DCC Basics for MRR layouts

By
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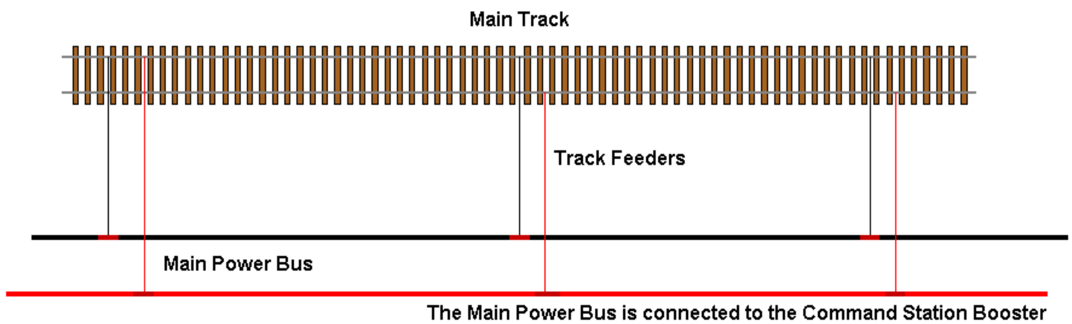
Part 3 <u>Track Wiring</u>

<u>Main Power Bus</u>



Power to run our model locomotives has to be put on the rails or track from the Command Station or Booster. We use wires to do this, as the interface or connection between the Booster and track. Since the DCC system allows for controlling multiple locomotives individually on the same piece of track, we do not need to separate our wiring into "control blocks" as we have done when using DC control. (Don't confuse the "control block" wiring that previously used toggle switches, with DCC block type wiring or Power Districts, which will be explained as we go along.) This makes the task of wiring our model railroad layouts simpler. However, because the DCC system is capable of providing more current to the track than our old DC system, the size of the wires used in various places is different.

The key to insuring that the wiring on any layout is correct for a DCC system is to perform and pass, a shorting test, also called the "Quarter test". All DCC Command Station Boosters have built in current protection. If the current protection device, usually an electronic circuit breaker built into the unit, does not trip and turn off the track power, the wiring is not sufficient in conductor size. The test then, is to place a Quarter on the track at various places around the layout and see if the circuit breaker trips and shuts down the track power. So what happens if the wiring is too small? If a short occurs on the layout, the small wire size will not allow enough current to flow from the Booster to the short, and the circuit breaker will not trip and will not stop the current flow. If the current flow does not stop, it is possible to melt or damage some parts of whatever is causing the short, or if left on a long time, burn the insulation off of the wires, which in turn may cause a fire. For that reason, it is important that the wiring be of the right size (or larger) and be done correctly.

Different size layouts have different wiring needs. However, all layouts required a Main Bus of some type. This bus is actually the main trunk line and is of heavier wire that runs under the layout and starts at the Command Station Booster and usually follows the track around the layout. If you have a small layout that has a circle of track, do not connect the bus together at the ends to make a loop. Also, do not connect the track together electrically to make a loop. Insulate the ends of both rails with an insulated rail joiner. The gaps both in the track and bus wiring should be at the farthest distance away from the Booster. The reason that we do this is because if the bus and track were in a loop, the DCC signal could be corrupted because the signal coming from both directions at the same time could cancel parts of the signal out, and control of our locomotives may become intermittent.

So the main question now becomes: "What size wire do I need for My power bus?"

Power Bus Wire Size

Small layouts can use smaller wire. That doesn't mean telephone wire, which is 24 gauge, or AWG 24 (American Wire Gauge). That means smaller than AWG 12. (Typical modern house wiring is three conductors of solid AWG 12 in a cable called Romex.)

A small layout, which is 8 feet by 12 feet or smaller can use 16 gauge wire. Layouts larger than this should use AWG 12. A layout that will fit in a single car garage can use AWG 12. A layout that fills a two-car garage can also use AWG 12, but should be broken up into separate Power Districts, each with their own Booster.

You may well ask at this point, Why such large wire? Two main reasons. The larger the wire, the less resistance. And, the larger the layout, the more locomotives we put on it, thus the more current that is needed. (This is also the reason that some layouts need separate power districts with their individual Boosters.) Since current travels down the wire, the longer the wire, the more resistance. So you see, if the wire size is large, the resistance will be less.

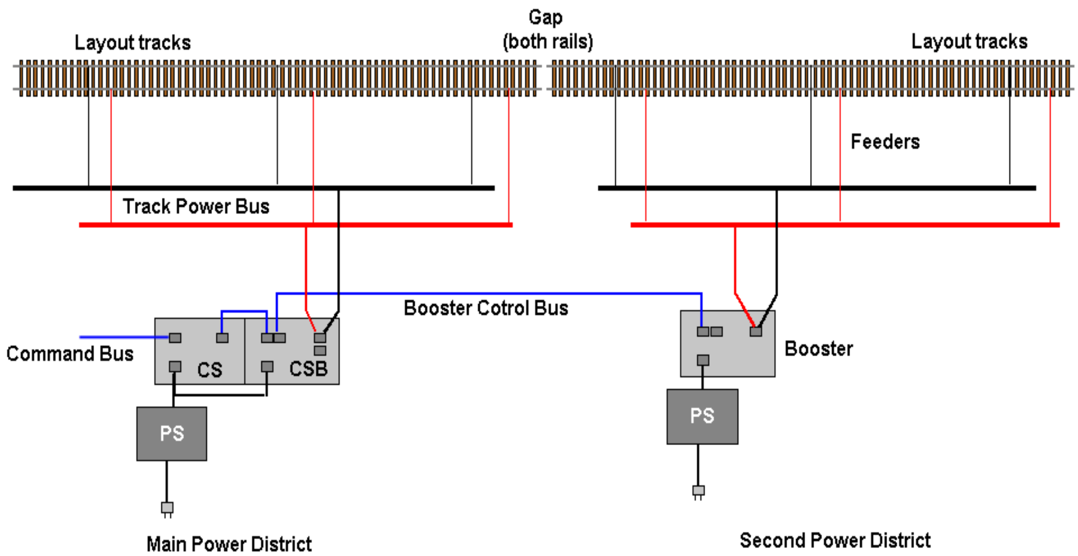
Others have gone into great detail and technical explanations as to why the bus wires should be a certain size, so I am not going to repeat them here. After all, this is supposed to be a hobby. The rule of thumb is: If the layout does not pass the quarter test, and / or the locomotives slow down when farthest away from the Command Station or Booster, the wire size is too small, or you don't have enough feeders from the Bus to the Track. (Smaller wire from the track to the Power Bus.) This now brings up another point. You have the bus wires in place but they are too small.

How do you fix it short of tearing out the wires and replacing them? By running a parallel set of wires of the same gauge or larger. When you add parallel wires, you effectively increase the current capacity and reduce the resistance. You are now using two wires as one. When you run the second set of wires, you do need to connect them to the old wires (observing the polarity or phase so they will not be shorted) at about every three to six feet. There is a non technical rule of "Three" that can be used when running parallel wires. If both wires are the same size, say AWG 16, subtract 3. You get 13. Thus the two parallel AWG 16 wires are equal to a single AWG 13 wire.

Another factor to consider is, should the bus be solid wire or stranded wire. Again the rule of thumb is, if the wire will be flexed, bent, or under vibration, use stranded wire. If the wire will be installed and not be continuously flexed, it can be solid. Wiring in buildings is solid, wiring in automobiles is stranded.

Because our Bus wires are usually AWG 12, in most cases they will not fit into the track connections on most Boosters. If this is the case with the system you have, you will need to connect a pair of smaller shorter wires between the main Bus and the Booster. These wires should be as large as possible and still fit into the Booster connection. AWG 16 will usually work. These wires should be six inches or less in length, and should be soldered to the Bus wires, or connected to the Bus through a terminal block.

Power Districts



The purpose of a power district is to increase the power on the layout tracks of a large layout. One Command Station Booster is usually not enough to power a large layout as found in a two-car garage or larger.

A Power District is an independent section of layout bus wiring that is connected to or powered by a Command Station or Booster. As an independently powered section, if a short occurs in one power district, only that section of layout is affected. The remaining section will still keep running.

My rule of thumb for the length of AWG 12 bus wires for a single Power District is 25 to 30 feet from the Booster in one direction. If the Booster is in the center of the bus, the bus can go in two or three directions, each 25 to 30 feet long, at the same time. The limiting factor in having this much wire in one Power District is the number of locomotives that will be present and running on the track in the Power District at any one time, and the current capacity of the Booster. Considering that each HO locomotive with sound will draw about 700 ma each when running, 7 locomotives with sound could be running in a Power District that uses a 5 amp Booster. So the amount of wire, or length of the Power Bus, is also dependant of the number of locomotives that will be running in the Power District at any one time.

A large home or club layout may need to be divided into two or more power districts. There are two types of Power Districts. One uses a separate auxiliary Booster, and the other uses Circuit Breakers. A true Power District will use a separate Booster. Power Districts that are made by using Circuit Breakers are called Sub-Districts because they are powered by the same Booster.

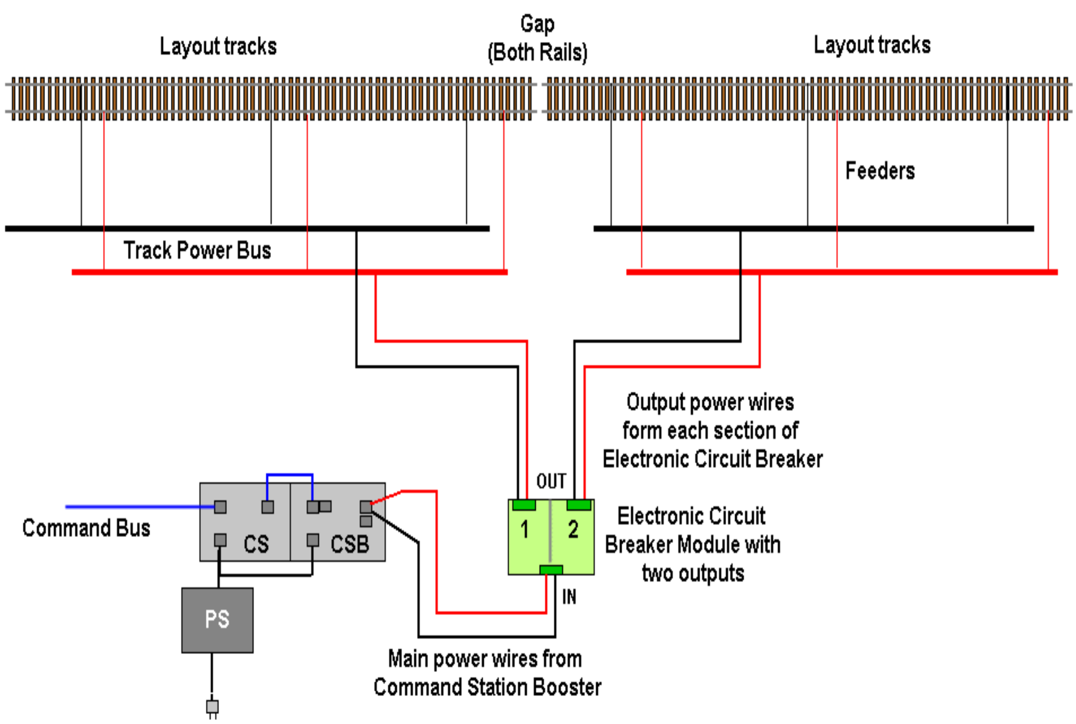
Sub-Power Districts

Power Districts that are made by using Circuit Breakers are called Sub-Power Districts because they are powered by the same main or auxiliary Booster.

The purpose of a Sub-Power District is to divide a layout into logical operating sections. As an example, one sub-district could be a classification yard, another could be the engine facilities, and another could be the main-line. Or the layout could be divided down the center with one Sub-Power District on one side and the other Sub-Power District on the other side. If a short would occur in any Sub-Power District, only that district is affected. The short will not cause the whole layout to stop working, just the section with the short in it.

In the example of the Power District in the above section that had three legs, each 25 to 30 feet long, it would be better if it were to be divided up into three Sub-Power Districts, each with it's own circuit breaker or other current limiting device in case of a short on the track. The placement of the circuit breakers would work best if they were right at the output of the Booster, thus each Power Bus leg would have it's own circuit breaker or current limiting device.

- Circuit Breaker



A Circuit Breaker can also be said to be a current limiting device.

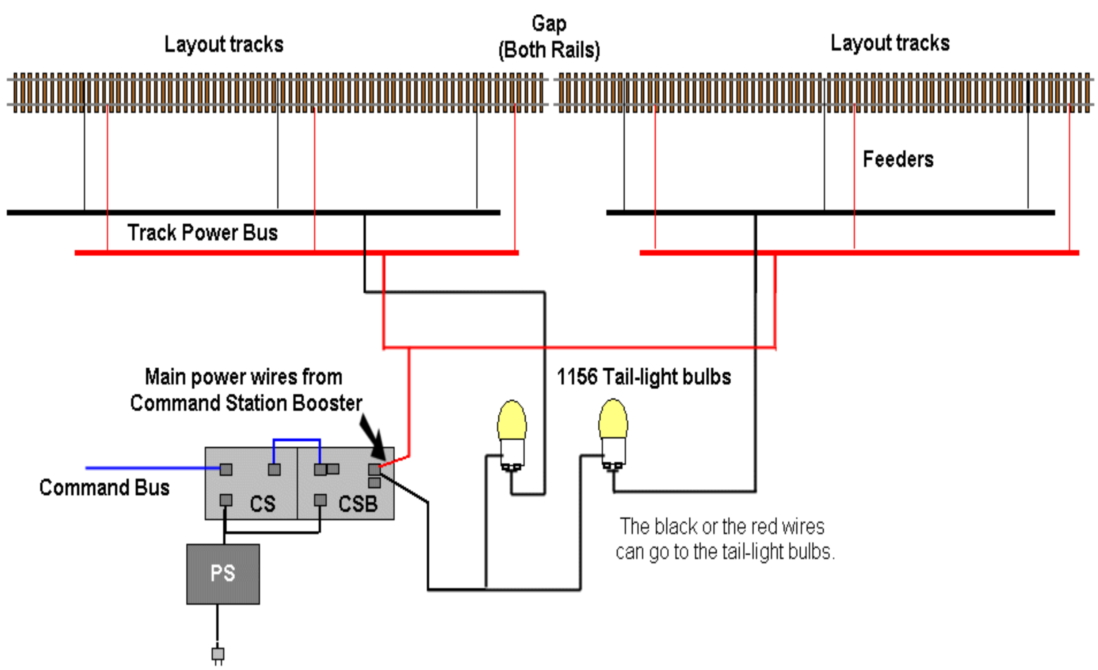
Most DCC manufacturers make some form of Circuit Breaker module or board for their systems. These are designed to detect whether or not there is a short on the output or not. If a short is detected, it will disconnect the power from the output or track. When the short is cleared, it will reset or restore the power to the track. There are third party vendors that also have Electronic Circuit Breakers for DCC systems. In most cases, you can use an Electronic Circuit Breaker made by one manufacturer, on another manufacturers DCC system.

The Circuit Breaker typically has it's input connected directly to the output of a Power Booster. The output is connected to the heavy gauge track power bus it protects.

Circuit Breakers can come in two or three forms. One type is strictly a fast acting Electronic Circuit Breaker that disconnects only one power leg or wire when a short occurs. Another type is an Electronic Circuit Breaker that disconnects both power legs or wires when the output is shorted. And yet a third type is a Circuit Breaker that disconnects power by closing or opening a relay.

Circuit Breaker boards or modules also vary in the number of output legs they have, or the number of sub-districts they can be connected to. They usually range between one to four. Some Circuit Breaker boards are also designed to provide some form of feedback to the operator. The feedback can be LED's that either go out, or illuminate, when a short occurs. Some even will provide a line, connection, or plug to provide status information to a remote location or even a computer interface.

- <u>Alternate Current Limiting Device</u>



An alternative to a circuit breaker is an automotive tail light lamp. Typically, the number 1156 lamp is used. As stated before, the object of any current protection device is to remove or limit the current supplied to the source. The 1156 lamp would be wired in series in one leg or wire coming from the Booster and connected to one power district leg.

The way that it works is as follows: If there is no short and no locomotives on the track, the bulb will not have any current through it. When a locomotive or two is on the track, a small amount of current (and DCC signal) will flow through the bulb. Since the current is low, the filament will not heat up and glow, thus the resistance of the filament will also be low, allowing current to flow. If a short occurs, the full current from the command station or booster will flow through the bulb. When that happens, the filament will heat up and glow, lighting the bulb. When that happens, the resistance of the filament increases because all of the power is being used to light the bulb. Thus little or no power is available to do damage to the area causing the short.

Track Feeders and Soldering Rail Joiners - The great debate

Track feeders are the wires that connect the track to the Main Power Bus. They are smaller wire than the main bus wires. They have to be because they have to be soldered to the track rails. You want them small, to a point, so they don't show. The smallest wire that I recommend is AWG 22. The shorter they are, the better. You can get away with AWG 20 if you are using code 83 or larger rail and use the solder sparingly. You don't want a big glob because it will show. We do want to hide our feeders if at all possible, because if you see wires connected to the track, it will ruin the illusion that our railroad isn't real. And that is our ultimate goal when building our model railroads. In the photos and videos that we take, we want the viewer to think that it is a real railroad and not a model.

The number of feeders used and their wire size is a debate in the DCC community that is always being discussed, debated, and argued.

- Wire size.

I say AWG 22 is adequate for a short feeder. Distance is relative. Again, the longer the wire, the higher the resistance. AWG 22 wire is capable of carrying 5 amps. The problem is that some modelers think a "short" feeder is two feet long. If you want to run your track feeders two feet before they are soldered to the power bus, use AWG 20.

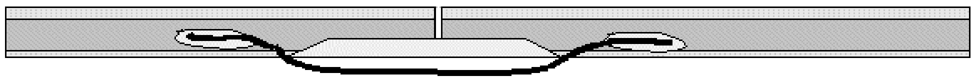
- Number of Feeders in a given length of track.

I say every six feet is good. But, it does depend on how many locomotives that you run in a consist. I usually run one or two locomotives consisted together. My track feeders are AWG 22 and six feet apart, if not a little more. I also solder my rail joints. So far I have had no problems.

- To Solder Rail Joiners or not to Solder.

Our track rails are electrical conductors. Electrical conductors should be soldered. On the other side of it, our track is a structure in our layouts, and it expands and contracts with temperature, so some gaps must be left or the track will buckle. So a trade off is required. This trade off starts with where your model railroad is located, and what kind of temperature changes it will go through during a year. The larger the temperature change, the more you must insure that you have adequate gaps. Gaps at every six feet should be adequate for most temperature changes. Everything else in between (all joiners) can be soldered.

What happens if you don't solder rail joiners? Most rail joiners will pass current when we first install them, but once we add scenery and ballast, and holding it down with water and glue, they have a tendency not to work as well. There is a trade off. If you don't solder your rail joiners, in order to insure a stable electrical connection you should probably do one of two things. Solder a feeder on every piece of rail, or, solder an AWG 22 jumper wire from one rail section to the other around the rail joiner. Having said that, most modelers probably don't do either of these things and most probably won't have problems. Some will.



Rail Joint with gap, rail joiner, and jumper wire

- <u>Rail Gaps</u>.

OK, so what is a gap? For expansion and contraction purposes, a gap occurs at a normal rail joint that is not soldered, and a small gap or space (about 0.005 to 0.010 inch or the thickness of an index card) is between the two rail sections when the temperature is warm. This type of gap is not the same as an electrical gap that is insulated, although insulated electrical gaps can be used for expansion purposes.

- <u>The track Feeder System</u>.

From the information above, you can see that Track Feeders can be a system all it's own.

Now let me tell you that I am an Electronics Technician and have been working in the field for more than 40 years, and a model railroader for most of those years. Here is what I do. I solder my rail joiners. I have some sort of gap every six feet, either and expansion gap or an electrical gap for a block. I solder bare AWG 22 feeder wires in the center of each six-foot section of track. The feeders are short. They get soldered to the rail, go down to the bottom of the sub-roadbed, and are formed into a small loop. Because of this they are about one inch long. Then I solder an AWG 18 insulated wire from the loop formed in the AWG 22 feeder to the Power Bus. If the track section is part of a block that will be detected electronically, the wire used from the feeder is AWG 16 and runs no longer than 14 feet to the detection board. So far I have not had any problems.

So as you can see, there several ways to attach and run feeders, and most will give you good performance. One thing to remember. Wires in parallel will reduce the resistance and increase the current carrying capability. So if you wire things differently and your locomotives seem to slow down, add more feeders.