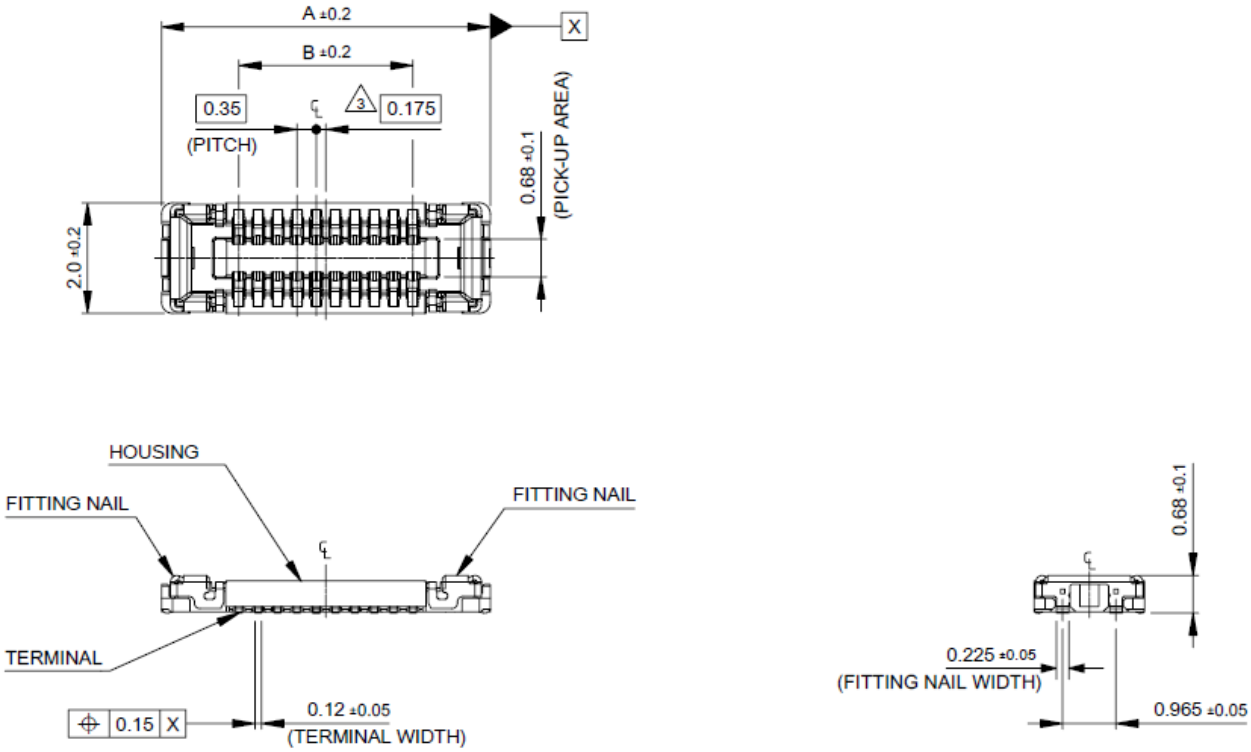
Figure 1: Vehicle Connector

Figure 2: Decoder Socket

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, or electrical damage will result.

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	19.5 mm
b	decoder width	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

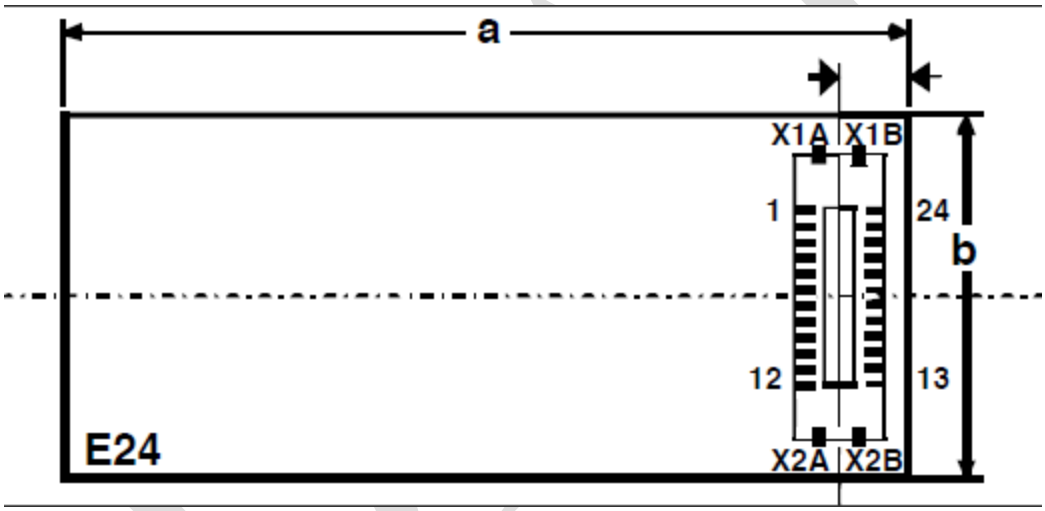


Figure 4: View of the decoder from below, component side of the socket

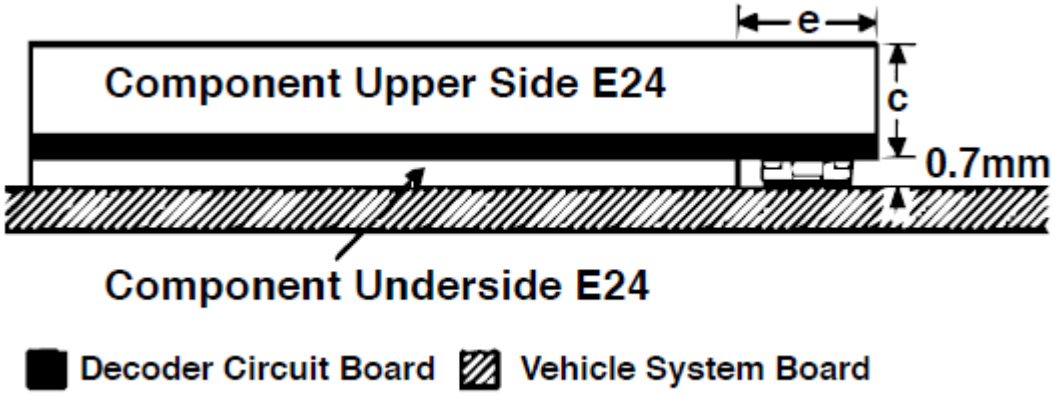
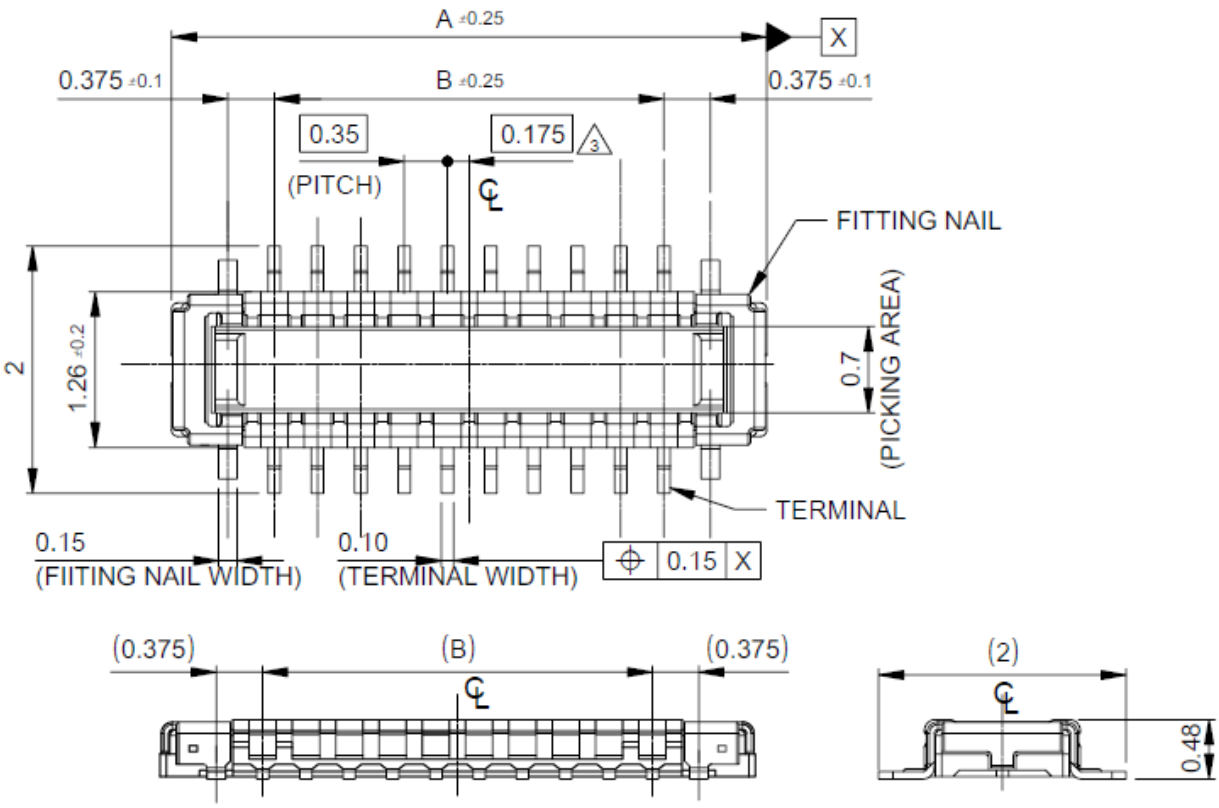


Figure 5: View of Decoder and System Board Connectivity

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 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.

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 2: 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 normally connected to the right rail. Motor – (pins 4 and 5) is normally connected to the left rail if no decoder is present.

Group 3: These outputs are open collector/drain switched against ground on the decoder side. The voltage for the load comes from the Track voltage 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 **Error! Reference source not found. Error! Reference source not found.**, 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 [NOTE: Not explicit in RCD-124, but assumed] 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 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 as provided in RCN-530 [IS THERE AN NMRA STANDARD THAT COVERS THIS?], with a maximum voltage of 15V.

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

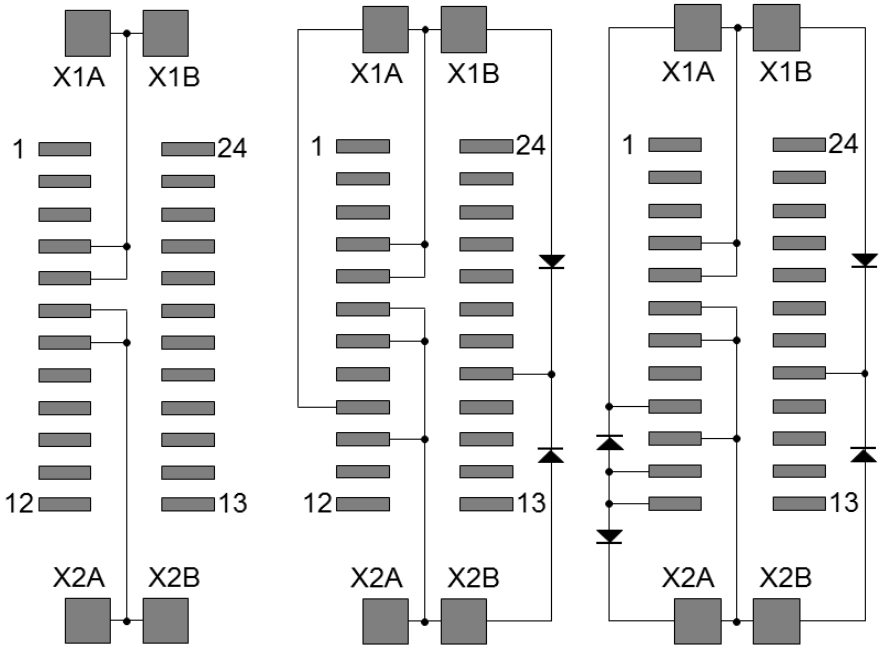
Table 3: TTL/LVTTL voltage levels

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 7 below.



Minimal Jumper Plug | Jumper Plug enabling F0_f, F0_r | Jumper Plug enabling F0_f, F0_r, AUX_1 and AUX_2

Figure 7: 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
Mar 31, 2025	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.

Important Notices and Disclaimers Concerning NMRA Standards Documents

The Standards (S), Recommended Practices (RP), Technical Note (TN), and Technical Information (TI) documents of the National Model Railroad Association ("NMRA Standards documents") are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notices and Disclaimers Concerning NMRA Standards Documents."

Notice and Disclaimer of Liability Concerning the Use of NMRA Standards Documents

NMRA Standards documents are developed within the Standards and Conformance Department of the NMRA in association with certain Working Groups, members, and representatives of manufacturers and sellers. NMRA develops its standards through a consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. NMRA Standards documents are developed by volunteers with modeling, railroading, engineering, and industry-based expertise. Volunteers are not necessarily members of NMRA, and participate without compensation from NMRA.

NMRA does not warrant or represent the accuracy or completeness of the material contained in NMRA Standards documents, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard or recommended practice, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, NMRA disclaims any and all conditions relating to results and workmanlike effort. In addition, NMRA does not warrant or represent that the use of the material contained in NMRA Standards documents is free from patent infringement. NMRA Standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of NMRA Standards documents is wholly voluntary. The existence of an NMRA Standard or Recommended Practice does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the NMRA Standards documents. Furthermore, the viewpoint expressed at the time that NMRA approves or issues a Standard or Recommended Practice is subject to change brought about through developments in the state of the art and comments received from users of NMRA Standards documents.

In publishing and making its standards available, NMRA is not suggesting or rendering professional or other services for, or on behalf of, any person or entity, nor is NMRA undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any NMRA Standards document, should rely upon their own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given NMRA Standards document.

IN NO EVENT SHALL NMRA BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: THE NEED TO PROCURE SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD OR RECOMMENDED PRACTICE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

NMRA's development of NMRA Standards documents involves the review of documents in English only. In the event that an NMRA Standards document is translated, only the English version published by NMRA is the approved NMRA Standards document.

Official Statements

A statement, written or oral, that is not processed in accordance with NMRA policies for distribution of NMRA communications, or approved by the Board of Directors, an officer or committee chairperson, shall not be considered or inferred to be the official position of NMRA or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of NMRA.

Comments on Standards

Comments for revision of NMRA Standards documents are welcome from any interested party, regardless of membership. However, **NMRA does not provide interpretations, consulting information, or advice pertaining to NMRA Standards documents.**

Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since NMRA standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, NMRA, its departments, Working Groups or committees cannot provide an instant response to comments, or questions except in those cases where the matter has previously been addressed. For the same reason, NMRA does not respond to interpretation requests. Any person who would like to participate in evaluating comments or in revisions to NMRA Standards documents may request participation in the relevant NMRA working group.

Laws & Regulations

Users of NMRA Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any NMRA Standards document does not constitute compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. NMRA does not, by the publication of NMRA Standards documents, intend to urge action that is not in compliance with applicable laws, and NMRA Standards documents may not be construed as doing so.

Copyrights

NMRA Standards documents are copyrighted by NMRA under US and international copyright laws. They are made available by NMRA and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of modeling, structural and engineering practices and methods. By making NMRA Standards documents available for use and adoption by public authorities and private users, NMRA does not waive any rights in copyright to the NMRA Standards documents.

IMPORTANT NOTICE

NMRA Standards documents do not guarantee or ensure safety, security, health, or environmental protection, or ensure against interference with or from other systems, devices or networks. NMRA Standards documents development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. Implementers and users of NMRA Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.