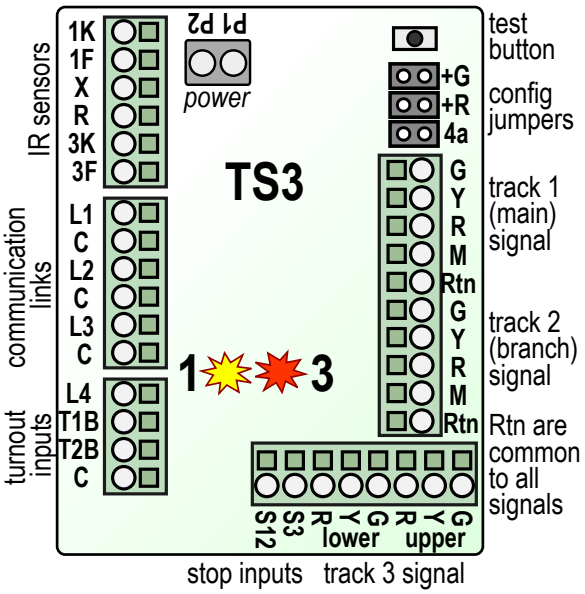
What it is: The TS3 operates up to four trackside signal heads at a single track junction to simulate the block signals of a real railroad. Trains are sensed at the signal location using IR (infrared) sensors that are independent of the room lighting. The TS3 does not require the rail to be cut into isolated blocks and does not require resistor wheel sets on the train cars.



Kit contents:

★ Circuit board
★ IR (infrared) light-emitting diodes (IR LEDs) with red & white wire leads
★ IR 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. Use caution to avoid damaging the leads.
★ 1,000 ohm resistor for interlocking functions (pg. 6)

TS3 units may be linked to other Azatrax TSx series signal circuits so that successive block signals along the track will be properly coordinated.

"**TSx**" refers to any Azatrax circuit in the TS2, TS3, ... series.	Signals with incandescent bulbs need solid state relays such as Azatrax model SSR6 between the TS3 and the signal.

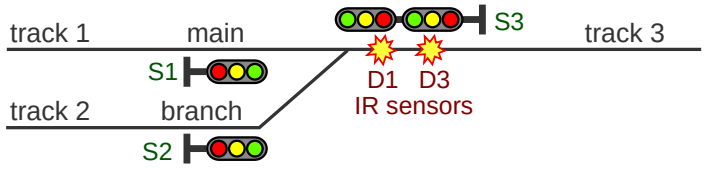
Most types of LED block signals may be used. The TS3 automatically adjusts to the polarity of the signals (common anode vs. common cathode).
All signals must be the same polarity.

This symbol represents a signal facing trains that are moving left to right.	
This symbol represents a signal facing trains that are moving right to left.	

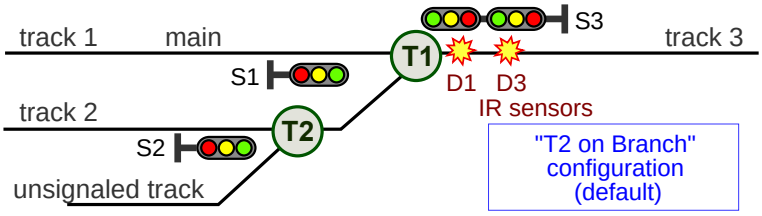
Limitations: The TS3 only senses trains as they pass the junction. Two TSx's, one at each end of a block, tell each other when a train enters or leaves a block, so they can deduce when the block is occupied or clear. Because the TS3 does not actually sense the physical presence of a train in the block, 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 TSx circuits. To compensate for this, see '**Interlocking Functions**' on pg. 6.

Signaling at a junction:

Trains approaching turnout (track switch) **T1** from the left on track 1 or track 2 see a single-head signal. The signals indicate the conditon of the track ahead.

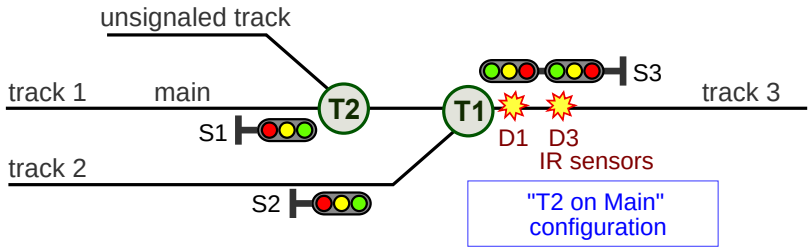


Trains approaching **T1** from the right on track 3 see a double-head signal. If **T1** is lined for the main track (track 1), the upper signal head indicates the condition of the main track ahead, and the lower head shows red. If **T1** is lined for track 2, the upper signal head shows red and the lower head indicates the condition of track 2. Turnout **T2** is optional, providing access to a non-signaled track.

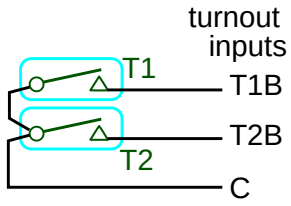


The most common location for T2 is on the branch track. In its default configuration this is where the TS3 expects turnout T2 to be. If T2 is on the main track (see below), then you must change the TS3's track configuration. Learn how on pg 8. Lining a train from track 3 to the unsignaled track will cause signal S3 to show 'restricting.' S1 and S2 will show 'stop.'

Turnouts must have an electrical contact (switch) that indicates the turnout's position. The contact must be 'open' ('off') when the turnout is in the Normal (main route) position, and 'closed' ('on') when the turnout is Reversed (branch or diverging route).

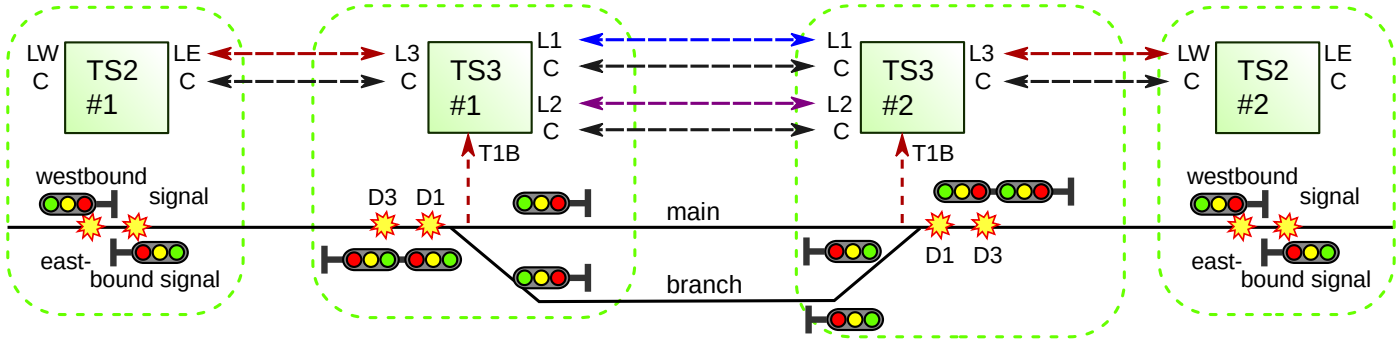


Some switch machines have built-in contacts. One side of T1's contact connects to 'T1B' on the TS3. The other side of the contact connects to 'C.' If turnout T2 is used, one side of its contact connects to 'T2B' on the TS3, and the other side connects to 'C.'



If your electric switch machine does not have built-in contacts, a relay can be connected to the switch machine. Relays for this purpose are available from Azatrax, see azatrax.com

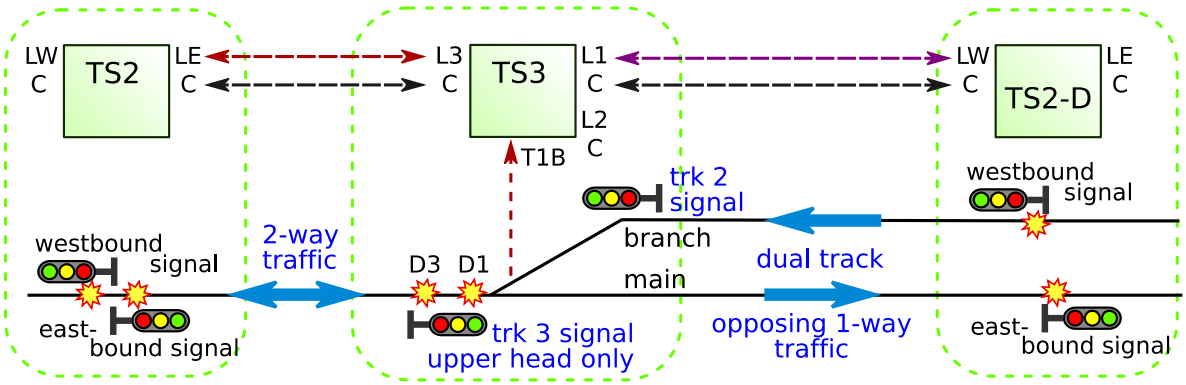
Link Connections: The L1, L2 and L3 terminals connect to adjacent TS2, TS3 or TS5 signal controllers. This allows the connected circuits to communicate and coordinate their signals. L1 connects to the next signal controller down track 1. L2 connects to the next controller down track 2, and L3 connects to the next controller down track 3. The 'C' terminal is a reference voltage. Each link consists of two wires that follow the track from one signal site to the next.



Example 1: Signaling a passing siding with two TS3 circuits. Two TS2 circuits control the intermediate ("distant") signals. All tracks support 2-way traffic.

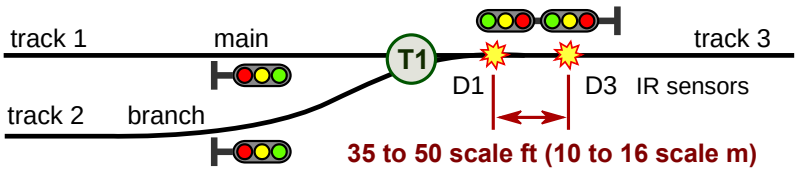
Example 2: Signaling a junction where two opposing 1-way tracks merge into one 2-way track.

Trains travel away from the TS3 on track 1 (main), and go toward the TS3 on track 2.



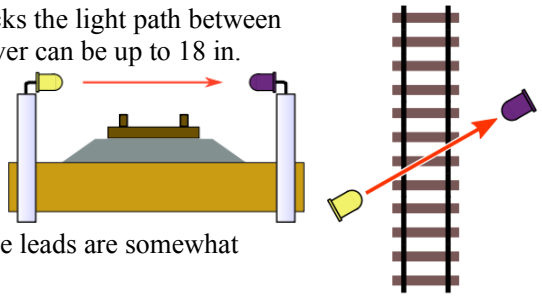
East / west orientation of the TS2 and TS2-D can be reversed.

Install the sensors: Place sensor pair **D1** just ahead of the turnout's point rails. Place sensor pair **D3** about the length of a freight car away from D1, on track 3.

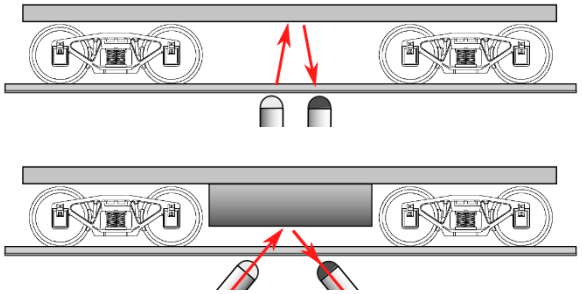


Each sensor pair may be installed in one of two different ways - 'Across the Track' or 'Reflective.'

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. (45cm), 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 bright light.



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.

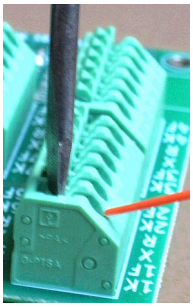
Angling the IR LED and photo receiver toward each other is best for N and HO scale where the trains are close to the rail head, and in places where an object above the track might otherwise cause false detections. Angle the IR LED and photo receiver so their centerlines intersect at the height of the 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 scrape the ballast from the sensor lenses. An opening of just 1 or 2 mm is required.

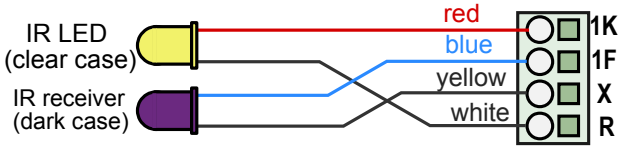
Connecting wires to the terminal blocks: The TS3 has 'spring cage' quick-connect terminal blocks.

- 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.

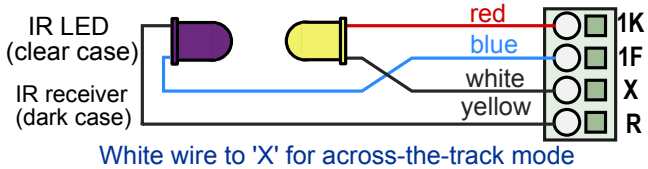
When two wires are connected to the same terminal, twist the bare ends of the wires together.



Connect D1 sensor pair: Connect the red wire from the IR LED to terminal 1K. Connect the blue wire from the IR receiver to terminal 1F. Where you connect the white and yellow wires to the TS3 will determine whether the D1 detector will operate in 'Across the Track' or 'Reflective' mode. See the diagrams below:

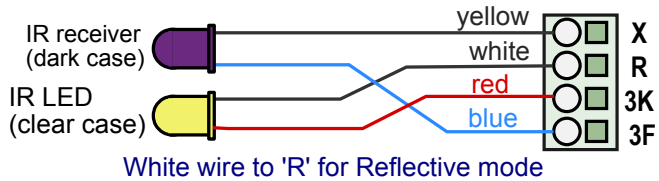


White wire to 'R' for Reflective mode

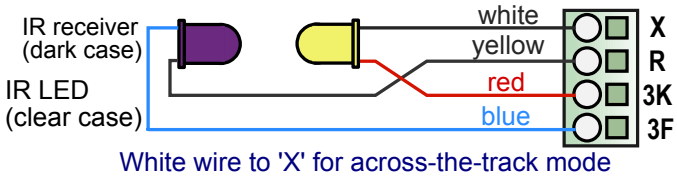


White wire to 'X' for across-the-track mode

Connect D3 sensor pair: Connect the red wire from the IR LED to terminal 3K. Connect the blue wire from the IR receiver to terminal 3F. As with sensor D1, where you connect the white and yellow wires will determine whether the D3 detector will operate in 'Across the Track' or 'Reflective' mode. Detectors D1 and D2 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 'R' for Reflective mode

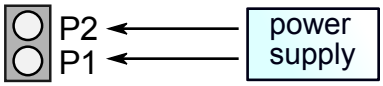


White wire to 'X' for across-the-track mode

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 1K must be paired on the layout with the IR receiver that is connected to 1F. The IR LED that is connected to 3K must be paired with the IR receiver that is connected to 3F.

Connect power to the TS3: Connect an accessory power supply of 8 to 16 volts AC or DC to terminals P1 & P2. The yellow and red LEDs will briefly flash to show that power is on and the circuit is working.



Test and adjust the sensors:

With trains clear of sensors D1 & D3, the '1' and '3' LEDs on the TS3 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. Push the IR LED and photo receiver a bit deeper into the roadbed, no higher than the tops of the ties.
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 black. Or use across-the-track sensing.

Are all detectors now off? Now **test for train detection**. Place a locomotive or car at the **D1** sensor. The '1' (yellow) LED should light. If the red LED also lights, re-adjust sensor pair **D3** for false detection (see above).
If the '1' LED does not light, correct sensor pair **D1** 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.

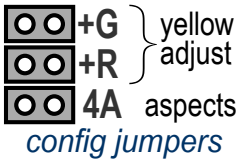
To fix a false clear indication for *Reflective* mode:

1. Verify that the sensor pair is wired correctly.
2. Adjust the sensors higher or lower in the roadbed. Are they pointed at the same spot on the loco or car?
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 detector D1 and make sure the '1' LED goes out.
Place a train at detector **D3**. The '3' (red) LED should light. If the '1' LED also turns on, adjust sensor pair **D1** for false detection (see above).
If the '3' LED does not light, adjust sensor pair **D3** for a false clear condition (same process as above for sensor pair D1).

Sensors must be working correctly before continuing the installation.

Configuration jumpers



Two configuration jumpers (small rectangular connector blocks, or 'shunts') are supplied with the TS3. Three pairs of pins can accept these jumpers. To enable a configuration feature, place a jumper across 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).

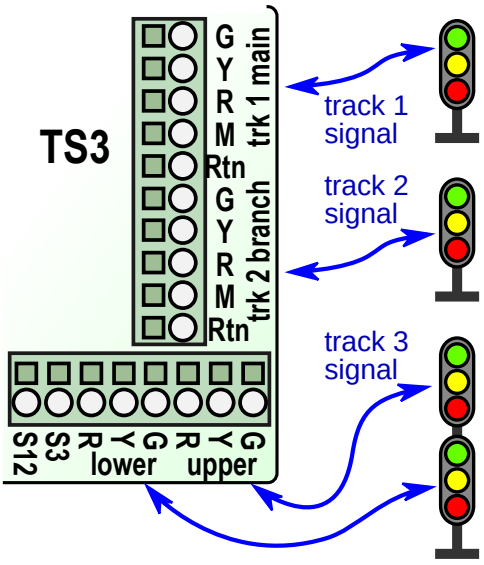
Signal Connections

The following types of signals may be used with the TS3:

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

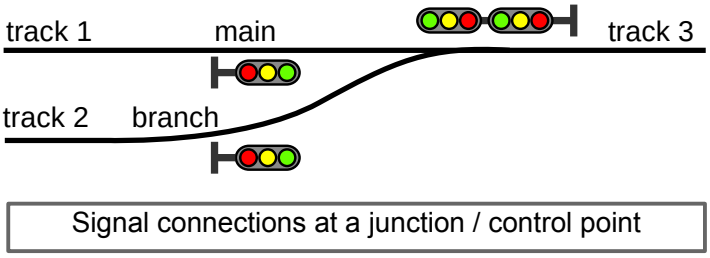
Connect your signals to the TS3 according to the diagram below that matches the signals. With very fine signal wires, it is best to attach larger wires (AWG #26 or #24, such as wire from phone or LAN cables), then insert the larger wire in the terminal block.

Searchlight (SA) signals with four wires have a true red/yellow/green (tri-color) LED and connect just like 3-LED signals.

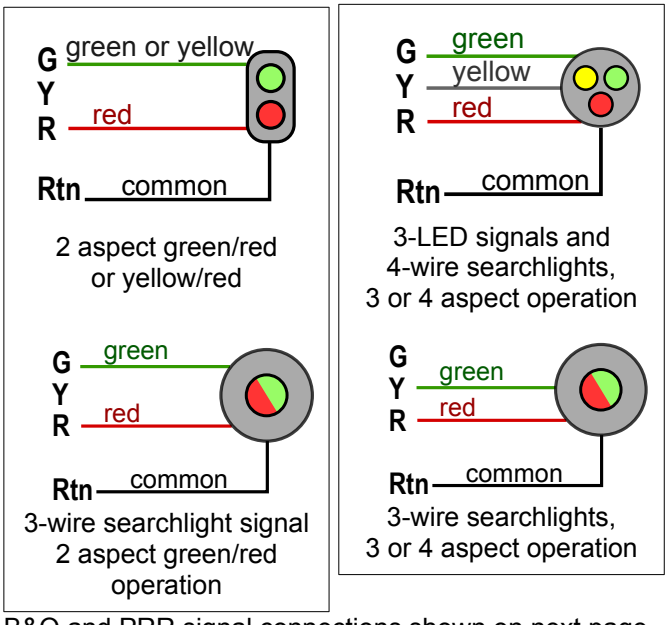


Only change connections when power is off.

Connect signal "commons" to any 'Rtn' terminal.



Signal connections at a junction / control point



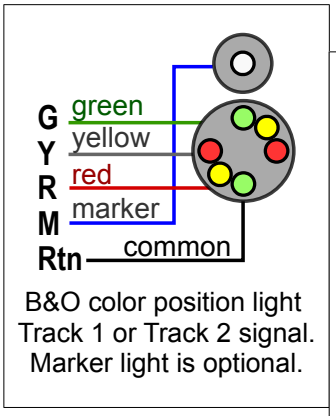
B&O and PRR signal connections shown on next page.

Note that **resistors are not required** because resistors are built in to the TS3 circuit board.

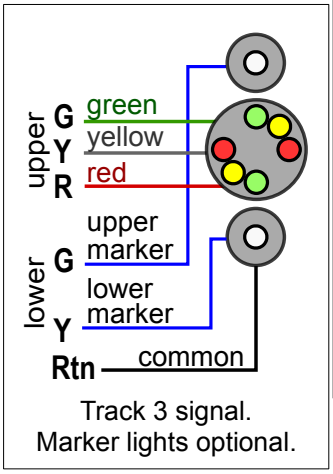
If your signals are pre-assembled with resistors, first connect the signals with their resistors. If the signal LEDs are too dim, remove the resistors and re-connect the signals.

If an individual color is too bright, a resistor may be wired in series with that LED's wire. Use up to a 1000 ohm resistor. Increasing the resistance value decreases the brightness.

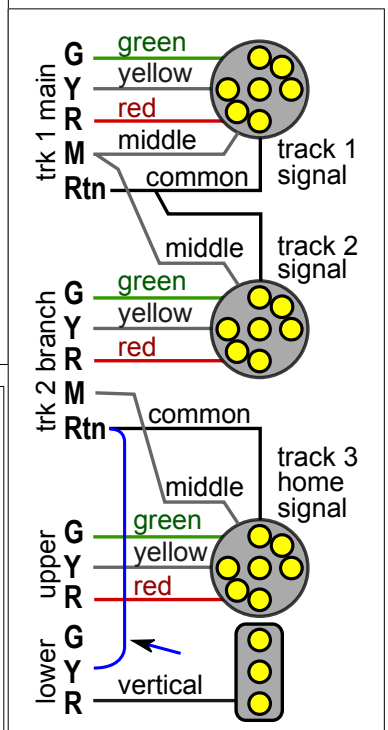
When power is turned on, the TS3 does not know if the block is occupied or not, because a train may have been added or removed from the track while power was off. The signals will show 'approach' (yellow) (or red for 2-aspect signals). Proceed with caution! Normal indications begin once the first train passes the IR sensors.



B&O color position light
Track 1 or Track 2 signal.
Marker light is optional.



Track 3 signal.
Marker lights optional.



PRR position light signals

When the TS3 is linked to other Azatrax TSx circuits, the TSx 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 a 'Link' terminal of one TSx to a 'Link' terminal of the TSx at the opposite end of the block. Connect 'C' of one TSx to 'C' on the other TSx. Use twisted pair wire such as found in telephone or ethernet (LAN) 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.

If the TS3 is not connected to another Azatrax TSx circuit down the track, it operates in a **timed mode**. The track beyond each signal becomes 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.

Interlocking functions

To force a block to 'occupied' status even when no train is in the block, connect a 1,000 ohm resistor between the 'Link' terminal (L1, L2 or L3) and a 'C' terminal. This can be connected via a dispatcher's switch, or a switch linked to a drawbridge, a switch machine, etc.

'Stop' inputs S12 and S3
Connecting S12 to any 'C' terminal will force signals on track 1 and 2 to show 'stop.'
Connecting S3 to any 'C' terminal will force the signal on track 3 to show 'stop.'

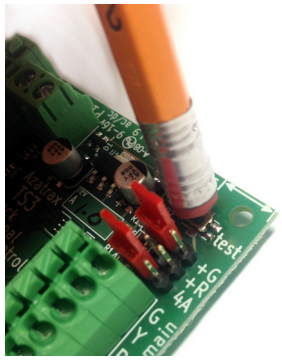
To manually clear an 'occupied' block, momentarily connect the 'Link' terminal (L1, L2 or L3) directly to a 'C' terminal. This may need to be done after a train leaves the block through a turnout onto a siding or branch line, or if it is removed from the track by hand.

Signal test button

Check signal operation with the 'test' button. The button is very small, it is best to use the eraser end of a pencil or other non-conductive tool to press it.

- Hold the test button down for 2 seconds until the **yellow on-board LED** starts flashing. Release the button. Signal 1 should show 'clear,' all others signals will be dark.
- Press and release the button. If the '4a' config jumper is in place the signal will change to 'advance approach,' otherwise it will show 'approach.'
- Continue to press the button for 'approach' and 'stop.'
- Press again and the **red on-board LED** will flash. Repeat the above steps for Signal 2.
- When the **yellow and red LEDs** are both flashing, Signal 3 will be lit. If terminal '**T1B**' is open (not connected to 'C'), the upper signal head will light. If '**T1B**' is connected to '**C**' (turnout set for branch), the lower head will light.

When the on-board LEDs stop flashing, the TS3 is back to normal operation.


Use a non-conductive tool to press the test button.

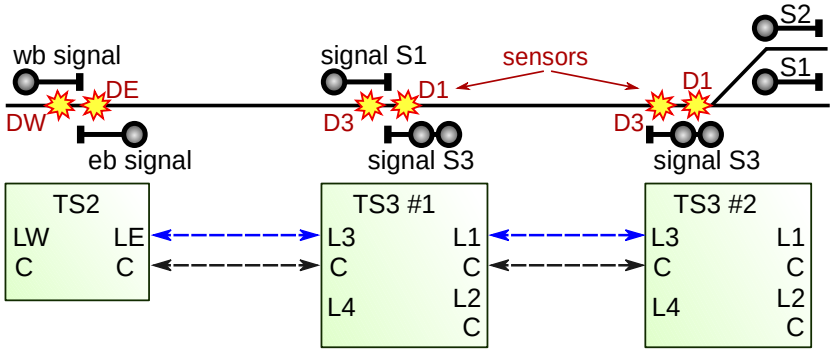
Intermediate signals, double heads

Intermediate (or "distant") signals are installed where there is no turnout. These often have single-head signals, but if the following signal has a turnout, then a double-head intermediate signal can warn a train crew when the upcoming turnout is lined for a diverging route. Taking a diverging turnout generally requires reduced speed.

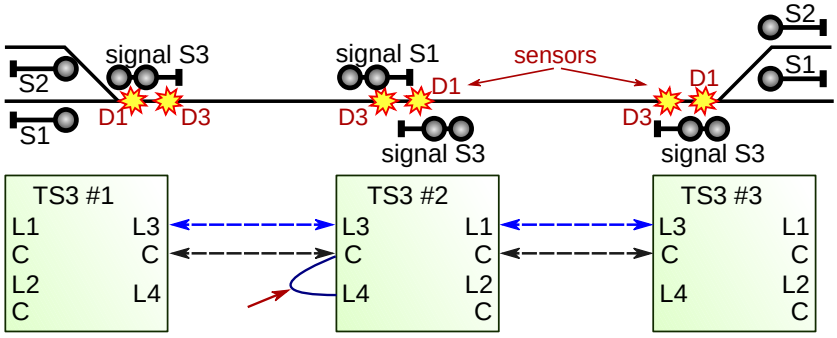
The TS3 will display "approach medium" (yellow over green) when the next signal is "diverging clear" (red over green).

The TS3 will display "approach slow" (yellow over yellow) when the next signal is "diverging approach" (red over yellow).

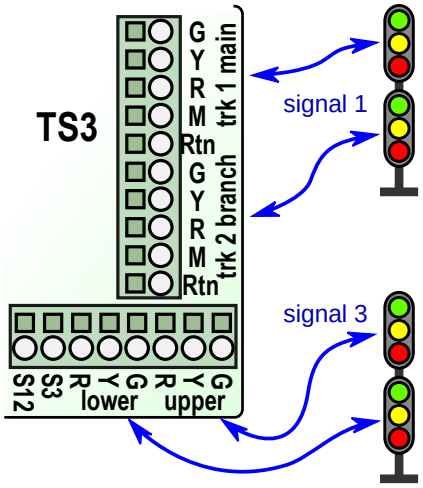
The example at right shows TS3 #1 in normal configuration controlling two intermediate signals, one signal for each direction. The next signal to the right protects a control point (it has a turnout). Therefor the intermediate signal ahead of the turnout has dual heads. The wb (westbound) signal controlled by the TS2 at left does not have a turnout, so the signal ahead of it (TS3 #1 signal S1) has a single head.



The next example shows a TS3 in **4-head intermediate signal configuration.** The next signals to the right and to the left are at control points, each has a turnout. The intermediate signals ahead of the control points have double heads.



Connect a short wire from L4 to any C terminal to enable 4-head intermediate operation.



4-head intermediate signal wiring:
The upper head of signal S1 connects to the "trk 1" terminal block.
The lower head of signal S1 connects to the "trk 2" terminal block.

For **B&O Color Position Light** (CPL) intermediate signals, an offset marker light can be used to indicate a diverging condition at the next signal.

CPL signal 1	TS3 terminal		CPL signal 3	TS3 terminal
main green	G trk 1		main green	G upper
main yellow	Y trk 1		main yellow	Y upper
main red	R trk 1		main red	R upper
upper marker	G trk 2		upper marker	G lower
offset marker	Y trk 2		offset marker	Y lower

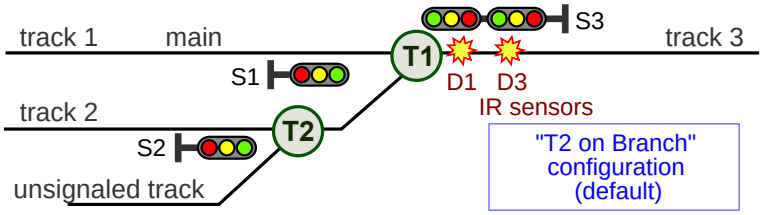
Restricting aspect:

TS3 signal S3 will display a restricting aspect if turnouts T1 and T2 are positioned to take a train from track 3 into the non-signaled track (T2 branch track). "Restricting" means the train may proceed, but slow enough that it can stop within half the visible distance ahead. This is often used when entering a yard lead or industrial tracks.

For 3-color signals, the default 2-head restricting aspect is red over yellow. You can change this to red over flashing red by following the procedure below.

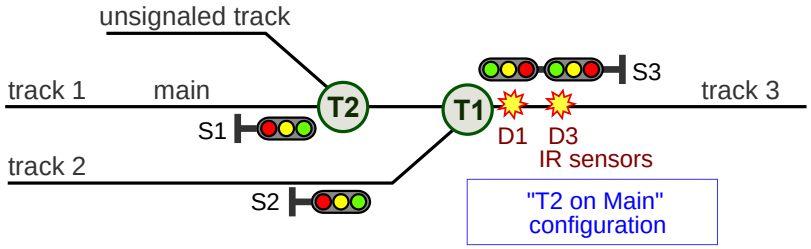
Turnout T2 on main vs. branch:

The default configuration is "T2 on main." To change, folow the procedure below.



Changing configurations:

You can change either of the above configurations by connecting a temporary wire according to the table below, then holding the "test" button down for two seconds until one of the on-board LEDs begins flashing rapidly.



Restricting Aspect	T2 on Main vs. T2 on Branch
1. Connect a wire from L2 to C. 2. Press and hold the test button for two seconds until an on-board LED begins flashing. • Flashing LED1 (yellow) = red over yellow • Flashing LED3 (red) = red over flashing red 3. To change configuration press and release the test button. 4. When the desired configuration is displayed, remove the wire from L2 and C.	1. Connect a wire from L3 to C. 2. Press and hold the test button for two seconds until an on-board LED begins flashing. • Flashing LED1 (yellow) = T2 on Branch • Flashing LED3 (red) = T2 on Main 3. To change configuration press and release the test button. 4. When the desired configuration is displayed, remove the wire from L3 and C.