



| NMRA Standard | |
|-------------------------|---------------|
| Power Station Interface | |
| Jun 18, 2020 | S-9.1.2 DRAFT |

1 General

1.1 Introduction and Intended Use (Informative)

The purpose of this Standard is to define communication between Command Stations and Power Stations to facilitate the basic interchange of DCC equipment produced by various manufacturers. It is applicable when Command Stations or Power Stations are tested for conformance independently of each other. It is also applicable when conformance testing an integrated DCC System, which includes both Power Station Interface and Power Station outputs. It is not applicable when conformance testing a DCC system [which](#) includes only a Power Station output but no Power Station Interface output.

The main goals are as follows:

1. Define the electrical characteristics of the interface.
2. Define limits on the amount of distortion that each component can introduce to the DCC signal measured at the track.
3. Define the transmission medium of the interface.
4. Define the allowable physical topology of the interface.
5. Define the labeling of various components and connections.

1.2 References

This standard is interpreted in the context of the following NMRA Standards, Technical Notes, Technical Information, and other documents.

1.2.1 Normative

- S-9.1 Electrical Standards for Digital Command Control, which specifies DCC bit timing and track voltage.
- S-9.2.4 Fail-Safe Operating Characteristics for Digital Command Control, which specifies how system components interact under adverse conditions.
- ~~S-9.1.2.1 Power Station Interface Feedback, which specifies feedback between Power Stations and Command Stations~~
- [S-9.3.2 DCC Basic Decoder Transmission, which defines communication from a DCC decoder to a track circuit based detector.](#)

1.2.2 Informative

- TN-9.1.2 Power Station Interface, which provides commentary on the Power Station Interface [Standard](#).

- ~~TN-9.1.2.1 Power Station Interface Feedback, which provides commentary on the Power Station Interface Feedback~~
- RCN-210 DCC Protocol Bit Transmission, with which S-9.1 is intended to be in harmony.ⁱ
- RCN-217 DCC Feedback Protocol (RailCom), with which S-9.3.2 is intended to be in harmony.ⁱ
- NEM 670 Digital Command Control Signal DCC Bit Representation, with which S-9.1 is intended to be in harmony.ⁱⁱ
- Electrical Characteristics of Balanced Voltage Digital Interface Circuits, ANSI TIA/EIA-422 Standard.ⁱⁱⁱ
- Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems, ANSI TIA/EIA-485 Standard.ⁱⁱⁱ

1.3 Terminology

Table 1

| Term | Definition |
|--|---|
| Bipolar Signal | An electrical signal that carries information having equal voltage components above and below 0 volts. In the context of the NMRA DCC standard, this signal will have a positive half-cycle and a negative half-cycle. (+ volts and to - volts <u>respectively</u>) |
| Unipolar Signal | An electrical signal that carries the same information as a bipolar signal, but only has a positive electrical component. This signal will have a positive half-cycle and a half-cycle where the output is at 0 volts. |
| Power Station Feedback | A means of transmitting information from a Power Station to a Command Station. |
| DCC Positive Polarity | The wire or rail which has a positive voltage for the first half-cycle of the DCC bipolar bit. |
| Command Station | The DCC system component whose purpose is to generate and <u>source send</u> a stream of DCC bit data to the Power Station Interface. |
| Power Station | A device intended to that <u>amplifies</u> the low current DCC electrical signals transmitted by a Command Station for the purpose of providing high current DCC signals with sufficient power to operate model trains and any accessory decoders that are connected to the track. Also known as booster or power booster. |
| Power Station Interface | The communications medium (“wires”) which <u>connects</u> a Command Station's signal generator to one or more Power Stations. |
| Power Station Interface Repeater | A device that amplifies the Power Station Interface signal to allow additional capacity for more Power Stations to be connected. |
| <u>Power Station Interface Segment</u> | <u>The singular Power Station Interface path between a Command Station and a given Power Station.</u> |

| Term | Definition |
|-------------|---|
| TIA/EIA-422 | ANSI differential signal standard commonly known as RS-422. |
| TIA/EIA-485 | ANSI differential signal standard commonly known as RS-485. |

1.4 Requirements

To meet this Standard, all electrical values and labeling requirements shall be met and respected, unless otherwise noted. It is not necessary to implement both the Full Scale Interface and Driver/Receiver Interface options. Only one of these interface options is required.

This ~~s~~Standard is required for all new products introduced after January 1st 2021. This ~~s~~Standard is optional for all products introduced before January 1st 2021. Exemptions may be granted at the discretion of the NMRA Conformance and Inspection department. Exemptions granted ~~shall must~~ be noted in the product ~~documentation manual~~ and reviewed for accuracy by the NMRA Conformance and Inspection department.

2 Electrical Characteristics

The ~~Power Station i~~Interface ~~interchange~~ specifications are divided into two types:

1. Full Scale Interface
2. Driver/Receiver Interface.

Command Station / Power Station combinations following one of these ~~interface~~ types may interchange with devices of the same type. There is no exclusion of interchange between the two types as long as the ~~product manufacturer of the equipment~~ documents the interchange.

2.1 Common Characteristics

2.1.1 Command Station (signal generator) Output Signal

The ~~Command Station to~~Power Station ~~Interface~~ signal ~~output by the Command Station~~ described in this ~~Standard document~~ shall conform to the timing specifications described in the NMRA DCC Standard S-9.1.

When a Command Station is not powered, or when its Power Station Interface output is disabled, it shall ensure that the two output signals do not have a floating voltage potential with respect to one another.

The Power Station Interface signal is specifically designed as bipolar, ~~and not unipolar so that the current on the two Power Station Interface wires is balanced.~~

2.1.2 Power Station Input to Output Distortion

Other than for the purpose of producing a basic decoder transmission cutout, as described in S-9.3.2, aPower Station shall not alter the signal from its Power Station Interface input to its track output terminals outside ~~the range defined~~an allowed signal propagation delay and distortion within the range in Table below.

Table 2

| | |
|--|--------------------------------------|
| T_{on} | Less than or equal to 5 microseconds |
| T_{off} | Less than or equal to 5 microseconds |
| ABS ($T_{off} - T_{on}$) | Less than or equal to 2 microseconds |

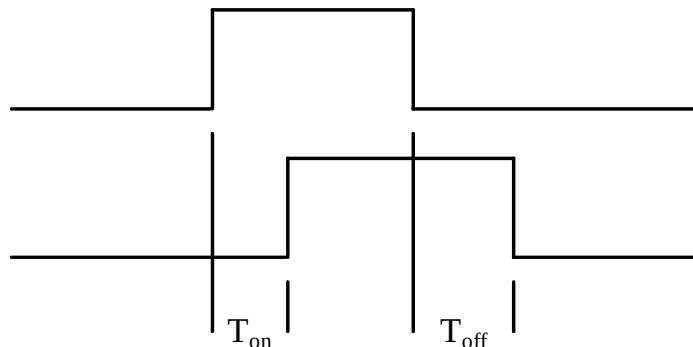


Figure 1

2.1.3 Power Station Interface Repeater Input to Output Distortion

A Power Station Interface Repeater amplifies the Power Station Interface signals so that additional power stations can be supported. Only a single repeater may be used on any Power Station Interface [S](#)segment. On input, the repeater has the same requirements as a Power Station. On output, the repeater has the same requirements as a Power Station except that the total [allowed signal propagation delay and](#) distortion is reduced as defined in Table above.

Table 3

| | |
|--|--|
| T_{on} | Less than or equal to 1 microseconds |
| T_{off} | Less than or equal to 1 microseconds |
| ABS ($T_{off} - T_{on}$) | Less than or equal to 0.5 microseconds |

2.1.4 Power Station Common

Power Stations without electrically isolated interface inputs ~~shall~~[must](#) provide the ability to connect the common side of their DC power supplies together. Instructions on the use of the Power Station [e](#)Common ~~must~~[shall](#) be provided in the product documentation.

2.1.5 Power Station Fail-Safe

Power Stations ~~must~~[shall](#) disable their output when a valid DCC packet is not received for more than 30 milliseconds on the Power Station Interface. ~~This is designed to be consistent with S-9.2.4 in order to prevent a digital decoder from converting to an alternate power source. If a power station is designed for multiple protocol use, this requirement may be disabled, or have a different duration set, through a configuration option. If this requirement can be disabled through configuration, it shall be noted in the product documentation.~~

95 **2.2 Full Scale Interface**

The term Full Scale is derived from the voltage levels of this interface being designed to match the standard track voltage levels defined in S-9.1.

2.2.1 Command Station Output Signal

100 | A bipolar signal [mustshall](#) appear differentially on a two-wire cable with a signal amplitude of no less $\pm 8.5\text{V}$ and no greater than $\pm 22\text{V}$. The Command Station output [mustshall](#) be capable of supplying $\pm 8.5\text{V}$ into a 100Ω resistive load, so that multiple Power Stations may be connected to this output.

105 | The output current shall be limited to no greater than 1A to reduce hazards in case of a short circuit in the Power Station Interface. The output shall be protected to prevent damage to internal devices when a short is present at the output.

| *Table 4: Summary of Requirement Values*

| | |
|---|---------------------------------------|
| Command Station Output Voltage Max | $\pm 22\text{V}$ (open circuit) |
| Command Station Output Voltage Min | $\pm 8.5\text{V}$ (100Ω load) |
| Command Station Output Current Limit | 1A |

2.2.1.1 Test Criteria

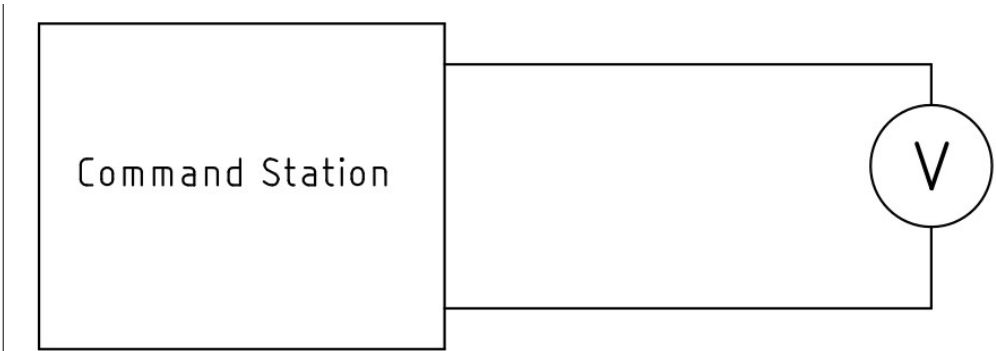


Figure 2: [Open Circuit Test](#)

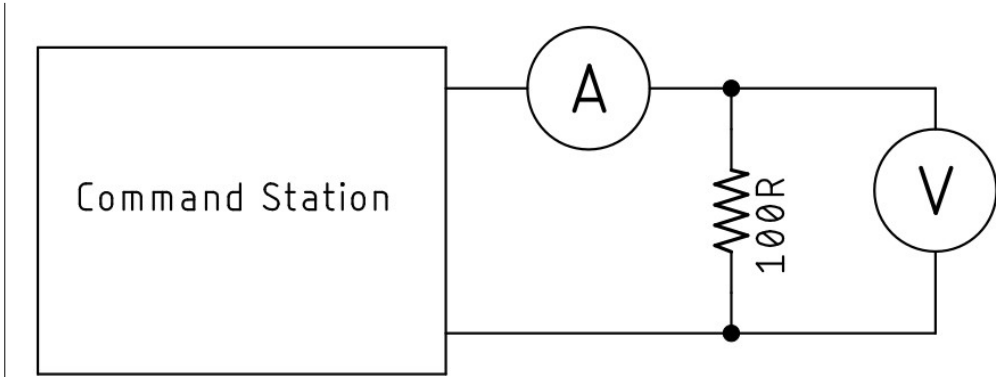


Figure 3: [100Ω Resistive Load Test](#)

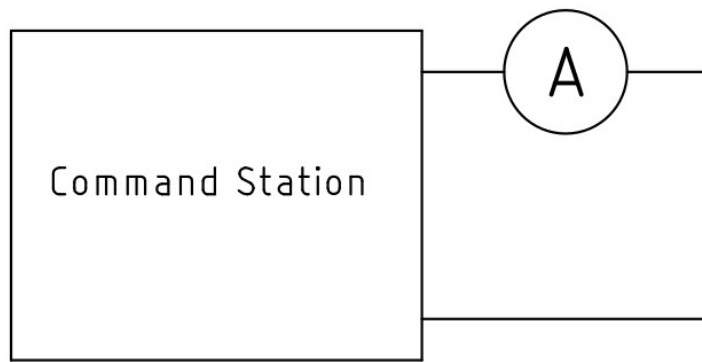


Figure 4: [Short Circuit Test](#)

110 2.2.2 Power Station Input Signal

The Power Station ~~must~~[shall](#) accept as a valid input a bipolar signal with an amplitude of at least $\pm 7V$ and shall be capable of accepting signals with an amplitude of up to $\pm 24V$ without damage.

A ~~p~~Power ~~s~~Station may reject signals of less than ± 7 volts, but is not required to do so, with no lower limit defined.

115 So that multiple Power Stations may be operated by parallel connection to the same Command Station output, the Power Station shall draw no more than 25mA from its input terminals when the input signal has an amplitude of $\pm 10V$.

Because the signal is bipolar, no particular relationship of either part of the signal to a ground reference may be inferred. Power Stations shall interpret the signal at their inputs as differential
120 in nature and shall not require any [explicit or](#) implied ~~third~~^{3rd} connection as a reference. The Power Station's ~~response to this differential signal shall not be adversely affected by~~ [shall operate in the presence of](#) common mode voltages ~~as great as up to $\pm 24V$ of either polarity~~
between the Command Station's internal reference and that of the Power Station.

[Table 5: Summary of Requirement Values](#)

| | |
|--|-------------------|
| Power Station Input Voltage Max | $\pm 24V$ |
| Power Station Input Voltage Min | $\pm 7V$ |
| Power Station Input Current Max | 25mA at $\pm 10V$ |

125 2.2.2.1 [Test Criteria](#)

[The circuit in](#) Error: Reference source not found [shall be used with the Command Station \(Test Harness\) output voltages of \$\pm 7V\$, \$\pm 10V\$, and \$\pm 24V\$. The Power Station load current shall only be evaluated at \$\pm 10V\$.](#)

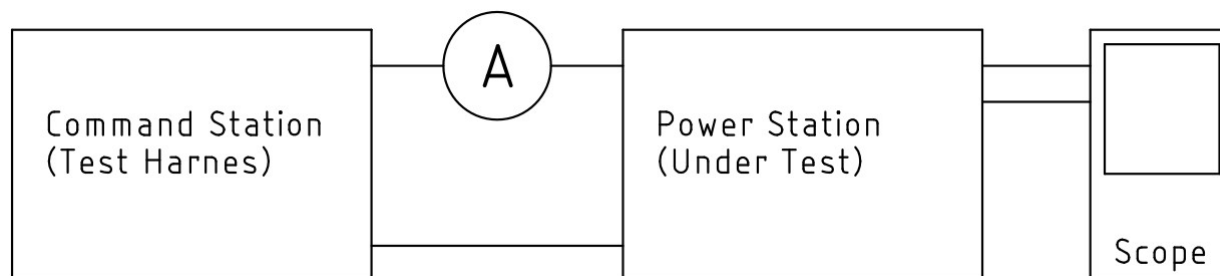


Figure 5

2.3 Driver/Receiver Interface

130 The Driver/Receiver Interface type is characterized by the Command Station output connected to the Power Station input using a differential TIA/EIA-422 or TIA/EIA-485 driver/receiver pair. This interface also carries a ground signal which the differential signals shall be referenced to.

135 The NMRA Conformance and Inspection department shall work with the manufacturer to determine conformance through design inspection. Conformance requires that industry standard TIA/EIA-422 or TIA/EIA-485 components are used.

2.3.1 Command Station Output Signal (TIA/EIA-422)

A bipolar signal ~~must~~shall appear differentially on a two-wire cable with a signal amplitude of no less ~~than~~ ± 21.5 V and no greater than ± 106 V. The Command Station output ~~must~~shall be capable of supplying ± 21.5 V into a ~~90~~100 Ω resistive load.

140 The output current of each differential signal shall be limited to no greater than ~~250~~150mA when shorted to the reference ground to reduce hazards in case of a short circuit in the Power Station Interface. ~~The output shall be short circuit protected to prevent damage to internal devices when a short is present at the output connection.~~

These specs are intentionally designed around ~~the~~ TIA/EIA-422 ~~and TIA/EIA-485~~ standards.

Table 6: Summary of Requirement Values

| | |
|--|--|
| Command Station Output Differential Voltage Max | <u>± 106V</u> (open circuit) |
| Command Station Output Differential Voltage Min | <u>± 21.5V</u> (90 Ω load) |
| Command Station Output Short Circuit to Ground Reference Current Limit | <u>150</u> 250 mA |

145 2.3.2 Command Station Output Signal (TIA/EIA-485)

A bipolar signal shall appear differentially on a two-wire cable with a signal amplitude of no less than ± 1.5 V and no greater than ± 5 V. The Command Station output shall be capable of supplying ± 1.5 V into a 60 Ω resistive load.

150 The output current of each differential signal shall be limited to no greater than 250mA when shorted to -7V or +12V to reduce hazards in case of a short circuit in the Power Station Interface.

These specs are intentionally designed around the TIA/EIA-485 standard.

Table 7: Summary of Requirement Values

| | |
|--|---------------------------|
| <u>Command Station Output Differential Voltage Max</u> | <u>±5V (open circuit)</u> |
| <u>Command Station Output Differential Voltage Min</u> | <u>±1.5V (90Ω load)</u> |
| <u>Command Station Output Short Circuit to -7V or +12V</u> | <u>250mA</u> |

2.3.3 Power Station Input Signal (TIA/EIA-422)

The Power Station ~~must~~shall accept as a valid input a bipolar signal with an amplitude of at least ±200 mV ~~and shall be capable of accepting signals with an amplitude of ±7V without damage.~~

So that multiple Power Stations may be operated by parallel connection to the same Command Station output, the Power Station shall have a receiver input resistance of 4KΩ or greater~~draw no more than 1.5mA from its input terminals when the input signal has an amplitude of ±5V.~~

To account for common mode noise and differences in reference ground potential between the Command Station and Power Station, the Power Station's ~~response to the differential signal shall not be adversely affected by~~ shall operate in the presence of common mode voltages up to ±7V relative to the Power Station's reference ground input.

Table 8: Summary of Requirement Values

| | |
|---|--------------------------|
| Power Station <u>Common Mode</u>Input Differential Voltage Max | ±7V |
| Power Station Input Differential Voltage Min | ±200mV |
| Power Station Input <u>Resistance Min</u>Current Max | <u>4KΩ</u> 1.5 mA at ±5V |

2.3.4 Power Station Input Signal (TIA/EIA-485)

The Power Station shall accept as a valid input a bipolar signal with an amplitude of at least ±200 mV.

So that multiple Power Stations may be operated by parallel connection to the same Command Station output, the Power Station shall have a receiver input resistance of 12KΩ or greater.

To account for common mode noise and differences in reference ground potential between the Command Station and Power Station, the Power Station shall operate in the presence of common mode voltages between -7V to + 12V relative to the Power Station's reference ground input.

Table 9: Summary of Requirement Values

| | |
|---|--------------------|
| <u>Power Station Common Mode Voltage Max</u> | <u>-7V to +12V</u> |
| <u>Power Station Input Differential Voltage Min</u> | <u>±200mV</u> |
| <u>Power Station Input Resistance Min</u> | <u>12KΩ</u> |

3 Physical Medium

The cable used for transmitting the signal from the Command Station signal generator to the Power Stations shall be a single pair of wires and may utilize any wireing method from twisted

175 pair to coaxial cable. The minimum wire size shall be 26 gauge. ~~While there may be no particular length limitations at the data rates involved, practical consideration suggests that no Power Station or Power Station Interface Repeater should be greater than 1000 ft (300 meters) in distance from the Command Station signal generator, or Power Station Interface Repeater output used to drive the Power Station Interface.~~

Additionally, the Driver/Receiver interface option shall carry a reference ground signal.

180 ~~To reduce possible RF interference, it is advisable to use twisted pair conductors or a cable that keeps the wires totally parallel as the bus. In the unlikely event that this is insufficient to eliminate the interference, then shielded twisted pair may be used. Heavier wire, shielded wire, or coaxial cable may be used if there is a need for longer run lengths, or a desire for better RF shielding.~~ The Power Station Interface shall not require special termination.

185 4 Topology

Only one Command Station signal generator output or Power Station Interface Repeater output may be connected to a Power Station Interface. Inputs of many Power Stations may be connected in parallel connection to the two wires of the [Power Station Interfacebus](#). It is acceptable to use tree, star, and daisy chain connections. However, it is not allowed to connect any part of the ~~is bus~~ [Power Station Interface](#) in a loop. The [Power Station Interfacebus](#), or branches, ~~must~~shall not create a loop to themselves or to another branch.

5 Labeling

The Command Station, Power Station, or Repeater shall be directly labeled and/or provide accompanying documentation to indicate the following properties:

- 195 1. Interface type used (Full Scale or Driver/Receiver).
2. Power Station Interface output [current](#) capacity or limit (Command Station and Repeater only).
3. Power Station Interface input loading (Power Station and Repeater only).
 1. [Current in the case of Full Scale Interface](#)
 - 200 2. [Receiver resistance in the case of Driver/Receiver Interface](#)
4. [Which terminals carry the P](#)positive and negative polarity signals. If [terminals are](#) labeled A and B, A ~~must~~shall correspond to the positive polarity and B ~~must~~shall correspond to the negative polarity.
5. Power Station [e](#)Common (only required if Power Station input is not electrically isolated).
- 205 6. [If the Power Station Interface on a Power Station is electrically isolated, it shall be noted.](#)

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- 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. RailCommunity is an organization of manufacturers that creates German language standards for model railway electronics.](#)
- ii [NEM stands for Norms of the European Model Railroads. Norms, in this context, is intended to have an equivalent meaning to Standards. MOROP is the organization that maintains the NEM documents. MOROP is an organization that creates model railway standards primarily targeted at the European market.](#)
- iii [ANSI stands for American National Standards Institute. TIA/EIA stands for Telecommunications Industry Association/Electrical Industries Association](#)