Automatic Control of East Penn Trolley Modules
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INTRODUCTION

This is a specification for applying automatic control to model trolley layout modules built to East Penn Traction Club 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, 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 or other functions of 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” 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 shoe of a live trolley pole.

The control system is expressed as interface requirements between modules, so that methods of implementation can vary from module to module. The sample circuits provided here use relays for control, and light bulbs or light-emitting diodes for signal lights. The methods used in the samples are based on earlier work by the Grant brothers (covered in a three-part article by Charles Grant and Gary Reighn in the *East Penn Club News),* 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 East Penn standard 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 control circuits needed to control the cars and signals on that module, using occupancy indications from other modules. The power for the control circuits and signal lights is +12 volts direct current, relative to the standard East Penn common rail return. The occupancy indication for a track block in the sample circuit shown is provided by the continuous grounding of a control wire. This grounding action activates the control circuitry. This indication is provided by insulating the track rails, so that a model trolley’s wheelsets bridge the right-hand signal rail (the “outside rail” on a typical two-track module) to the left-hand (“inside”) return rail, (Using the left rail as the return rail conforms to NMRA wiring conventions.) Since wheel contact is 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 amp capacity sufficient to handle whatever logic circuits may be on adjoining modules. Every module must provide both “red” and “yellow” indications, even if it does not use both of them itself.

The automatic control connection between modules is by a six-wire cable about 18" long. To differentiate, the standard East Penn connector pins are labeled with an "S" prefix, and 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. End-to-end pin connections for this connecting cable are A1 to A1, A2 to A5, A3 to A6, A4 to A4, A5 to A2, and A6 to A3. Matching six-pin sockets (Radio Shack #274-236 or equivalent) are mounted on each interface end of a module. Pin assignments are as follows:

A1 - Provides control and signal light power at 12 volts direct current ("+12VDC")
A2 - Sends a yellow indication to the module behind ("Yellow Out")
A3 - Sends a red indication to the module behind ("Red Out")
A4 - Provides a common rail return, identical to East Penn standard connector pin S3 ("Rail")
A5 - Receives a yellow indication from the module ahead ("Yellow In")
A6 - Receives a red indication from the module ahead ("Red In")

Pin A4 can be used to ground the signal rail back to the common rail when automatic control is not in use, so that the module conforms fully with East Penn standards. (Both rails then act as the return circuit.) This can be done by a "dummy" plug, tethered to the socket at each interface end of a module, which connects pin A3 to pin A4 . Cable and module bus wires for pins A1 and A4 should be 18 AWG gauge at a minimum.

TYPICAL CHANGES TO 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. (Note that it is possible to have more than one signal block per track on a module, particularly in smaller scales.)
2) Rails must not touch the rail ends on adjoining modules.
3) The power feed to the trolley wire line poles must now pass through the control circuits.
4) A stopping section must be created in the overhead, using insulators. In 'O' scale, it must be at least 8" long and no closer than 20" to the next track block in the direction of travel.
5) Automatic control connectors, dummy plugs, control circuits and wiring must be added to the module.
6) An automatic control cable must also be provided with each module.

SAMPLE METHODS

Figures 1 and 2 show two sample control systems, both built using rail detection and relay circuits. Other compatible methods are equally suitable. Note that both figures are symmetrical, with identical circuits for each of the two tracks. The system shown in Figure 1 uses a single "red" relay per track which, when energized, stops the car in the stopping section and can light a red signal bulb while darkening a green bulb. The system shown in Figure 2 uses two ("red" and "yellow") relays per track. It, too, stops the car in the stop section. In addition, it provides for 3-color signals and slows down the car by lowering the trolley voltage through diodes under certain circumstances, providing somewhat smoother operations. Installing actual trackside model signals is optional. Most trolley lines were not heavily signaled, and many operated on a "sight" basis. One option would be to place model signals only where traffic conflicts are possible (at converging tracks or crossings) or where sight would be impossible (around city street corners).

In both cases, the automatic control wiring shown consists of two relay control units, the connectors and the optional signal displays. The particular relays employed should be rated to handle the maximum current draw for the trolley cars in use (usually 2-3amps is sufficient for O scale). For the two aspect signals, use a two pole, double throw relay; for the three aspect, use a four pole, double throw relay. The relays in the following circuits are assumed to be 12V relays. Three bus wires run the length of the module. (A1 to A1 provides a 12VDC power feed, while A2 to A6 and A6 to A2 convert a "red in" detection from the module ahead through to the module behind, as a "yellow out" occupancy detection.) The stop sections have been added to the overhead, so a number of line poles now serve as trolley line feeds. More detailed explanations follow.

SIMPLE AUTOMATIC STOP AND 2-COLOR SIGNALS

In Figure 1, the relay is normally lighting the green signal bulb and powering the stop section. (Note that if the control system is not powered and the signal rail is "grounded" by a dummy plug, the stop section remains energized and the module completely conforms to basic East Penn standards.) When the relay's coil is energized by a car ahead "grounding" pin A6 through the signal rail on the module ahead, the upper relay contact cuts off power to the stop section, and the lower contact lights the red signal bulb instead of the green bulb. When the car ahead clears the track block ahead, the relay relaxes, changing the signal back to green and restoring power to the stop section in the overhead.

The 12 volt power is fed to the relay panel through a diode. This protects the capacitor from negative voltage in the event someone hooks up a power supply backwards. The capacitor and resistor in series across each relay coil act as a delay circuit, smoothing out the 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. These components are sized to cause a delay of about a half-second in the dropping of the relay. This is enough to overcome gaps, dirt, or switch/crossing frogs. Increasing the capacitance or resistance would increase the delay time.

AUTOMATIC SLOWING, STOPPING, AND 3-COLOR SIGNALS

The example in Figure 2 has more functions. A second ("yellow") relay is activated when A5 is grounded by a car two blocks ahead, changing the green signal to yellow. The red relay, when energized, does what it did in the previous example, stopping the car, lighting the red signal light, and turning off the other (green or yellow) light. (A fourth contact cuts power to the mooted "yellow" relay, to reduce power consumption.)

The bottom contact on each relay is used to vary car speed. When a coil is energized, the power to various overhead wire sections must now pass through two diodes in series, which reduce the voltage about 1.5 volts to slow the car. (Since many cars are being run from one controller, an operator cannot manually slow down an individual car. This circuit performs this nicety in a rudimentary way.) When the red relay turns the stop section off, it also reduces the voltage in the approach section, so the car makes a less-abrupt stop. When the stop section is reenergized (yellow signal), it and the departure section ahead of it are voltage-reduced by the yellow relay, causing a smoother start. The single diode oriented in the opposite direction on each relay provides a means to back up a car using the reversing switch on the controller. For flexibility, manual bypass switches have been added, in case quicker high density operation, without slowing the cars, is needed on the layout. These frills can be omitted.

OTHER FIGURES

Figure 3 shows the wiring for the interconnecting cables. Figure 4 shows the internal wiring of a relay panel. Figure 5 shows the general physical arrangement of this system under a module, and Figure 6 explains the need for the bypass switch when high density operations are desired. Figure 7 shows a simple schematic for a 12VDC power supply useful for power the relays and other 12V accessories (building lights, signal lamps, etc.)

POWER HOOKUP

In practice, the O Scale division uses simple unfiltered 12 VDC power supplies consisting of a 120VAC on/off switch, a fuse, a transformer and a bridge rectifier (see Figure 7). Supply hookups are made using Radio Shack 2-pin Molex connectors. A short two-wire "tail" is attached to the module at the terminal strip screws for pins A1 and A4. At the other end is the Molex plug with round-topped pins. The angled "arrow head" side of the connector is the positive. The power supply sits on the floor with long leads to the shrouded 2 pin Molex socket, with the open end pins inserted. (This same power supply hookup method is used for the controller throttles, too.) Multiple 12VDC power supplies can be used on large layouts as power consumption dictates. Simply unscrew the +12VDC wire leading from the 6-pin Molex socket at the terminal strip on the module where you wish to break the layout into sections. Then power each section with its own power supply, connected to one module.

IN OPERATION

In a typical layout setup, whole branches of automated modules are established. Operators control junction points, places where automated and non-automated modules abut and non-automated branches. By stopping an incoming car on the closest "detected" section, an operator is assured that any following cars will stack up behind it on the automated branch. Typically, another club member will "rove" the automated areas, talking with the public and watching for any dewires 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. Densities of up to one car per double track module (a headway of 8' in O scale) are achievable, especially with cars of similar speed characteristics.

CONCLUSION

The O Scale Division of the East Penn Traction Club has found this automatic control system to be reliable and effective, without altering normal manual operations.

> ***Editors Note**: At the time of this writing, the East Penn Traction Club does not have an endorsed standard for automated module control. The specific implementation described in this document is patterned after that in use by many of the O scale module owners in the club and could therefore be considered a "common parctice" for that scale. However, before wiring a module for automated control we recommend you discuss the requirements with the module owners you plan to interconnect with to ensure interoperability.*

Digital drawings and document layout by Gary M. Reighn

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Figure 1 - Sample Automatic Control Circuits
Two Aspect Signals and Automatic Stop

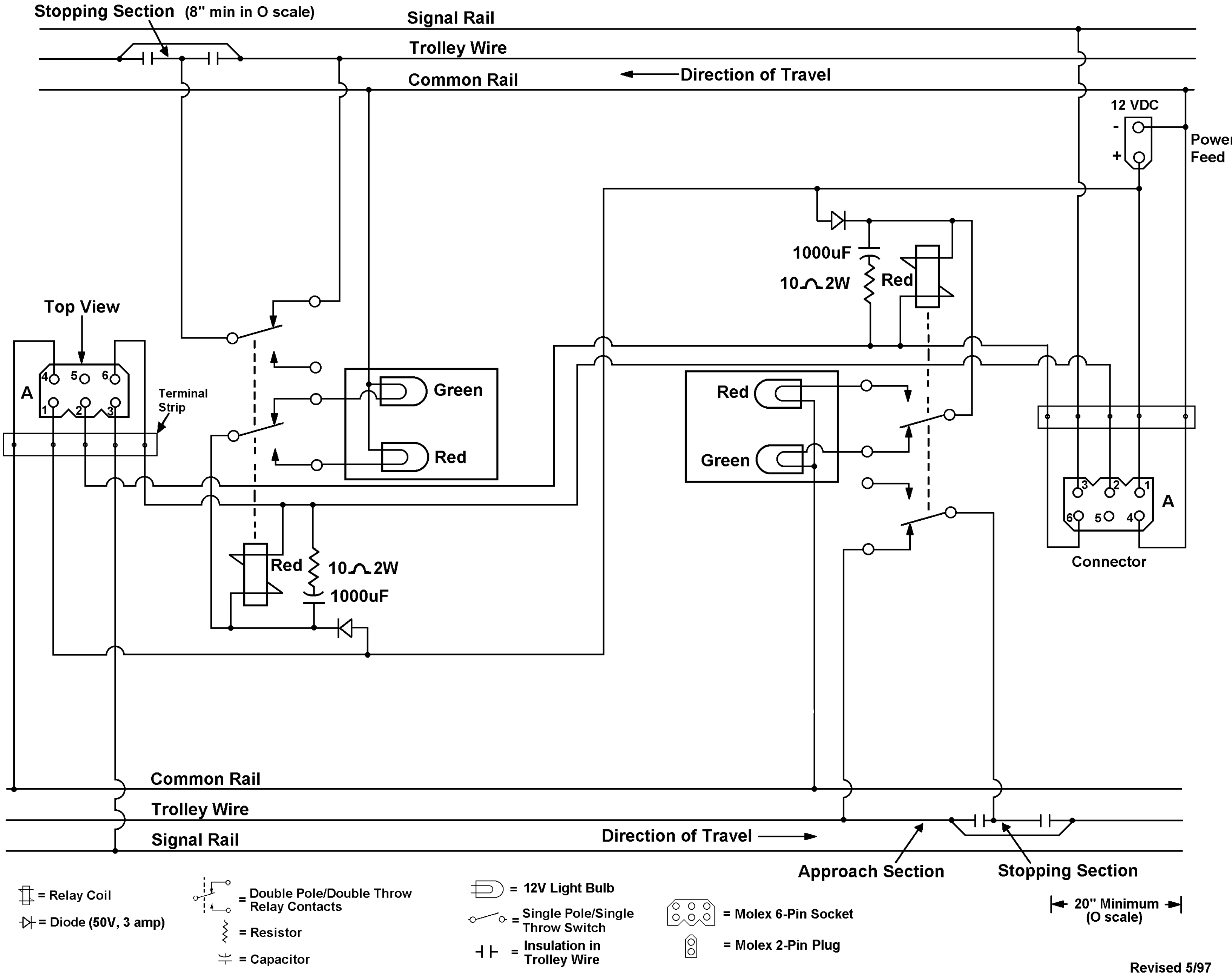

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Figure 2 - Sample Automatic Control Circuits
Three Aspect Signals and Automatic Slow-Down/Stop

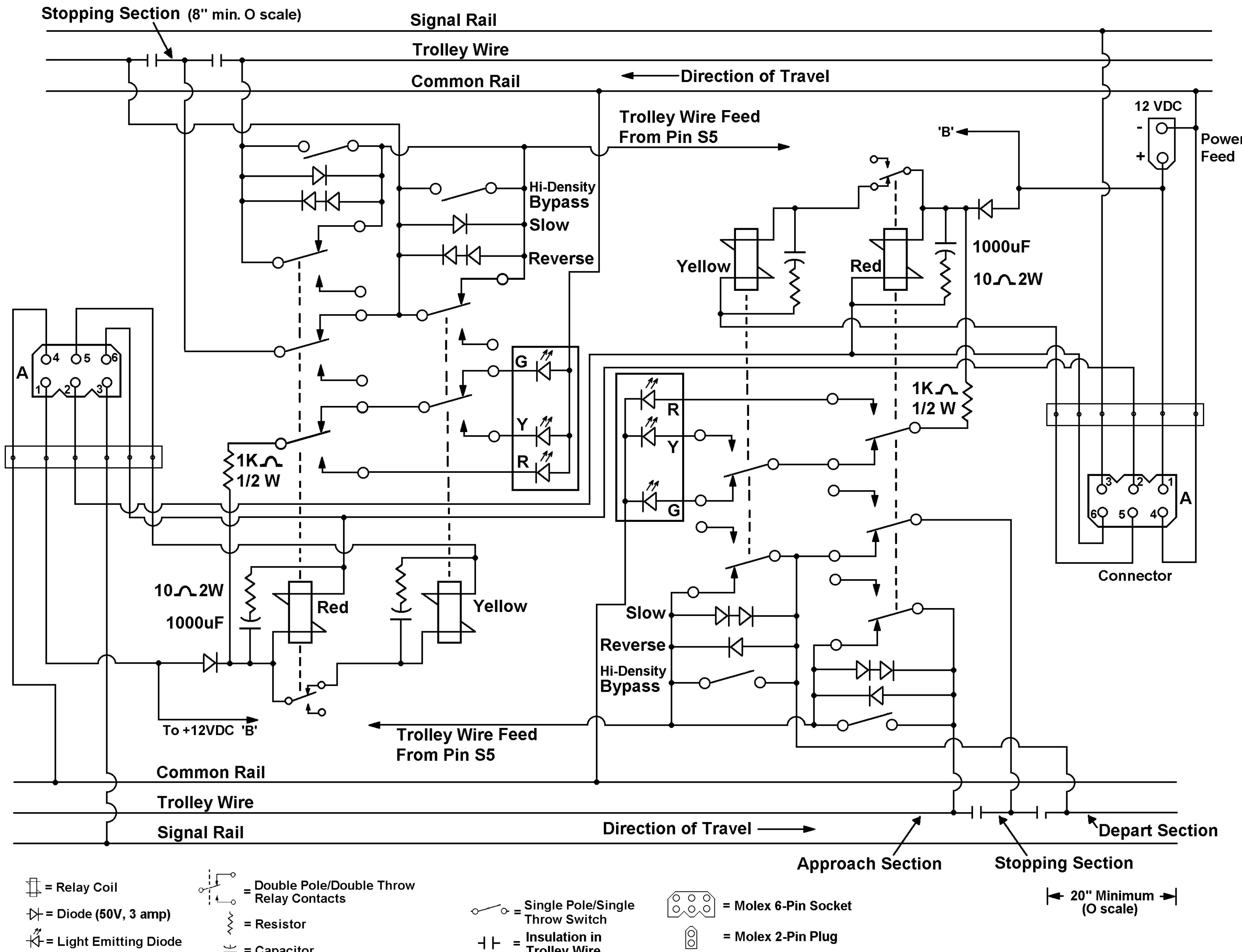

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Figure 3 - Cable Wiring

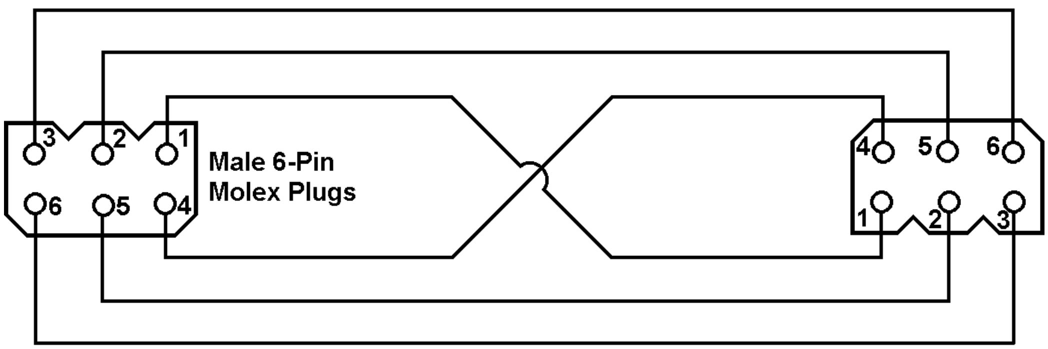

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Figure 4 - Relay Panel Wiring

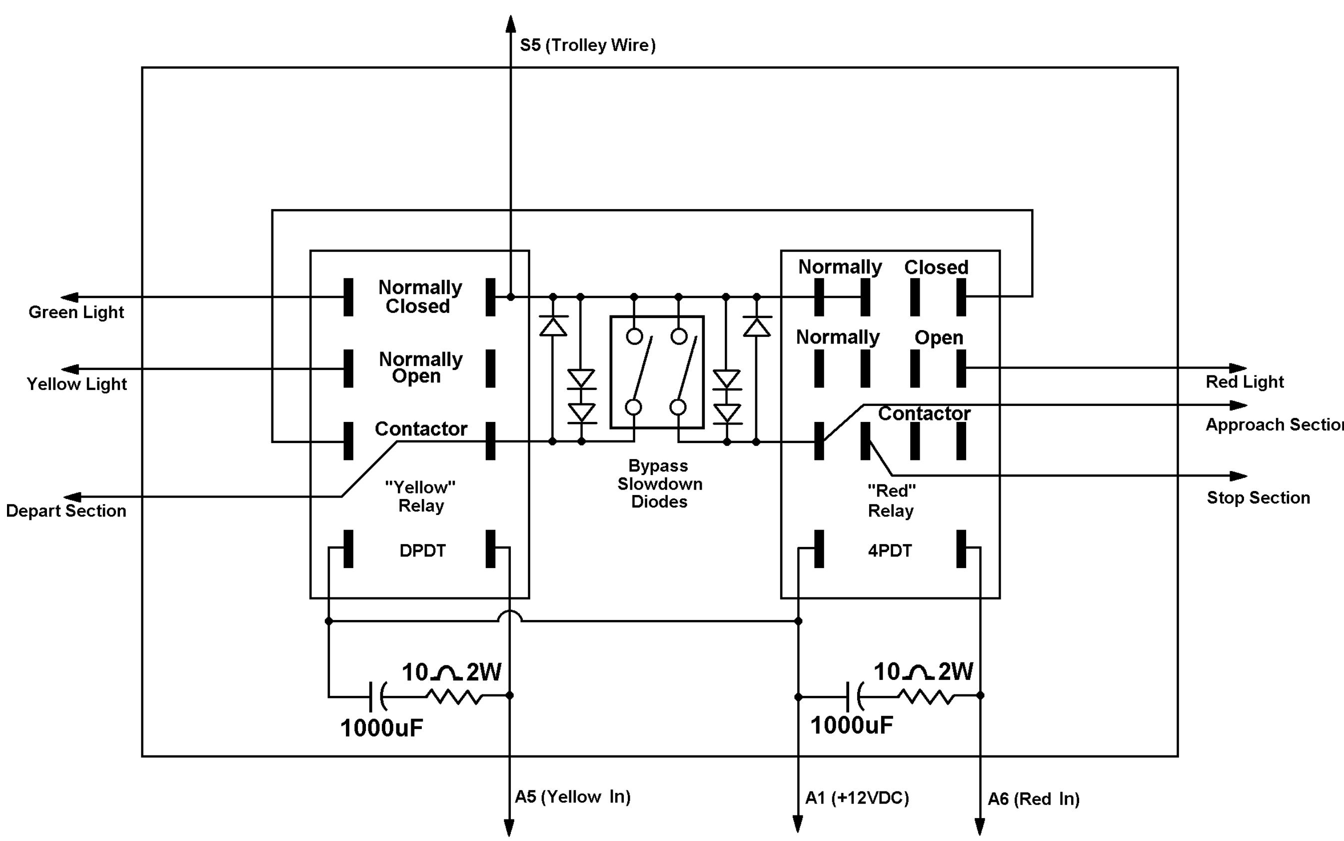

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Figure 5 - Wiring Plan - Half of Module (Bottom View)

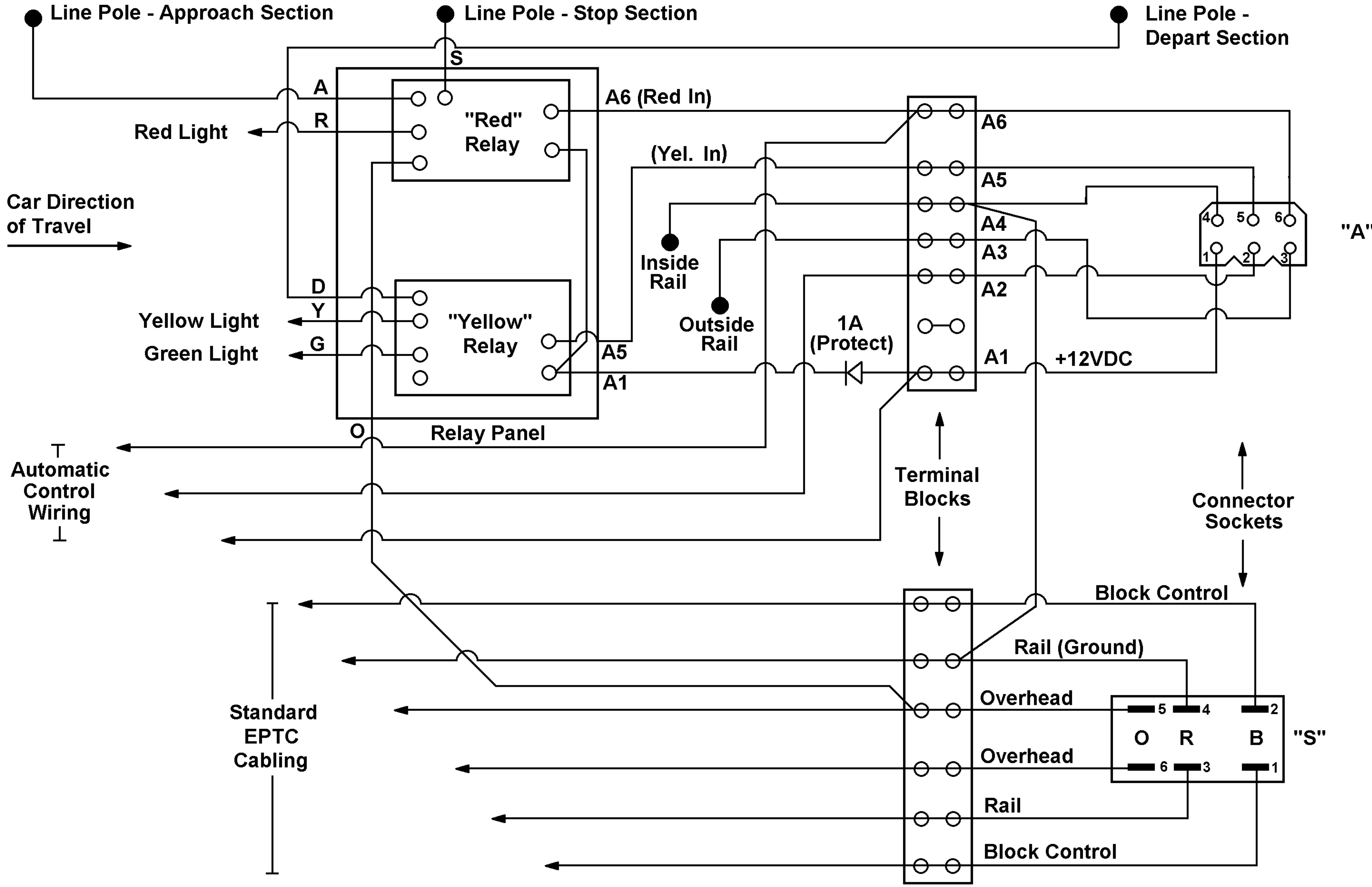

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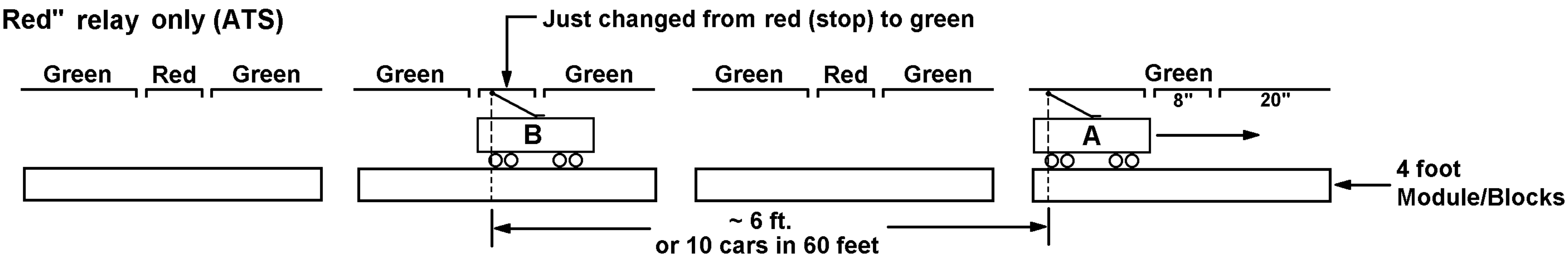
Figure 6 - Minimum Full Speed Headways
(Demonstrates the need to bypass the “yellow” slowdown diodes for close-headway operations)

1. "Red" relay only (ATS)



2. "Red" & "Yellow" relays with slowdown feature on yellow (ATC)

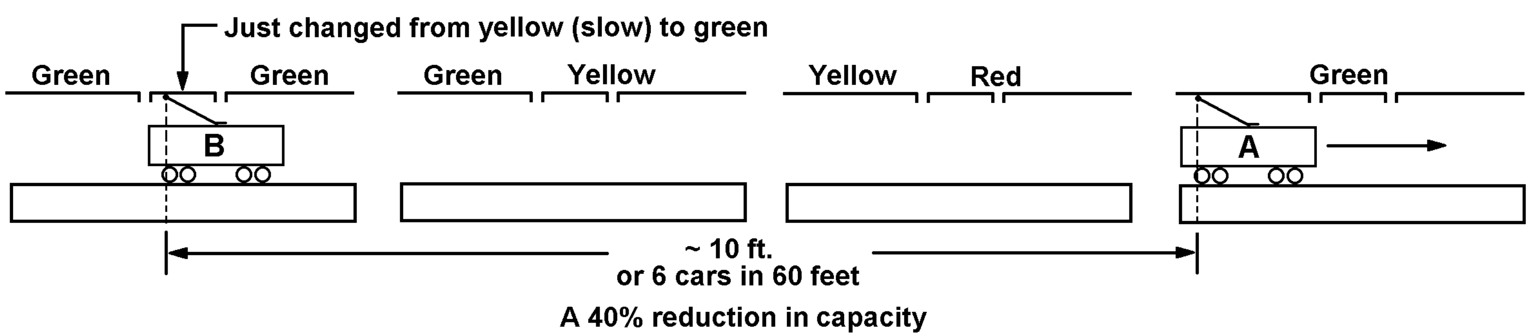


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Figure 7 - 12VDC Relay Power Supply