# Signal Animator (SGA)
# ABS Application Notes


**Figure 1**

The SGA may be used without separate signalling logic for basic Automatic Block Signalling (ABS) applications. For this mode of operation, the $\overline{\text{ABS}}$ jumper (JP3) must be installed - see Figure 1.

In ABS mode, occupancy detectors drive the **RD**, **YL**, and **GN** inputs of the SGA directly. **RD** is duplicated with the **R2** input, and **YL** is duplicated with the **Y2** input. With both duplicated inputs, an active input may be applied to either input to get the same results. This is provided for situations where two sources are needed for these signals that cannot simply be wired together. Inputs on the SGA are are active-low, meaning that they are normally held at +5 volts and must be brought down to below +0.8 volts to be considered active. Our Quad Occupancy Detector provides outputs capable of this.

In addition to the inputs being connected to an occupancy detector’s output, it is also necessary to connect the ground (V-) of the SGA to the ground or V- of the occupancy detector. In order to keep diagrams easy to follow, they will only show a single connection to an input on the SGA. Additionally, to keep diagrams from getting complicated with crossing lines, neither occupancy detectors nor signal appliances will not be shown. An SGA will be shown to the right of the line that represents a track, and it will be located at the exit of a block, in the location where a signal would be installed. In many cases, the source of inputs will be labelled “OCC*X*” where the *X* represents the block number of the occupancy detector output that is driving the input.

## Single-Direction Signalling

To help with understanding, we will first look at single-direction signalling. This might be implemented on a double-track mainline where a current of traffic is defined. Consider Figure 2 that shows single-direction block signals:

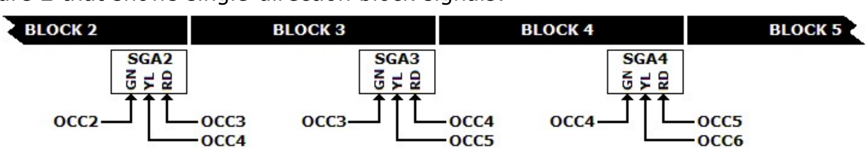


**Figure 2**

Each SGA has its **RD** (or **R2**) input driven by the occupancy detector for the block to the right - the block that the signal is protecting entry into. To remember this, think red: If this input is active, the signal will display stop, which is all red. Note that this will supercede any other input, meaning that all other inputs don’t matter if **RD** or **R2** are active.

The **YL** (or **Y2**) input of each SGA is driven by the occupancy detector of the next block beyond the one the signal is protecting. To remember this, think yellow: If this input is active, the signal will display an approach (or something to stop) indication. With no speed restrictions, the high aspect is yellow. Note that the **YL** or **Y2** inputs alone will not light the signal display unless the **GN** input is active.

The **GN** input controls approach lighting. If approach lighting is used, the **GN** input should be driven by the detector for the block a train would be in when it is approaching the signal. In Figure 2, SGA2 has its **GN** input driven by OCC2, SGA3 has its **GN** input driven by OCC3, and so on.

Take a look at BLOCK 4 in Figure 2. The occupancy detector for this block (OCC4) feeds three different SGAs: the **YL** input of SGA2, the **RD** input of SGA3, and the **GN** input of SGA4. All other occupancy detectors feed three SGAs as well, but they are not all shown on this diagram. An open collector drive, like what the outputs of our Quad Occupancy Detector have, are capable of driving many digital inputs such as the ones on the SGA.

If not using approach lighting, where the signal is to be constantly lit, the **GN** input should be grounded. This can be done by placing a jumper on the input header between the **GN** input and its neighbouring ground pin. See Figure 3 to see what connections are made for the same single-direction signals as are shown in Figure 2. For simplicity, all other figures will show **GN** being grounded for continuous lighting of signals.

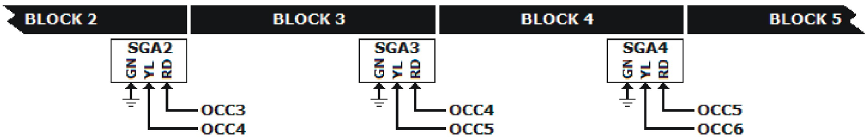


**Figure 3**

With constant lighting, each occupancy detector drives only two SGAs for single-direction operation. To simplify drawings after this point, the **GN** input will not be shown but it will be necessary to either ground it as in Figure 3 or drive it with the occupancy detector of the block in advance of the signal as in Figure 2.

## Bi-Directional Signalling

Since bi-directional signals are likely to be used in many situations, see Figure 4 for an example of this. In this diagram, SGAs driving eastbound signals are below the track line with labels ending in E, and SGAs driving westbound signals are above the track line with labels ending in W.

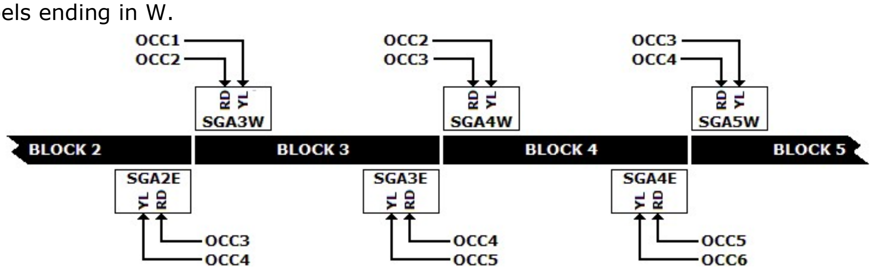


**Figure 4**

In this example, each occupancy detector drives four SGAs, though not all are visible on the diagram. The occupancy detector for BLOCK 4 must drive the **RD** input on SGA5W and the **YL** input on SGA6W (not shown) for westbound signals and the **RD** input of SGA3E and the **YL** input of SGA2E for eastbound signals. If approach lighting were used, each detector would drive six SGAs - refer to Figure 2.

## Four Indication Block Signalling

Some signalling installations provide an additional block with advance warning of an upcoming stop signal. One such implementation uses a *Clear to Medium* indication (yellow over green aspect) in advance of a *Clear to Stop* indication (yellow or yellow over red aspect). This requires two-head signals and additional signalling logic that is not available with the SGA in ABS mode. Alternatively, an *Advance Clear to Stop* indication (flashing yellow aspect, Figure 6C) can be implemented with a single-head signal and is implemented on the SGA.


**Figure 5**

For clarity, Figure 5 only shows SGA for the exit signal from BLOCK 2 to BLOCK 3.

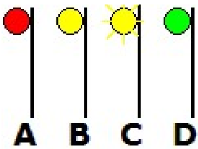


**Figure 6**

SGA2 will need to indicate *Stop* with the aspect shown in Figure 6A, if BLOCK 3 is occupied. Therefore, the detector OCC3 drives the **RD** input. When BLOCK 3 is vacant but BLOCK 4 is occupied, a *Clear to Slow* indication with the aspect shown in Figure 6B is displayed.

With the connections of Figure 5, when both BLOCK3 and BLOCK 4 are vacant, but BLOCK 5 is occupied, an *Advance Clear to Slow* indication with the aspect shown in Figure 6C is displayed. This is enabled by driving the **AV** input with OCC5.

Only when the three blocks beyond the signal are vacant, will a *Clear* indication be displayed as aspect Figure 6D.

## Interlockings

This is where a signalling system can get rather complex. A true interlocking has the operation of turnouts and the clearing of signals interlocked to prevent the clearing of conflicting routes, or the changing of turnout positions along a cleared route, or worse, under a passing train. Implementing such an interlocking is rather complex, and requires human input and control. This is best left to a system that will perform the logic separately with the SGA operating in CTC mode. Since this document deals with ABS mode, we will look at a simplified "interlocking" where signals will automatically display the most permissive indication dictated by turnout position and track occupancy.

Another complication for the signalling system at an interlocking is that the interlocking is a block with its own detector, but there are no exit signals. Instead, a home signal protecting entry to the interlocking also protects entry into the block beyond the interlocking. Just what block is beyond the interlocking is dependant on the position of turnouts in the interlocking. Turnout position information is also needed in order to generate the correct speed restriction indications needed at home signals protecting entry to the interlocking, and it is also needed to select what occupancy detector is needed for the block beyond the interlocking.

Turnout position information comes from electrical contacts on the switch machine or device used to throw the switch. As you will see in the examples below, there will be a need for more sets of contacts than are typically available. Often there will only be two sets of contacts and it is likely that one of them will be needed to provide traction power to the frog of the turnout. One way to extend the number of contacts is to drive a relay with the needed number of contacts using one set of switch machine contacts. Another way is to drive a digital "selection" circuit that effectively does the same thing with digital information. Both of these will be covered at the end of this document in the section titled Extending Switch Machine Contacts.

Compared to basic ABS signalling, the simplified interlocking that will be covered can be fairly complex to understand. To facilitate this understanding, we will look at a situation where a switch at the start of a passing siding or double track section begins. We will begin with the home signal at the points end of the switch.

# Home Signal - Points End

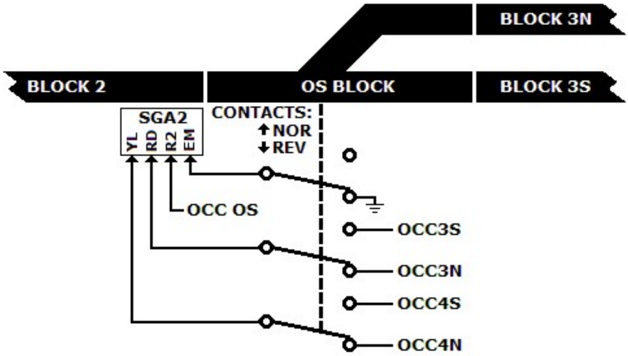


**Figure 7**

In Figure 7, the track around the turnout has a separate occupancy detector from other blocks. It is labelled *OS BLOCK* where *OS* stands for *On Switch*. Unlike other blocks, there is not a signal at each of its ends protecting entry into the next block. This is because this block must be logically treated as part of neighbouring blocks. The OS BLOCK is logically part of BLOCK 2, which means that signals protecting entry to BLOCK 2 will indicate danger if either BLOCK 2 or OS BLOCK are occupied. To the right, the OS BLOCK will be logically part of BLOCK3N when the switch is in the reverse position, or part of BLOCK3S when the switch is in the normal position.

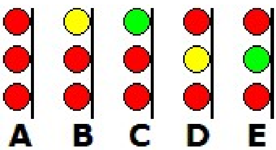


**Figure 8**

SGA2 will need to indicate *Stop* with the aspect shown in Figure 8A, if either OS BLOCK is occupied or if the next block, depending on switch position, is occupied. Therefore, the detector for OS BLOCK can drive the **R2** input, and the other detector can drive **RD**. The other detector depends on switch position, so a set of contacts is needed to choose OCC3N or OCC3S to drive the **RD** input. The **YL** input also must use a contact to select between OCC4N or OCC4S (not shown), depending on switch position.

The other input needed is the speed restriction for entering the interlocking. In Figure 7, the input **EM** is used for a medium speed restriction. **ES** could be used for slow and **EL** could be used for limited. If a restricting speed is required, **ER** is used. Note that with a restricting speed indication, there is no need to know what the next signal displays, so the connection (and contact) for the **YL** input can be eliminated.

The **EM** input is grounded only when the switch is in the reverse position. If the **EM** input is not grounded and the **YL** input is active (BLOCK 4N occupied), the aspect shown in Figure 8B is displayed (*Clear to Stop* indication). If **EM** is not grounded and BLOCK 4N is vacant, a *Clear* indication will be displayed as Figure 8C.

When the switch is in the reverse position, the **EM** input will be grounded. The **YL** input will determine whether the aspect shown in Figure 8D is displayed (*Medium to Stop* indication when **YL** is active) or if the aspect shown in Figure 8E is displayed (*Medium to Clear* indication if **YL** is not active).

## Distant Signal - Points End

Next we look at the distant signal to the home signal just discussed. Figure 9 adds the distant signal to Figure 7, greying out connections that are only for the home signal.

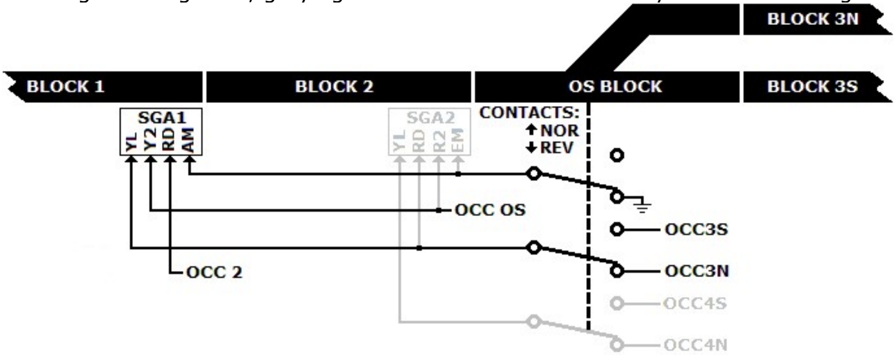


**Figure 9**

As in all the examples so far, the **RD** input of SGA1 is driven by the occupancy detector of the block beyond its signal. For SGA1, that is OCC2. The **YL** and **Y2** inputs are driven by the same sources as the **RD** and **R2** of the following signal's SGA, SGA2 in this case. Since the home signal has an entry speed restriction input, **EM** in this case, the same source that drives that input must also drive the **AM** input of SGA1.

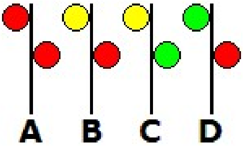


**Figure 10**

Figure 10 shows the aspects possible on this distant signal. When BLOCK 2 is occupied, aspect A is displayed (*Stop* indication). When BLOCK 2 is vacant, but the home signal shows *Stop*, the aspect shown in Figure 10B is displayed (*Clear to Stop* indication). This will occur if the OS BLOCK is occupied, or if the block beyond the interlocking is occupied.

When neither any of the red inputs (**RD** or **R2**) nor the yellow inputs (**YL** or **Y2**) are active, then the most permissible signal may be displayed, but this will depend on the position of the turnout. If the turnout is in the reverse position, then input **AM** will be low and the aspect shown in Figure 10C is displayed (*Clear to Medium* indication). If the turnout is in the normal position, the aspect shown in Figure 10D is displayed (*Clear* indication).

## Home Signal - Frog End Reverse Route

Next we will look at the home signal on the reverse (diverging) route of the turnout. Figure 11 adds the frog-end home signal to Figure 7, greying out connections that are only for the points-end home signal.

The signal at the frog end of the turnout in Figure 11 would usually be installed to the right of the track, which is above the track in the diagram. To simplify the lines in the diagram, its SGA is shown to the left of SGA2.

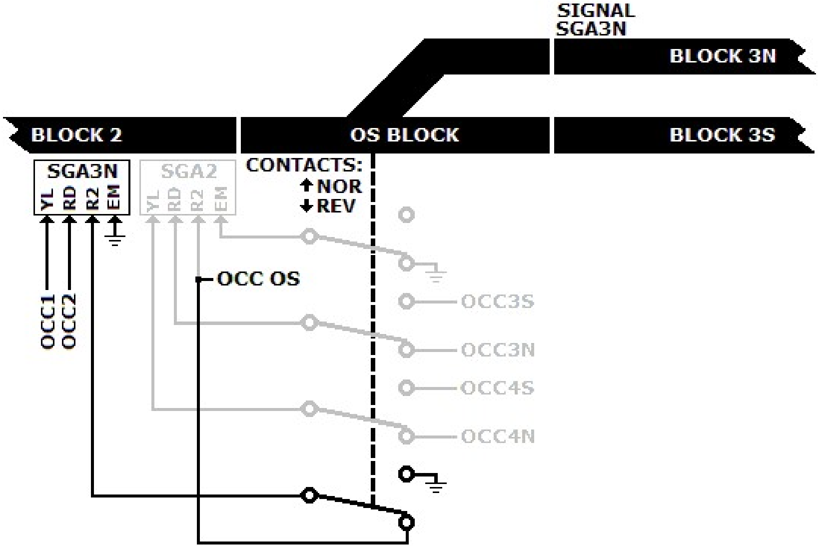


**Figure 11**

As in all the examples so far, the **RD** input of SGA3N is driven by the occupancy detector of the block beyond its signal, that is OCC2. Back in Figure 7, the **R2** input was driven by OCC OS, but in this direction there is a third piece of information that can result in a *Stop* indication: the turnout position. If the turnout is in the normal position, the home signal on the reverse route must show *Stop*, see Figure 12A. To combine these two pieces of information, a set of contacts is used to drive the **R2** of SGA3N. When the turnout is in the normal position, **R2** will be connected to ground, forcing a *Stop* indication. When the turnout is in the reverse position, **R2** will be connected to the occupancy detector for BLOCK OS.

The **YL** input is driven by the occupancy detector for the block beyond the interlocking, OCC1. If the turnout is not in the reverse position, the **YL** input won't matter as the signal will display *Stop*. As for the speed restriction, the **EM** input is simply grounded. Since this is the reverse route, there will always be a medium speed restriction for entry into the interlocking of this example.

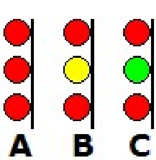


**Figure 12**

Figure 12 shows the aspects possible on this home signal. The aspect shown in Figure 12A (*Stop* indication) is displayed when either BLOCK 2 is occupied, OS BLOCK is occupied, or if the turnout is in the normal position. When the turnout is in the reverse position and both BLOCK 2 and OS BLOCK are vacant, the indication will depend on the occupancy of BLOCK 1 (not shown in Figure 11). If occupied, the aspect shown in Figure 12B is displayed (*Medium to Stop* indication). If vacant, the aspect shown in Figure 12C is displayed (*Medium to Clear* indication).

## Distant Signal - Frog End Reverse Route

Next we look at the distant signal to the home signal at the frog end reverse route. Figure 13 adds the distant signal to Figure 11, greying out connections that are only for previously described signals.

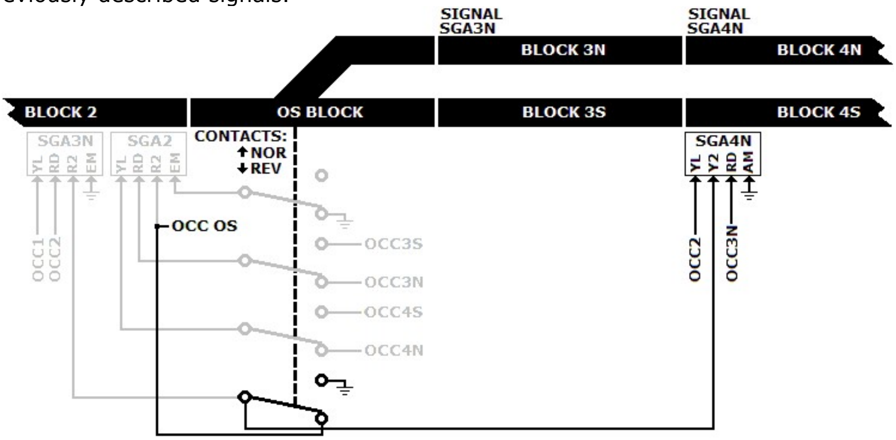


**Figure 13**

Again, the **RD** input of SGA4N is driven by the occupancy detector of the block beyond its signal, that is OCC3N, as seen in Figure 13. The **YL** and **Y2** inputs are driven by the same sources as the **RD** and **R2** of the home signal, SGA3N. Since the home signal has a fixed entry speed restriction of medium, the **AM** input of SGA4N is grounded.

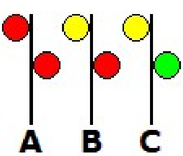


**Figure 14**

Figure 14 shows the aspects possible on this distant signal. When BLOCK 3N is occupied, the aspect shown in Figure 14A is displayed (*Stop* indication). When BLOCK 3N is vacant, but the home signal shows *Stop*, the aspect shown in Figure 14B is displayed (*Clear to Stop* indication). This will occur if either BLOCK 2 is occupied, OS BLOCK is occupied, or if the turnout is in the normal position.

When BLOCK 3N is vacant, the turnout is in the reverse position and both BLOCK 2 and OS BLOCK are vacant, the aspect shown in Figure 14C is displayed (*Clear to Medium* indication).

## Home Signal - Frog End Normal Route

Next we will look at the home signal on the normal (straight) route of the turnout. Figure 15 adds the frog-end home signal to Figure 11, greying out connections that are only for the points-end home signal and the frog-end reverse home signal.

The signal at the frog end of the turnout in Figure 15 would usually be installed to the left of the track, unless it is mounted on a cantilever structure to the right, so it is shown on the left side, beneath BLOCK 3S, in the diagram.

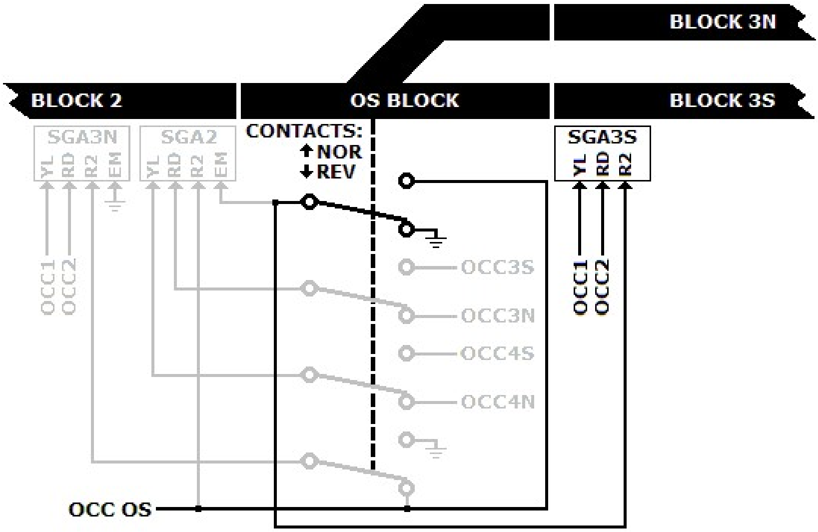


**Figure 15**

Again, the **RD** input of SGA3S is driven by the occupancy detector of the block beyond its signal, OCC2. Back in Figure 7, the **R2** input was driven by OCC OS, but in this direction there is a third piece of information that can result in a *Stop* indication: the turnout position. If the turnout is in the reverse position, the home signal on the normal route must show *Stop*, see Figure 16A. To combine these two pieces of information, a set of contacts is used to drive the **R2** of SGA3S. When the turnout is in the reverse position, **R2** will be connected to ground, forcing a *Stop* indication. When the turnout is in the normal position, **R2** will be connected to the occupancy detector for BLOCK OS.

At this point in the progress of installing the signals at this interlocking, this would be the fifth set of contacts needed. However, it is possible to make use of an already-used set of contacts. The set used to ground the **EM** input of SGA2 when the turnout is in the reverse position can be used for the **R2** input of SGA3S. Doing this will mean that the output of the detector OCC OS will drive input **EM** of SGA2 when the turnout is in the normal position. This is acceptable because OCC OS also drives input **R2** of SGA2, and when this is active, input **EM** does not matter.

The **YL** input is driven by the occupancy detector for the block beyond the interlocking, OCC1. If the turnout is not in the normal position, the **YL** input won't matter as the signal will display *Stop*. As this signal is the normal route, there is no speed restriction inputs.

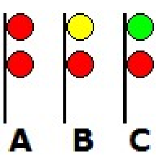


**Figure 16**

Figure 16 shows the aspects possible on this home signal. The aspect shown in Figure 16A (*Stop* indication) is displayed when either BLOCK 2 is occupied, OS BLOCK is occupied, or if the turnout is in the reverse position. When the turnout is in the normal position and both BLOCK 2 and OS BLOCK are vacant, the indication will depend on the occupancy of BLOCK 1 (not shown in Figure 15). If occupied, the aspect shown in Figure 16B is displayed (*Clear to Stop* indication). If vacant, the aspect shown in Figure 16C is displayed (*Clear* indication).

## Distant Signal - Frog End Normal Route

Finally, we look at the distant signal to the home signal at the frog end normal route. Figure 17 adds the distant signal to Figure 15, greying out connections that are only for previously described signals.

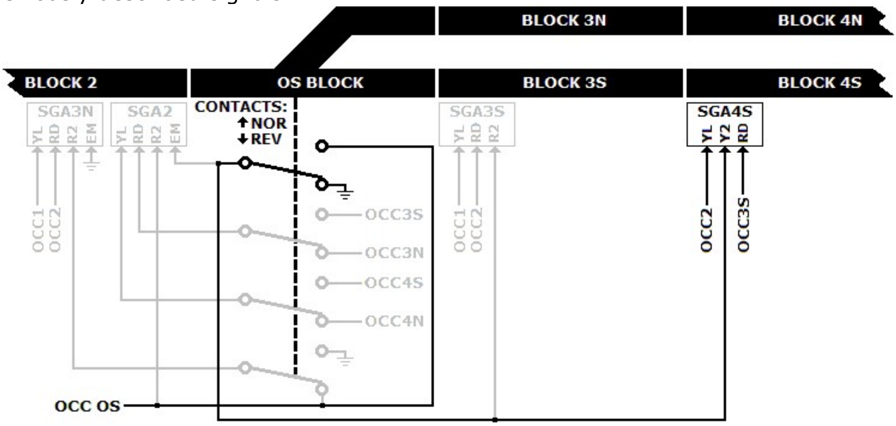


**Figure 17**

Again, the **RD** input of SGA4N is driven by the occupancy detector of the block beyond its signal, that is OCC3S, as seen in Figure 17. The **YL** and **Y2** inputs are driven by the same sources as the **RD** and **R2** of the home signal, SGA3S. Since the home signal has no speed restriction, the approach speed inputs (**AR**, **AS**, **AM** or **AL**) are left alone.

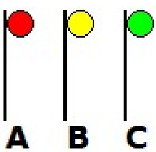


**Figure 18**

Figure 18 shows the aspects possible on this distant signal. When BLOCK 3S is occupied, the aspect shown in Figure 18A is displayed (*Stop* indication). When BLOCK 3S is vacant, but the home signal shows *Stop*, the aspect shown in Figure 18B is displayed (*Clear to Stop* indication).

When BLOCK 3S is vacant, the turnout is in the normal position and both BLOCK 2 and OS BLOCK are vacant, the aspect shown in Figure 18C is displayed (*Clear* indication).

# Restricting Speed Siding

For a Restricting Speed siding, the Restricting indication is used on the home signal when the diverging route is selected. Since restricting speed involves proceeding at a very slow speed, there are no indications involving the next signal, not even stop. This makes wiring simpler as there are no connections to be made for any of the Approach Speed inputs nor the **YL** or **Y2** inputs.

For a Restricting speed siding, the Restricting indication is used on the home signal when the diverging route is selected. The SGA generates a Restricting indication as the three-head aspect red-over-red-over-yellow, however CROR Rule 436 allows it to be displayed as the two-head aspect red-over-yellow. Unless the home signal needs to display some other aspect that requires three heads, a two-head signal appliance may be used with the top head powered by the High output of the SGA and the bottom head powered by the Low output of the SGA.

## Restricting Home - Clear to Stop Distant

Prior to the CROR rule change in 2008, there was no signal indications warning of an approach to a restricting speed signal. When a home signal displays Restricting, its distant signal would display Clear to Stop.

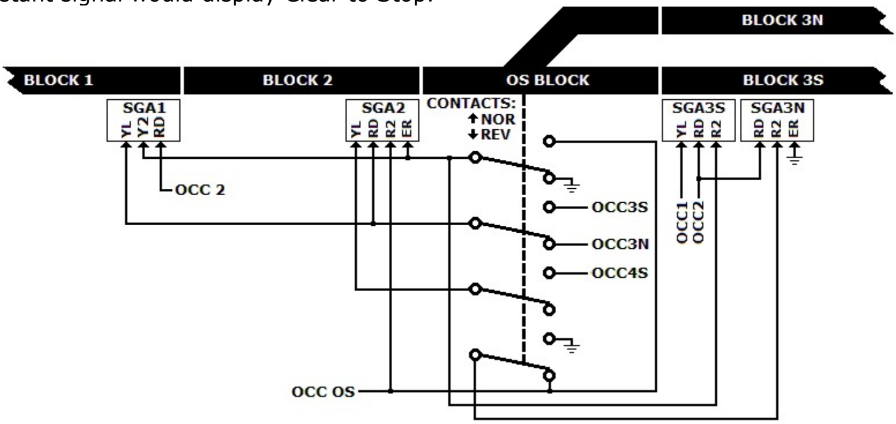


Figure 19

The signal that SGA1 drives only has to display red (*Stop*), yellow (*Clear to Stop*), or green (*Clear*) with either one or two heads.

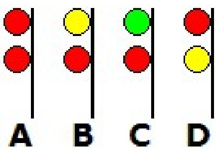


**Figure 20**

One benefit of this implementation, shown in Figure 19, is that the logic for the Restricting indication does not care what the occupancy of the next block is. The home signal driven by SGA2 only needs to display the aspects shown in Figure 20, obtained by using the high head outputs for the top head, and the low head outputs for the bottom head. Regardless of turnout position, Figure 20A is displayed when OCC OS is occupied. It is also displayed with either BLOCK 3N or BLOCK 3S is occupied, depending on switch position.

When the turnout is in the normal position, Figure 20B or Figure 20C will be displayed, depending on the occupancy of the BLOCK 4S (not shown). The aspect of Figure 20D (*Restricting*) will be displayed when the turnout is in the reverse position, regardless of the occupancy of BLOCK 4N.

## Restricting Home - Clear to Restricting Distant

Another option is available for a contemporary setting. In 2008, an update to the CROR introduced three new indications used for approach to a Restricting signal. Rule 410, Clear to Restricting, is displayed as either the three-head aspect yellow-over-red-over-flashing-red (Y-R-FR) or as the two-head aspect yellow-over-flashing-red (Y-FR). An approach signal only uses three heads when it is also a home signal for another interlocking, so the two-head aspect could be used in this situation.

Similar to the home signal, a two-head signal appliance may be used with the top head driven by the high output and the bottom head driven by the low output of the SGA. See Figure 21.

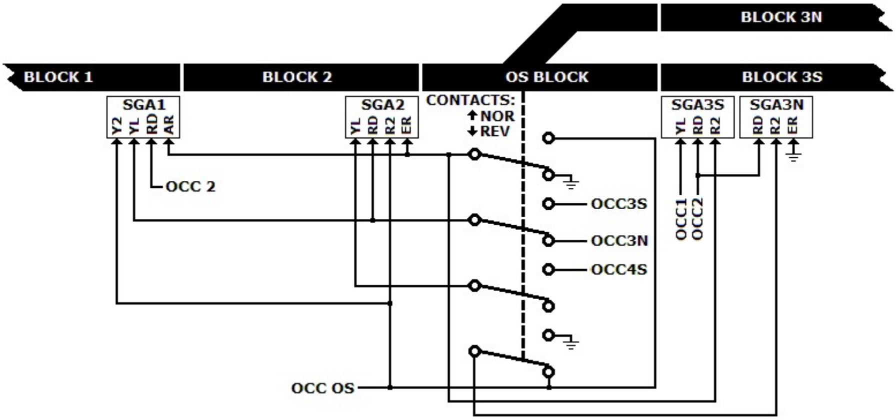


Figure 21

This option is very similar to the one shown in Figure 19. The only differences are with the connections to SGA1. Instead of connecting the contact that feeds **ER** on SGA2 to the **Y2** input, it connects to the **AR** input. **Y2** is now driven by the occupancy detector of OS BLOCK.

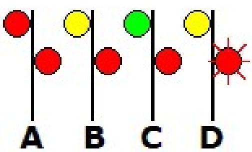


**Figure 22**

The aspects displayed by the signal driven by SGA1 are shown in Figure 22. When BLOCK 2 is occupied, the aspect shown in Figure 22A is displayed (*Stop* indication). When BLOCK 2 is vacant, but the home signal shows *Stop*, the aspect shown in Figure 22B is displayed (*Clear to Stop* indication). If the home signal display a permissive indication and the turnout is lined for the normal route, the aspect shown in Figure 22C is displayed (*Clear*). The new aspect, shown in Figure 22D is displayed when the home signal's indication is *Restricting*, shown in Figure 20D. This occurs when the turnout is lined for the reverse route, and both OS BLOCK and BLOCK 3N are vacant.

# Extending Switch Machine Contacts

In the examples shown in this document, up to four sets of contacts controlled by the position of the points on a turnout are needed for signalling. In most cases, only one or possibly two sets of contacts are available on a switch machine. It is therefore necessary to use a circuit to extend the number of contacts available. One way to do this is by using the one set that is available to energize one or more relays, and use the contacts on those relays for signalling.

Since the SGA uses TTL-level digital signals (0 to 5 volts), an alternate choice to using relays is to use a digital circuit known as a data multiplexer. Multiplexers take multiple sources of information and select one at a time. A two-input multiplexer functions like a double throw relay contact, as far as passing information. More than one multiplexer that share the same selection input functions like a multiple pole relay.

A device known as the 74x157 (x is a family designation, such as LS or HC) is a Quad 2-Input Multiplexer. This device acts like a 4PDT digital relay, taking four pairs of inputs and selecting one from each pair and providing their state at four outputs. All it takes to make this selection is a single input that can come from a switch machine contact. A circuit using this device is shown in Figure 23. The inputs are numbered 1 to 4 and the two choices for each are designated A and B. The input header has input 1A on pin 2 and 1B on pin 4 and the sequence repeats for each pair.

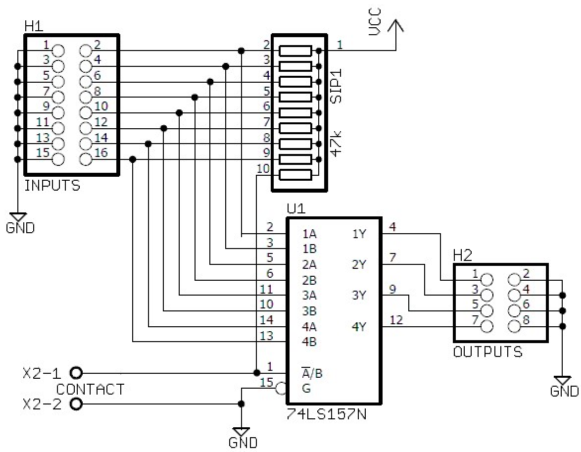

**Figure 23**

The switch machine contact is connected to the terminals labelled X2. When the contact is closed, the A inputs will be selected for the outputs. When the contact is open, the B inputs will be selected.

All the inputs are active-low, just like the inputs of the SGA. This means that any input that has nothing connected will be high and need to be actively brought low by something to be seen as low.

At the time of the current release of this document, Circuits4Tracks does not make a ready-to-use or kit version of this circuit, however we are investigating the possibility of adding it to our product line. Check our website for any announcement on this.

*This document is available in PDF format on our website.*