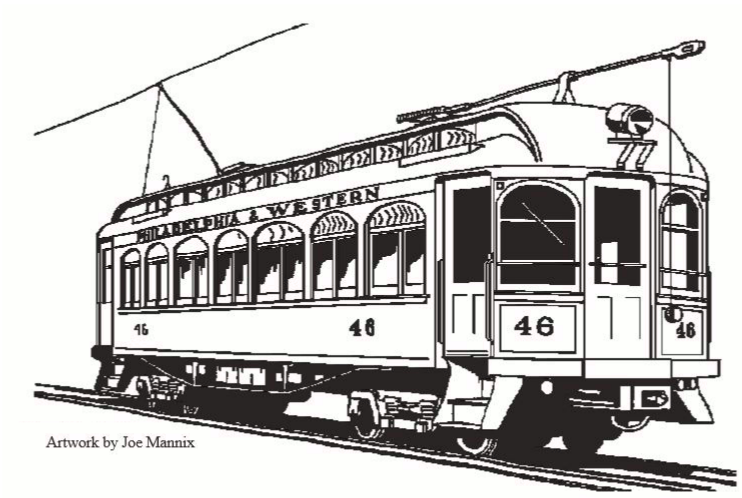
EAST PENN TRACTION CLUB

Philadelphia, PA, USA



O-SCALE TROLLEY MODULE AUTOMATIC BLOCK CONTROL

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AUTOMATIC BLOCK CONTROL

By Richard D. Kerr
Revised May, 2013

INTRODUCTION

This is a specification for applying automatic control to model trolley layout modules built to EPTC standards. On such a layout, an operator normally has charge of any number of cars on the section that he controls with a single throttle control. Automatic control can reduce the number of operators needed to run a layout, provide working signals, let operators talk with the public at shows without leading to distraction and collisions, and act as a safety net to back up less proficient operators. Application of the automatic control system does not interfere with manual block control using the existing East Penn standards. In fact, the automatic control system can be used in conjunction with the normal manual “near block” and “far block” cabling.

However, this system does add some new constraints. The model trolleys being operated must ground across the rails to be protected by the automatic control. They must not coast excessively (over 8 inches in O-scale) at normal operating speeds, and cars or trains must not exceed a given length (20" in O- scale) measured from the first grounding axle back to the contact shoe of a live trolley pole or pantograph.

The control system is expressed as interface requirements between modules, so that methods of Implementation can vary from module to module. The circuits provided here use relays for control, and light bulbs or light-emitting diodes for signal lights. The methods used in these circuits are based on earlier work by the Grant brothers (covered in a three-part article by Charles Grant and Gary Reighn in past EPTC newsletters), as well as refinements by Fred Weigle and others.

PHILOSOPHY

An automatic control system is intended to help operate cars, and to keep them running smoothly and without collisions. The system should not interfere with, and should work in concert with, existing East Penn standards. The interface design should be as simple as possible, using inexpensive and readily available connectors that prevent possible confusion with EPTC standard Cinch-Jones connectors. The construction of automatic control, including retrofit to existing basic modules, should also be as simple as possible. The specifications for automatic control should permit different methods, like relays or solid state electronics, to be used together compatibly.

INTERFACE

Each module contains the active control circuits needed to control the cars and signals on that module, using passive occupancy indications from other modules. The power for the control circuits and signal lights is +12 volts direct current, relative to the common rail return. In the circuits shown in this paper, the occupancy indication for a track block is provided by the continuous grounding of a control wire. This grounding action activates the control circuitry. The indication is provided by electrically isolating a track's two rails from each other, then having a model trolley with un-insulated wheelsets bridge the rails. This method can protect unpowered trailers and freight cars as well as powered cars. The detection rail is the right-hand rail in the direction of travel (the "outside rail" on a typical two-track module), while the left-hand ("inside") rail continues to serve as the ground return rail. (Using the left rail as the return rail conforms to National Model Railroad Association wiring conventions.) Since dirt and rolling can make the wheel contact erratic, the control circuits need to smooth this detection signal. Other detection systems, such as optical detectors or latching circuits, may be used as long as they provide the same continuous grounding indication at an electric current capacity sufficient to handle whatever logic circuits may be on adjoining modules. Each module must provide both "red" and "interface" output indications, even if it does not make use of both of them itself.

The automatic control connection between modules is made by using a six-wire cable about 18 inches long. To differentiate, the EPTC standard connector pins are labeled with an "S" prefix, and the automatic control pins with an "A" prefix. The automatic control cable has six-pin Molex-type plugs (Radio Shack #274-226 or equivalent) at each end. Matching six-pin sockets (Radio Shack #274-236 or equivalent) are mounted on each interface end of a module. Cable and module bus wires should be 18 AWG gauge at a minimum. End-to-end pin connections for the connecting cable are A1 to A1, A2 to A5, A3 to A6, A4 to A4, A5 to A2, and A6 to A3. Pin assignments and labels are as follows:

A1 - Provides control and signal light power at 12 volts direct current ("+12 V DC")
A2 - Sends an interlock indication ("a car is coming") to the module ahead ("Interlock Out")
A3 - Sends a red indication ("a car occupies this block") to the module behind ("Red Out")
A4 - Provides a common-ground rail return with East Penn standard connector pin S3 ("Rail")
A5 - Receives an interlock indication ("a car is coming") from the module behind ("Interlock In")
A6 - Receives a red indication ("a car is ahead") from the module ahead ("Red In")

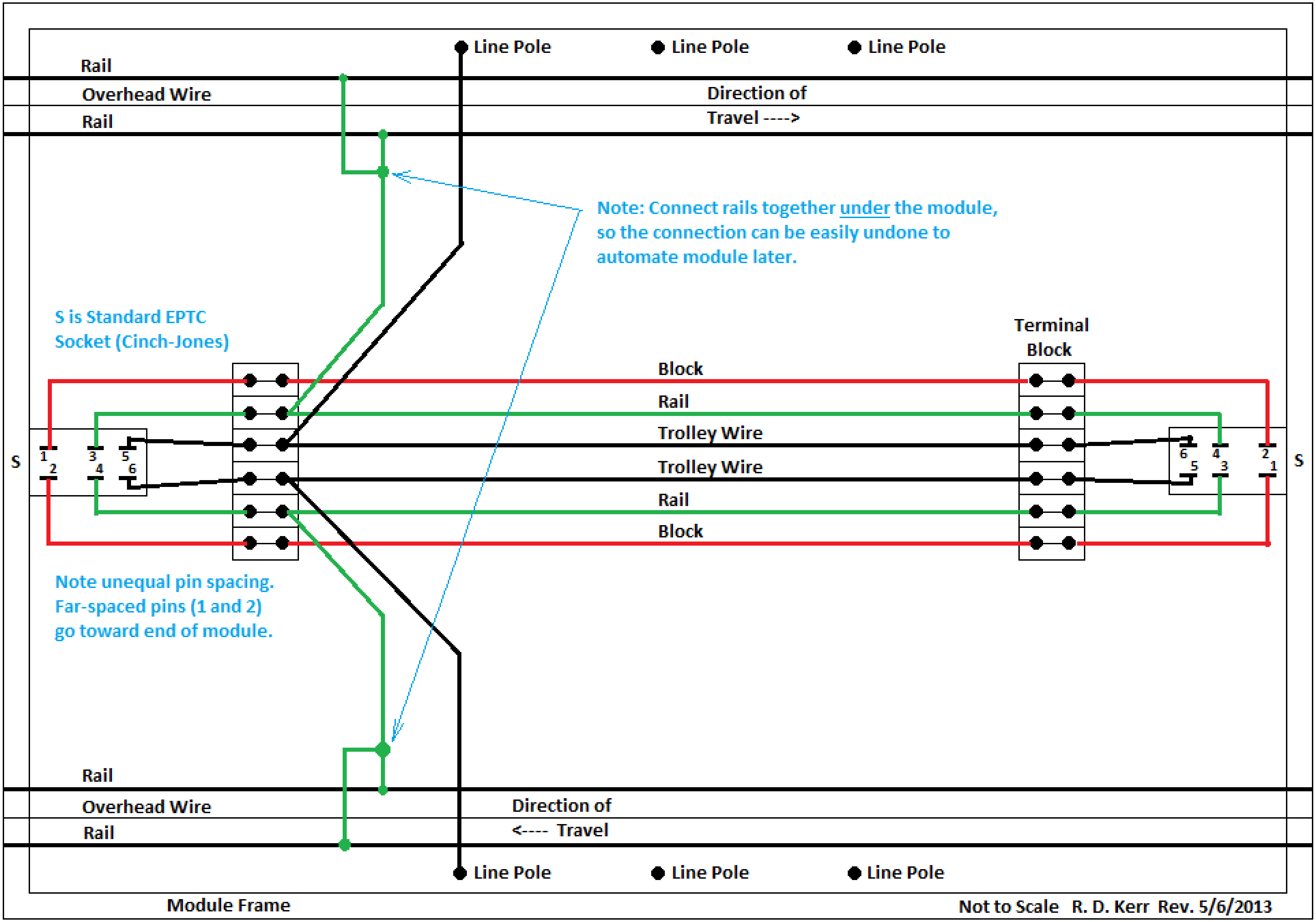
TYPICAL CHANGES NEEDED TO AUTOMATE A STANDARD MODULE

1) If the right-hand ("outside") rail of each track is to act as the occupancy detector, it must be isolated electrically from the "inside" rail.
2) The ends of the detection rail must not touch the rail ends on adjoining modules.
3) Stopping sections must be created in the overhead wire using insulator plates. In O-scale, they must be at least 8 inches long and must end no closer than 20 inches to the next track block in the direction of travel.
4) Automatic control circuits, connectors and wiring must be added to the module.
5) An automatic control cable must also be provided with each module.

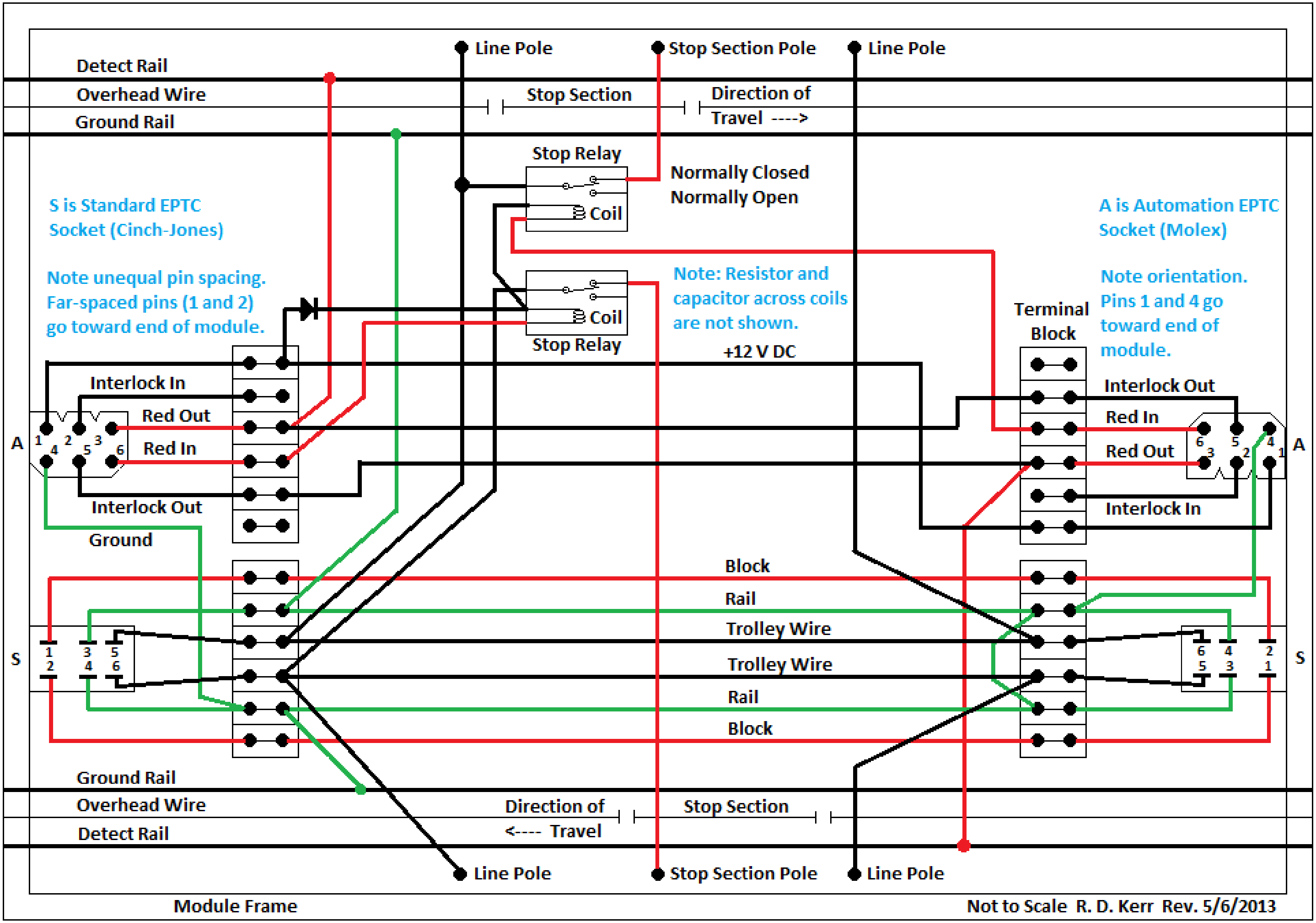
SCHEMATIC DIAGRAMS

As a point of reference, the **"Basic Manual Block Control Wiring"** schematic drawing on the following page illustrates the original EPTC standard module wiring for manual control. The **"Automatic Block Control Wiring"** schematic which follows that shows the additional wiring and

East Penn Traction Club O-Scale Module
Basic Standard Manual Block Control Wiring
(shown looking at underside of module)



East Penn Traction Club O-Scale Module
Automatic Block Control Wiring
(shown looking at underside of module)



features needed to automate a basic module. The two drawings are similar, in order to illustrate that the automation wiring overlays the traditional manual system and builds upon it. (Most of the club's automated modules were created by retrofitting older modules.) Both drawings are not only electrical diagrams, but also represent the physical arrangement of the wiring and electrical components on the underside of a module. The method shown uses relays, but other compatible methods would be equally suitable. Note that the wiring is symmetrical, with identical circuits for each of the two tracks, and that each track's connections are on "its side" of the connectors and terminal blocks.

The automation system shown uses a single relay per track which, when energized by the "Red In" wire being shunted to ground by a wheelset bridging the rails on the next module, stops the car in the stopping section. (Additional contacts on the relay can be used to control signal lights. Most trolley lines were not heavily signaled and generally operated on a "sight" basis. One option is to place model signals only where traffic conflicts are possible at converging tracks or crossings, or where an adequate line of sight is impossible, for example around city street corners.)

The addition of automation adds a second set of connectors (and a second cable between modules), a second set of terminal strips (useful for troubleshooting if something goes wrong during a show) and two relays (each with a resistor and capacitor across the coil pins), plus added wiring and line pole connections. Additionally, insulated stopping sections must be created in the overhead trolley wire.

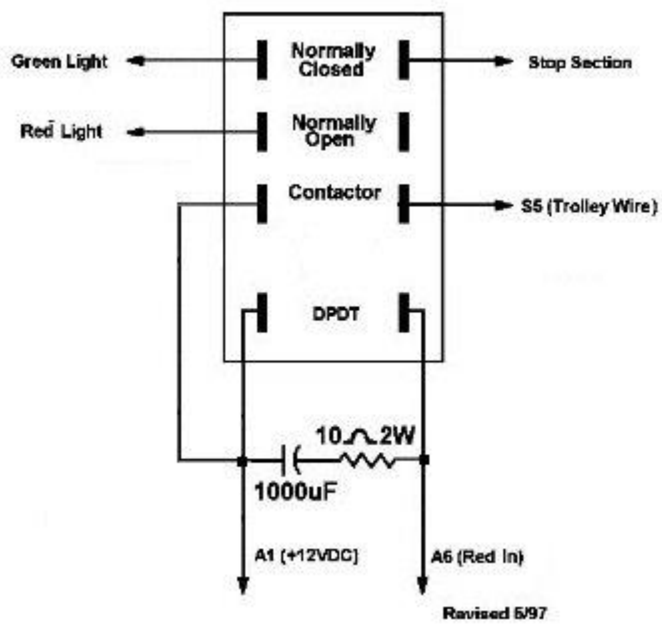
The relays should have 12 V DC coils, have at least double-pole double-throw (DPDT) contacts, and should be rated to handle the maximum current draw for the trolley cars in use (usually 2-3 amps is sufficient for O-scale). Three additional bus wires run the length of the module. (A1 to A1 provides a 12 V DC power feed along the layout, while the A3-to-A5 and A5-to-A3 wires convey the "Interlock Out" indication to the module ahead in each direction.

DESCRIPTION OF OPERATION

In its normal relaxed state, a stopping relay is powering the stop section through a normally-closed contactor. (Note that if you simply do not provide the 12 V DC automation power, all stop sections will be energized and the modules can be operated in the traditional manual control method.)

When the un-insulated wheelsets of a car on the module ahead ground that module's detection rail to the ground rail, pin A6 is grounded (a "Red In" indication). This completes the circuit for the relay coil, and the relay is energized. This throws the contactor finger in the relay, which interrupts trolley power to the stopping section in the overhead wire. The relay remains energized as long as wheelsets bridge the rails of the track block ahead. When the car ahead does clear the block ahead, the relay relaxes, restoring trolley power to the stop section in the overhead and letting a car there proceed forward.

The 12 V DC power is fed to the relays through a diode. This serves to protect the capacitors across the relay coils from negative voltage in the event someone hooks up the power supply backwards. The capacitor and resistor in series across each relay coil act as a delay circuit, smoothing out the

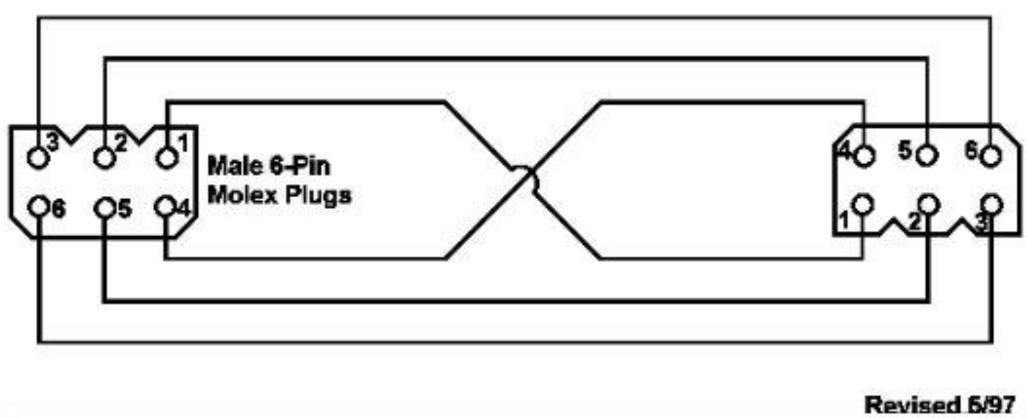


Typical relay pin arrangement showing capacitor, resistor and optional signal light wiring.

jittery "grounding" action of the car's wheels on the rail. Without this help, the relay would chatter, and sparking would pit the wheels of the car. The resistor and capacitor are sized to cause a delay of about a half-second in the relaxing of the relay. This is enough to overcome grounding interruptions because of gaps, dirt, or switch/crossing frogs. Increasing the capacitance or resistance values would increase the delay time. It is important that the resistors be wire-wound resistors, so they can better withstand transient voltage spikes from energizing and de-energizing the relay coil.

OTHER SCHEMATICS AND FIGURES

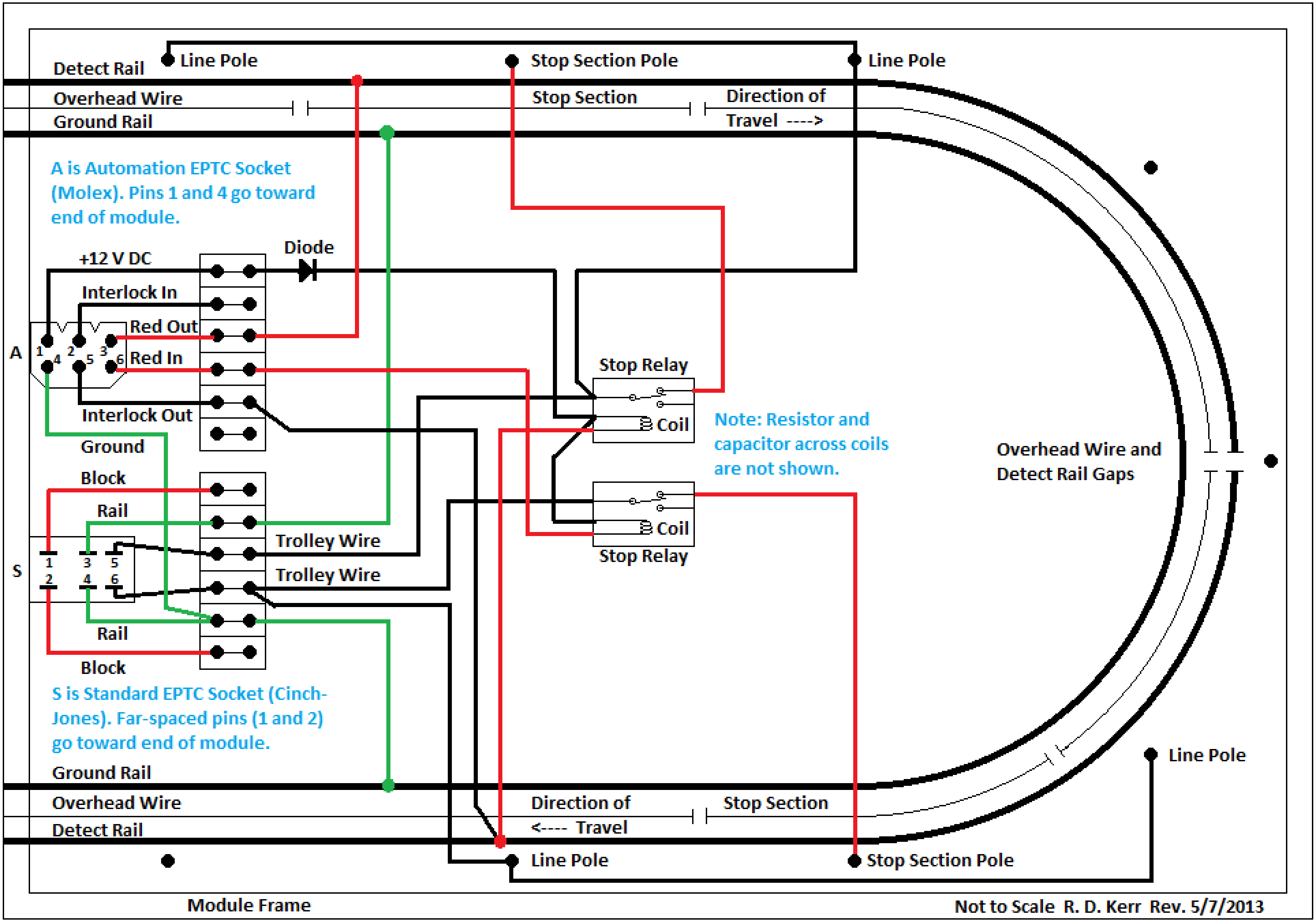
The schematic below shows the wiring for the automation cable that goes between modules. Some useful variations of this basic cable are explained in a later section. Build one per module.



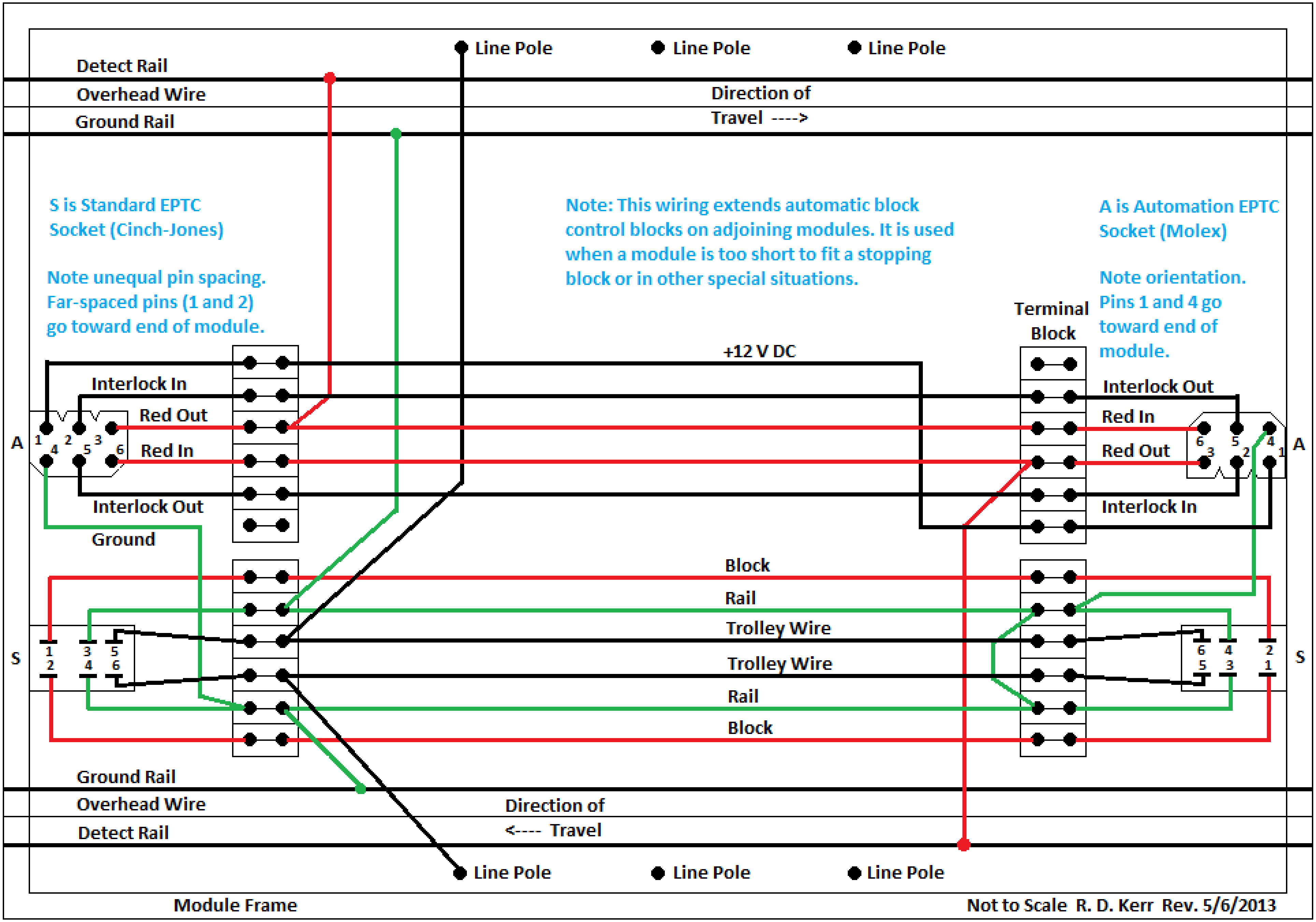
"Automatic Block Control Wiring – End Loop" shows the wiring and general arrangement schematic for automating an end loop module.

"Automatic Block Control Wiring – Block Extension shows a schematic for a basic module that acts as an extension of automatic control blocks on adjoining modules. This is used when the tracks on a module are physically too short to contain an 8 inch stopping section and a 20 inch distance from the stopping module to the next block. There are other cases where it may be necessary to use this schematic, but in general it should be avoided, since it increases the minimum distance between cars and therefore reduces the traffic capacity of a layout.

East Penn Traction Club O-Scale Module
Automatic Block Control Wiring – End Loop
(shown looking at underside of module)



East Penn Traction Club O-Scale Module
Automatic Block Control Wiring – Block Extension
(shown looking at underside of module)



POWER SUPPLIES

We generally no longer build our own power supplies for automation or running the trolleys. One reason is that modern electronic supplies (120 V AC to 12 V DC with 3 amp or greater capacity) can be bought cheaply. They are so well voltage-regulated that light bulbs on the layout do not even flicker as relay coils activate and de-activate. They are also electronically protected for thermal overloads and for amperage overloads. In short, they are better, smaller, lighter and less expensive that the ones we used to build ourselves. In addition, “homebrew” 120 volt supplies are not Underwriters Laboratory (U.L.) approved and are therefore increasingly being frowned upon by code and safety inspectors, as well as operators of public halls and facilities. To minimize any inspection or use issues, we use purchased U.L. approved power supplies. We no longer incorporate or attach 120 volt supplies or power cords to our control panels or modules, since that makes the whole layout subject to safety inspection. We do all of our specialized work on the “12 volt side” of the power supplies.

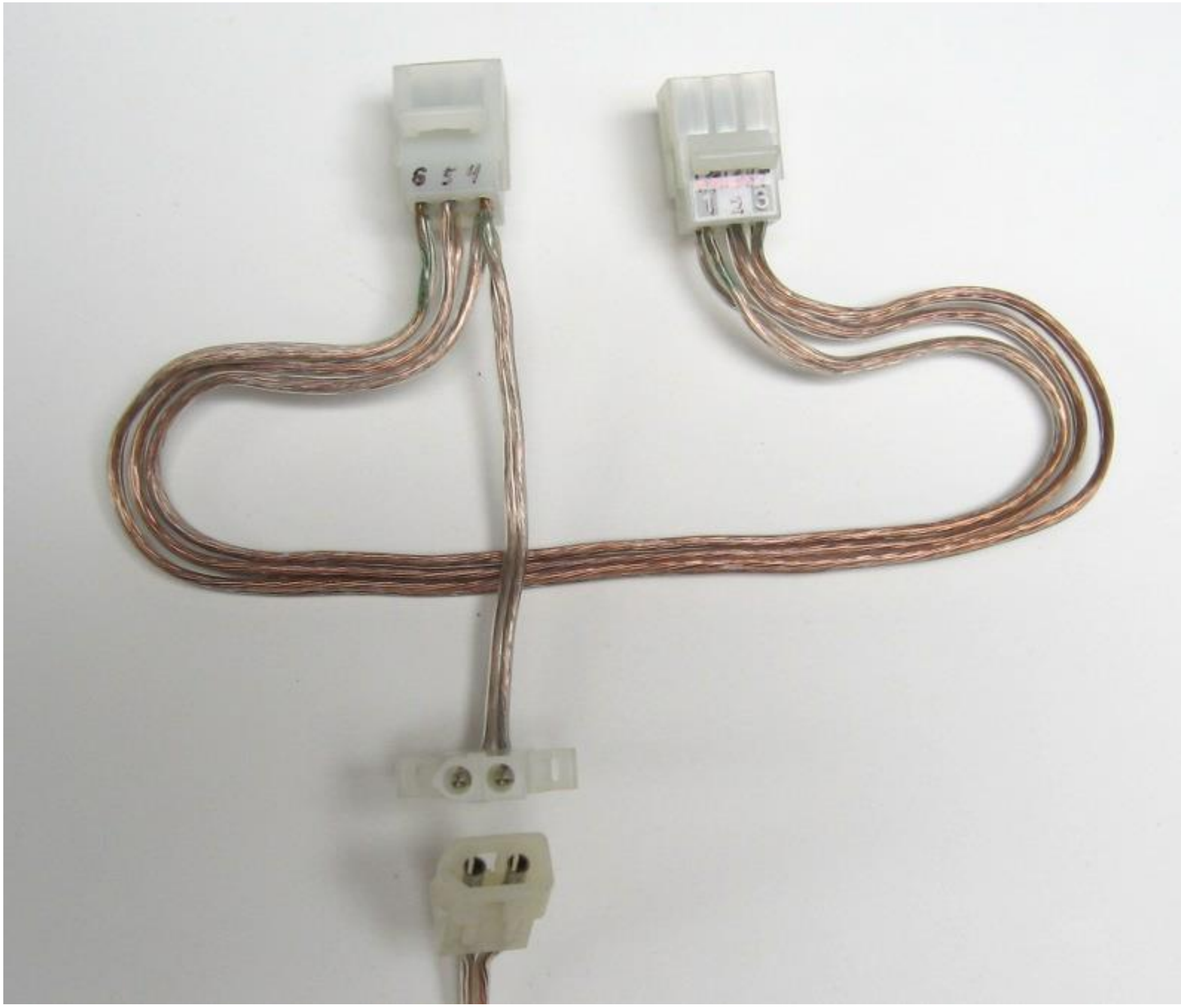
POWER SUPPLY HOOKUP

The East Penn O-scalers have adopted power supply hookups made using Radio Shack 2-pin Molex connectors. A short two-wire “tail” can be added to an automatic block control cable, or can be attached to a module at its terminal block screws for pins A1 and A4. It uses the nylon Molex plug housing with round-topped (“male”) pins. The pin near the pointed edge of the nylon connector housing is used for the positive wire, and the other pin is used for the negative wire. The power supply sits on the floor, with a cable long enough to reach and connect with the “tail” cable dangling from the cable or module. The power supply cable uses the shrouded 2-pin Molex housing and the open-end (“female”) pins.

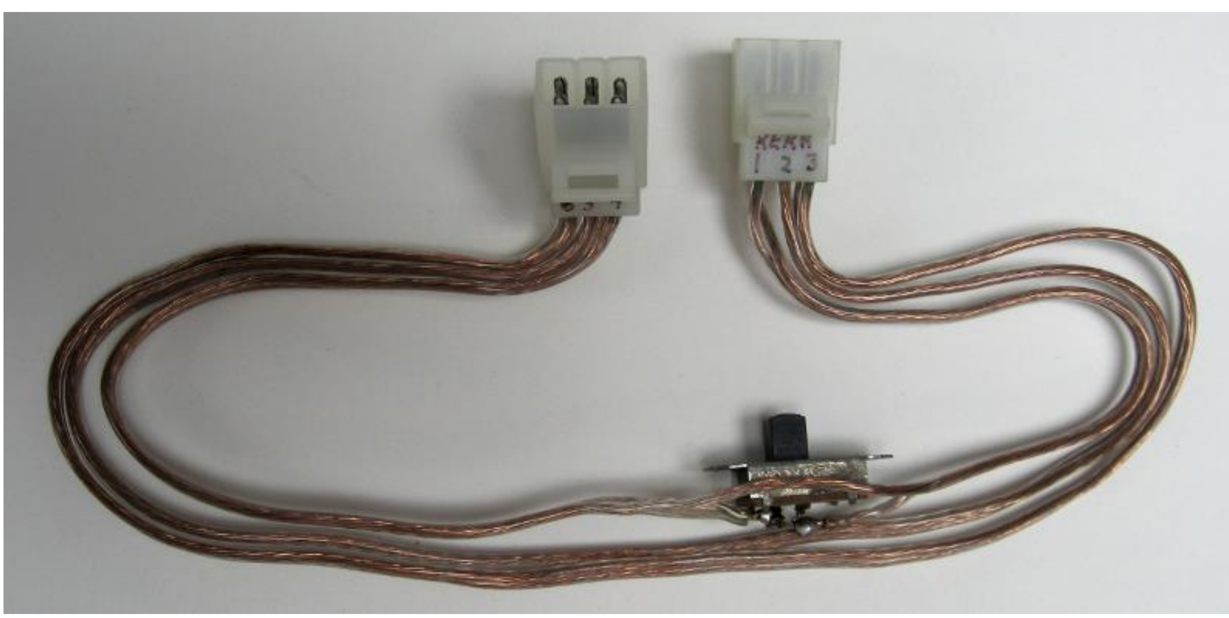
We use this same power supply hookup method for our trolley control throttles, too. We clearly mark any 2-pin sockets on the modules as “12 VDC” or “T” (for trolley power). Standardizing these connectors lets us quickly remove a failed power supply and replace it with a good one if something should fail.

We break large layouts into divisions, each with its own 12 volt power supply, to avoid overloading a supply. We isolate these divisions using a special automatic control cable between divisions. This cable has a single-pole single-throw switch inserted in the + 12 V DC wire. Moving the switch to its “off” position electrically isolates the power divisions on either side, while still making the common ground connection and the automatic detection connections between the modules.

The photos below show these cables with their specialized added features. You can see that the connectors are aligned 180 degrees opposite of each other, as shown in the wiring schematics. Also note that in general the pin numbers (and owner’s name) are marked on the connector housings for clarity. The wires are cleanly arranged as well. On the right-hand connector in both photos, you can see a half-twist in the leftmost wire pair, which keeps pin 1 (12 V DC) on the left connector attached to pin 1 on the right connector. Likewise, pin 4 (ground) is connected to pin 4. The top photo shows the socket, pin and connector housings arrangement for connecting a power supply to the layout. The positive wire is to the left, nearest the pointed edge of the housings.



Automation cable with 12 V DC power feed "tail" and cable up from power supply.



Automation cable with slide switch in A1 12 V DC wire to break layout into power divisions.

IN OPERATION

Before all of our modules were automated, we would establish wholly automated sections in our layouts. Operators manually controlled junction points, places where automated and non-automated modules abutted, and non-automated sections. By manually stopping an incoming car on the "detected" rail of the nearest automated module, an operator assured that any following cars stopped automatically behind it on an automated section.

With today's fully automated layouts, we position operators and trolley speed controls at junctions and other places where route selection and the throwing of track switches is required.

Typically, other club members will rove the automated areas, talking with the public and watching for any dewirements or stalled cars. The problem car is always at the front of any line of stopped cars, and correcting it will restart the whole parade. We have found that automated sections can handle higher traffic densities that operator controlled sections. More cars in operation give the public more to watch and enjoy. Smooth operation with a density of up to one car per double track module (an average headway of 8 feet in O scale) is achievable, especially with cars of similar speed characteristics.

CONCLUSION

The O-Scale Division of the East Penn Traction Club, as well as the Long Island Traction Club, has found this automatic control system to be reliable and effective. It is well suited to trolley-style operations with many cars running on close headway. Manual control of cars with "Near" and "Far" block control switches can still be used, and we use it to keep cars evenly spaced around the layout. Otherwise cars will bunch up behind the slowest-running car on the line. We feel more able to talk with the public, without fear of collisions from inattention.

EPTC O-scale modelers have begun using Digital Command Control (DCC) systems on show layouts, on a separate module setup. This is a good use for non-automated modules. DCC offers the benefit of more realistic and prototypical operations, with smooth starts and stops, closing right up to the rear of a trolley stopped ahead, and so on. At the same time, DCC does not offer what was mentioned above as the goals of automatic block control -- reducing the number of operators needed, letting operators talk with the public at shows without leading to distraction and collisions, and acting as a safety net to back up less proficient operators. Offering both control methods allows us to welcome and handle "visiting equipment" of both types.

[Author's Note: This is an update to an earlier document, "Automatic Control of East Penn Trolley Modules," published in August, 1998. At that time, the automation approach was new and only a few modules had automatic block control applied. In the 15 years since, the O-scale layouts of the East Penn Traction Club (EPTC), as well as the Long Island Traction Society, have progressed to full automation of large multi-route setups. Based on this experience, certain aspects of the earlier document have been revised. The "yellow" signal aspect, with diodes inserted in the trolley power feed to slow down cars when approaching and departing a stop section, has been abandoned. In practice, the great variety of motor types used in O-scale trolley models led to some cars stalling with the reduced voltage, while others did not slow down at all. In addition, signal lights were rare

on most real trolley lines, except for interurbans built to higher, railroad-like standards, and many lines used two-aspect instead of three-aspect signals where they used them at all. Automation cable pins 2 and 5 have been reassigned instead to send forward and receive a "car is coming from previous block" interlock indication, which can facilitate the automation of complex junction and terminal modules. This change simplified the wiring, reduced the number of relays, and generally required only the shifting of a few module wires to other screws on the terminal blocks.]

Digital drawings by Gary M. Reighn and the author.