This Recommended Practice received final approval from the NMRA Board of Trustees in January 1995, March 1997 and July 2003. Changes since the last approved version are indicated by change bars on the left or right side of the document.

Electrical Interface & Wire Color Code For Digital Command Control, All Scales

Approved, July 2003 | RP 9.1.1

The purpose of this Recommended Practice is to simplify the installation and exchange of electronic devices (hereafter called "controllers") which are designed to control or modify the behavior of motors, lights, and other similar accessories installed in locomotives and other rolling stock by recommending:

- a color code for the wires used in these locomotives or cars, and
- a method to interface the controllers with the internal wiring or power-routing PCB of the locomotive or car.

This Recommended Practice applies to locomotives and cars of various sizes and scales, all kinds of controllers (digital command control decoders in particular), and 2-rail, 3-rail (central or trackside) and overhead wire power distribution systems. Refer to NMRA Data Sheet 9.1.1 for further information as it relates to this area.

A. General Interface Requirements

The primary purpose of an interface is to make it easy to insert a controller between the power pick-up system and the motor(s), light(s), and/or other similar accessories installed in the locomotive or car. The interface should assure an easy, precise, and error-free installation or exchange of a controller. When an interface and/or controller are installed in the locomotive or car by the manufacturer, this should be done in such a manner that it does not restrict the removal of the body from the chassis.

If no controller is installed by the manufacturer, that part of the interface that would be connected to a controller shall be replaced by a "dummy" part that should enable the locomotive or car to operate as if no interface had been present. Also, enough room must be available around the installed part of the interface to enable the replacement of the "dummy" part by one connected to a controller (i.e. enough room shall be available for the missing part and for its associated wiring to reach an area where a controller could be easily installed).

B. Locomotive Color Code of Wiring

If the manufacturer of model locomotives or cars uses wires within these to connect the power pick-ups to the motor(s) and/or light(s), the following is the recommended color assignment for these wires. All other wiring connections have no recommended color, but may not use one of the following colors. Also, the purpose of any other wiring connections has to be documented.

RED	from right-hand rail power pick-up (or center rail, outside third rail, traction/overhead wire) to motor or interface
ORANGE	from interface to motor brush (+) connected to right-hand rail (or center rail, outside third rail, traction wire)*
BLACK	from left-hand rail power pick-up to motor or interface
GRAY	from interface to motor brush (-) connected to left-hand rail *
WHITE	front headlight(s) power sink
YELLOW	rear headlight(s) power sink
BLUE	common (+) headlight(s)/function(s) power source
BLACK with WHITE stripe	common (-) power sink

* Present only when an interface is built-in the locomotive or car

C. Locomotive Interface Electromechanical Specifications

The interfaces can be of two kinds: basic service or extended service. The basic service interfaces only provide connections from the power pick-ups to one motor and to front and rear headlights, while the extended service interfaces also provide connections to additional motor(s), light(s) and/or other accessories[1].

When an extended service interface socket (or plug) is built-into a locomotive or car by a manufacturer, the manufacturer shall document very clearly which connection is wired to which built-in equipment. The extended service socket (or plug) should be made in such a way that it is possible to insert a basic service plug (or socket) only in those socket holes (plug pins) corresponding to the basic service socket (plug).

[1]The Medium design interface optionally allows the use of one of the basic service connections for an accessory control function.

Three different interface designs (Small, Medium, and Large) are specified for different size and power applications. Their electromechanical characteristics are specified in Table 1, while the assignment of their connections is given in Table 2. Figures 2 and 3 illustrate the Medium interface socket and the Small interface socket, and the numbering of the connections on each one.

Locomotives or cars that have a built-in interface (socket or plug) shall be identified as having one of the specified designs by using the appropriate pictogram as shown in Figure 1. The same pictograms shall be used to identify the interface plug or socket design that is on the controller. These pictograms shall be clearly visible on the locomotive, car or controller packaging.

For the Small and Medium designs, connection 1 shall be identified clearly on both parts of the interface. In Figures 2 and 3 a small triangle is used to identify connection 1, but other symbols may be used. The connection layout for the Large design is left to the manufacturer but each connection shall be labeled such that its purpose can be identified easily. It is recommended that these connections be identified either with their number or their corresponding wire color.

For Medium Interface designs, a minimum distance of 0.180" (is required for decoder clearance above the socket.

Table 1: Basic Interface Electromechanical Characteristics

	Small	Medium	Large
Connections (layout)	6 (1x6)	8 (2x4)	4 (none)
Part in locomotive/car	female	female	male
Pitch	0.050"	0.100"	None
Pin Section	circular(1)	circular(1)	Circular
Pin length	0.118"	0.155"	0.300"
Tolerance	0.001"	0.010"	0.030"
Pin diameter	0.017"	0.022"	0.050"
Tolerance	0.002"	0.002"	0.003"
Power rating (2)	0.50 A	1.50 A	4.00 A
Peak Power rating	0.75A	3.00 A	6.00 A
Suitable for scales	N or larger	HO or larger	O or larger

(1) Pins with a square or rectangular section are an acceptable alternative provided they offer similar power rating and physical contact quality as pins with a circular section.
(2) This power rating value applies to the individual connections of the interface - it does not reflect a controller's power capacity nor a locomotive's motor or light power requirements. Because most controllers provide less current on the light(s) & function(s) connections, it is recommended that locomotive manufacturers clearly document the required power for each light/function. Similarly, controller manufacturers should clearly document the power rating for the light/function connections.

Figure 1: Pictograms

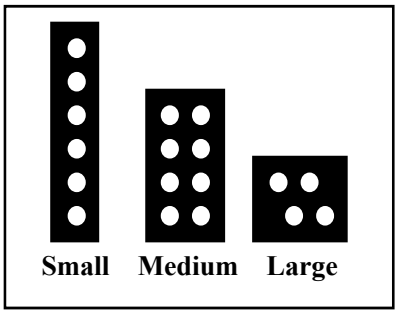


Figure 2: Top View Medium Interface

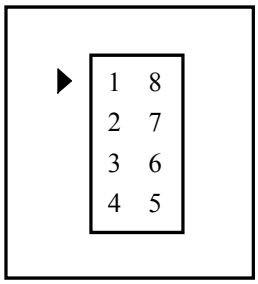
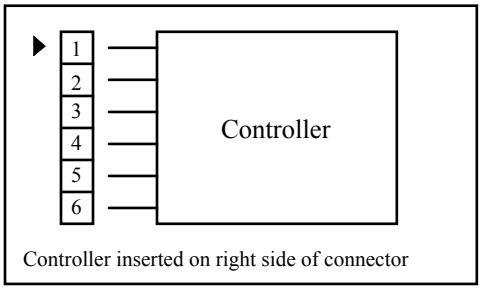


Table 2: Basic Interface Connection: Wire Assignments

Pin No.	Small	Use	Pin No.	Medium	Use
1	Orange	Motor Right	1	Orange	Motor Right
2	Gray	Motor Left	2	Yellow	Rear Headlight
3	Red	Right Rail	3	(1)	
4	Black	Left Rail	4	Black	Left Rail
5	White	Front Headlight	5	Gray	Motor Left
6	Yellow	Rear Headlight	6	White	Front Headlight
			7	Blue	Common (V+)
			8	Red	Right Rail

Connection #	Large	Use
1	Gray	Motor Left
2	Orange	Motor Right
3	Black	Left Rail
4	Red	Right Rail

Figure 3: Top View Small Interface

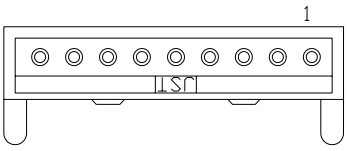


(1) This connection on the socket (in the locomotive) may be left unconnected or may be connected to an accessory. If connected to an accessory, the accessory must be protected by a diode, if it is polarity sensitive, to avoid any damage in case the plug is inserted the wrong way into the socket. On the plug, this connection may be left unconnected or may be connected to connection 7 or may be connected to a decoder's function output. In all cases, the use of this connection must be documented by the manufacturer.

Note: There must be no electrical connection on the locomotive side of the interface between either of the motor leads and either of the track leads. In addition, a direct connection must not be made between pins 3 and 7 on the locomotive side of the interface for the medium plug. Either type of connection can lead to decoder damage.

D. Controller Electromechanical Specifications

Controller circuit boards may contain an socket for the wiring harness. This socket / harness combination is currently manufactured by JST. The socket part number is S 9B-ZR-SM2-TF for the surface-mount version.



View looking into end of Decoder

Color	Use	Pin Number
Violet or Brown	Output 4	1
Black	Track – Left Rail	2
Gray	Motor (-)	3
Yellow	Output 2 (Rear Headlight)	4
White	Output 1 (Front Headlight)	5
Blue	+V	6
Orange	Motor (+)	7
Red	Track – Right Rail	8
Green	Output 3	9

E. Controller Color Code of Wiring

If the manufacturer of a controller uses wires for the connection of the controller to the locomotive, the following color scheme must be used. All other wiring connections besides those described below have no recommended color-code. The purpose of any other wiring connections and color-codes must be clearly documented.

RED	from right-hand rail power pick-up (or center rail, outside third rail, traction/overhead wire) to motor or interface
ORANGE	from interface to motor brush (+) connected to right-hand rail (or center rail, outside third rail, traction wire)*
BLACK	from left-hand rail power pick-up to motor or interface
GRAY	from interface to motor brush (-) connected to left-hand rail *
WHITE	front headlight(s) power sink
YELLOW	rear headlight(s) power sink
BLUE	common (+) headlight(s)/function(s) power source
BLACK with WHITE stripe	common (-) power sink
GREEN	Output 3 power sink
VIOLET or BROWN	Output 4 power sink