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Constructional Project

AUTOMATIC TRAIN SIGNAL

by ROBERT PENFOLD

An easy-to-build, low cost starter project for your model radio system.

This very simple project, suitable for beginners, is a two-color (red/green) signal for a model railway. It uses a simple form of automatic operation, and if you stop the train in front of the signal it automatically switches from "green" to "red". When the train is restarted the signal automatically switches to "green" again.

To an onlooker it appears as though the signal is changing color and the train is responding to the change. In reality the train and the signal are both responding to changes in the track voltage. The signal will, in fact, go to "red" wherever the train is stopped on the layout, but

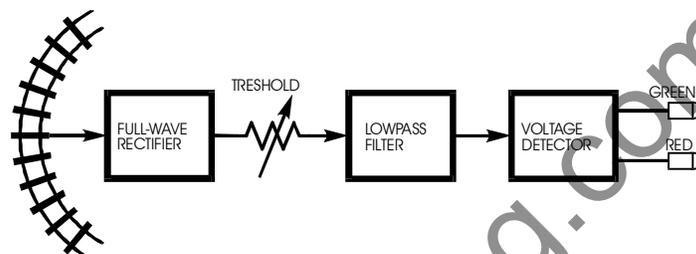this is of no practical importance, as the state of the

Fig.1. Block diagram for the Automatic Train Signal.

signal is irrelevant except when the train is approaching it.

SYSTEM OPERATION

The block diagram of Fig.1 helps to explain the way in which the *Automatic Train Signal* functions. The voltage from the track is fed to a full-

wave rectifier circuit. The voltage on the track is a DC signal, but its polarity depends on the direction of the train.

To operate the main circuit reliably it is important that the input signal has the correct polarity, and the purpose of the rectifier is to ensure that the main circuit is fed with a positive signal regardless of the train's direction. The output of the rectifier is fed to a potentiometer that enables the output voltage to be reduced. This enables the user to adjust the threshold voltage at which the signal changes state.

The threshold level used is not critical, but the signal should not go to red while the train is still moving. On the other hand, some types of train controller
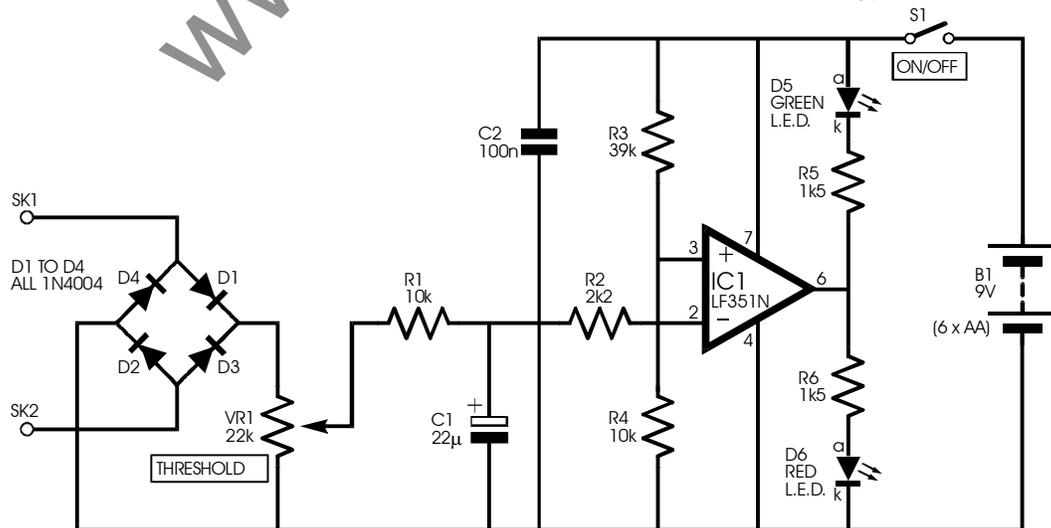

Fig.2. Complete circuit diagram for the Automatic Train Signal

never produce an output level that is right down at zero volts, and the threshold level must be high enough to ensure that the signal does go to red when the train stops.

It cannot be safely assumed that the signal across the tracks is a steady DC potential. The motor in the train is likely to introduce large amounts of noise onto the track voltage, which might not be a simple DC signal anyway. Many train controllers use some form of pulsed output signal, where the motor is controlled by varying the average output signal. Others use the rectified but non-smoothed output from a mains transformer.

In order to avoid problems with noise on the input signal, and to accommodate pulsed controllers, the output from the threshold control is fed to a lowpass filter. This provides a reasonably smooth DC output signal at a potential that is equal to the average input voltage.

Finally, this signal is applied to a simple voltage detector circuit. With an input voltage of up to about 1·8V the detector

circuit activates the red signal LED, but with higher input potentials it switches on the green LED instead.

CIRCUIT OPERATION

The full circuit diagram for the Automatic Train Signal is shown in Fig.2. The voltage from the rail tracks is connected to sockets SK1 and SK2, which feed into a full-wave bridge rectifier (D1 to D4). The positive DC output signal from the rectifier circuit is fed to a volume control style variable attenuator (VR1) and then to a simple lowpass filter comprised of resistor R1 and capacitor C1.

The cut-off frequency of this filter is low enough to ensure that there are no problems with flickering of the signal lights when the track voltage is near the threshold level. On the other hand, it is not so low that the unit is slow responding to changes in track voltage.

An operational amplifier, IC1, is used here as a voltage comparator. Resistors R3 and R4 form a potential divider that biases the non-inverting input of IC1 (pin 3) to about 1·8V. The output of IC1 at pin 6 will go high if the inverting input (pin 2) is taken below this potential, or low if it is taken above the reference level.

The voltage fed to the inverting input will be very low with the train stationary, sending the output of IC1 high. As a result red LED D6 is switched on, but green LED D5 is switched off.

When the train is started, the voltage fed to the inverting input rises, and eventually becomes greater than the reference level at the non-inverting input. The output of IC1 then switches to the low state, switching off D6 and switching on D5. Things revert

to their original states when the train is stopped again, with the red LED switched on.

ON TRACK

The current consumption of the circuit is about 7mA. A PP3 size battery is just about adequate to supply this, but a battery pack consisting of six AA size cells in a holder will provide cheaper running costs.

Operation from a mains power supply unit is made slightly awkward by the fact that neither supply rail can be earthed. This is because one of the input lines
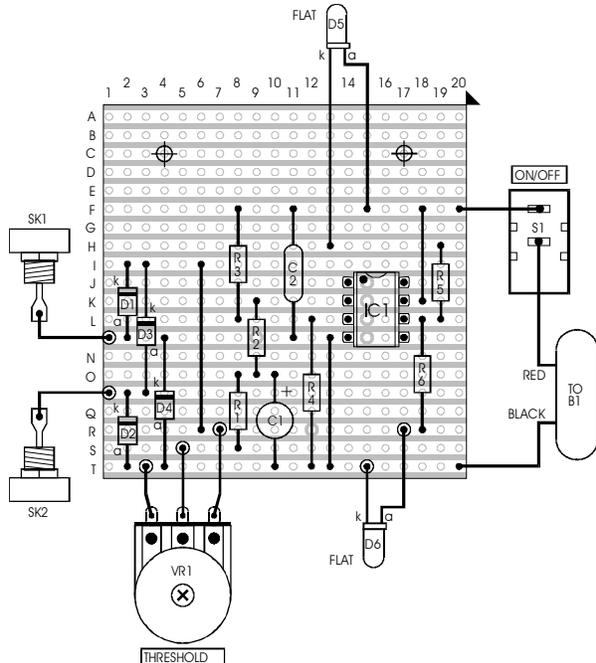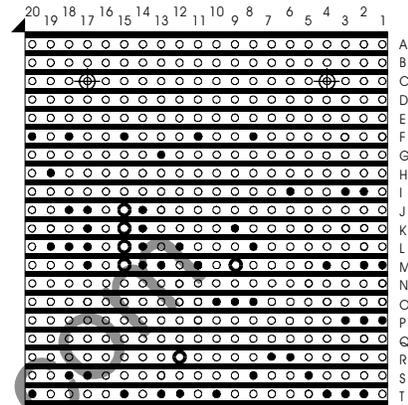
Fig.3. Stripboard component layout, inter-wiring to off-board components and details of breaks required in the underside copper strips.

might be earthed, and neither of these lines connects to a supply rail of the signal circuit.

Earthing one rail of the signal circuit could produce an unwanted connection that would prevent the unit from working, and could result in a heavy current flowing through the input rectifier circuit. The most practical solution is to use a 9V or 12V regulated battery eliminator. These use double insulation and have neither supply rail earthed.

CONSTRUCTION

The Automatic Train Signal circuit is built up on a piece of stripboard containing 20 holes by 20 copper tracks. The component layout, together with details of breaks required in the copper strips, is shown in Fig.3.

Construction follows along the normal lines with a standard size board being cut down to the correct size using a hacksaw. Next drill the two mounting holes, which have a diameter of 3mm and accept Metric M2·5

mounting bolts. There are just six breaks in the copper strips. These can be made using a special tool or by using a small hand-held twist drill bit of about 5mm diameter.

The board is now ready for the components and the three link-wires to be added. It is generally considered best to start with the small components and work up to the largest, but in this case the components are all quite small.

It is probably best to work across the board methodically, being careful to get everything in the right place. In the cases of IC1, C1, and the four rectifier diodes (D1-D4) you must also be careful to fit them the right way round. The LF351N used for IC1 is not a static sensitive component, but as with any DIL integrated circuit it is still advisable to mount it on the board via a holder.

It might be possible to make the link-wires using the wire trimmed from the resistor leads, but one or two

of them might be too long to permit this. They will then have to be made from 22s.w.g. or 24s.w.g. tinned copper wire. Fit single-sided solder pins at the points where connections will be made to the controls, LEDs, and sockets.

CASING UP

If the unit is powered from a PP3 size battery it should be possible to fit it into practically any small plastic box. A medium size case about 150mm or so long will have to be used if an AA battery pack is to be accommodated.

Threshold control VR1 and On/Off switch S2 are mounted
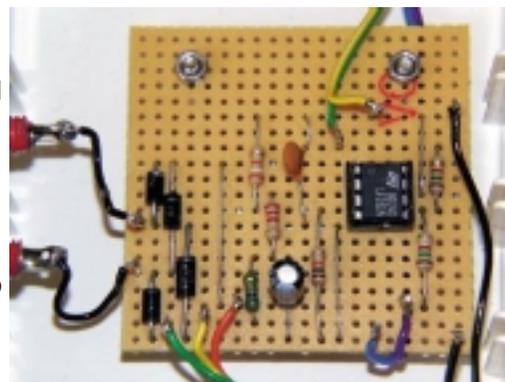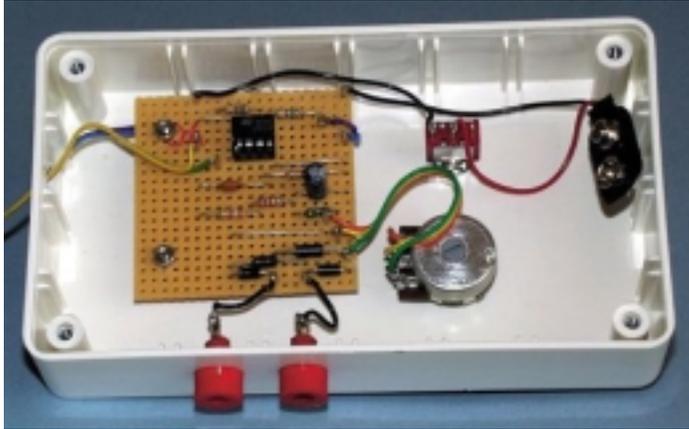
Layout of components inside the small plastic box. Note, the input sockets must be fed with the track voltage.

on the front panel, while input sockets SK1 and SK2 are mounted on one side or at the rear of the case, see photographs. An exit hole for the lead to the signal LEDs is required in one side or the rear of the unit. The circuit board is mounted in any convenient space, and it is advisable to use some extra nuts or short spacers between the board and the case. This avoids any tendency for the board to buckle and break when the mounting nuts are tightened. To complete the main unit the hard wiring is added. This is all shown in Fig.3 and is perfectly straightforward.

SIGNAL BOX

Construction of the "signal" is left to the ingenuity of individual constructors. At its most basic the signal can just consist of a very small plastic box for the two LEDs. However, it should not be too difficult to fabricate a more convincing signal from balsa wood, bits of dowel, etc. Provided you know what you are doing, it would probably be possible to adapt a ready-made signal "tower" to work with this circuit.

The size of the signal must be varied to suit the gauge of the model railway, as must the size of the two LEDs. For the usual smaller gauges 3mm diameter LEDs are the best choice, but for larger gauges 5mm types would be better. The LED current is not very high, so "high brightness" types are preferable.

Unlike filament bulbs, LEDs will only work if they are connected with the correct polarity. Having the cathode (k) lead slightly shorter than the anode (a) lead is the normal way in which the polarity of a LED is indicated. There may also be a "flat" on the cathode side of the encapsulation.

TESTING

Input sockets SK1 and SK2 must be fed with the track voltage, and the way in which this is done must be varied to suit the equipment with which the signal is used. In most cases the easiest way is to make up a twin lead fitted with 4mm plugs to connect to SK1 and SK2, and small, insulated covered, crocodile clips at the other end. The power connectors on the track are often quite crude, and will permit power to be tapped off using the crocodile clips.

Alternatively, by simply leaving some bare wire at the ends of the leads it might be possible to make connections to the screw or spring connectors on the train controller, being careful to leave the connections to the track intact. Failing that, it will be necessary to make up a dual supply lead to enable both the signal and the track to be fed from the controller.

With Threshold control VR1 at a roughly middle setting the signal should work quite well, with "red" and "green" signals being obtained when the train is respectively stopped and running fast. The signal will probably be at "red" when the train moves very slowly, or possibly at "green" when the train has stopped. A little experimentation with various settings for VR1 should soon get the signal switching states at the start/stop track voltage of the train.

Note that the more simple types of controller tend to provide a start voltage that is much higher than the one at which the train stops. The threshold voltage of the signal then has to be set at a compromise level somewhere between these two voltages.