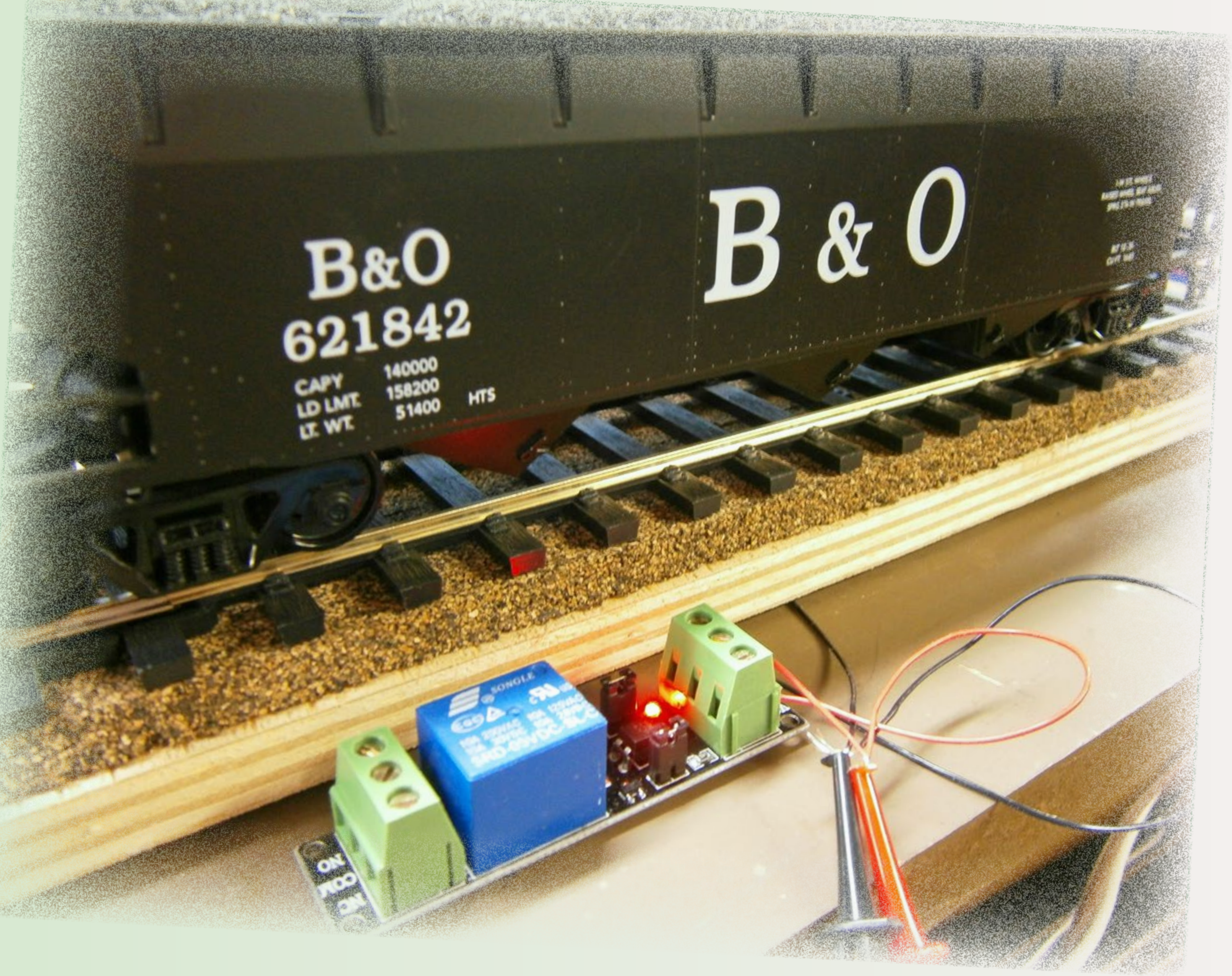


OPTICAL TRAIN DETECTION

Build a detector for $10

– By Terry Terrance
Model photos by the author

Build a detector by interconnecting pre-assembled modules ...

Reader Feedback (click here)

Being able to detect trains and rolling stock is necessary to implement automated control systems and prototypical signaling on your model railroad.

The cost and complexity of train detection deters many model railroaders from having a functional block signaling system, which should be a part of most mainline railroads. The trade-offs involved in choosing and designing a signaling system are often treated as a form of "black art", reserved for the adepts or the advanced modelers; but it need not be so.

Types of detectors

When I was designing my model railroad I spent a considerable amount of time determining how I would eventually signal the railroad. One key differentiating feature between signaling systems is how the trains are detected.

Detectors fall into two broad categories – electrical and optical. Electrical detectors come in many different configurations but all of them rely on detecting the flow of current between the rails.

Powered locomotives and lighted cars are readily detected because the motors have windings and the bulbs have filaments that allow current to flow across the rails. But electrical detectors cannot detect common rolling stock unless these cars are modified with special wheelsets that allow a small amount of current to flow between the rails.

Some of the electrical detector designs require that the current to the train pass through an electrical component in the detector circuit, typically a diode. That diode by its very nature causes a voltage drop in the block where the detector is installed.

Additionally, the diode must be sized to carry the full current available on the rails which, if you are in the larger scales or have a 10 amp DCC system, requires a pair of large diodes in each detector. Most electrical detectors require that you make additional connections in the wiring to the rails, each one of which is a potential source of trouble.

Some electrical detectors will work with AC and some won't. Some will work with DCC and some won't. While we're talking about DCC, all electrical detectors require that the railroad be segmented into blocks. This isn't so much of a problem if you are already running DC, but it defeats the otherwise simplified wiring associated with DCC and requires the same amount of wiring complexity as DC.

Optical detectors, on the other hand, have certain advantages. Optical detectors will detect all rolling stock – powered or unpowered – without modification to the models.

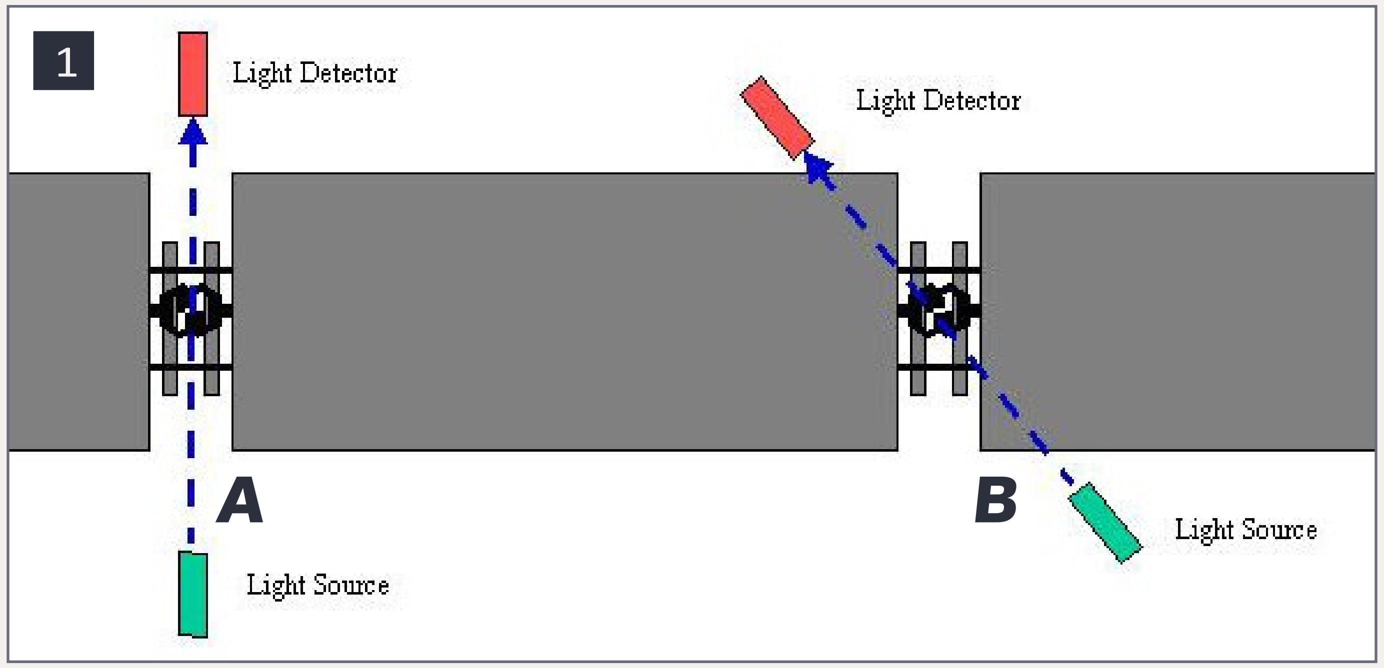
Because optical detectors are independent of the rails, they will work with AC, DC, DCC, MTH's Protosound, Lionel's Legacy & Trainmaster, 2-rail or 3-rail, even with catenary systems. Also, since the system does not detect the propulsion current you could be running a Z scale system at less than an amp or a large scale railroad at tens of amps – it makes no difference.

Since optical detectors have no connection to the rails, they cannot introduce any maintenance trouble spots or interfere with the operation of the trains. Finally, segmenting a DCC railroad into electrical blocks is not necessary and the simplicity of DCC wiring is maintained.

Optical detectors are not perfect however; and to understand their quirks we need to look at the three types of optical train detectors.

Types of optical detectors

Interrupter: I'll start with the type of optical detector that I'll call an "Interrupter", a light source (lamp, visible or Infrared



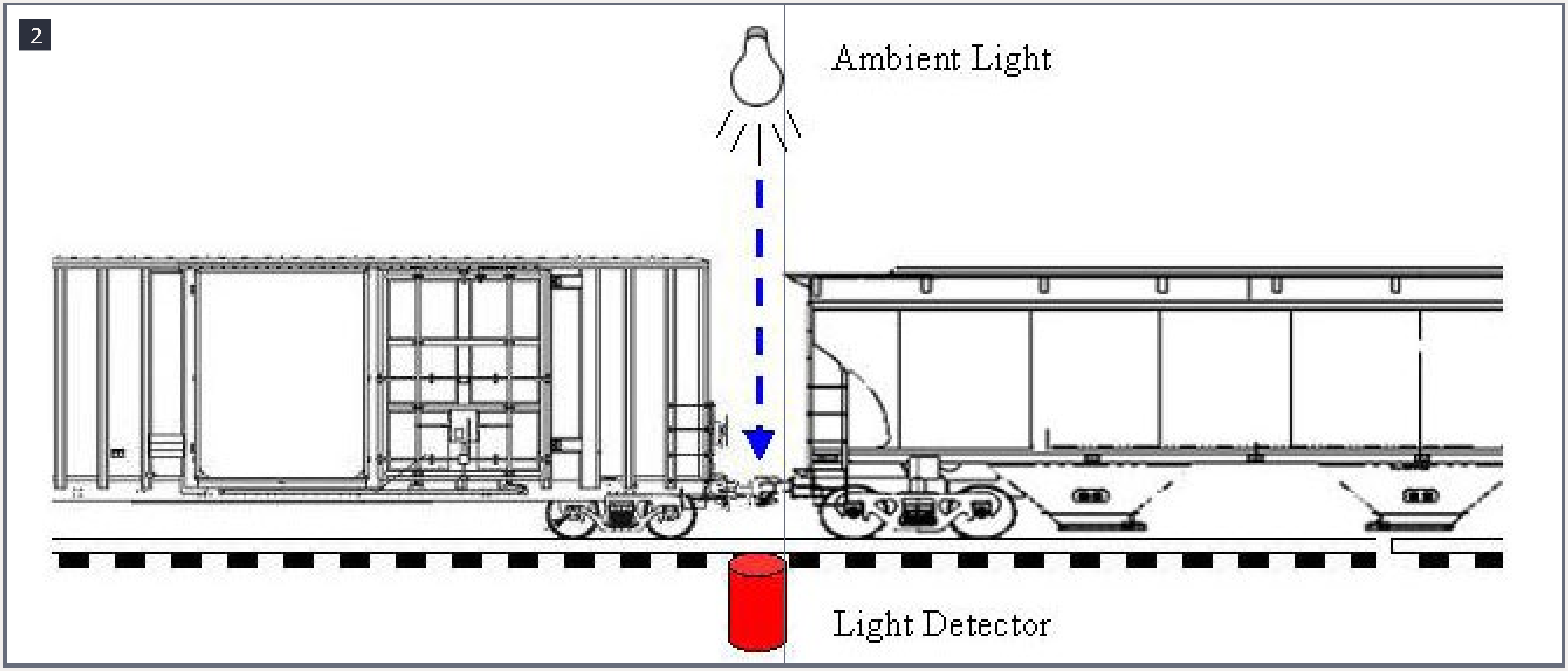
1. The "Interrupter" Optical Train Detector.

LED) is aimed across the rails. On the opposite side of the tracks from the light source is some form of photo detector (photovoltaic cell, photo-resistive cell, photodiode or photo transistor).

When the train comes along it breaks the beam between the light source and the detector and the train's presence is detected. Don't be put off by the technical terms within the parenthesis above; the key concepts are: light source, light detector and breaking the beam.

You can see the principles illustrated in [1]. In [1-A] the light source shines perpendicularly across the rails and is received at the light detector. The train comes along and breaks the beam, which results in the train being detected.

This illustration points out a shortcoming of the interrupter detector. At each gap between cars, the detector will "drop out" and give a clear indication. This can be addressed in a couple of ways:



2. The Ambient Light Optical Train Detector.

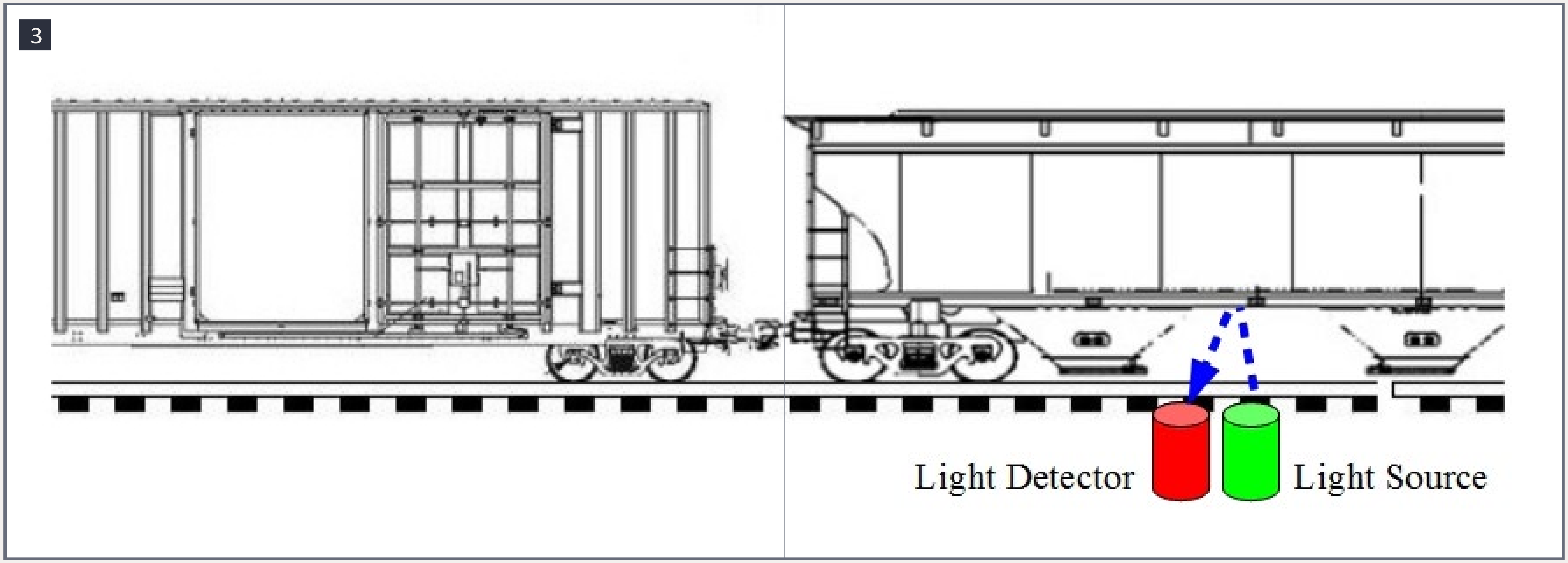
1. A delay can be built into the circuit or into computer logic downstream of the detector to hold the indication for a time to allow the next car to move into position. When the train has finally passed, this delay will time-out and give the clear indication.
2. A strictly mechanical method to address the problem is indicated in [1-B]. The source/detector pair is set across the rails at an angle such that the largest gap between cars will not expose the detector. Setting up the source/detector pairs in this way avoids any further electronic or software complications.

Aiming an interrupter detector can sometimes be a problem, especially with LEDs which can have a narrow beam. But this problem can be overcome.

A somewhat thornier issue is how to scenically camouflage all of the line-side light sources and light detectors. Some can be hidden behind relay cabinets, bushes, sheds, signs, etc.

But after some number have been hidden, the layout might become cartoonish for all of the clutter beside the track.

The problem is compounded if double or triple track has to be detected separately. All of these limitations can be overcome



3. The Reflective Optical Train Detector.

and an interrupter optical detection system can function satisfactorily on a model railroad.

Ambient light: A second type of optical detection system I'll call the ambient light sensor. In this system a light detector is placed between two ties and is facing upwards. The light detector is kept on by ambient room light. When a train passes over it and cuts off the ambient light, the train is detected. This arrangement is illustrated in [2].

Other than a small hole between two ties at intervals down the track, there is nothing to interfere with your scenery. The ambient light sensor does suffer from the inter-car drop out limitation; but that can be addressed with an electronic or software time delay.

So, is the ambient light sensor is the perfect optical train detector? No, not really. The ambient light sensor has its own quirk.

If you want to have night operations, and you turn off the room lights and/or the lights over the railroad, it's very likely that the ambient light system will cease to function because there's now insufficient light to activate the detector in the first place, and all, or almost all, of the sensors will indicate a detection all of the time. It has been suggested that a secondary, point-source light system be placed above each detector for just this reason. But this has its own problems.

For one, if your system uses visible light, the secondary lighting system will have to use visible light too. So during night operations there would be these spots of light at intervals down the track.

“Ambient light sensor detectors will work in hidden staging or anywhere else that the lights are kept on constantly.”

In the author’s opinion the secondary light source “solution” is more trouble than it’s worth.

However, if you don’t have night operations, and never want to have night operations, the ambient light system may be the perfect choice. Ambient light sensor detectors will also work in hidden staging or anywhere else that the lights are kept on constantly.

Reflective: The third type of optical train detector is generally referred to as a “reflective” detector. In the reflective detector a light source is mounted between the ties aimed upward. Next to it, and also looking upward, is a light detector.

Light is emitted from the source and, when no train is present, the detector sees nothing. When a train is present, the light is reflected off of the bottom of rolling stock and back into the detector, thereby signaling the presence of a train. This arrangement is shown in [3].

Like the ambient light system, the reflective system has no sensor mounting or aiming issues and nestles between the ties and does not interfere with scenery. Unfortunately, like the ambient light sensor, the reflective sensor has the inter-car dropout; which can be addressed in the same manner with a time delay.

Each reflective sensor has its own light source, so night operations are not an issue. Since the light source is pointed straight upwards and readily visible, a reflective system is rarely done in visible light. Infrared is almost always used; which also means that the detector is either a photodiode or phototransistor for maximum sensitivity.

The reflective sensor is not perfect, however. The detection range is usually limited (ergo the need for maximum sensitivity) and it is sometimes difficult to prevent the detector from “seeing” the light source right next to it and generating false triggers.

Installing optical detectors

By now it probably comes as no surprise that I decided to go with optical train detectors for my own railroad. I chose optical to preserve the wiring advantages of a DCC-controlled railroad and, as an O scaler, the immunity to high currents was another plus.

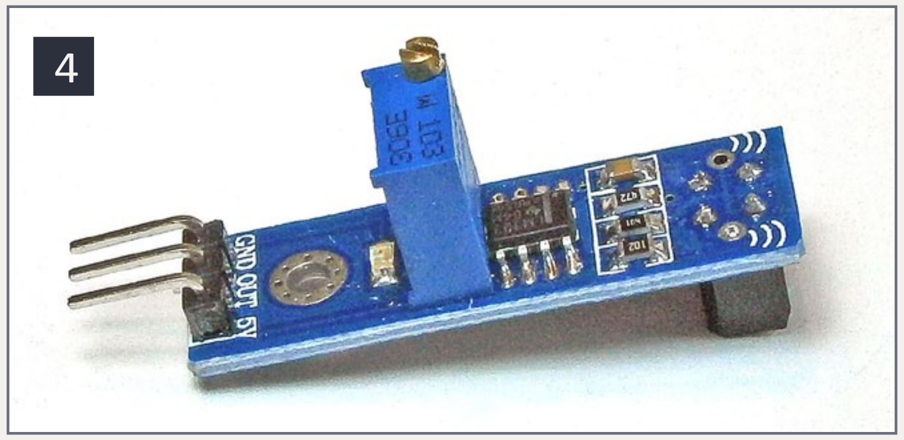
What may not be quite so obvious is that I chose the reflective sensors for their compatibility with night operations and easy concealability.

Having made the decision for optical detectors and having the sensors in hand are two different things. I had obtained a sample of at least one commercially available reflective train detector when I stumbled across something interesting.

The robot experimenter’s community has a number of modules available to them that allow the robot’s microprocessor to sense and detect the outside world. These modules are self-contained, easy to interface and generally inexpensive. Among these modules are reflective optical sensors.

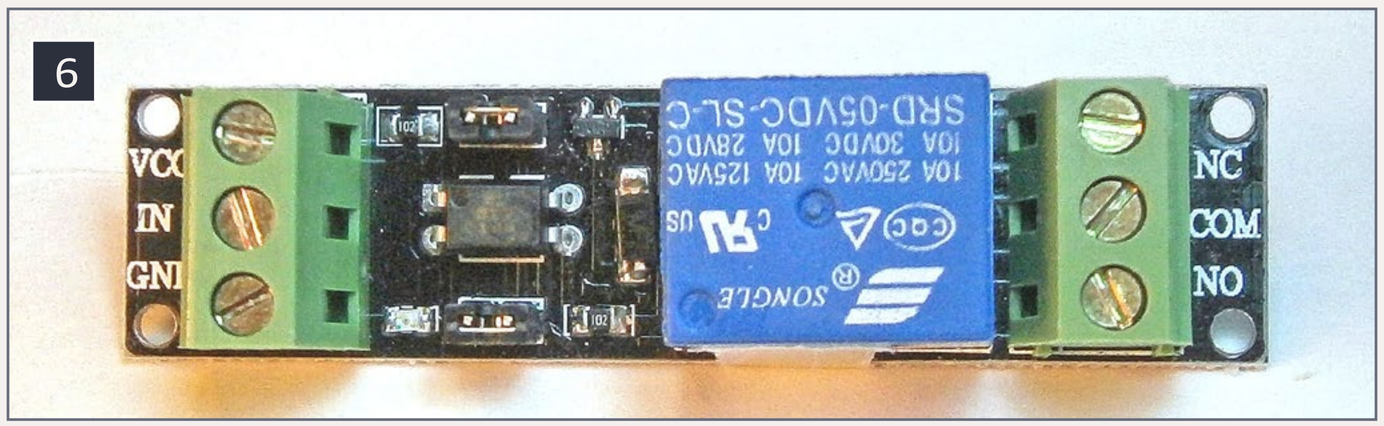
I found a reflective optical sensor offered by a company called Good Luck Buy (goodluckbuy.com) and it goes by the awkward title “Infrared IR Reflectance Sensor Module for Smart Car LM393” and it’s SKU 74447; cost is $4.59.

See: goodluckbuy.com/infrared-ir-reflectance-sensor-module-for-smart-car-lm393-.html.



4. Optical reflective sensor module.

5. The sensor side of the module.



6. The DC 5V relay control panel controller module with optical isolator.

The 1.26”x0.43”x0.79” board is dominated by a multi-turn potentiometer on one side (which adjusts the detection range) and on the other by the source/detector pair. Figure [4] shows the potentiometer side and [5] shows the emitter/detector side of the module.

This module has a hole that can be used for mounting. Hookup is via a three pin “header” on one end consisting of +5V, ground and output pins. In use, the source/detector pair would be inserted facing upward between the ties. When powered up and an object passes within the detection range the output pin goes to “logic low” (computer ‘logic low’ is between 0V and 0.8V).

Connecting to a signal system

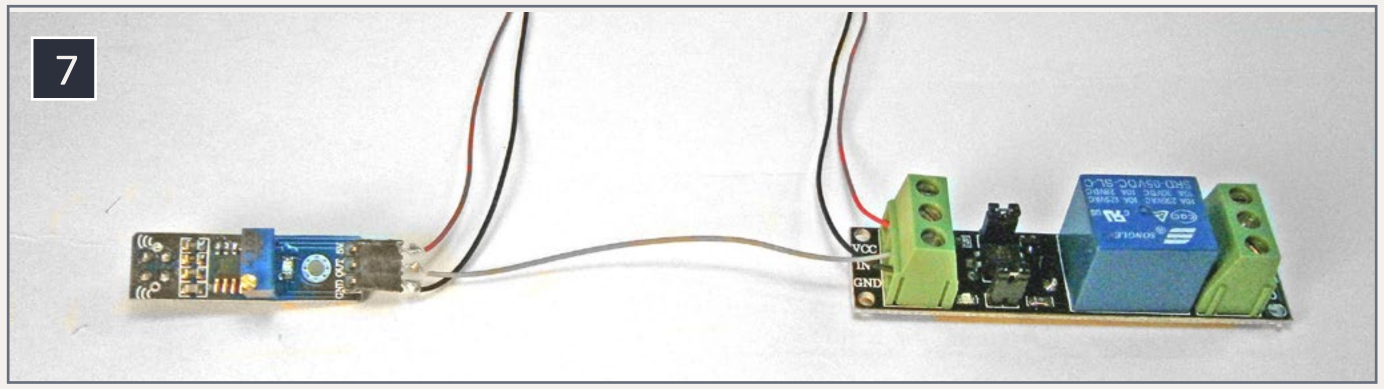
If your signal system can accept logic-level signals, then you supply power to the module, run the output to your signal system and you’re done.

But most signal systems are set up to detect a switch closure. In which case another module is needed. On eBay I found the following module which goes by the equally awkward name of “DC 5V Relay Control Panel Controller Module with Optical Isolator”; item #280823518850, from vendor “bosity”; price: $4.99

(ebay.com/itm/DC-5V-Relay-Control-Panel-Controller-Module-with-Optical-Isolator-/280823518850?pt=LH_DefaultDomain_0&hash=item416262d682).

This 2.8 x 0.7 x 0.8 inch module has a 10 amp SPDT relay and the interface circuitry necessary to read a logic low signal at it’s input. One end of the relay module has +5V (on the terminal marked VCC), ground and input screw terminals. On the opposite end are screw terminals for the normally open, normally closed and common connections to the relay [6].

To make the two modules function together each module needs to be supplied with regulated +5V (more on this later) and the output from the sensor is wired to the input of the relay module – that's all there is to it. To prevent soldering directly to the pins on the sensor module, I cut off 3 female sockets from a strip of header sockets (SAMTEC BCS-130-L-S-TE, for 0.01" pins on 0.100" spacing) and soldered to the sockets.



7. The two modules interconnected.

8. The sensor mounted below the track.

If you wield a hot soldering and solder quickly, there's no harm in soldering directly to the pins. On the relay module the wires go directly into the screw terminals. For how the detectors modules are interconnected see [7]. The red and black wires carry +5V and ground respectively to the modules and the gray wire carries the signal between the two modules.

Reading the LEDs

Both the sensor and the relay module have surface-mount red LEDs on them. When the sensor detects an object, the LED lights up. Similarly when a logic low signal appears on the relay module's input pin, it's LED lights up and the relay pulls in (which you can hear).

These LEDs are handy for troubleshooting, but the likelihood of having to troubleshoot this circuit is low. The potentiometer on the sensor board adjusts the detection range, turning the screw clockwise increases the range. At maximum range a white index card is detected at about an inch and a blackened card is detected at about half an inch.

The LED in the source is an infrared LED and, therefore, not visible when powered; but if you want to see the LED light up, look at it with your cell phone's camera or your digital camera; most of their sensors can 'see' in the infrared.

Connecting and testing the modules

The output of the relay will go to your signal system; either as a switch closure on detection (the normally open contacts) or as a switch opening on detection (the normally closed contacts). Since the relay module has a hefty 10-amp relay, this set-up can also be used for automation as it can switch track current on and off, activate accessories (e.g. crossing gates/lights), lights, etc.

If you look at [8] you can see the sensor mounted between the ties of a section of O scale test track that I set up. The bulk of the sensor module is hidden below the cork roadbed. Position the top of the sensor level with the top of the ties to maximize the detection distance.

"Each detector draws about 10 milliamps steady state and 85 milliamps when a train is detected and the relay is energized. "

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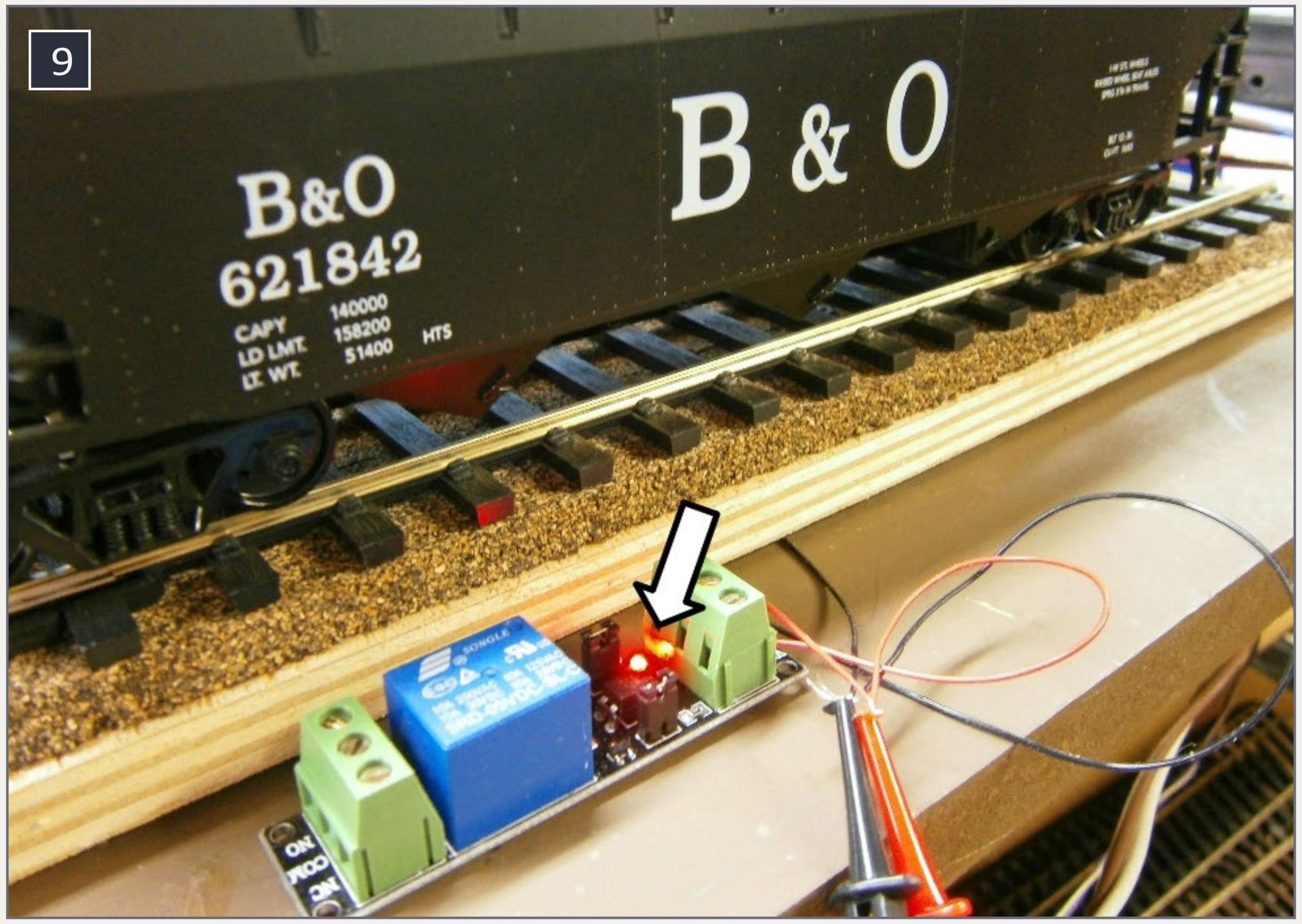

9. The detector in operation.

The relay module should be mounted within several inches of the sensor module so that the logic level signal does not pick up any interference or is degraded. The light purple color that you may be able to see in the LED nearest the camera is the camera's sensor seeing the infrared light being emitted by the LED.

Putting an O scale hopper over the sensor as in [9], the arrow points to the LED on the relay module that illuminates to indicate that the car has been detected and the relay has closed.

The 5VDC needed to power these modules should be reasonably well-filtered and regulated. While these modules do not use any critical digital circuitry, a power pack set to 5V is probably not the way to go to supply the 5V needed.

There are many options to supply clean 5VDC: bench-top and laboratory power supplies; open-frame power supplies and regulated plug-in wall transformers (wall-warts) are good choices (just be sure that the output of the wall-wart is regulated and DC, not AC).

Each detector draws about 10 milliamps steady state and 85 milliamps when a train is detected and the relay is energized. Therefore for each ampere that the power supply can provide will power up to 50 detectors or so, given that few will be energized at any given time.

A final word

Both of these modules are sold by and will ship from vendors in China. To allay your concerns: I have ordered many items from vendors in China with complete success and satisfaction. Chinese vendors offer products that are not available here and prices are very reasonable; plus shipping is usually free. I pay exclusively via PayPal.

With PayPal the vendor does not see your credit card information; PayPal also has a dispute resolution process as well as a refund

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process should you not receive your merchandise. Payment with PayPal is far safer for international payments than direct payment with a credit card.

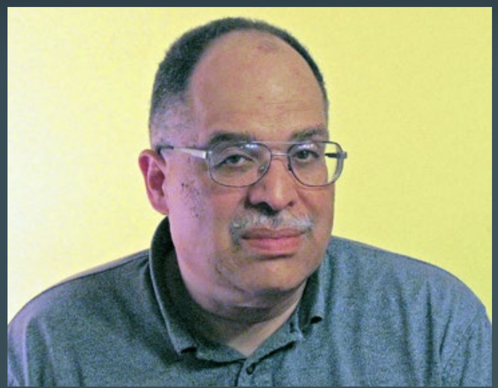
The only drawback with ordering from China is the “free” shipping. Orders from China are sent via China Post – which gives new meaning to the term “snail mail”; so don’t expect to receive your order in less than three weeks, and five to six weeks is possible. But I haven’t lost an order in the post yet.

Optical train detection offers several advantages over electrical detection of trains – particularly so for command control systems, AC operators and high current systems.

A reflective optical detector can be constructed out of modules designed for the robotics/micro-controller hobbyist with just a few interconnections between them. The resulting detector can operate from between two ties and reliably detect trains passing above. Using this detector can help simplify the design and construction of a signaling or automation system for your railroad.

Give it a try; for $10 what do you have to lose? ☑

Reader Feedback (click here)



Terry Terrance has been a model railroader since receiving his first Lionel train set at age 7. The next couple of decades he spent as a 3-railer attempting to scale model in the days before 3 Rail Scale. Eventually, rather than go the HO route, Terry jumped into 2-rail O Scale where he has been ever since.

Currently Terry is building a model of the B&O “West End” centered around the M&K Junction helper station circa 1950/2 in his basement. The layout features the Cranberry (three-track) and the Cheat River (two-track) grades and is designed for helper operation closely following the prototype.

Terry’s blog (2railoscale.blogspot.com) features the construction progress as well as tips and techniques, articles and videos. Terry is part of the regular crew of the *Model Rail Radio* podcast and has also appeared on the *Model Railcast* podcast.