

## About our DCC columnist



**Bruce Petrarca** is a well-known expert on all things DCC.

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# DCC Impulses: Layout Wiring – Planning for the future

## Getting to know DCC!

### Key decisions made in the beginning make for easy progress later ...

**F**irst, let me thank you all for your kind comments on my humble efforts. Knowing that MRH readers are getting something of value from this makes it worth the effort. It seems there are enough folks just starting out or early in the DCC trek to make these basic ideas useful.

This month I'm going to tackle a basic subject that can have deep implications for the future expansion of your layout: planning and installing the wiring.

This is not intended to be an encyclopedic treatise on layout wiring. Instead, I'll introduce some concepts and thought processes.

There are a lot of (sometimes conflicting) ideas available from manufacturers' literature, books, webpages and fellow modelers. Let's work on making sense of them.

I am currently president of the club in my subdivision, the PCMRC ([pcmrc.org](http://pcmrc.org)). In 2006 we started building a 19 by 41 foot HO layout. It uses three DCC boosters feeding 19 power districts. A full operating session can keep 8 or 9 operators busy for up to three hours. I'll be referring to

this layout throughout this column, because it was designed from the beginning to be a "large layout" with radio DCC operation.

## Catching the Bus

There are two types of buses in a DCC system. No, these are not public transit, but electrical paths!

- Track bus – carries power and control data from the boosters to the track and, therefore, to the locos and cars.
- Throttle bus – connects your controllers to the DCC command station (system) box. This bus is called by various proprietary names, depending upon brand of system: LocoNet, XpressNet, CabBus, etc.

## Converting from DC

If you are converting an existing layout from DC to DCC, you may already have much of the track bus done and only need to add a throttle bus.

The "quarter test" (see [www.mrdccu.com/curriculum/basics/wiring.htm](http://www.mrdccu.com/curriculum/basics/wiring.htm)) will show if the existing DC track bus is adequate (DON'T perform this test with DC power-packs hooked up!) If it fails the quarter test, I highly recommend that you rip all the track wiring out and start over. Otherwise patching

and testing will probably be time consuming and frustrating.

## Planning for DCC

Okay, whether we are talking about a DC layout that needs upgrading or starting with a new layout, the best place to begin is by doing some planning.

I'm going to discuss S and smaller scale layouts in this column, as they cover the vast majority of DCC applications. That lets us use two- to eight-amp systems but precludes 10-amp systems, which are designed for larger (most specifically G) scales.

First, think about how you are starting and what – within reason – you plan for the future:

- What type of operation – round-and-round or switching – how much of each?
- How many operators – normal and maximum?
- How long a wiring run will your bus(es) require?
- Wireless control, now or later?

## Throttle Bus

Just like you need a keyboard and pointer device to communicate with your computer, you need a throttle (or cab) to talk to your DCC system.



Figure 1

Figure 1: A Digitrax UP-5 throttle panel on the PCMR layout.

Figure 2: Good and bad throttle panel configurations. There should be a single path connecting each throttle panel to the DCC system. Loops in the throttle bus will cause problems.

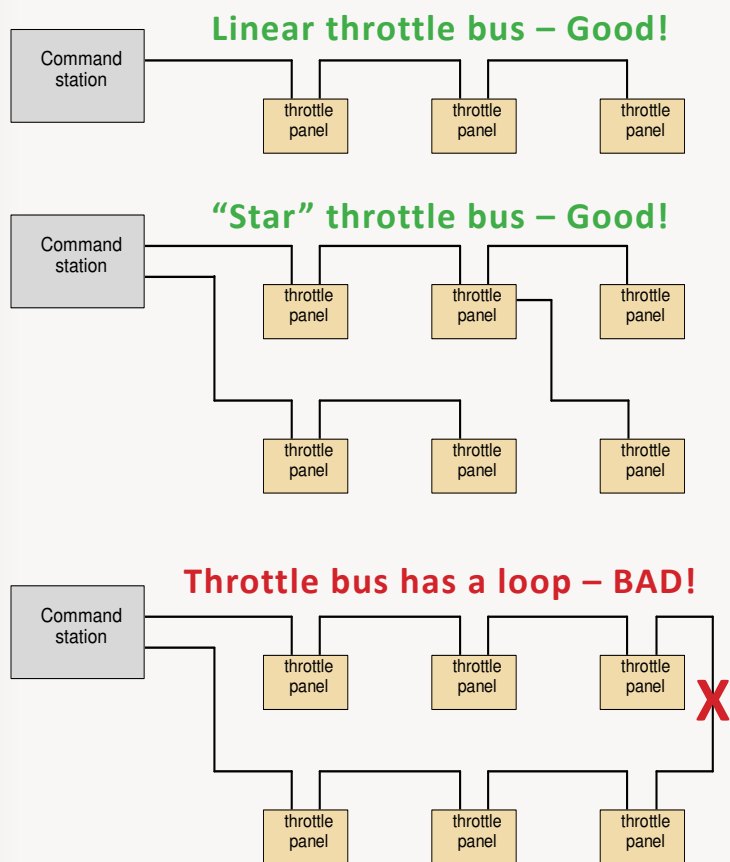


Figure 2

With your computer, you tend to sit in one place. With your DCC system, trains move around the layout, often with their crews wanting to walk along with them. If that's you, you'll want lots of places to plug in your throttle(s).

## Throttle Panels

Throttle panels are where your throttles plug in. They're usually mounted in the fascia (figure 1).

At a minimum, you will need one place to plug-in your throttle. It may be a throttle panel or the front of your system box. That is, of course, unless you have a set, like the Digitrax Zephyr, where a throttle is built into the system box.

If your layout is larger, you may want a large number of throttle panels – the number can increase dramatically depending on how far you are willing to stretch your throttle cable.

Most throttle cables are about five feet long. Throttle panels are often spaced two cable lengths (about 10') apart. Sometimes they're placed in strategic locations, such as at junctions and yards.

Layouts that use mostly radio throttles often have only a few throttle panels. Some radio throttles must be plugged in to acquire and release locos or to change MU (multiple unit) lash-ups, so panels are provided where these actions are most likely to occur.

## Bus Interference

There can be interference between the signals on the track bus and the signals on the throttle bus. It's best to allow for this in your wiring. There are three ways to minimize interaction:

- Physically separate parallel runs of the throttle bus and the track bus as much as possible.
- When you need to cross over the other bus, make the crossing at a 90° angle. Separate them vertically as much as possible, too.
- Later, I'll discuss "snubbers" to attack possible gremlins.

## Throttle Panel Wiring

Throttle panels are daisy-chained with the appropriate cable. That is, a cable comes from the system box to the first throttle panel. The next cable runs from the first throttle panel to the second, etc.

Frequently folks locate their system box in the middle of the layout to

minimize the length of track bus wiring. The throttle bus daisy-chains out in both directions from there.

Throttle buses always run straight out from the system box to the throttle panels. End each daisy-chained throttle bus at the final panel. NEVER loop it back to the system box. Each panel should have ONE path to the system box. Closing the loop will cause interference and unreliable operation on the throttle bus (figure 2).

## Throttle Bus Cable

There are two primary types of throttle bus cable:

**RJ-25 cable:** this is NOT a phone cord, no matter how much it might look like one. It is data-wired or straight-through (figure 3).

Phone cables invert and are not suitable for connecting throttle panels. Remember this when you are buying or making a cable. You will NOT find straight through cables at a hardware or home-improvement store. Buy them from your DCC dealer!

Figure 3: RJ-25 cable (six conductor) for interconnecting throttle panels on your fascia (photo courtesy NCE). Inset shows 6P6C cable end.



Figure 3

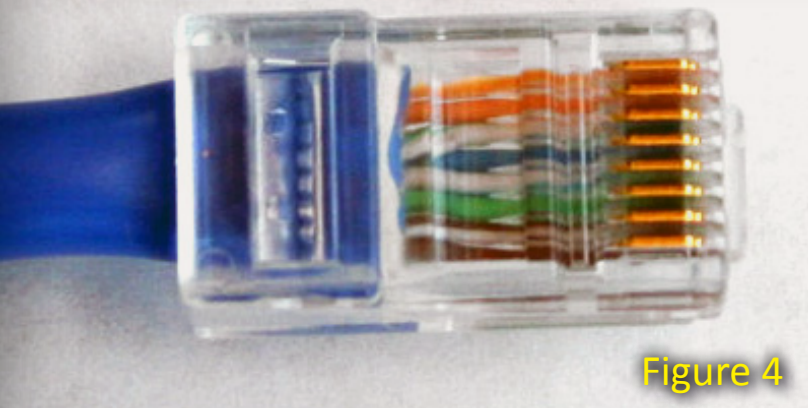


Figure 4

**Figure 4: Cat-5 Ethernet cable used by some DCC systems to connect throttle panels.**

Some folks incorrectly refer to these cables as RJ-11 or RJ-12 cables. RJ-25 is the official term for six-position connectors containing six contacts (called 6P6C). Although some DCC systems will work with four-conductor cables (6P4C), I recommend that you use six-conductor cables (6P6C) in case you change systems in the future.

**Ethernet (Cat-5 or RJ-45) cable:**

Some DCC panels use industry-standard Ethernet cables. Frequently the design doubles-up data and/or power lines. The strong insertion force and duplicate communications lines make for added reliability. This is why I recommend Ethernet cable if your manufacturer supports it.

Spacing your panels every 10' or so and connecting them with 12' to 15' cables (behind the layout fascia) allows some slack to pull out the panels for maintenance purposes.

One last caveat: stick with your manufacturer's throttle panels and cables. Don't be tempted to make your own – hardware store jacks and cables are

not designed for the frequent plugging and unplugging encountered in DCC operations.

**Track Wiring**

The #1 rule for track wiring:

*Every piece of rail should be connected to the track bus!*

Do not depend on rail joiners to conduct DCC track power between sections of rail.

One way to do this is to solder a track power drop (sometimes called a feeder) wire to every piece of rail – the metal rail joiners are responsible only for mechanical alignment of the rails and allow them to expand and contract with changes in temperature and humidity.

Another way is to solder every other rail joiner to the rails and connect power drops to the soldered joiner (figure 5). This still allows for expansion and contraction at alternate rail joints, and it halves the number of feeder wires.

Try to limit the length of your drop wires to about a foot (1/3 meter) and use 20 to 24 AWG (0.8 to 0.5 mm diameter) solid wire.

This many drops may sound like overkill. However, I've never seen a layout wired this way have conductivity issues. I have seen ones with inadequate drops destroy rolling stock with a short. The inadequate wiring

didn't allow the DCC system to detect a short and shut down. Power dissipated in a short can damage or ruin car parts! I've even seen photos of brass trucks that fell apart after the solder holding them together melted.

**Power Districts**

Power districts are areas of track that are isolated from each other for ease of troubleshooting, or to keep one operator's mistake from frustrating other operators by shutting down the entire layout.

Frequently folks look at a layout plan and think, "well, I'll make the mainline one district and the two yards their own two districts." While this will work, it doesn't lend itself to easy expansion.

Instead I offer the following concept. Define each operator's "work area." For example, a yard or an industrial district could be a work area. Make each work area one power district, including an appropriate amount of mainline.

This accomplishes the following:

- Since you are working with building blocks of layout functions, expansion is easier – just add more blocks.
- Each operator's section is isolated, so if an operator causes a short circuit, only that section loses power.
- It's much easier to find a short circuit in the track if you can isolate the problem to a small area instead of searching the entire layout. Figure 6 shows how to wire a layout to facilitate trouble-shooting.

**Color Coding**

It can be hard to remember which wire goes where while under the layout with a hot soldering iron in your hand! That's why I like to color-code.

For example, here's what we did on the PCMRC layout.

**Figure 5: Drawing of soldered rail joiner with a single drop to two pieces of track.**

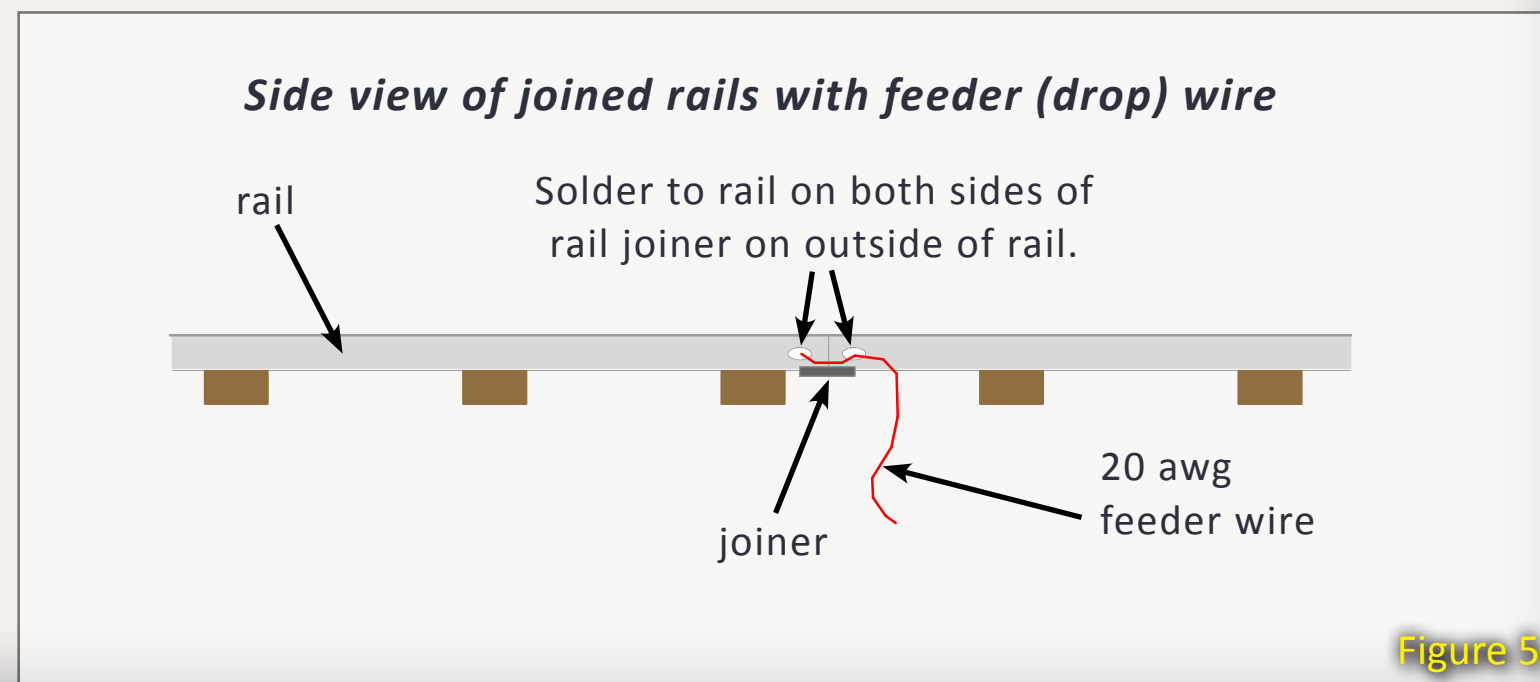
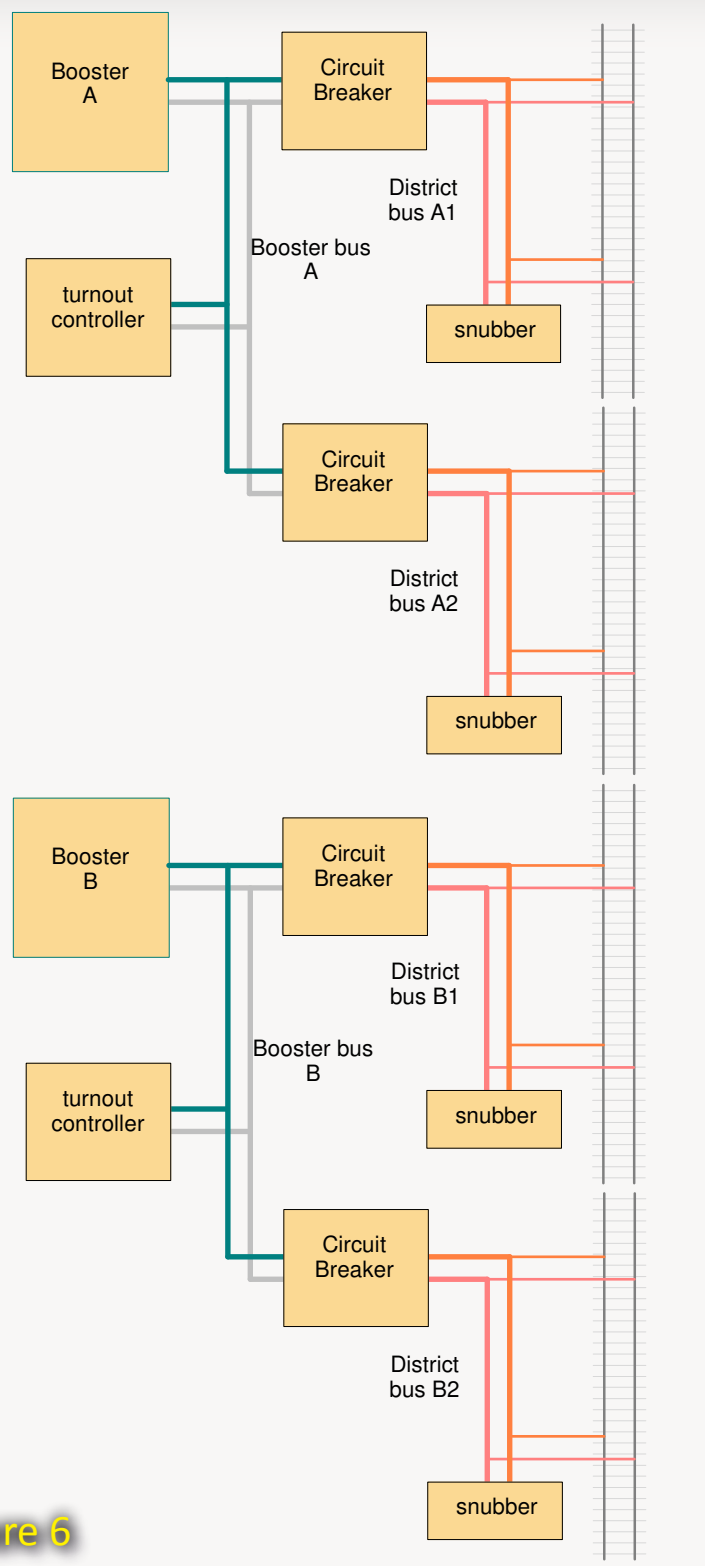


Figure 5



**Figure 6: Wiring schematic showing boosters connected to circuit breakers via booster buses, and circuit breakers connected to track districts (work areas) via district buses.**

**Figure 7: Black and white booster bus (yellow lugs) connected to a barrier strip. The metal jumpers bring the bus to a new set of terminals, ready to be connected to the input of a circuit breaker for a district bus.**

**Figure 8: Track power drops soldered to a district bus.**

**Figure 9: Two district buses in the same section of a layout. Physical position (closest to the plywood) and color allows whoever does the wiring (or repair) to know exactly which bus is being used.**

- All booster buses are twisted 12 AWG (2 mm diameter) stranded wire – white and black. This is shown running along the benchwork in figures 7 and 11.
- Each booster district is assigned a color (red, green, yellow). A piece of shrink tubing of the appropriate color can be slipped over the twisted pair wherever differentiation is needed. Barrier terminal strips are used to connect the booster bus to a district bus, as shown in figure 7.
- The district buses are 14 AWG (1.6 mm diameter) solid bare wire with track power drops connected to them. Each district is assigned its own color, such as blue.
- The circuit breakers we used switch only one side of the DCC signal. They were carefully wired so that the un-switched side was connected to the black side of the

booster bus. So, on the red booster district, the blue district bus coming out of the circuit breakers was color coded with red and blue on the switched side and red, blue and black on the un-switched side.

- Track power drops are made using 20 AWG (0.8 mm diameter) solid wire that was also color-coded. For the blue district, discussed above, the rail closest to the aisle got a blue drop. The rail closest to the backdrop got a black drop. The rhyme makes it easy to remember.

That way, when under the layout, no thinking is required. Wire the blue wire to the bus with the red and blue tubing on it. Wire the black wire to the bus wire color coded red, blue, and black (figure 8).

Our main yard has many districts under it. The color-coding allowed the wiring of it without a single mistake. Don't

Figure 6

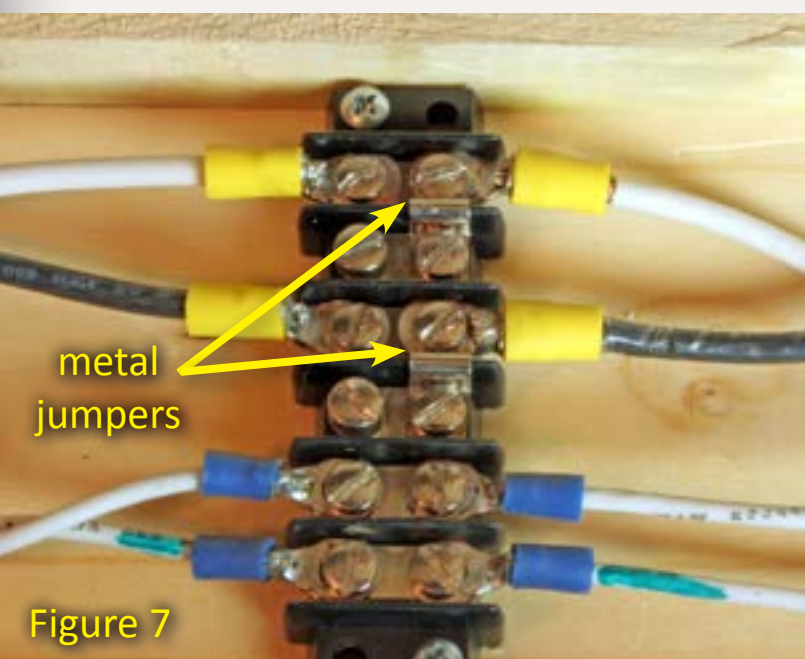


Figure 7

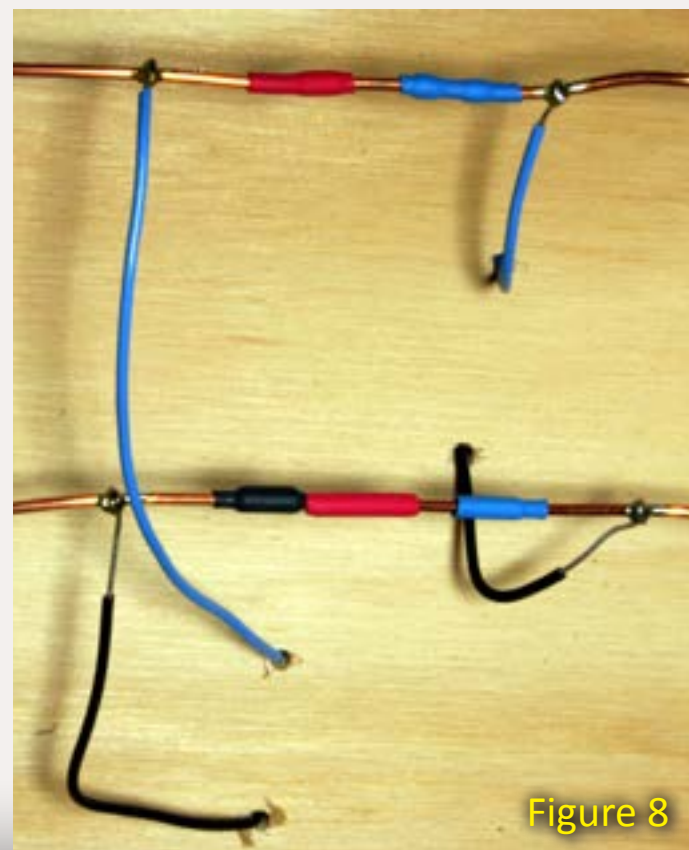


Figure 8



Figure 9



Figure 10

cross-wire power districts – keep them separate. When two districts are cross wired, a short on one takes down at least both of them and sometimes, the booster, too! This separation of colors is shown in figure 9.

## Layout Style

I'm going to discuss three basic categories of layouts. Yours may not exactly fit one of these, but they should help you get started. Read about all of them and look at your current layout and where you think you might be going. By planning for the largest, you can save time and money spent reworking your wiring!

## Simple layout

What is a simple layout? Here's a quick definition ...

One or two operators, with at most two trains running at a time and a maximum layout length from end to end of 20 feet. Something like a bedroom shelf layout might fit this category.

A simple layout usually has a single power district and can be readily operated with a two- to five-amp system with a 16 to 18 AWG (1.3 to 1.0 mm diameter) track bus and 20 to 24

AWG (0.8 to 0.5 mm diameter) solid wire feeders.

Why go for a higher-powered five-amp system when a smaller system would easily power two locomotives? One of the properties of DCC is that full power is available on the track at all times. Thus, on a simple layout, lots of things can be powered from the track that otherwise would be powered from an accessory bus on a more complex layout. Items such as:

- Building lighting
- Automation
- Background sound modules

could be powered from the track bus. Lighted cars are less likely to overload the larger system, too.

What I did with the layout shown in figure 10 was to start with an NCE PowerCab. Then, as I needed more power, I added an NCE Smart Booster, bringing it up to five amps.

## Intermediate Layout

This type of layout might fill a bedroom or be a small club layout. It often has multiple operators and trains. Separate power districts protect trains in one district from a short

Figure 10: Simple shelf layout about eight feet long, suitable for switching problems and loco testing. Built by Bruce Petrarca.

Figure 11: Circuit breaker wiring – black and white twisted 12 AWG booster bus feeds the circuit breaker. The red and black wires are the circuit breaker's output to the district bus.

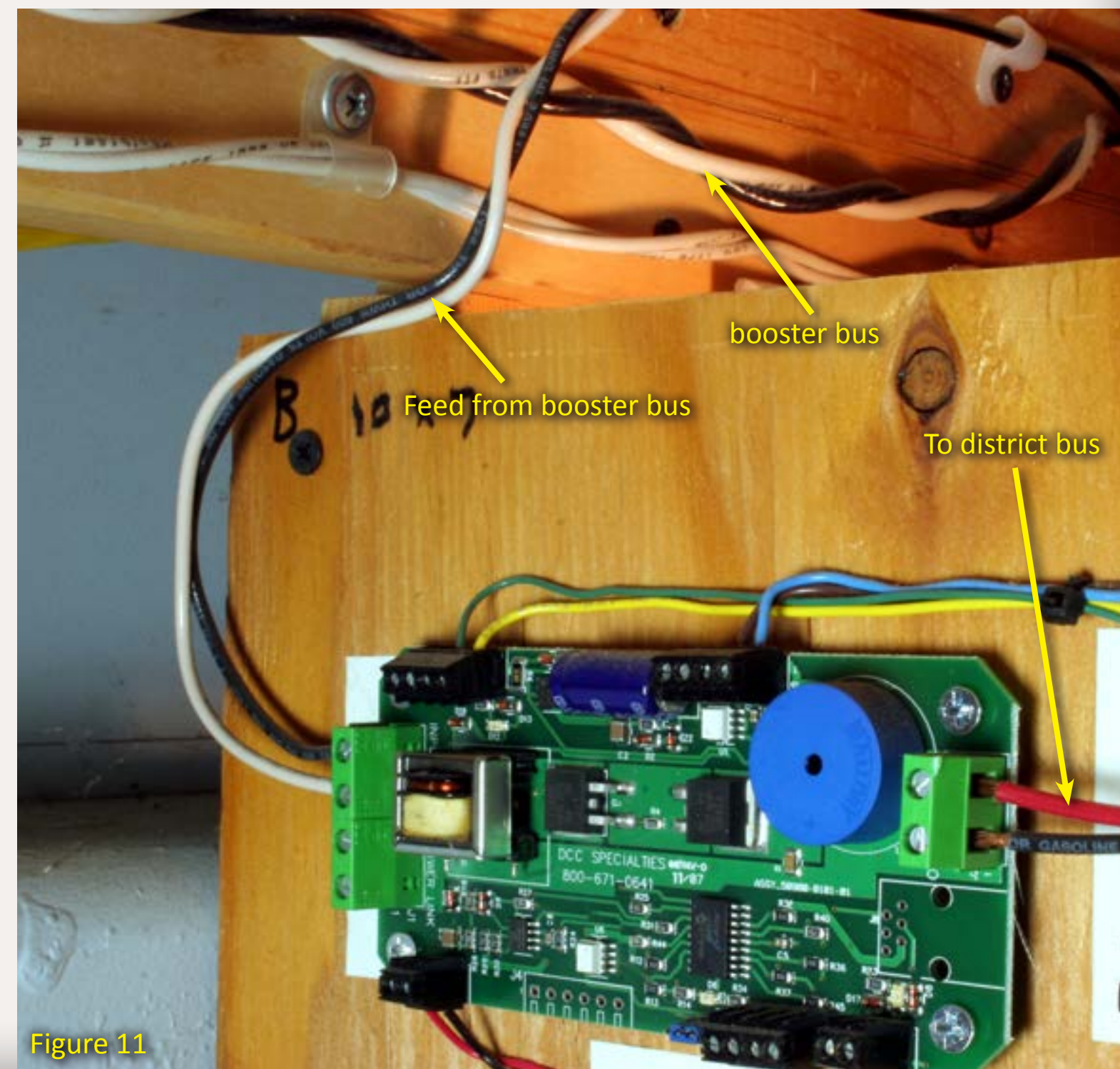


Figure 11



Figure 12

Figure 12: A snubber made from a 100 ohm 1/2 watt resistor and a 0.1 µF 50 volt or higher capacitor.

in another one. This sort of layout would have a five- to eight-amp system running it.

The system box would connect to a booster bus to use 12 to 14 AWG (2.0 to 1.6 mm diameter) wire lightly twisted and running around the layout. Stranded wire makes twisting easier. Remember to keep your booster buses as far from the throttle bus as possible to minimize interference. Check out the twisted black and white wiring at the top of figure 11.

One convenient way to set up power districts is using 14 AWG (1.6 mm diameter) bare solid wire. Adding colored shrink (or non-shrink) tubing allows color-coding of the wires. These “district buses” can be stapled to the bottom of the layout cross members or through holes drilled in them. See figures 8 and 9.

Track power drops are 20 to 24 AWG (0.8 to 0.5 mm diameter) solid wire, soldered to the district bus (figure 8).

The district bus is connected to the booster bus through a circuit breaker, as shown in figure 11.

This single-booster layout might grow to need multiple boosters in the future. You might want to think about dividing the tracks into two or three relatively-equal sections. In the future, they could be easily separated, letting each district have its own booster, as described next.

## Large Layout

This category covers everything from a full basement layout to medium-size and larger clubs.

An intermediate layout in one corner of a basement may grow into a large layout. That’s why I covered some serious issues in the last section.

On a large layout, there likely will be several boosters with multiple power districts each. When wired as multiple, interconnected, intermediate-size layout segments, the wiring won’t be much more complex than several intermediate-size layouts.

On the PCMRC HO layout, each of the three booster districts is wired as I described in the Intermediate Layout section. The layout is brought together when the LocoNet (throttle bus) and

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the track (frequently a single mainline) connect between booster districts.

An advantage of this separation came up at a recent operating session. One booster didn't want to play. So, we disconnected the booster bus wires from the offending booster and used alligator clips to jumper from the red booster district to the yellow booster district. After the session, we had the time to troubleshoot the problem and make the booster happy again.

## Turnout Control

If you plan to control turnouts from your DCC system, you want to have the stationary decoders wired directly to a booster. This "Turnout

Bus" can be as simple as 18 AWG lamp cord.

If someone runs a loco into an incorrectly-set turnout and trips a power district circuit breaker, the turnout bus will still have power and you may be able to correct an improper turnout setting to remove the short, and avoid resorting to the 0-5-0 helper.

## Snubbers

Earlier I mentioned snubbers. That is a term used by NCE for a part made by connecting a resistor (47 to 100 ohms) and a capacitor (0.1  $\mu$ F) in series (figure 12). Snubbers are wired to each end of the track (and


turnout) buses. The effect of this is similar to what you get by twisting all the bus wires everywhere. It reduces interference between packets of data on the bus and, to some extent, interference between buses.

Why use snubbers? Frequently, no matter how carefully you wire the layout, gremlins may hide under the bench. Snubbers aren't expensive and adding them won't hurt. They just might choke a gremlin or two.

Build your layout using best practices and thoroughly test-run it. If you have unexplained problems, such as locos or stationary decoders losing their addresses, then try adding snubbers.

## Go and Do It!

By now, I hope that you see that, if you plan ahead, you can start small and build a huge empire without rewiring or throwing out equipment!

Next month, I'll start a two-part series on hard-wired decoder installations. 

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