How to build a better model railroad the first time

Part 6 Wiring

I have never met a model railroader who just absolutely loved wiring. On the contrary, wiring is usually considered a tedious task, and is reviled by many. One of the many benefits of the DCC control system is a major reduction in the amount of wiring needed. The two most popular control systems, DCC, and traditional DC, have some wiring in common and substantial differences as well.

Similarities:

Model trains, using either system, still need to get their power from the metal rails of our track. Metal rails are good electrical conductors, but not as reliable as wire. The rail joiners can be loose or corroded to the point that they start to act as insulators, instead of conductors, and create “dead spots” in the track. To assure reliable power is always available; anywhere along the track, it is a good practice to string a pair of large (14 gage) “bus” wires below the layout, right under the track. These bus wires are connected up to the rails by smaller (22-28 gage) “drop” or “feeder” wires. I strongly recommend having a drop wire for each and every individual rail on the layout. This means that no matter what the rail joiners do, in terms of electrical conduction, every rail will always have power. There will now simply be no “dead spots”, ever.

Now if you are using sectional, or roadbed, track, those sections are pretty short, and you would need a great many wires. This is where the soldered rail joiner comes in. When two rails are connected by a soldered rail joiner, they can (electrically) be considered one rail. So by soldering some of those short track sections together, you will create longer sections of track, and reduce the number of feeder wires needed. Some advocate soldering all the rail joiners on the whole railroad. This method creates one giant section, and reduces the feeder wires to very few. However, I recommend that you solder the joints on curves, but leave the straight track's joiners unsoldered. If temperature or humidity changes affect the wood supporting the track, or the rails themselves expand or contract; having an unsoldered joiner every so often can prevent track damage. With feeder and bus wires, we no longer have to rely on rail joiners to conduct electricity, so some unsoldered joiners won't be able to cause any dead spots.

The wheels of a model locomotive pick up power, from the rails, via wipers that are in contact with the wheels. From the wipers, power is then fed up to the locomotive's motor. What kind of electric power is picked up from the rails, and how that power gets to the motor, are two points where DC and DCC differ.

Differences:

On a DC layout the rails carry simple direct current, which travels from the loco's right side wheels directly up to motor. After current has passed through the motor, it then travels back down to the left side wheels, into the left rail, and back to the power pack.

Increasing the voltage on the rails increases the speed of the locomotive. Reversing the polarity of the voltage in the rails makes the locomotive run backwards. This system is very simple, until you add a second locomotive, which you want to control separately. (More on that later) Inside a DC locomotive, the path from wheels to motor is a simple wire, or metal contact. If the loco has a metal frame, that frame is often used as an electric conductor.

To control two or more locomotives separately with traditional DC, the track needs to be divided, with insulated rail joiners, into multiple track sections or “blocks.” Note: If you are using bus wires, they must also be broken up into separate “blocks” by cutting them at the same block boundaries where you fitted insulated rail joiners. If this is not done, then the bus wires will bypass all the insulated joiners, and you will still have one big section electrically. As a practical matter, on a small DC layout, you could omit the bus wires altogether. Individuals or clubs with large, basement-filling DC layouts may want to (and in my opinion, should) include bus wires, since their track sections will likely be long enough, and have enough rail joiners in them, to benefit from the low resistance and reliable power of bus wires. There will be a set of bus wires for each block, and the wires of one block should not connect to those of any other block.

Each of these blocks will need a pair of wires* running from that track block, back to a toggle switch on a central control panel. The toggle switches are used to select which of two power packs the track block will be connected to. Often modelers using DC control will use “center off” type toggle switches. These have a center position where neither power pack is connected to that toggle switch’s track block. This allows parking of a locomotive on that block. This system is called “dual cab control.” When two people are each operating separate trains, on a DC, dual cab control, layout; they must constantly throw the toggle switch for the next block their train will enter, over to their control. The other operator must do the same. This requires careful co-operation, and constant flipping of switches, to keep both trains moving without letting both trains get into the same block. It can get complicated.

- There is an alternate wiring scheme for a dual cab control layout which basically uses half as many wires. It's called "common rail." On a common rail layout each boundary between track blocks has only one insulated rail joiner, instead of two. The other rail has a normal metal rail joiner. The insulated joiners are always in the same (inner or outer) rail. The rail with metal joiners is the "common" rail. It is one, unbroken, continuous, rail/"block." The advantage of common rail is that each block need have only one wire to the control panel instead of two. This reduces the number of wires considerably. The common rail needs only one wire for its entire length. The toggle switches can be the single-pole-double-throw- center-off (S-P-D-T c/o) type, instead of the perhaps slightly more expensive, double-pole-double-throw-center-off (D-P-D-T c/o) type.

On a DCC layout, the track power is not the simple direct current found on a traditional DC layout. Instead, the rails carry a modified, or modulated, form of alternating current (AC). This AC power is a constant 16 volts or so. It does not change its voltage to make the loco speed up, or slow down. It does not change polarity to change the locomotive's direction of travel. Rather, the power stays constant.

Riding along on top of this constant AC current are digital signals sent out by the DCC control station, and addressed to various individual locomotives. Once these digital signals have traveled into a locomotive, they are sent into a DCC decoder circuit board. This decoder will only act on signals addressed to it. Each locomotive has its own decoder and each decoder has its own unique digital address. The decoder interprets the digital signals and sends more power to the motor to speed up, if that's what the digital signals tell it to do. All other things electrical aboard the loco, lights, sounds, etc. are also controlled by the DCC decoder. The motor on a DCC locomotive should not be electrically connected to the loco's frame. It needs to be isolated, and get its power only from the decoder. So for DCC control of all the trains on the railroad we only need two wires from DCC the control station, to the bus wires, which feed it to the rails.

That's it for train control. However, to control accessories, like turnouts, lighted buildings, signals, etc. you have two options. They can all be controlled by the DCC system, but each thing you want to control will need its own decoder. These are called "stationary decoders." Some stationary decoders have more than one output and can therefore control more than one accessory. Buying all those decoders gets very expensive, very quickly. For this reason, many modelers chose the other option, (gasp, horror!) traditional wiring. The accessories are all wired to a control panel with electrical switches on the panel to control each accessory. A separate power source is needed for accessories. An old DC power pack, or a small "wall wart" transformer, like the one that recharges a cell phone; are common choices.

So, even on a DCC layout, there will still be some wiring, just not as much as that needed for a DC layout.

Certain track arrangements require special wiring because they would otherwise cause short circuits.

They are: 1) Reverse loops

2) Wyes

3) Turntables

These items have one thing in common. Each of them can reverse a locomotive’s direction of travel on a given piece of track. Reverse loops are not always as obvious as wyes or turntables. These loops may hide inside complex track arrangements. Here is a handy trick for recognizing such potential short-circuit-causing track arrangements. On your track diagram, trace the outer rail with a yellow highlighter. Trace the inner rail with a blue highlighter. (Obviously you can use any two other colors of highlighters.)

As you trace all around a train’s route, watch for any spot where yellow and blue traces meet. That will create a dead short circuit between rails and shut down the layout. To prevent this short, we will need to put insulated rail joiners in both rails. This is true regardless of which wiring/control system you are using; Traditional (two- rail) DC, Common rail DC, or DCC. A short circuit between opposite rails will shut down any of the three.

With both rails insulated the train can enter the reverse loop and run freely until it gets to the other end of the loop and tires to go back onto the same track that it came in from. When it spans the insulated rail joints, the loco itself will cause a short circuit. Oh my, what to do, what to do. Well, that’s going to depend on which control system you are using.

The DCC folks have it easy, as usual. They can simply install a device called a “frog juicer.” It will detect the short circuit, and instantly reverse the polarity of the track feeding into/out of the reverse loop. The train can then continue on.

DC modelers, whether they use conventional two-rail, or common rail, will need to create an “X-section.” This means installing another pair of insulated rail joiners further along the track. The section of track between the two sets of insulated joiners is now completely isolated (electrically) from the rest of the track. We will need to control the polarity of this isolated “X-section” of track separately from the rest of the track. This can be done manually with a double pole double throw toggle switch. The wires from the X-section are connected to the center terminals on either side of the toggle switch. The buss wires are connected to the terminals on one end of the toggle switch, then crossed over one another, in an x shape, and then connected to the terminals at the other end of the toggle switch. Flipping the toggle switch changes the electrical polarity of the X-section so that it agrees with the polarity of the track from which the train is approaching. Various systems of automating this polarity reversing process have been used. Switch machine contacts, and relays triggered by track mounted photo sensors are two such systems. For that matter, the commercial “Frog Juicer” circuit board mentioned earlier could probably be used for this job.

Good luck;

Traction Fan