

This Recommended Practice received approval by the NMRA Board of trustees in July 2003.

1. Overview

The purpose of this RP is to define standardized communication between Command Stations and Power Stations (boosters) 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 not applicable when testing an integrated Digital Command Control System for Conformance, unless a Power Station Interface output is to be tested for Conformance.

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 eventual DCC signal measured at the track.
3. Define the transmission medium of the interface.
4. Define the allowable physical topology of the interface.
5. To allow common labeling of the various components and connections
6. Since this RP is optional all devices designed to follow this RP shall be clearly labeled.

1.1. Terminology

Throughout this RP the following terms are used:

Digital Command Control (DCC)	Method of controlling multiple trains and accessories using digital communications packets to send commands. The NMRA DCC Standards S-9.1 and S-9.2 for digital command communication for model trains.
Bipolar signal	An electrical signal that carries the NMRA DCC information that has 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 to - volts)
+Unipolar signal	In the context of the NMRA DCC standard, 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.
Topology	The physical layout of the connecting cable(s) that carry the signal from the Command Station or Computer Command Station to the Power Station.
Power Station Feedback	An electrical signal that carries information from the Power Station back to the Command Station or Computer Command Station.
DCC Positive Polarity	The wire or rail, which has a positive voltage for the first half of the DCC bipolar bits.
Command Station Signal Generator	The portion of the Command Station whose purpose it is to send a continuous stream of packets to the Power Station Interface.
Power Station (Booster)	A device intended to amplify the low current DCC electrical signals transmitted from the Power Station Interface 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 boosters or power boosters.
Power Station Interface	The communications medium ("wires") which connect the Command Station's signal generator to Power Stations.
Power Station Interface Repeater	A device that amplifies the Power Station Interface power to allow additional power stations to be connected.

2. Electrical Characteristics

25 The interface interchange specifications are divided into two types, one for opto-isolated, or current input type, and one for Driver/Receiver, voltage input type. Command Station / Power Station combinations following one of these types may interchange with devices of the same type. There is no exclusion of interchange between the two types as long as the manufacture of the equipment documents the interchange.

2.1. Common Characteristics

30 The Command Station to Power Station signal described in this document shall conform to the timing specifications described in the NMRA DCC Standard S-9.1, and to the protocol specifications of NMRA DCC standard S-9.2, and related Recommended Practices. Signal characteristics for the Command Station to Power Station signal are described in this document.

2.1.1. Command Station (signal generator) output signal

35 The Signal Generator portion of the Command Stations must provide, as input to the Power Station Interface, a signal that conforms to the specifications of NMRA S-9.1 with the following additional restrictions. The Signal Generator shall transmit "1" bits with the first and last parts each having duration of between 56 and 59 microseconds. . The Signal Generator shall transmit "0" bits with each part of the bit having duration of between 97 and 9898 microseconds.

2.1.2. Power Station input signal

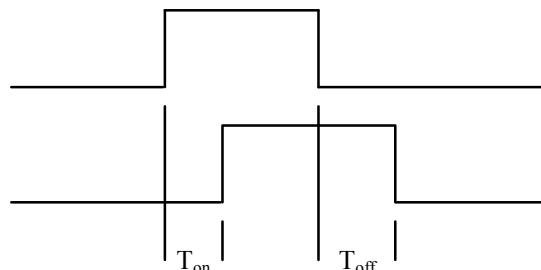
40 A Power Station should not alter the signal from its Power Station Interface input to its track output terminals outside the range of the following:

Tonrising edge delay

Toff falling edge delay

45 The total skew (Ton) should not exceed 5 micro seconds.

The total distortion (the combination of $|T_{\text{off}} \text{ minus } T_{\text{on}}|$) should not exceed 2 micro seconds.



2.1.3. Power Station Interface Repeater Input and Output

A Power Station Interface repeater amplifies the Power Station Interface signals so that additional power stations can be powered. Only a single repeater can be used on any Power Station Interface segment. On input, the repeater has the same requirements of a power station with the additional requirement. The input amplitude that it must accept is reduced to $\pm 4.5V$. On output, the repeater has the same requirements as a command station's signal generator plus the additional requirement that the total distortion (the combination of $|T_{on} - T_{off}|$) should not exceed .5 microseconds.

2.1.4. Power Station Common

Power Stations must provide the ability to connect the common side of their DC power supplies together.

2.2. Opto-isolated (Current) Interface

The opto-isolated (current) interface type is characterized by the Power Station input connected to the LED portion of an opto-coupler. It is not required to be implemented with an opto-coupler.

2.2.1. Command Station output signal

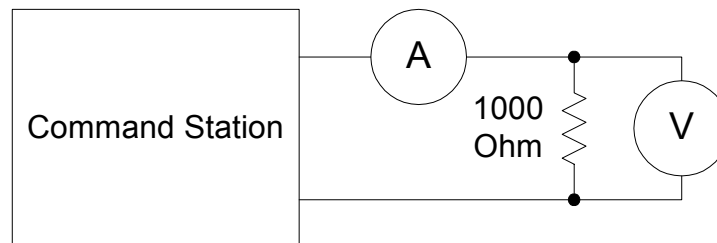
A bipolar signal must appear differentially on a two-wire cable with a signal amplitude of no less $\pm 8V$ and no greater than $\pm 22V$. The Command Station output must be capable of supplying ± 8 volts into a 1K-ohm resistive load, so that multiple Power Stations may be connected to this output.

A unipolar signal must appear on a two-wire cable, one signal, one ground, with a signal amplitude of no less $\pm 8V$ and no greater than $\pm 22V$. The Command Station output must be capable of supplying ± 8 volts into a 1K-ohm resistive load, so that multiple Power Stations may be connected to this output.

The output current should be limited to no greater than 1000 mA to reduce hazards in case of a short circuit in the Power Station Interface. The output should be short circuit protected to prevent damage to internal devices when a short is present at the output connection.

Test Criteria (Circuit)

The following test circuit should be used to determine conformance:



2.2.2. Power Station input signal

The Power Station must accept as a valid input a bipolar, or unipolar signal with an amplitude of at least $\pm 7V$ and should be capable of accepting signals with an amplitude of $\pm 22V$

without damage. A power station should reject signals of less than 4 volts or noise signals of less than 2 milliamps of current.

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

90 If the input signal is bipolar, no particular relationship of either part of the differential signal to a ground reference may be inferred. Power Stations should interpret the signal at their inputs as differential in nature and should not require any implied 3rd connection as a reference. The Power Station's response to this differential signal should not be adversely affected by common mode voltages as great as 22V of either polarity between the Command Station's internal reference and that of the Power Station, as happens if both were powered from a common power source.

95 If the input signal is unipolar, the signal will be referenced to signal ground.

2.3. Driver/Receiver (Voltage) Interface

The Driver/Receiver (Voltage) interface type is characterized by the Command Station output connected to the Power Station input using bi-polar, differential, driver/receiver pair.

2.3.1. Command Station output signal

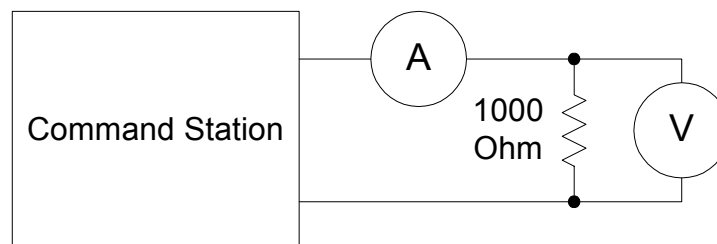
100 The bipolar signal must appear differentially on a two-wire cable with a signal amplitude of no less $\pm 3V$ and no greater than $\pm 12V$. The Command Station output must be capable of supplying ± 3 volts into a 1K-ohm resistive load, so that multiple Power Stations may be connected to this output.

105 The unipolar signal must appear on a two-wire cable, one signal, one ground with a signal amplitude of no less $\pm 3V$ and no greater than $\pm 12V$. The Command Station output must be capable of supplying ± 3 volts into a 1K-ohm resistive load, so that multiple Power Stations may be connected to this output.

110 The output current should be limited to no greater than 100 mA to reduce hazards in case of a short circuit in the Power Station Interface. The output should be short circuit protected to prevent damage to internal devices when a short is present at the output connection.

Test Criteria (Circuit)

The following test circuit should be used to determine conformance:



2.3.2. Power Station input signal

115 The Power Station must accept as a valid input a bipolar, or unipolar signal with an amplitude of at least $\pm 2.5V$ and should be capable of accepting signals with an amplitude of $\pm 12V$ without damage. A power station should reject signals of less than 2 volts or noise signals of less than 2 milliamps of current.

So that multiple Power Stations may be operated by parallel connection to the same Command Station output, the Power Station should draw no more than 2.5mA from its input terminals when the input signal has an amplitude of $\pm 5V$.

If the input signal is bipolar, no particular relationship of either part of the differential signal to a ground reference may be inferred. Power Stations should interpret the signal at their inputs as differential in nature and should not require any implied 3rd connection as a reference. The Power Station's response to this differential signal should not be adversely affected by common mode voltages as great as 12V of either polarity between the Command Station's internal reference and that of the Power Station, as happens if both were powered from a common power source.

If the input signal is unipolar, the signal will be referenced to signal ground.

3. Safety

To prevent locomotives from converting to analog power and begin operating uncontrollably, power stations shall not generate signals when the Power Station Interface has less than ± 2 volts or current less than 2 milliamps. High-impedance Power Station inputs must guarantee a minimum of ± 1 volt differential when the inputs are open or tri-stated.

To prevent dangerous heat buildup in the Power Station Interface any connection capable of acting as a Power Station Interface ground must be of sufficient size to handle the required current.

4. 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 the Power Station Interface wires and may utilize any wire method from twisted pair to coaxial cable. The minimum wire size should 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.

Two additional optional wires for feedback from the Power Station to the Command Station may be provided. The protocol on these lines is to be determined. Manufacturers that utilize these additional lines are encouraged to provide these specifications to the NMRA for possible future standardization

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.

5. 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 bus. It is acceptable to use tree, star, and daisy chain connections. However, it is not allowed to connect any part of this bus in a loop. The bus, or branches, must not create a loop to themselves or to another branch. If multiple Power Station Interfaces are used on a layout, they must not be interconnected. They should be clearly identified to eliminate possible cross connecting.

6. Labeling

165 Command Stations and Power Stations (boosters) that are designed to follow this RP shall be clearly labeled. A standard method of labeling should be applied to Command Stations and Power Stations to let end users know how many devices may be connected.

It is preferred that a physical label be applied or incorporated into the device's graphics, but it is only required for the documentation to indicate the output or load requirements.

170 Example: This Command Station uses the Opto-isolated (Current) Interface and will drive 125ma to the Power Station Interface.

The Power Station and Repeater label should indicate the amount of power required to properly drive the device.

175 Example: The Power Station uses the Driver/Receiver (Voltage) Interface and requires 10ma.

175

180 All devices will clearly label all Power Station Interface wires and also which lead is intended for positive polarity of both the Power Station Interface and the output rail. For this RP positive polarity is defined by the wire that has the leading edge of the first half of each data bit going positive.

All common connections (both signal and earth ground) that are possible or built in to each device shall also be clearly labeled. Rail Outputs shall be labeled Rail(A) and Rail(B) for each phase.

185