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NMRA Tech Note	
Wiring for DCC	
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1 General

1.1 Introduction and Intended Use (Informative)

This Tech Note is intended to provide information and guidance to end users for wiring for Digital Command Control (DCC) which will render good performance and reliable operation. There exist on the internet at several websites information on wiring. This Tech Note has been written by assembling the best practices based on experience and has been reviewed and approved by several manufacturers of DCC equipment.

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 Electrical Standards for Digital Command Control, which specifies signal voltages.

1.2.2 Informative

- None

1.3 Terminology

Term	Definition
Bus	Pair of wires carrying DCC signal and power from the power station to the track.
Feeder Drop	Smaller wires making a connection from the track to the bus.
Power Station	Booster providing DCC signal from the Command Station and power from the booster.
Decoder	DCC receiver for controlling vehicle animation.
Vehicle	Mobile model railroad device. This includes locomotives and other rolling stock.

2 Electrical Properties

DCC decoders have a minimum voltage at which they will operate reliably. In addition, a minimal voltage is required to properly drive the motor in the vehicle. Good wiring practices and following these guidelines will assure that at any point on the model railroad, sufficient voltage is present as well as a clear DCC signal with minimal distortion.

2.1 Voltage loss

All electrical conductors have some resistance. Because rail has more resistance than the wire that we will use in the bus we will not depend on long stretches of rail to conduct power and DCC signals.

2.1.1 Bus Wire Size

The bus wire conducts the power and DCC signal from the power station to the track. Both the length of run and current draw must be considered. As the length of run increases the bus resistance increases. As the current draw increases the voltage drop increases. E = I x R. Wire size and material will also affect voltage loss. It is recommended copper wire be used. The wire may be stranded or solid; the wire gauge accounts for the conductive cross sectional area be it stranded or solid.

The operating voltage is different for each scale. Refer to S-9.1. For best performance the bus size in American Wire Gauge (AWG) shall be such that there is no more than a 5% voltage loss at the furthest point from the power station at the maximum current of the power station. The Charts 2.1 – 2.4 below gives recommended wire size for length of run and at various currents.

The maximum current for the power station varies much between scales. For N scale a power station of 3-5 amps is typical, for HO 5 amps, for O scale power stations of 10 amps are common. The graphs below shows the voltage loss for common wire sizes at various distances. Each graph is for different currents that are common ratings for power stations.

Chart 2.1 Voltage Loss at 3A

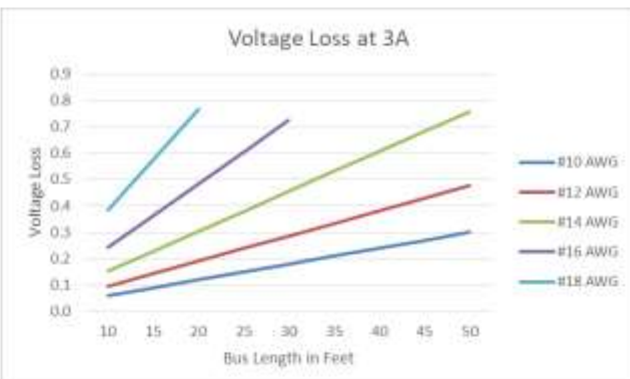

Chart 2.2 Voltage Loss at 5A

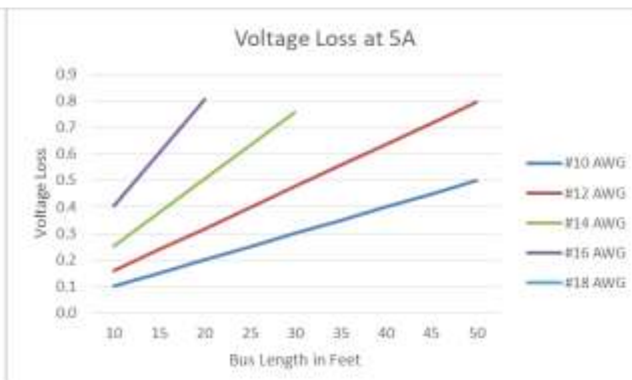

Chart 2.3 Voltage Loss at 7A

Chart 2.4 Voltage Loss at 10A

Should sections of track exceed the length of run supported by a given wire size, one may need to place the power station closer to the track, or the center of the section of track to feed in both directions, or break up the track into power districts and use multiple power stations one supplying each power district.

2.1.2 Feeder Drops

The feeder drop attached to each rail will be smaller than the bus wire to accommodate connecting the feeder to the rail. The feeder drop should be soldered to the rail for a good connection and may be either a solid or stranded wire. The feeder drop may be soldered to the side of the rail (field side) or to the bottom. With a little practice one can solder to the bottom of track with plastic ties without melting them. Once the track is painted and ballasted the connections nearly disappear.

Each section of rail should have a feeder drop wire attached. In no case should an unsoldered rail joiner be relied on to conduct the power and signal. Feeder drops should be spaced at no more than 3 feet or 1 meter apart. For very short sections of rail, less than 6 inches (15cm); a soldered rail joiner may be used to connect that short rail section to an adjacent rail with a feeder drop.

Table 2.1

Scale	Feeder Drop Min wire size
N	24-26 AWG
HO	20-22 AWG
S & O	18 AWG
G & F	16 AWG

The feeder drop may be attached to the bus wire by various means including; stripping each wire wrapping and soldering, displacement connectors, or other suitable means for a secure connection. Bare connections should be covered by heat shrink tubing, electrical tape or other suitable means of insulation. Feeder drop wires should be kept as short as possible, never exceeding 12 inches/30cm.

2.2 Signal Distortion

2.2.1 Twisted bus pairs

To reduce induction and high frequency interference the bus wires should be twisted at a rate of at least 4 turns per foot (30cm). Where there is a run where no feeder drops are to be attached the number of twist per unit length may be increased.

2.2.2 Bus terminations

The bus may be fitted with a resistor capacitor (RC) filter using a 150Ω resistor of adequate wattage in series with a 0.1µf capacitor across the bus. Such a filter is best located near the end of the bus but additional filters may be placed at points along the bus if needed.

The purpose of such filters are to reduce ringing and to shunt any voltage spikes created when there is a short circuit created by a derailment or equipment running into a turnout set against it.

Such filters will draw a small amount of current and should not be placed down line from any current sensing occupancy detector.

2.2.3 Routing of Bus

The bus should be laid out linearly. It should never be in a circle, nor should there be a loop that goes out to a branch and comes back to connect to the main. The reason for this is to prevent conflict in the DCC signal timing as it reaches the decoder.

The bus should not be run parallel for long distances to other data busses such as Computer Model Railroad Interface or Layout Command Control. Coupling and induction of signal is possible.

2.3 Short Circuit Protection

2.3.1 Power Districts

Depending on the size of the model railroad, how much track, how many locomotives and operators are in use at any given time; it may be beneficial to divide the track into power districts. Should a short circuit occur in one location, the circuit breaker for that section would protect it without interrupting the power to other power districts.

Although in the past some have used 12VDC automotive tail light bulbs to protect against short circuits, today there are circuit breakers that are much faster and can be set for various trip currents and response times. It is not recommended to use tail light bulbs for short circuit protection.

Should the number of vehicles (locomotives) in use exceed the power capacity of the power station boosters may be added to supply additional power. Boosters should be is separate power districts. Sub-districts may be divided, each protected by individual circuit breakers.

3 Document History

Date	**Description**
24-Dec-2020	First Release

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