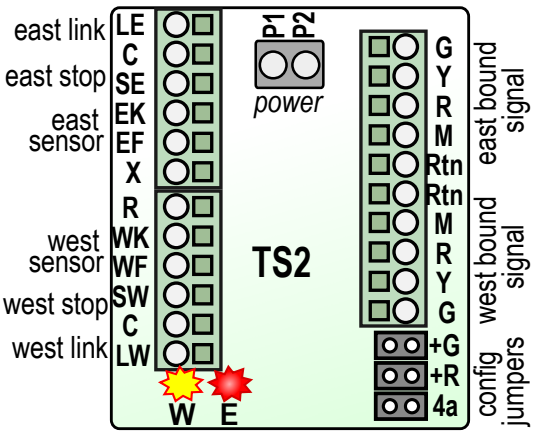


What it is: The TS2 operates one or two trackside block signals (one in each direction) on one track to simulate the block signals of a real railroad. Trains are sensed at the signal location using infrared sensors, independent of the room lighting. The TS2 does not require the rail to be cut into isolated blocks and does not require resistor wheel sets on the train cars.

Multiple TS2 units may be linked together so that successive block signals along the track will be properly coordinated.

LED signals must be used. Signals with incandescent bulbs need solid state relays such as Azatrax model SSR6 between the TS2 and the signal.

Most types of LED block signals may be used. The polarity of the signals (common anode vs. common cathode) is automatically detected by the TS2.

Limitations: The TS2 only senses trains as they pass the block boundary. Two TS2's, one at each end of a block, tell each other when a train enters or leaves a block, so they can deduce when the block is occupied or clear. Because the TS2 does not actually sense the physical presence of a train in the block, it can give false indications if part of a train becomes uncoupled and is left behind in the block, or if a train enters or leaves the block by some route other than the two ends that are monitored by the TS2's. To compensate for this, see '**Interlocking Functions**' on pg. 5.

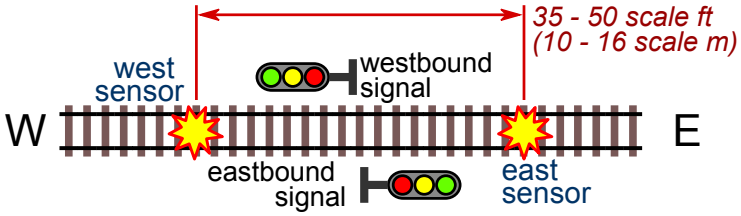
Kit contents:

★ Circuit board
★ Infrared light-emitting diodes (IR LEDs) with red & white wire leads
★ Infrared photo receivers with blue & yellow wire leads
★ Plastic mounting tubes. The tubes are for protection of the sensor leads and to provide mounting support. They are not essential for detector operation and may be shortened or removed entirely to best fit your situation. Just use caution to avoid damaging the leads.
★ 1,000 ohm resistor for interlocking functions (pg. 5)
★ Mounting screws

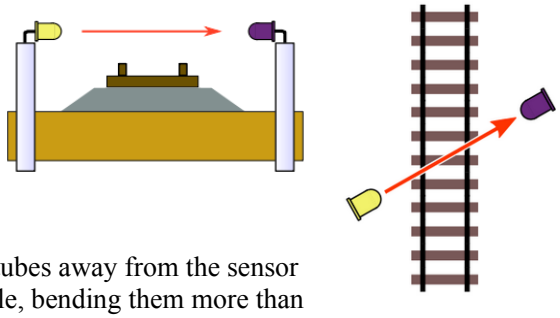
Installation

This guide assumes an east/west direction of the track.

Install the sensors: Choose a location for the signals. If using only one signal for one-way traffic, install only the east-bound signal. Each sensor pair may be installed in one of two different ways - 'Across the Track' or 'Reflective.'



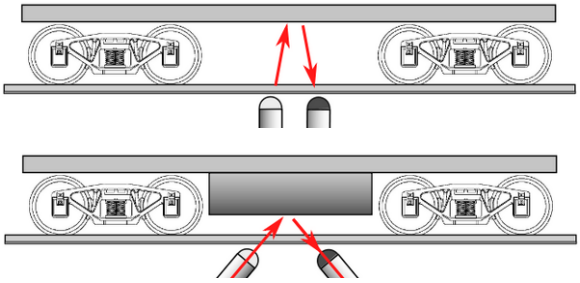
Across the Track sensing: The IR LED is positioned horizontally on one side of the track, and the IR photo receiver is placed on the opposite side. A train is detected when it blocks the light path between the LED and photo receiver. The distance between the LED and photo receiver can be up to 18 in. (46cm), or more with careful alignment. Placing the sensors at an angle across the track avoids possible detector flickering caused by the gaps between cars.



Tip #1 - If mounting the sensors vertically as shown here, slide the plastic tubes away from the sensor then carefully bend the leads to a right angle. The leads are somewhat brittle, bending them more than two or three times may cause a break.

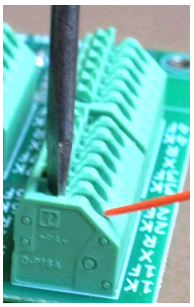
Tip #2 - Locate the photo receiver so it faces away from bright lights or sunny windows. Use scenery or structures to conceal the sensors and shade them from room lighting.

Reflective sensing: Trains are detected when light from the IR LED is reflected off a train and sensed by the IR photo receiver. Typically the sensors are mounted in two 3/16-inch (4.8mm) holes drilled in the roadbed as shown here. Vertical installation works for S and larger scales as long as there is no structure above the track such as a bridge.



Angling the IR LED and photo receiver toward each other is best for N and HO scale where the trains are close to the rail head, and in places where an object above the track might otherwise cause false detections. Angle the IR LED and photo receiver so their centerlines intersect at the height of the bottom of your rolling stock.

Tip #3 - You can ballast your track after sensors are installed. Cover each sensor with a bit of transparent tape. Apply ballast. When the glue has dried use a dental pick or similar tool to remove ballast from the sensors. An opening of just 1 or 2 mm is required.

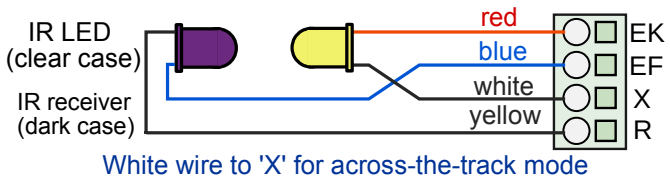


Connecting wires to the terminal blocks: The TS2 has 'spring cage' quick-connect terminal blocks.

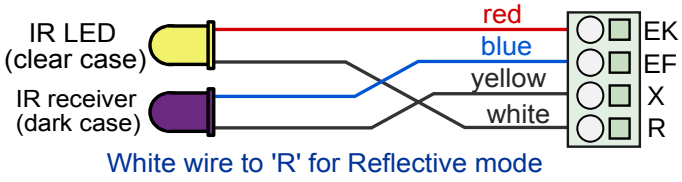
- ♣ Strip 3/8 inch (1 cm) of insulation off the end of the wire.
- ♣ Use a small screwdriver to push down (push, do not turn) the terminal's button. Push firmly.
- ♣ While the button is pushed in, hold the wire at a 45 degree angle to the terminal block and push it in. About 3/8 inch of wire should go into the terminal block.
- ♣ Release the button. Tug on the wire to make sure it is secure.

When two wires are connected to the same terminal, twist the bare ends of the wires together.

Connect east sensor pair: Connect the red wire from the IR LED to terminal EK. Connect the blue wire from the IR photo receiver to terminal EF. Now, how you connect the white and yellow wires to the TS2 will determine whether the east detector will operate in 'Across the Track' or 'Reflective' mode. See the diagrams below:



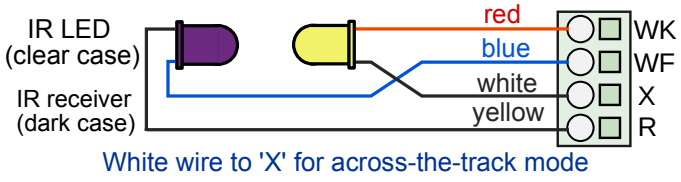
White wire to 'X' for across-the-track mode



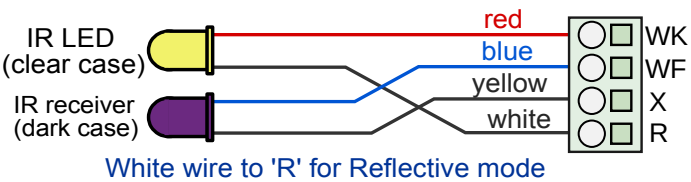
White wire to 'R' for Reflective mode

Connect west sensor pair: Connect the red wire from the IR LED to terminal WK. Connect the blue wire from the IR photo receiver to terminal WF. As with the east sensor, how you connect the white and yellow wires will determine whether the west detector will operate in 'Across the Track' or 'Reflective' mode. The two detectors may operate in the same mode or in different modes.

When both sensor pairs are connected, there will be two yellow (or white) wires in 'X' and two white (or yellow) wires in 'R.'



White wire to 'X' for across-the-track mode



White wire to 'R' for Reflective mode

Additional wire may be spliced to the sensor leads if needed. Use similar twisted pair wire for total length up to 26 ft (8m).

➽ **Pairing is important!** The IR LED that is connected to EK must be paired on the layout with the IR photo receiver that is connected to EF. The IR LED that is connected to WK must be paired with the IR photo receiver that is connected to WF.

Connect power to the TS2: Connect an accessory power supply of 8 to 16 volts AC or DC to terminals P1 & P2. The red and yellow ('E' and 'W') LEDs will briefly flash to show that power is on and the circuit is working.

Test and adjust the sensors:

With no trains near either sensor pair, the 'E' and 'W' LEDs on the TS2 module should be off. If either LED is on, correct the false sensing condition.

To fix false sensing for *Across-the-Track* mode:

1. Verify that the sensor pair is wired correctly.
2. Make sure the IR LED and photo receiver are pointed at each other, and nothing is between them.
3. Shade the photo receiver from bright lights, and point it away from windows or other strong light sources.
4. Change the nearby room light from incandescent to a fluorescent or LED bulb if possible.

To fix false sensing for *Reflective* mode:

1. Verify that the sensor pair is wired correctly.
2. Pull the IR LED and photo receiver a bit deeper into the roadbed.
3. Infrared light may be 'leaking' through the roadbed material from the IR LED to the photo receiver. Push a metal shim, such as the tip of a hobby knife blade, vertically into the roadbed between the IR LED and photo receiver.
4. Is there an object above the sensor, such as a bridge, or an upper layout level? Mount the IR LED and photo receiver at a shallower angle, or paint the object flat black. Or use across-the-track sensing.

Are all detectors now off? Now **test for train detection**. Place a locomotive or car at the **east** sensor. The 'E' (red) LED should light. If the yellow LED also lights, re-adjust the *west* sensor pair for false detection (see above).
If the 'E' LED does not light, correct the *east* sensor pair for a false clear condition.

To fix a false clear indication for *Across-the-track* mode:

1. Verify that the sensor pair is wired correctly.
2. Adjust the sensor height so the train is fully blocking the light path from the IR LED to the photo receiver.

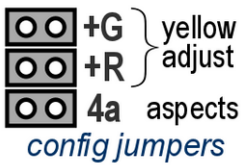
To fix a false clear indication for *Reflective* mode:

1. Verify that the sensor pair is wired correctly.
2. Adjust the sensors higher or lower in the roadbed.
3. A bright light source above and to the side of the track may be saturating the IR photo receiver. Try pulling it deeper into the roadbed or create shade with scenery or a structure. Change the nearby light from incandescent to a fluorescent bulb.

Test with several types of rolling stock and adjust the sensors as needed.
Remove the train from the east detector, make sure the 'E' LED goes out.
Place a train at the west detector. The 'W' (yellow) LED should light. If the 'E' LED also turns on, adjust the *east* sensor pair for false detection (see above).
If the 'W' LED does not light, adjust the *west* sensor pair for a false clear condition (same process as above for the east sensor pair).

Sensors must be working correctly before continuing the installation.

Configuration jumpers



Two configuration jumpers (small rectangular connector blocks, or 'shunts') are supplied with the TS2. Three pairs of pins can accept these jumpers. To enable a configuration feature, place a jumper on both of the pins. To disable a feature, remove the jumper or park it on one pin.

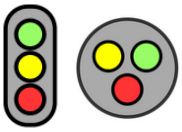
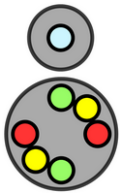
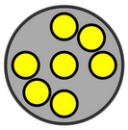
Yellow adjust jumpers are only for searchlight signals with one bi-color (red/green) LED. To produce a yellow color, the red and green internal LED chips are illuminated together. The quality of the 'yellow' light is variable, depending on the viewing angle, ambient light and the LED itself.

+G: If the 'yellow' color looks too reddish, place a jumper across the **+G** pins to increase the green intensity.
+R: If the 'yellow' color looks too greenish, place a jumper across the **+R** pins to increase the red intensity.
A 'middle' yellow is produced when both jumpers are off.

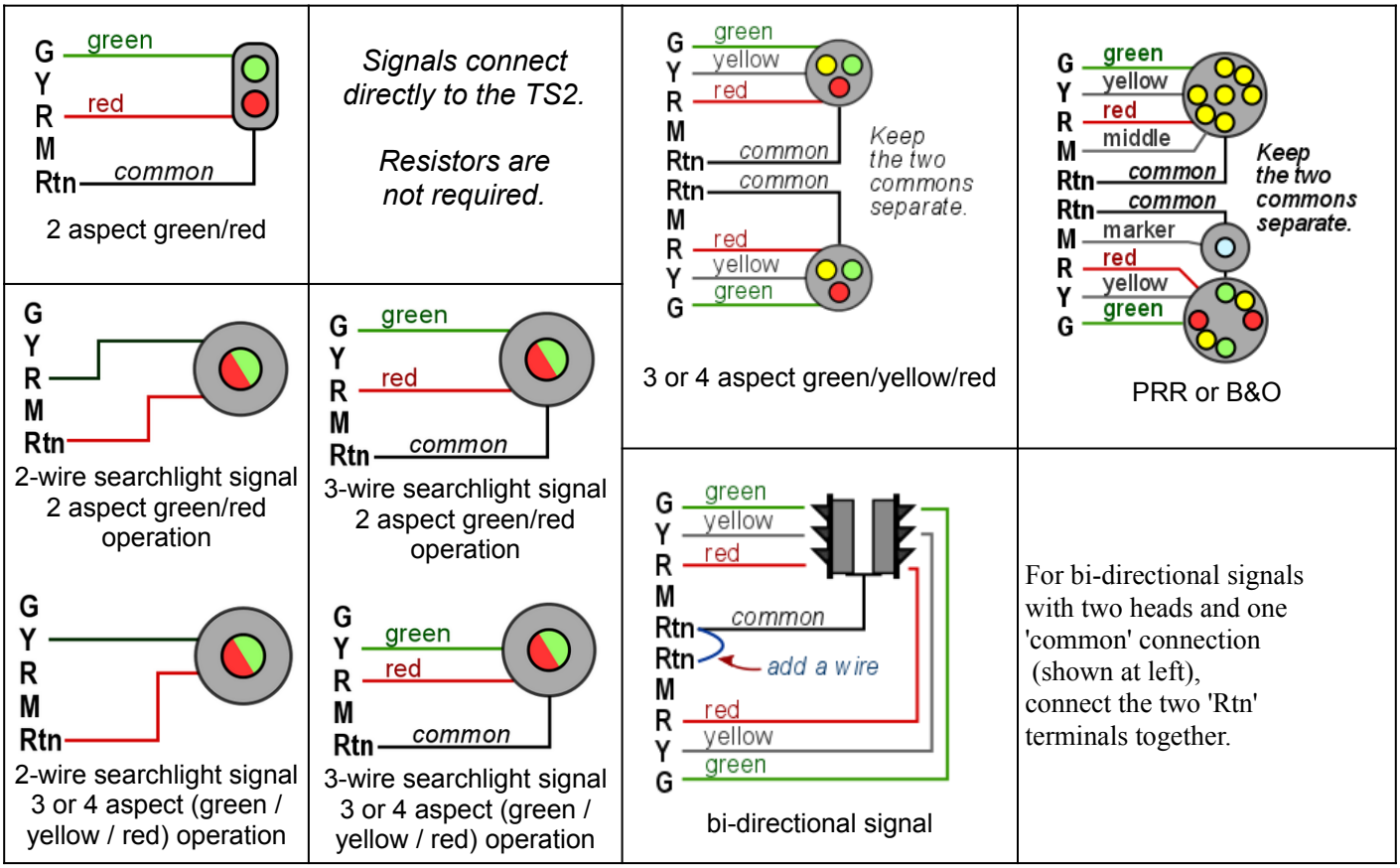
4a: A jumper across this pair of pins enables **four aspect** signaling (clear / advance approach / approach / stop).
Removing the 4a jumper selects **three aspect** signaling (clear / approach / stop).

Signal Connections

The following types of signals may be used with the TS2:

Signal Operation	 2 LEDs	 3 LEDs	 B&O CPL	 PRR	 bi-color LED (red/green)
2 aspects	green / red	green / red	green / red	vert / horiz	green / red
3 aspects	not available	green / yellow / red	green / yellow / red with or without marker	vert / diag / horiz	green / yellow / red
4 aspects	not available	green / flashing yellow / yellow / red	green, marker on / yellow, marker on / yellow, marker off / red, marker on	not available	green / flashing yellow / yellow / red

Connect signals to the TS2 according to the diagram below that matches your signals. With very fine signal wires, it is best to attach larger wires (AWG #26 or #24, such as found in phone or LAN cable), then insert the larger wire in the terminal block.
Searchlight (SA) signals that have a true red/yellow/green (tri-color) LED connect just like 3-LED signals.



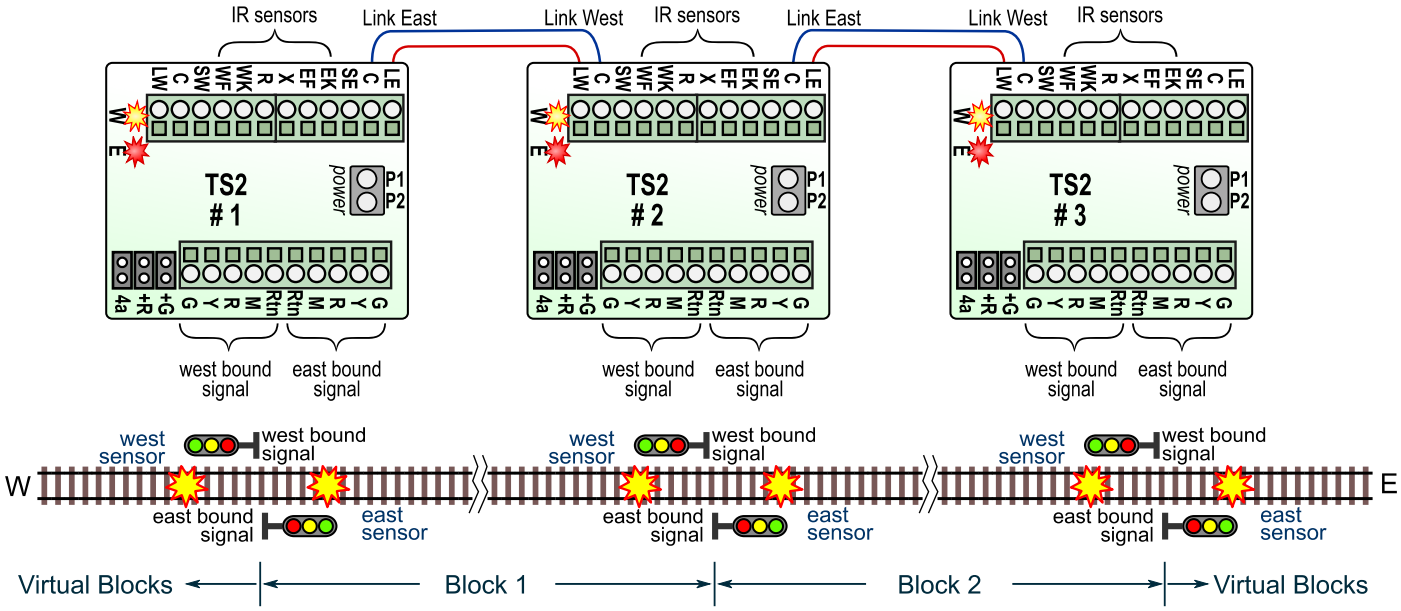
Note that **resistors are not required** because resistors are built in to the TS2 circuit board.
If signals are pre-assembled with resistors, first try the signals with their resistors. If the signal lights are too dim, remove the resistors.

If an individual LED is too bright, a resistor may be wired in series with that LED's wire. Use up to a 1,000 ohm resistor. Increasing the resistance value decreases the brightness.

When power is turned on, the TS2 does not know if the block is occupied or not, because a train may have been added or removed from the track while power was off. The signals will show 'approach' (yellow) (or red for 2-aspect signals). Proceed with caution! Normal indications begin once the first train passes the IR sensors.

If the TS2 is not connected to another TS2 circuit down the track to the east or west, it operates in a **timed mode**. The track beyond each signal is a 'virtual' block. When a train passes the signal and enters the virtual block, the signal shows a 'stop' aspect (red) to indicate the virtual block is occupied. After a time delay, the signal changes to 'approach' for 3- or 4-aspect operation, or 'clear' for 2-aspect operation. After another delay the signal changes to the next less restrictive aspect, and so on until the signal shows 'clear' (green).

Length of the time delay depends on train speed. Fast trains cause shorter time delays because they would clear successive blocks faster than slow trains. The minimum delay is 7 seconds, the longest delay is 14 seconds.



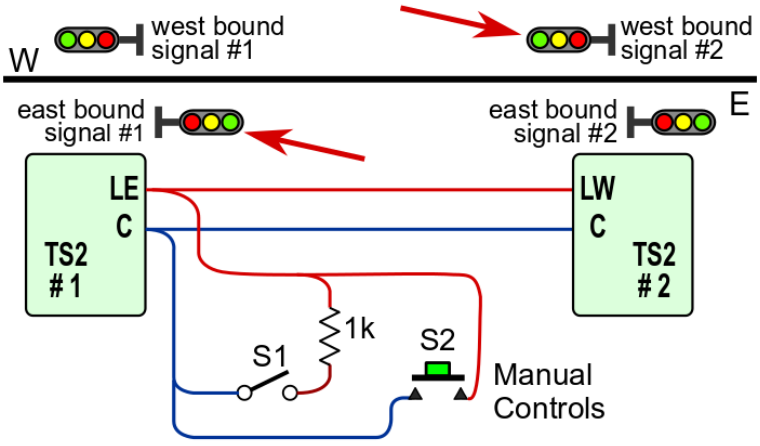
The TS2 may be linked to other TS2 circuits to the east and west. The TS2 circuits tell each other when they sense a train entering or leaving the block between them. When a train enters a block, the block is 'occupied' until a train exits the block. The block is then considered to be 'clear.'

Connect 'LE' (link east) of one TS2 to 'LW' (link west) of its eastern neighbor. Connect 'C' of one TS2 to 'C' on the other TS2. Use twisted pair wire such as found in telephone or ethernet ('Cat 5') cable, AWG #26 or #24. To avoid interference from high power or high frequency currents, keep this wire away from track power and switch machine wiring.

Any number of TS2 circuits may be linked in this way.

Interlocking functions

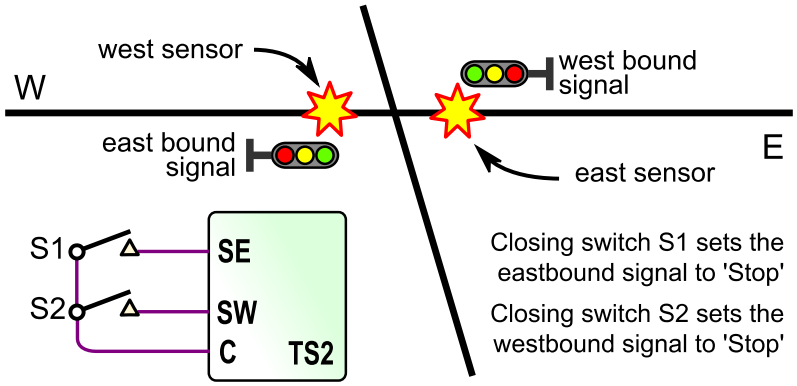
To force a block to 'occupied' status even when no train is in the block, connect a switch or relay and a 1,000 ohm resistor between the 'Link' terminal (LE for the east side, or LW for the west side) and the 'C' terminal.
The switch can be a dispatcher's switch, auxiliary train detector or a switch linked to a drawbridge, a switch machine, etc. In this diagram, closing switch S1 will cause eastbound signal #1 and westbound signal #2 to show 'stop.' The entire block between TS2 #1 and TS2 #2 will have an 'occupied' status.



To manually clear an 'occupied' block, momentarily connect the 'Link' terminal (LE for the east side, or LW for the west

side) directly to the 'C' terminal. This may need to be done after a train leaves the block through a turnout onto a siding or branch line, or if it is removed from the track by hand. Briefly pressing S2 clears the block between TS2 #1 and TS2 #2.

To force either signal to a 'stop' condition, rather than for an entire block as shown above:
♦ Connecting '**SE**' to '**C**' will force the eastbound signal to show 'stop.'
♦ Connecting '**SW**' to '**C**' will force the westbound signal to show 'stop.'

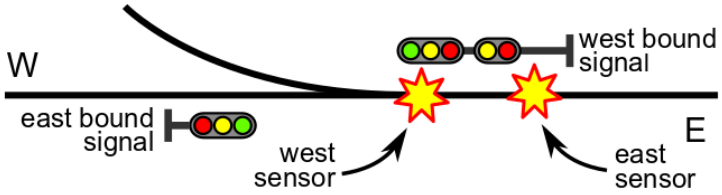


In this example the east/west main line is crossed by a north/south track. Closing switches S1& S2 will set the eastbound and westbound signals to 'stop' to allow traffic to cross on the north/south track. Sensors may be placed on opposite sides of the crossing, or both may be on the same side.

Use with a Dual Head Signal

If the 'M' terminal is not used for a B&O marker lamp or for the middle lamp of a PRR signal, the 'M' terminal can be used to light an LED on a second signal head.

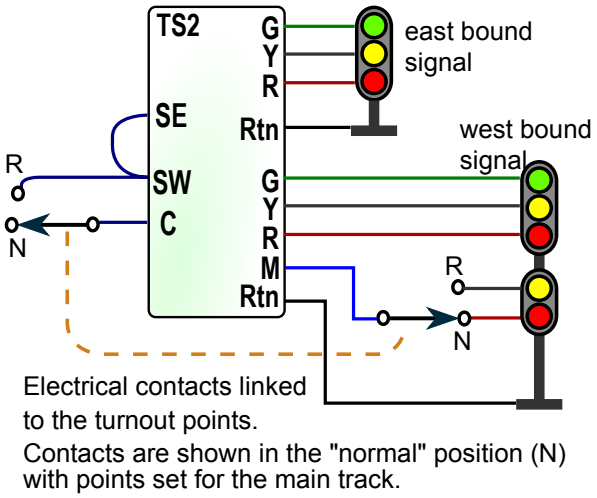
In some places railroads will mount two signal heads on one mast, one below the other. The lower signal head can be used for different purposes depending on location and situation. It's up to you to decide what information the second signal head will display to the train crews on your railroad.



For example – a turnout is to the west of a dual head signal. The 2-light lower signal head indicates the position of the turnout points.

When the turnout is lined for the main track ('Normal'), the upper signal head displays the condition of the main track and the lower head shows red.

When the turnout is lined for the siding ('Reverse'), the upper head shows red and the lower head shows yellow. The eastbound signal shows red when the turnout is lined for the siding.



To enable full brightness of the second signal head LED, install a connecting jumper across the two +G pins or across the two +R pins. As long as you are not using a bi-color red/green searchlight signal, the jumper setting will not affect the signal appearance.

The two sets of electrical contacts are linked to the switch machine. These can be internal contacts such as are built in to Tortoise® and Cobalt® switch machines, or they can be contacts of a latching relay that operates in parallel with a 'snap' switch machine.

config jumpers

The contact on the left connects terminal 'SE' and 'SW' to 'C' when the turnout is lined with the siding. This causes the westbound upper signal head to show 'stop.'

The contact on the right directs power to either the yellow or the red LED in the lower signal head.