

SIGNALLING YOUR MODEL RAILWAY

OBJECTIVES

The quest of every railway modeller is to create a part of the real world in miniature that is as close as possible to the prototype. As with most other aspects of modelling, exactly depicting a real world signalling system is an unreasonable challenge. What we usually achieve is a simplified version that adequately replicates the most important aspects.

A major factor in satisfactorily achieving this quest is installing train signals. Adding train signals to your layout is a fascinating aspect of creating the semblance of the real world, using electronics and special wiring effects in model railroading. The addition of signals adds life and the opportunity to actually control train movements in a real life of way. Imagine your train travelling from one part of your layout town to another through freight yards and stations with a series of signals changing as your train goes along. Signals can also provide safe operation, provided they are observed, of course.

LIMITATIONS

Prototypical train signalling systems are generally complicated and designed specifically for the individual railways, each system being a little different. Basically, for our modelling purposes and considering the signals that are commercially available, we will concentrate on what is feasible for the general layouts we build and use, rather than trying to exactly replicate a complex real life system.

WHAT DO SIGNALS MEAN

What do train signals mean? For this discussion we will just consider the simplest arrangement of coloured light signals in three colours - red, yellow and green in either two aspect or three aspect signals. The discussion does not include semaphore signals. Their operation is different to coloured light signals and thus they would constitute a completely separate discussion.

Railway signals are not traffic lights!

Signal Colours

The standard meanings of the signal colours we will generally use on our layouts are as follows.

Red – the section or block of track ahead is occupied by another train or the train controller requires the train to wait for some preceding action to take place. The driver must stop and wait till the signal is changed to yellow indicating that he can proceed with caution or green indicating that the track ahead is clear.

Yellow – the section or block ahead is clear but the one further on is occupied by another train. The driver should slow down but can proceed with caution.

Green – The section or block immediately ahead and the one after that are unoccupied. The driver can proceed normally.

In some signalling configurations these colours may be used in conjunction with each other to give the drivers more information.

TYPES OF SIGNALS

Signals are used to indicate one or more of the following:

- that the line ahead is clear (free of any obstruction) or blocked;
- that the driver has permission to proceed;
- that points are set correctly;
- which way points are set;
- the speed the train may travel;
- the state of the next signal; or
- that the train orders are to be picked up by the crew.

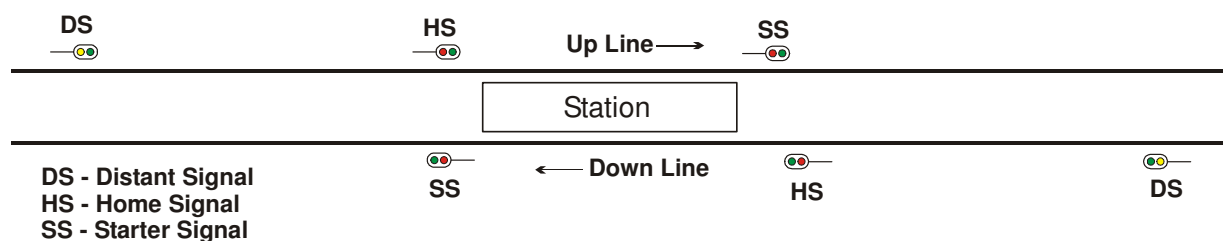


Figure 1 – Typical Signalling At a Station

In the NSW system signals generally fall into one of the following designations, although this is not a complete list, as there are other signals used for specific purposes that are outside the scope we can expect most model layouts to encompass. On the suburban and intercity networks dual coloured light signals are used in a number of different configurations. Generally the top signal informs the driver whether he can proceed or not and the bottom signal provides information about the status of the sections or blocks ahead.

Running signals, except for distant signals that cannot show stop, are used to protect the section or block ahead and are designated according to their purpose. Signals can be controlled or automatic. Controlled signals are operated from signal boxes by signallers and automatic circuits. Automatic signals are controlled only by automatic circuits and trackside monitors.

Signal Types

Home Signal

A home signal is used to protect points leading to an interlocked area, for example a junction, crossing or yard.

Outer Home Signal

An outer home or accept signal is used to control entry to the section or block ahead. But it does not otherwise protect points or other risks.

Distant Signal

A distant signal is a caution signal that is normally set to either caution or clear and cannot be used to protect the portion of the line to the next signal. However, some controlled distant signals can be set to stop and can, therefore, be used to protect the portion of the line to the next signal.

Landmark Signal

A landmark signal is effectively a distant signal that is fixed at caution.

Starting Signal

The starting signal authorises the train to leave a controlled area. Sometimes the starting and home signals are combined to function as both home and starting.

WHERE TO PLACE SIGNALS

Placing signals will always be a compromise, even on the best of model layouts. It is usually not too difficult to place home and starter signals reasonably well but distant signals are always likely to be difficult. This is because the distant signal in real life would normally be located around 1.5 to 2 km before its home signal, which is 17 to 23 metres in HO gauge, a length hard to achieve on all but the largest of layouts. Most modellers need to settle for shorter distances and so could not obtain sufficient distance between the distant and home signals. But, as long as the longest train is well past the distant by the time it approaches the home signal, a reasonable compromise may be achieved. However, on most model layouts distant signals need to be omitted.

Signals can be placed:

- at the start of a section of track;
- in advance of other signals;
- on the approach to a level crossing;
- at a set of points; or
- ahead of platforms or other places that trains are likely to be stopped.

Running lines are usually continuously signalled from one end to the other. Each line of a double track is normally signalled only in one direction, with all signals facing the normal direction of travel. Where signalling is required to allow bi-directional operation, for example on a single line, signals are installed to face in both directions. Bi-directional signalling may also be provided for double tracks where reverse direction operation is normally allowed.

Signals are generally not provided for controlling movements within sidings or yard areas.

An important factor to consider when deciding where to install signals on your layout is that you must avoid making the signalling system too complex and so create a situation that is too hard to operate. Start with a simple system and add to it as the need for more signalling arises.

Layout Signalling Examples

The following diagrams show some examples of where signals may be placed on your layout.

At a Station

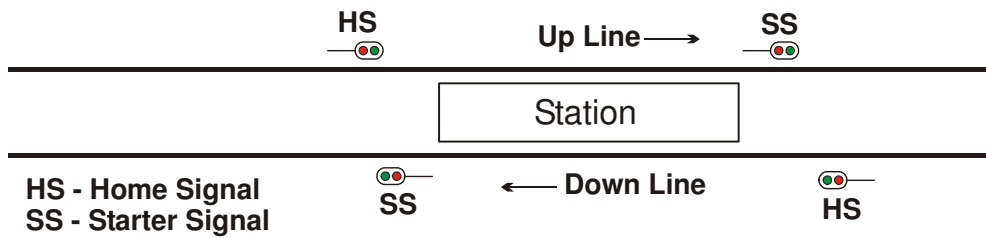


Figure 2 – Through Station Signals

The above diagram shows a fairly standard signal arrangement for a station where the home signal controls access to the station area and the starter signal gives authority for a train to leave, when the following block is clear. On smaller layouts the home signals could be left out.

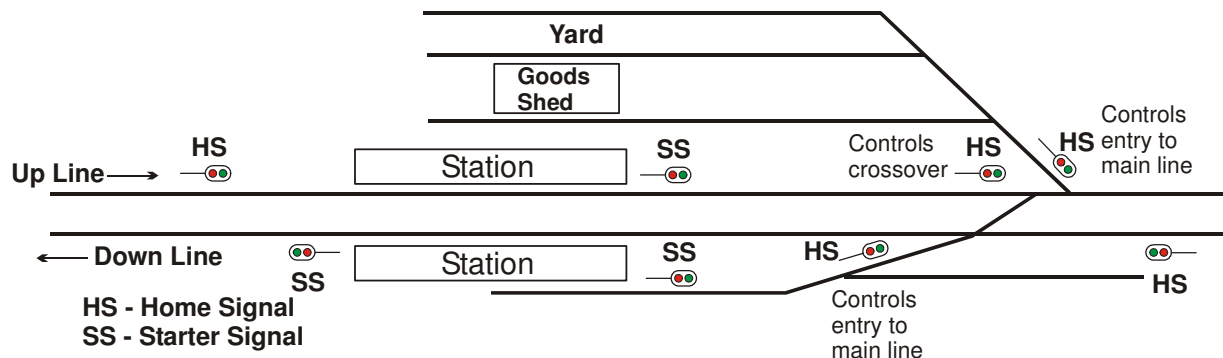


Figure 3 – Station with Yard and Dock

To effectively control the movement of trains for a main station with a yard a more complex signalling system is needed. The above diagram shows a suggested system that includes signals to control entry to the main line from the yard and from a dock platform. It also includes a signal to control the crossover points.

At a Passing Loop

HS - Home Signal
SS - Starter Signal

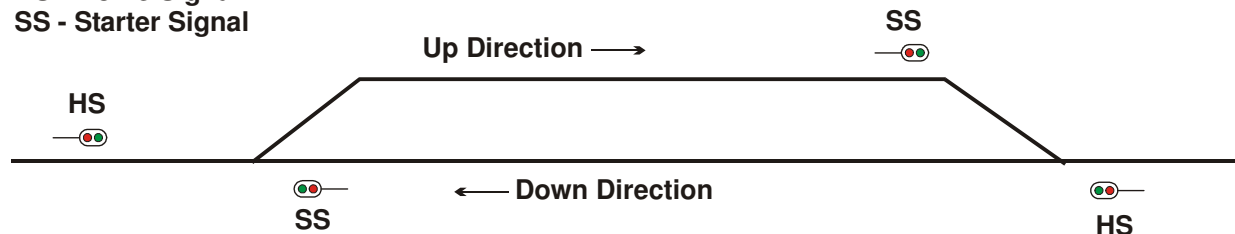


Figure 4 – Loop Signals

At each end of the loop the home signal is used to protect the points by preventing trains from proceeding until the points are correctly set. This signal could either be red/yellow or red/green. The starter signal is used to hold a train in the loop until another train passes, in either direction.

In this arrangement controlling the home signal by an auxiliary points switch would be unsatisfactory as passing in the same direction could be difficult. If an auxiliary switch is used then the signal would, for example, be green when the points are set straight ahead and red when set to branch. If a train is waiting in the down direction loop could not be passed by another train using the up direction loop could not proceed against the red signal. It needs to be possible for the signal to be set to green regardless of the points direction.

At a Crossover

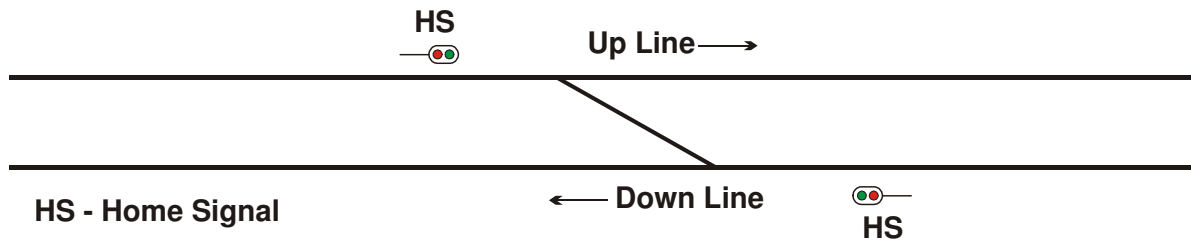


Figure 5 – Crossover Signals

At a crossover signals are used to protect the points and prevent a train from proceeding until the points are correctly set. For a double crossover four signals would be required for full protection and control.

HOW TO CONTROL SIGNALS

There is a large number of options available for controlling the signals on your layout. The more common of these options is discussed below. The choice of method depends on factors such as the size and complexity of the layout, the number of trains to be operated at the same time and the type of control required – manual or automatic – to name just a few.

Each of the more common available methods are summarised in the following table.

Method	Complexity	Advantages	Disadvantages
Manual Switch	Simple	Relatively cheap Easy to install Switch position can indicate signal colour	Interlocking with other signals or points is difficult Wiring can get complex
Points Auxiliary Switch	Simple	Relatively cheap Easy to install	Not very prototypical The only way to change the signal is to change the points Controls track not trains
Automatic Control	Reasonably simple	Gives more realistic control Easy to operate	Relatively expensive

Method	Complexity	Advantages	Disadvantages
DCC Handset Control	Reasonably simple	Gives full control of signal operation Gives control from a single point on the layout Easy to operate	Relatively expensive
Computer Control	Reasonably complex	Gives more realistic control Gives easy interlocking with other signals and points Gives control from a single point on the layout Easy to operate	Relatively expensive Can be difficult to set up
Automatic Block Control	Complex	Gives very realistic control Fully automatic operation	Relatively expensive Complex wiring and electronics

Manual Switching

Manual switching is the simplest method of control and is generally achieved by the use of electromechanical switches. These can be located near each signal or they can be centrally located on a control panel.

The following diagrams show how to wire switches to manually control signals. The switches can be toggle or slide depending on your preference. If you use double pole switches instead of single pole, you can use the second pole to drive indicator LEDs on your control panel. To do this, wire the LEDs to the second pole of the switch, the same as for the signal.

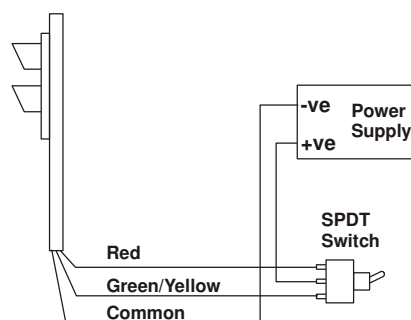


Figure 6 – Manual Switching 2 Light

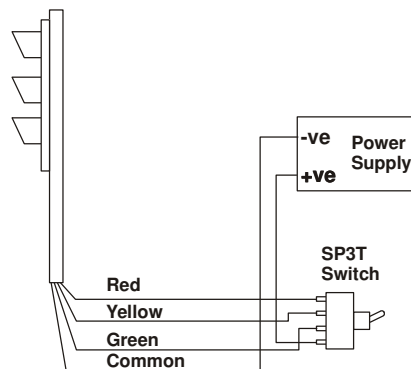


Figure 7 – Manual Switching 3 Light

Automatic Switching

Automatic switching of signals will generally be achieved by combining the signal switching with some other switching action, for example points. By using an auxiliary switch attached to the points the signal can be automatically switched when the points are changed. However, this type of switching action is not very prototypical as the only way to change the signal is to operate the points. This also means that you are controlling the track and not the movement of trains.

Consider the situation where the road is set in readiness for the next train but for operational reasons the train needs to be held. If the signal is linked to the points the only way to set it to red is to change the points and so destroy the road setting.

Another method for automatic signal operation is block signalling that is discussed later.

Train Detection

To obtain any sort of automatic signal control it is necessary to have some type of train detection devices. The types of train detection devices readily available are as follows.

Block Detection – This type of detection requires block wiring and current sensing devices that detect the presence of a train in the block by the change in current that occurs due to the motor operation or a resistor between the wheels. You will need track circuit current detector boards that recognize the change in current and activate a relay to change the signal.

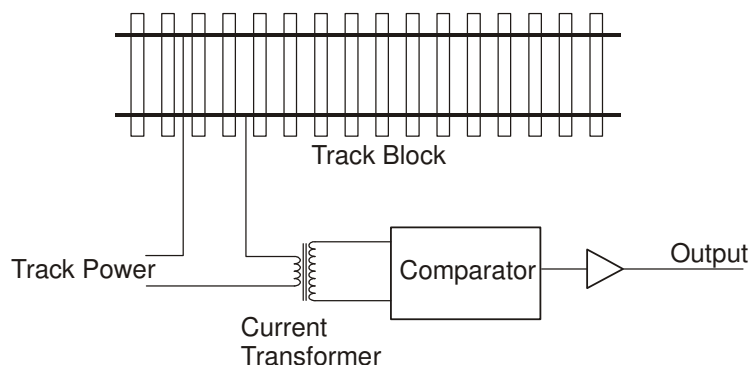


Figure 8 – Block Diagram for a Current Sensing Device

A considerable number of commercial current sensing devices is available and if you have an understanding of electronics a web search will turn up several designs for current sensing devices you can build.

Position Sensors – These detect the passing of the train as it over the sensor. Position can be optical sensors, magnetic reed switches or infrared light sensors. These types of sensor are generally associated with an electronic circuit that converts the sensor pulse to a switching action, generally by a relay or transistor.

Types of Position Sensors

Optical position sensors are usually small devices that you can place between the track sleepers. When a train passes over, the device detects a change in the light and sends an electronic message to the circuit board, which then operates the signal. Optical sensors can be photo transistors, light dependent resistors or infrared devices. A major advantage of these detectors is that they do not require any modification to the trains, such as resistors across the wheels.

The following diagram provides an electronic circuit for constructing a light dependent resistor (LDR) activated sensor. While the LDR is exposed to light the relay remains inactive. A train passing over the LDR cuts off the light falling on it and causes the LM311 comparator to switch and power the relay to provide a switching action that can be used to operate a signal.

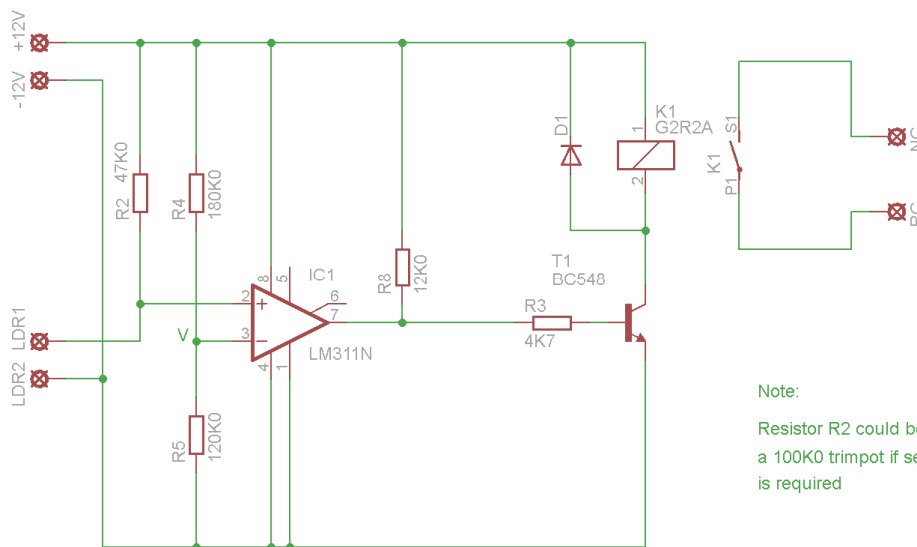


Figure 9 – LDR Optical Sensor Circuit

Magnetic reed switches are also placed between the track sleepers, and when a train with a magnet on the bottom passes over the switch, the magnet causes the contacts in the switch to close and send an impulse to the associated electronic circuit board to change the signal. Reed switches have the disadvantage of requiring magnets to be fitted to the trains, they can also suffer from false triggering by the magnetic field generated by some motors.

Hall effect devices can also be used for position sensing. In operation these are similar to reed switches as they require a magnet for operation.

Infrared sensors can set up across the tracks with the emitter one side and the receiver on the other. When a train passes it interrupts the infrared beam and a signal is sent to the circuit

board to change the signal. Alternatively the infrared device can be of the reflective variety that has the emitter and the sensor mounted side by side in a single package that is mounted between the sleepers. When the train passes over the device infrared from the emitter is reflected by the underside of the train to the receiver. Infrared sensors have the advantage of working independent of any ambient light and work when the room lights are on or off. However, infrared sensors are more complicated in operation as the infrared signal needs to be set to a particular frequency for reliable operation.

The following figure shows an infra red set up where the emitter and receiver are positioned on opposite sides of the track. It can be an advantage to place the emitter and the receiver at an angle of 30 to 40 degrees to the track so the gaps between carriages do not cause false triggering.

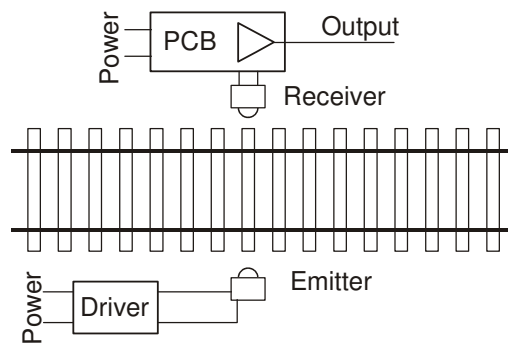


Figure 10 – IR Sensor Across Track

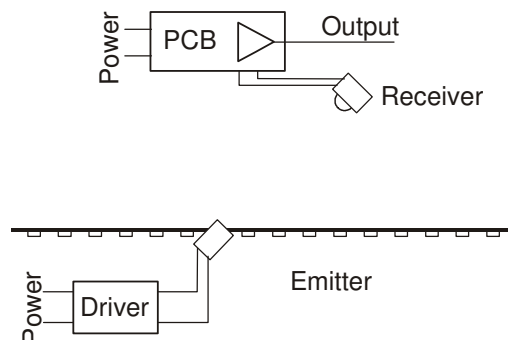


Figure 11 – IR Sensor Overhead

Combined emitter/receiver units can be mounted in the track as shown in the following figure. Reflected IR light from under the train is seen by the receiver. These combined devices have the emitter and receiver mounted side by side in a single casing.

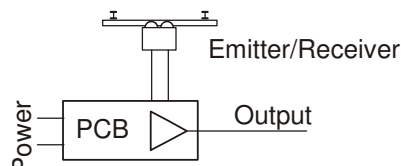


Figure 12 – Combined Emitter/Receiver IR Sensor

Block Signalling

Fully automatic block signalling is a real possibility on any layout – small, medium or large or end-to-end or point-to-point. Achieving a full block signal system is, however, a reasonably complicated process. The electronics and wiring to make the system work can be extensive as considerable interlocking is needed to get the right signalling action across up to three blocks or sections of track.

However, seeing the signals change automatically as your trains make their way around the track is very realistic and enthralling for you and anyone else viewing your layout in operation.

The first phase to be considered in the design of an automatic block system is designating the number and position of signal blocks for your layout. The number of blocks will largely be determined by the following factors:

- The complexity of the layout (number of points and interlocks);
- The size of the layout and length of the main lines;
- The number of trains simultaneously using each track; and
- The maximum length of your trains.

Since most blocks will begin and end at points, the more points you have the more blocks you will need. The total number of blocks can be reduced by grouping points wherever possible by separating them with short track sections. These short sections of track can be ignored for the purpose of creating blocks. It is always good modelling practice to avoid locating points inside tunnels and this particularly so for block systems as the signals will be hidden from view.

Computer Control

In modern real railway systems signalling is now computer controlled. Replicating computer control for your layout is most feasible, particularly with DCC systems and the PC software that is available.

A computer controlled signalling system allows you to relatively easily achieve the following:

- full layout control from a central point;
- a visual indication of the status of the layout;
- route signal setting;
- interlocking; and
- semi automatic signal operation.

The following figure shows part of a layout set up for computer control.

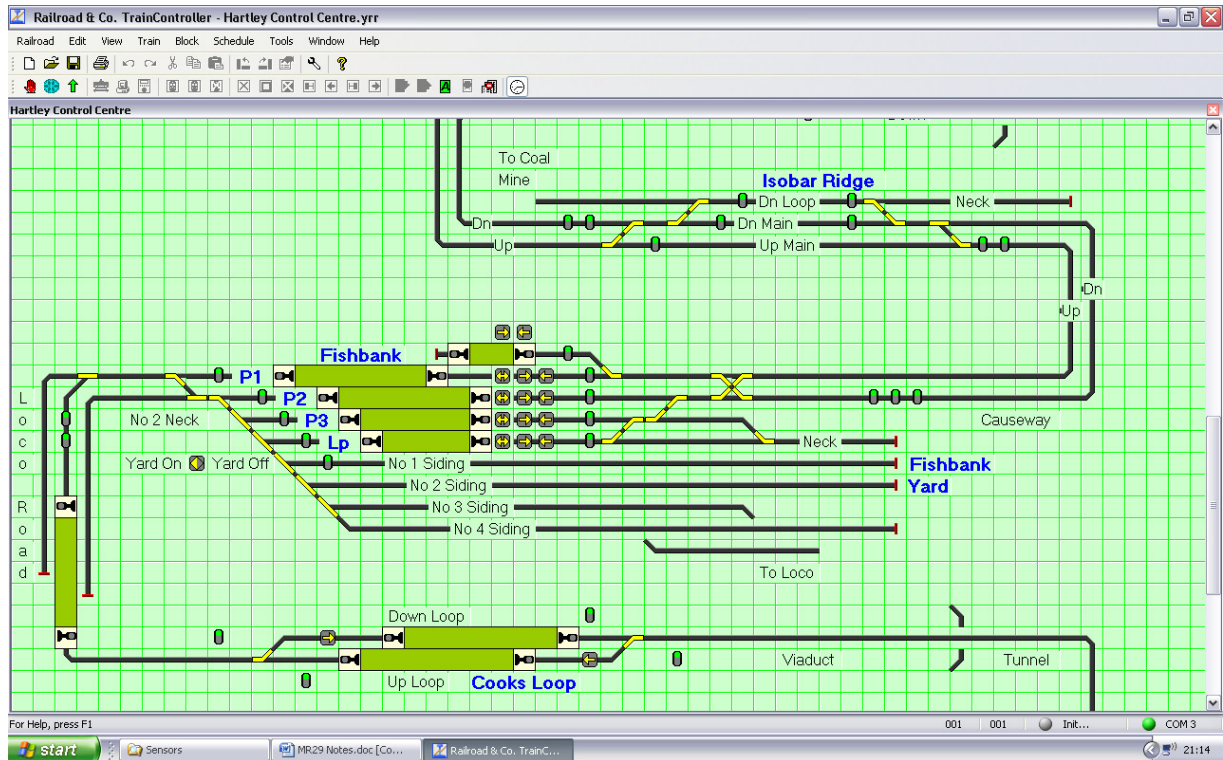


Figure 13 – Computer Controlled Signalling

To set up a computer controlled system you will need the following items:

- a personal computer;
- and interface between the PC and your DCC system;
- suitable software; and
- DCC accessory decoders.

Setting Up a Simple System of Operating Train Signals

First you have to decide whether you want to use track circuit detection or position sensor detection. Position sensor detection is a little easier to set up and is great for smaller layouts. Also, you do not have to install insulated block sections in your track system, as you do with the track circuit detectors. If you're already using block wiring for train control, then the difference in set up is not that significant.

One other thing to consider is that if you are using current (circuit) detection, the block will appear occupied whenever there is current being drawn on that block, either by a locomotive or by an insulated metal wheel set (on a wagon or carriage) containing a resistor between the wheel flanges - of course you also need to be using metal wheels. If the power is not on to that block, or if the loco or other power-drawing rolling stock is not actually in that block, it will not be detected. So you could have one or more pieces of rolling stock sitting in a block that will not be detected and the signal to that block will remain green.

By the same token, in order for a position sensor to work properly, the train has to be located directly over the photo-sensor or within the beam of the IR detector. If the train is present in the area, but not covering the detector, then it will not be detected.

You will need a Signal for each section of track that you wish to control. If your layout is single track or has single track sections that need signal control and want to run trains in both directions, you will probably need to install a signal at each end of the controlled area, facing in opposite directions, both of which could possibly be controlled by the same circuit board, since the light change will be the same for both signals. However, if you want the train to activate the signal as it approaches the signal, you will need to use two sensors and two electronic circuits. This way, as a train approaches the controlled area from either direction, it will pass over a sensor, activate the circuit board and change the lights on both signals to prevent the flow of any other traffic into that section of track.

Next, you will need to decide whether to use 2-light (red and green or yellow and green) or 3-light train signals.

To install your signalling system, you have to determine where you need to place signals to achieve the control you want. Basically, you will most likely want to place your signals wherever there is a place where two trains could potentially run into each other or to control passing loops, junctions, exits from yards or branches onto a mainline.

References

NSG600 Running Signals Version 4 – a description of the running signals used in the Railcorp network.

This document can be downloaded from:

http://www.railsafe.org.au/railsafe_docs/pdf/68/NSG_600_Running_signals_v4.pdf

Useful Web Links

Computer Control Software

<http://berros.eu/itrain/en/>

<http://www.gppsoftware.com/ViewProd.aspx?P=41582C2324262825>

<http://jmri.sourceforge.net>

<http://www.traintools.com/>

<http://www.freiwald.com/>

Signal and Control Equipment

<http://www.railconmodels.com>

<http://www.customsignals.com/signals.php>

<http://www.handmadeacc.com/>

<http://www.integratedsignalsystems.com/signals/index.htm>