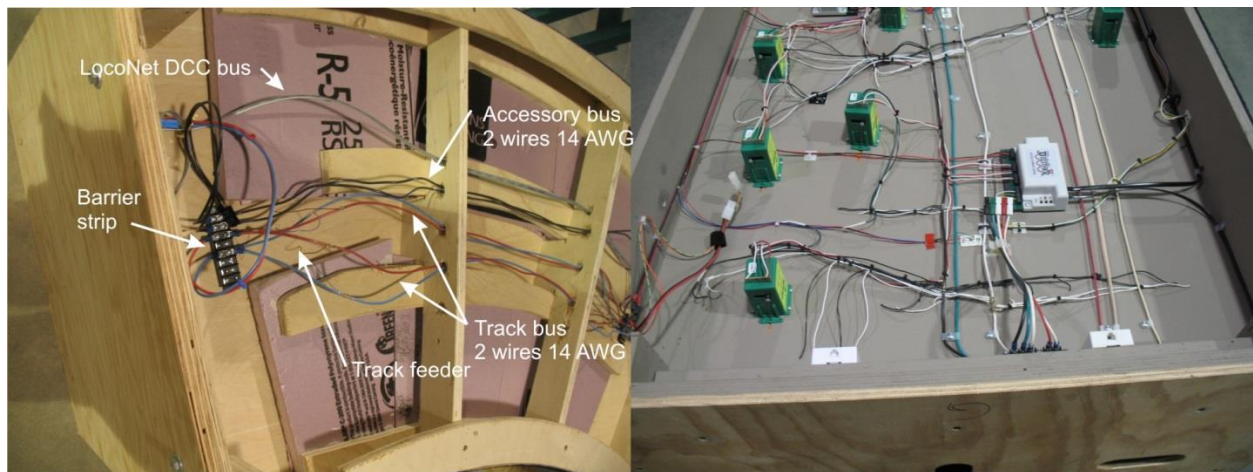


# An Introduction to Free-mo Part 4: Electrifying a Module for Power and Control

By Frank M. Wilhelm with contributions by Al Cunningham

**Disclaimer.** This article and those that precede or follow are not intended to be a substitute for reading the official Free-mo standards for HO scale at <http://www.freemo.org/standard>. This and other articles published herein do not represent any attempt to cover all of the standards. Our primary purpose is to provide a starting point for new Free-mo modelers and to share the experiences of current modelers as they went through the process of building their first modules. The author(s) also wish to acknowledge that some clubs and Free-mo groups or gauges other than HO have added local standards that go beyond the official ones. We have made no effort to review or include all such super-standards but want to recognize that they are often valuable and worthy of your consideration. Also realize Free-mo just recently updated electrical standards, some of which are already in effect or will come fully into effect in 2016. We refer to the new standards here, assuming that those building modules will want to be compliant with the new standards, rather than undertake a re-wiring project shortly. That said, let us begin.

You've built the module and laid some track; now it's time to focus on providing a path for electrons to get engines rolling. While electrical work can seem daunting given what is under some modules (Figure 1), don't be intimidated, it is not at all difficult. Completing a module from start to finish is rewarding, and doing the wiring yourself contributes to that accomplishment. Let's have a look at what's needed under the tracks to make everything purr.



**Figure 1.** A contrast of simple and complex electrical wiring on the bottom of modules. Both of these meet the electrical standards, but the degree of complexity depends on what is topside. Also note that the left module is double tracked and has a separate track bus for each track to facilitate signaling/detection. Neither of these modules has the newly required single wire for the booster common installed. (Frank Wilhelm photo)

There are four things you need as part of the electrical installation with your module (S4.1): i) power to the tracks - this is done via what is called the **track bus** (2 wires); ii) a means to power other things (building / street / yard lights, switch machines ó if you use them - and anything else that goes gee-whizz-bang and requires power) - this is done via the **accessory bus** (2 wires); iii) a single wire **booster common** (S4.16); and iv) a means to pass digital command control (DCC) information through your module ó the **LocoNet bus cable** (a telephone type 6-conductor cable S4.3).

### **The Track / Accessory Bus, and Booster Common**

For the **track** and **accessory bus**, as well as the **booster common**, all wires shall be *stranded* AWG 14 or larger (S4.2, 4.16). Note that in the American Wire Gauge (AWG) system, wire diameter decreases as the gauge number increases; this is related to the number of times a wire must be drawn through dies to achieve a desired diameter ([https://en.wikipedia.org/wiki/American\\_wire\\_gauge](https://en.wikipedia.org/wiki/American_wire_gauge)).

To hook up the bus wires under the module, a 4 (or more) position barrier strip at each end is required (S4.4; see left part of Figure 1 and Figure 3A). The barrier strip also provides a handy place at which to attach the 18ö -free endsø(RP 4.1) to electrically connect the module to others. The barrier strips also provide a quick way to troubleshoot wiring, should that become necessary.

After a change in the standards in 2015, Anderson Power Pole connectors are used on all free bus wire ends (except the LocoNet/DCC cable). These consist of plastic housings (PP 15-45) available in different colors, and a contact (30 amp. for Free-mo), which is attached to the stranded wire via crimping or soldering and then inserted into the housing. If crimping, use the specifically designed crimping tool, as just squeezing them will cause them to deform, preventing insertion, and/or proper seating in the housing. Probably the best connection is obtained via soldering, but expect to apply some heat. See the links at the end for some suggestions of suppliers of the PP. (Note that some Free-mo groups choose to specify colors for the PP housings on their different buses, none are specified in the Free-mo Standard because there is no chance to mix connections if the housings are connected as specified. The figures included here are color-coded for ease of clarity and represent the colors in use by some Free-mo groups in the Pacific Northwest and western Canada. Free-moN for example, uses red housings stacked left-over-right for the track bus and black housings side-by-side for the accessory bus.

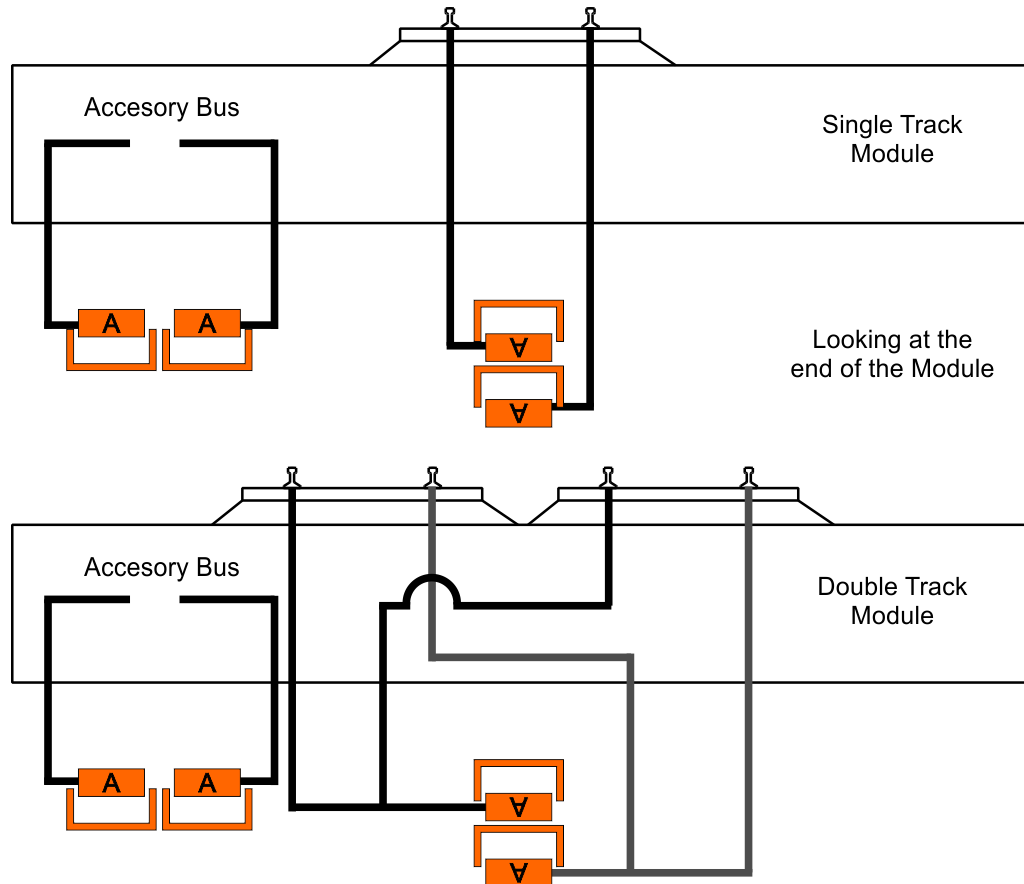
For the **track bus**, the PP15-45 connectors shall be **stacked vertically** (hood up, tongue down, Figures 2, 3A).

While facing the module from any end with the hood of the stacked connectors up:

- The top PP15-45 shall connect to the left rail.
- The bottom PP15-45 shall connect to the right rail (Figure 2).

(Think of going to the fridge for leftovers!)

Feeder wires (24 AWG or larger, but not longer than 60 to avoid voltage loss - S4.9) are used to power **each** section of track from the **track bus**. Soldered rail joiners/joints between rail sections do not count as an electrical connection! ó drop a feeder from the track section to the track bus. This will ensure trouble-free operation.



S4.5 & S4.6 - Free-mo Anderson Powerpole Standards for Accessory and Track Buses (colors of housing are optional)

**Figure 2.** Schematic diagram showing orientation of the Anderson Power Pole (APP) Standard Housings at the end of a module for each of the track (left over rule, left track on top, hood up) and accessory bus (side-by-side). The single wire common booster APP is not shown. (Schematic from [www.free-mo.org/standard](http://www.free-mo.org/standard))

The **accessory bus** is wired straight through and will have a voltage of approximately 16 volts alternating current (AC) or DCC (S4.11). Because the signal is AC, there is no wire polarity and the PP15-45 connectors are **stacked horizontally** (tongue-to-tongue, hood-to-hood ó see Figure 2). Any applications that require AC or DCC signal can use power directly from the bus. For direct current (DC) applications, a bridge rectifier and filtering capacitor may be used to convert the AC or DCC. Because Free-mo set ups can get very large, you should power any switch

machines via the accessory bus to i) preserve the voltage of the track bus to ensure engines run reliably over the layout modules served by their boosters, and ii) so that in case of a short that causes the track bus circuit breaker to trip (e.g., engine enters an incorrectly aligned switch), the switch machine can still be operated to correct the fault.

The **booster common** is a single wire carried through each module that provides a common reference for the boosters in a set up. Nothing on your module connects to this wire. It is terminated on each end with an Anderson Power Pole PP15-45 standard housing connector incorporating a 30 amp contact for use with 12-14 gauge wire (S4.17).

The connectors for the **track bus**, **accessory bus**, and the **booster common** shall be three separate sets of connectors (S4.18 ó see Figures 2 and 3A).

### The LocoNet Bus

The use of digital command control (DCC) makes it possible to run multiple trains in any direction and speed on the same rails. For Free-mo, óLocoNet compliant DCC and accessories are standard for interoperability within and between Free-mo groupsö (S5.1). The identification of LocoNet as the standard generally means that Digitrax is the default DCC system. Note that some HO groups and other Free-mo scales use DCC systems other than Digitrax. Although Digitrax is the norm in North America, FREMO in Europe developed their own controllers (see [http://fremodcc.sourceforge.net/diy/fred2/fredi\\_d.html](http://fremodcc.sourceforge.net/diy/fred2/fredi_d.html) - in German), and booster-to-booster network transition switches for very large layouts.

A telephone-type 6 conductor flat cable is used for the LocoNet bus. Please take note of the recommended practice (RP 4.3) that Digitrax advises against using Computer CAT type cable. We strongly recommend that you follow this practice to avoid issues at setups. See the Yahoo Free-mo discussion group (Free-mo@yahogroups.com) for lively discussions of this topic ó not everyone agrees on use of the 6 conductor telephone type flat cable, or Digitrax. At Free-mo setups, and as a standard use Digitrax components and the 6 conductor flat cable for smooth operation.

All endplates to which adjacent modules connect need to have a surface mount 6 conductor 6 position module jack (RJ12) mounted to the inside (S4.7, see Figure 3B). Module-to-module LocoNet connections are made with a straight-through (S4.13), 2-foot RJ12 to RJ12 type cable (S4.14) (Figure 4). Note this is not a typical phone cable (which is twisted between plugs), thus it requires purchase of cables from a vendor, or making them. If making them, use a high quality crimper to install the connectors, and test the cable with a cable tester (Figure 5) when finished. The cable testers can be had inexpensively from major online auction sites, and are worth the investment, as many setups are hampered by poor or failed LocoNet cables.

To allow operation from all sides, each module has to have one dual flush mount 6 conductor 6 position modular jack (RJ12) faceplate ([Digitrax UP-5 Throttle Jack](#) or equivalent) for throttles mounted on each exposed side (S4.12). It is recommended that in areas where operators congregate (such as yards, or other high traffic areas) one or more throttle jacks should be

considered (PR 4.12.1). A throttle jack is also recommended for each exposed surface of multi-section modules (RP 4.12.2).

## **Double Track, Signaling, and Turnouts**

Double mainline tracks on a module are wired similar to the single track. In the simplest form, feeder wires can be taken from a single bus. Alternatively, and to assist with signaling/detection (optional at this point, but used by some local groups) separate feeders or even track buses are recommended so that detection can discern a train on either track (RP4.8.1).

Controls to operate turnouts must be on all sides of a module or module section, except the end plates (S5.2). As well, all turnout frogs shall be powered (S4.10) and shall not rely on switch points to power the frog. This will ensure that all engines, no matter what their size will run smoothly over all the tracks. It is recommended that turnout controls should be mounted on the fascia, and not on the horizontal or vertical surfaces of the scenery (RP5.2.1). A variety of turnout controls exist ranging from manual (push/pull rods), to electrically driven switch motors such as Tortoise by Circuitron, or small servos typically used in the R/C hobbies. We'll cover the wiring of turnouts for DCC in a future note.

Most modules can be easily set on a side on a workbench to allow ready access to both the top and bottom simultaneously. This greatly simplifies the wiring task. Take your time as you connect tracks and bus wires. Although you may eventually end up with a few wires on the underside, if you pull in sections sequentially (i.e., track bus and all feeders first), you'll be amazed at the simplicity of the seemingly complex mass of wires.

## **Some Final Thoughts**

Ensure you build your module to the highest standards possible, including track work and electrical. It is pretty frustrating to travel a large distance to encounter modules that do not perform according to the standards (track or electrical). Provide to others what you expect from them for flawless operations and minimum use of the 0-5-0 big hook.

- Power your frogs, this may not matter if you run large 6 axle engines, but unpowered frogs present insurmountable challenges to those that run short wheelbase engines.
- Power every single section of track for the same reasons as above and watch short sections of rail, especially after the frog, or where you fit in small sections. Drop a feeder to the track bus, don't count on a soldered rail joiner.
- Be prepared to clean your track ruthlessly at least once a day, or even more frequently, to ensure reliable contact and operation. Each owner is expected to clean their own rails to avoid damage to scenery or structures.
- Keep ballast out of the rail web when you ballast your tracks to ensure good electrical contact.

## Links and supplies

Anderson Power Poles: (note these are 2 part components of housing and contact, be sure to purchase both.

<http://www.andersonpower.com/us/en/products/powerpole/pp15-to-45.aspx>

APP Housings

<http://www.powerwerx.com/anderson-powerpoles/housings-contacts/1327-1327G6-pp15-30-45-colored-housing.html>

[http://www.mouser.com/search/refine.aspx?Ntk=P\\_MarCom&Ntt=146599283](http://www.mouser.com/search/refine.aspx?Ntk=P_MarCom&Ntt=146599283)

APP contacts

<http://www.powerwerx.com/anderson-powerpoles/housings-contacts/1332-15-amp-powerpole-contacts.html>

[http://www.mouser.com/search/refine.aspx?Ntk=P\\_MarCom&Ntt=146599283](http://www.mouser.com/search/refine.aspx?Ntk=P_MarCom&Ntt=146599283)

Tools

<http://www.powerwerx.com/powerpole-accessories/tricrimp-crimping-powerpole-contacts.html>

[http://www.mouser.com/search/refine.aspx?Ntk=P\\_MarCom&Ntt=146599283](http://www.mouser.com/search/refine.aspx?Ntk=P_MarCom&Ntt=146599283)

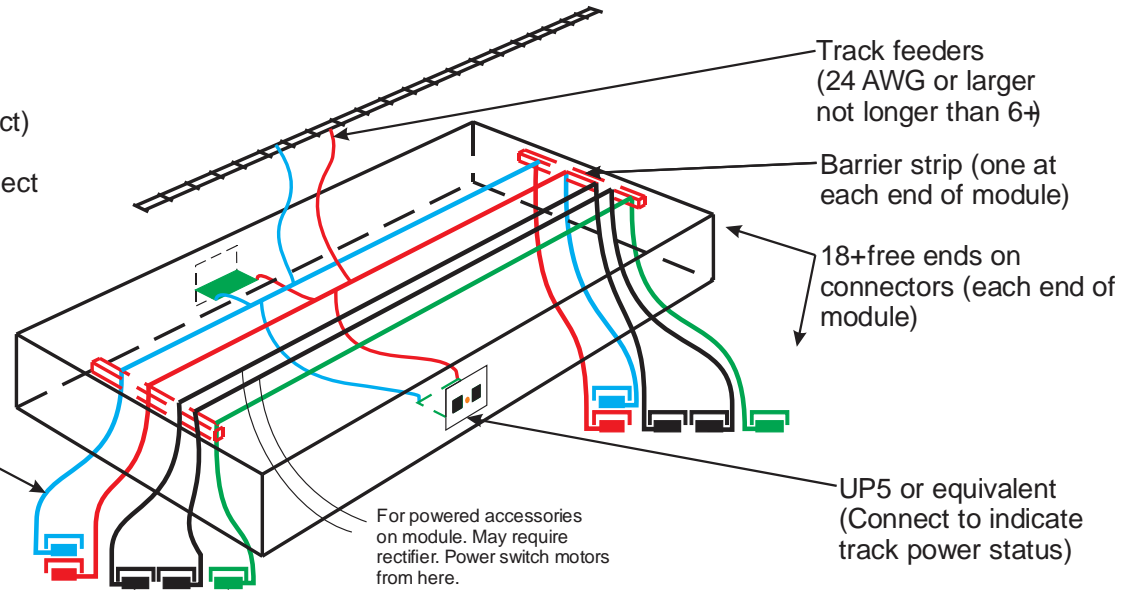
## A) Track / accessory bus, and booster common wiring

Connectors: Anderson Power Pole  
(PP 15-45 housing and 30 amp. contact)  
Note: Housing or wire colors are NOT specified in standard - some groups elect to specify them amongst themselves

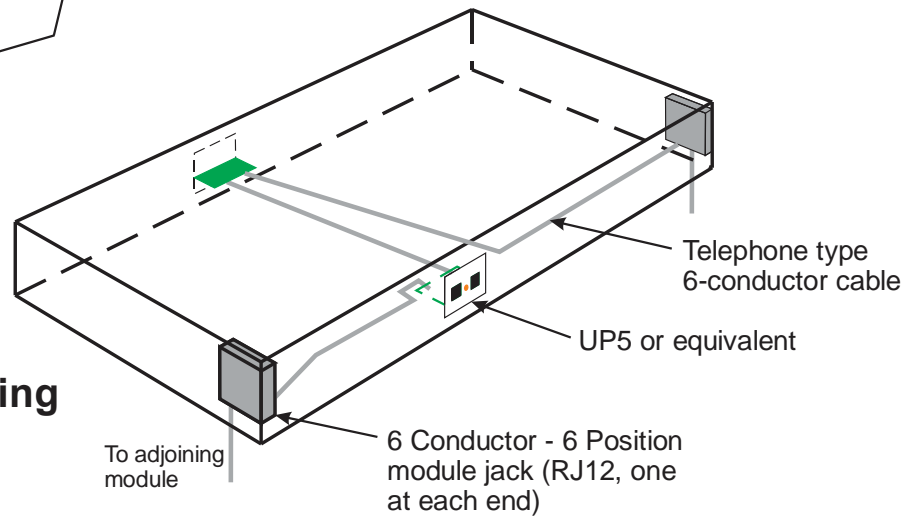
Track power bus  
(Connectors - Left rail on top, right on bottom with hoods up when facing each end of module; stranded 14 AWG or larger)

Accessory power bus  
(Connectors side-by-side carries approx. 16 VAC)

Booster common  
(single wire stranded 14 AWG or larger)



## B) DCC / LocoNet wiring



**Figure 3.** Bus and LocoNet wiring diagrams for a simple single track Free-mo module. Note: For a double track module, just replicate the single track bus. (Drawn by Frank Wilhelm)



**Figure 4.** Straight through LocoNet cable ó Note that the blue outside wire is in the same location relative to the tab on each connector plug. (Schematic by Frank Wilhelm)



**Figure 5.** Typical cable tester, will test variety of connector types/cables and can be used remotely for cable ends far apart. Ideal for testing Free-mo cables, and available relatively inexpensively at large online auction sites. (Image sources: Left - [www.lightinthebox.com](http://www.lightinthebox.com); right - [www.tandyonline.co.uk](http://www.tandyonline.co.uk)).