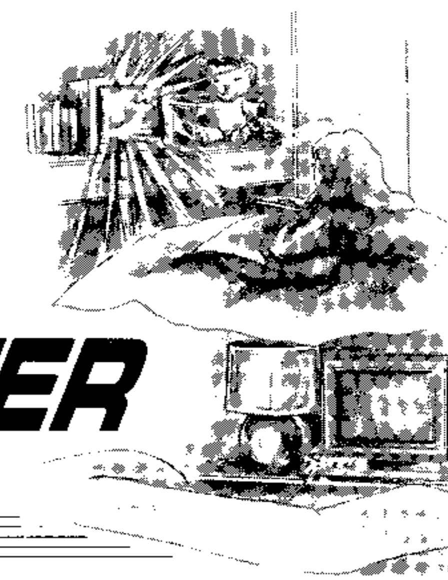


IMPROVED INFRA-RED REMOTE REPEATER

ROBERT PENFOLD

Control your video or satellite tuner from the bedroom when it's in the lounge!

A PREVIOUS article in *EPE* featured a project for a device that enabled an infra-red remote control unit to be used via a connecting cable (*Infra-red Remote Control Repeater*, July 1997 issue). Although this might seem to be a retrograde step, adding a cable into the system means that it is no longer limited to "line-of-sight" operation. The operating range can also be extended.

No doubt there are other applications for a system of this type, but the most common use is to provide remote control of a VCR or satellite receiver from another room. If you have a television receiver in (say) a bedroom and it is fed from a VCR or satellite receiver in the lounge via a coax cable, you only have limited control over what you see. There is no way of setting the VCR to fast-forward or changing the channel of the satellite receiver, because the infra-red remote control handsets will not work through walls, ceilings, or anything opaque. Their maximum operating range is also very limited.

LONG-RANGE

With a hard wired relay unit such as the unit featured here it is possible to use an infra-red control system over a range of at least 20 metres, and it will operate from one room to another. The general idea is to fit a thin screened audio cable alongside the coax cable that connects the signal source to the television set. This second cable carries a signal in the opposite direction, and provides the necessary control of the receiver or VCR.

A simple receiver unit picks up the infra-red pulses from the remote control handset and sends them down the cable. A transmitter unit at the other end of the cable transmits infra-red pulses that control the VCR or satellite receiver.

The design featured previously had a reasonable range at the transmitting end of the system, and the transmitter only needed to be within a few metres of the unit being controlled. Due to its extreme simplicity, the range obtained at the receiver end of the system was strictly limited. In fact, the remote control handset had to be held within about 0·5 metres of the receiver or the system failed to work at all.

Such limited range is usable, but is not very convenient. The improved system featured here is still quite simple, but it offers an operating range of several metres at the receiving end of the system. This means that in most cases the receiver can be tucked away in one corner of the room, and the system will then function well with the remote control handset anywhere in the room.

SYSTEM OPERATION

The block diagram of Fig.1 helps to explain the basic function of the Improved Infra-Red Remote Repeater. The infra-red pulses from the IR Handset are received by a photo-diode where they produce corresponding electrical pulses.

These pulses are likely to be extremely weak, and will often be only a fraction of a millivolt "peak-to-peak". A large amount of amplification is therefore needed in order to raise the signal level to one that can operate the output stages of the unit.

A low-noise preamplifier stage is followed by two further stages of amplification. This produces an output level of a few volts peak-to-peak from the final amplifier, and this is more than adequate to drive the subsequent stages. In fact the final stage of the amplifier block will normally be driven into clipping.

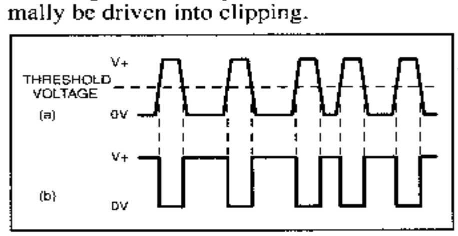


Fig.2. Example input (top) and output waveforms of the voltage comparator.

IN COMPARISON

Although the infra-red diode and amplifier stages have fairly wide bandwidths, there is still some degradation of the waveform, especially when a weak signal is received. This results in reduced rise and fall times, giving a waveform of the type shown in Fig.2 (top).

The methods of pulse coding used in infra-red remote control systems are reasonably tolerant of waveform distortion, but any distortion must still be kept to a minimum in order to ensure good results. A voltage comparator is therefore used to

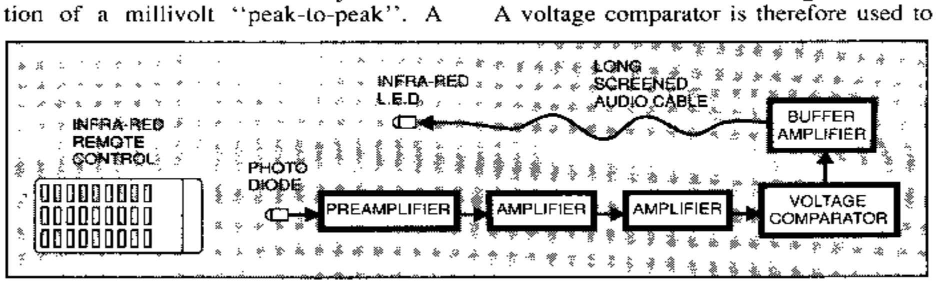


Fig.1. Block diagram for the Improved Infra-Red Remote Repeater

speed-up the waveform and minimise any distortion through the circuit.

The amplified signal is compared with a reference voltage of about half the supply potential. The output of the voltage comparator goes high when the input voltage is below the mid-supply threshold level, and low when the input is above the threshold level.

The signal is therefore inverted through the comparator, but this simply cancels out an inversion through the amplifier stages. Because the output of the comparator can switch relatively quickly, the output signal has improved rise and fall times, as in the lower waveform of Fig.2.

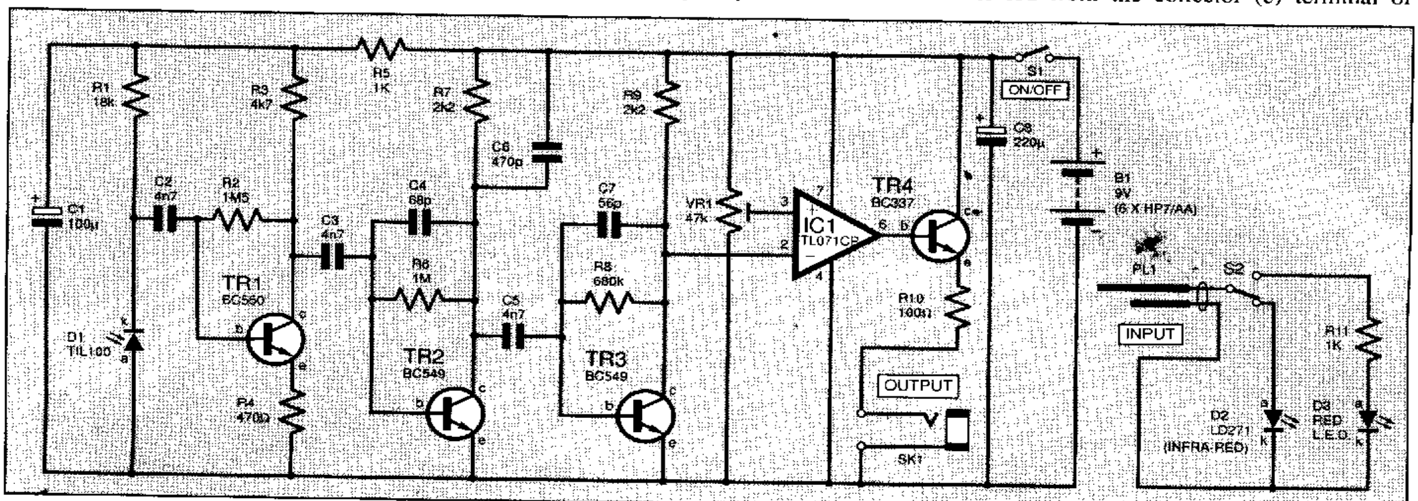


Fig.3. Full circuit diagram for the Improved Infra-Red Remote Repeater. The infra-red l.e.d. D2 (transmitter) is sited with the main household VCR/satellite receiver and linked to the "repeater" by screened cable at the second TV.

Returning to the block diagram of Fig.1, the final stage is a buffer amplifier. This enables the infra-red l.e.d. at the transmitter end of the relay link to be driven at a suitably high current. The transmitter unit is basically just an infra-red l.e.d., and it contains no active circuitry.

There is likely to be a substantial amount of capacitance in the long connecting cable, but due to the low output impedance of the circuit this will not produce a significant degradation of the output waveform. On the other hand, it does place an upper limit on the length of the connecting cable. The prototype has only been tried with cables of up to 20 metres in length, but the unit should function with cables somewhat longer than this.

CIRCUIT OPERATION

The complete circuit diagram for the Improved Infra-Red Remote Repeater is shown in Fig.3. D1 is the infra-red diode, and this is used in the reverse biased mode.

Under dark conditions D1 has the very low leakage level associated with normal silicon diodes, but the pulses of infra-red "light" from the infra-red keypad handset cause increased leakage, and generate small pulses at the cathode (k) terminal of D1. These pulses are coupled by way of capacitor C2 to the preamplifier, which is a common emitter stage based on transistor TR1. A common emitter amplifier normally has a high voltage gain, but in this case the voltage gain is only about 10 (20dB) due to the local negative feedback introduced by resistor R2.

The output from TR1 is fed to further common emitter amplifiers (TR2 and TR3) which operate at full gain and provide most of the circuit's voltage gain. It is important that the circuit has poor sensitivity at low frequencies so that problems with 100Hz pickup from mains powered lighting are avoided.

Coupling capacitors C2, C3, and C5 have been given quite low values so that they introduce highpass filtering that greatly reduces the sensitivity of the circuit at 100Hz. On the other hand, they give an adequate low frequency response for the brief input pulses which do not have a significant low frequency content.

The combined voltage gain of the three amplifier stages is very high indeed, and this can lead to problems with instability. Matters are made worse by the use of stripboard construction which tends to encourage stray feedback due to the capacitance between the copper strips.

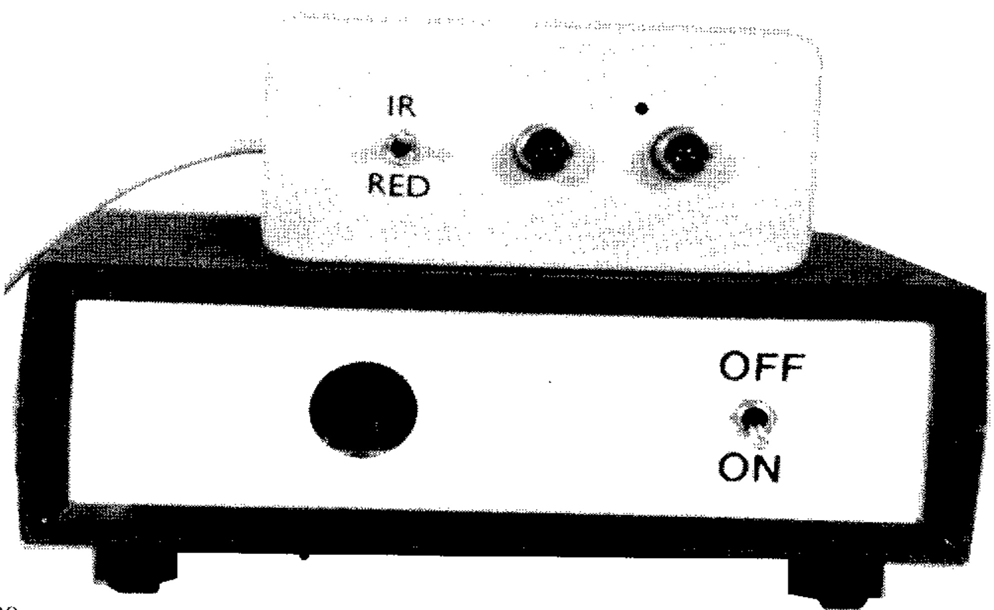
In order to prevent instability the high frequency response of the circuit has to be rolled-off slightly, and this is the function of capacitors C4 and C7. These simply provide increased negative feedback over transistors TR2 and TR3 at high frequencies.

VOLTAGE COMPARATOR

An operational amplifier, IC1, is used here as the voltage comparator. The basic function of an op.amp is to amplify the voltage difference across its inputs. The output goes more positive if the non-inverting (+) input is at the higher voltage, or more negative if the inverting (−) input is at the higher voltage. The voltage gain is so high (about 100000 times), that even a minute voltage difference is sufficient to send the output fully positive or negative.

In this case the inverting input, at pin 2, is fed from the collector (c) terminal of transistor TR3, and the non-inverting input, at pin 3, is fed with the reference voltage generated by preset potentiometer VR1. This reference potential can be varied from zero to the full supply voltage, and in practice it is set slightly lower than the voltage at the collector of TR3.

Under standby conditions the non-inverting input (pin 3) will be at a lower potential than the inverting input, and IC1's output will therefore go low. When a signal is received from the remote control handset, at the "window" of D1, a pulsed signal appears at the collector of TR3.



During negative half cycles the inverting input of IC1 will be taken below the reference voltage, sending the output of IC1 high. The relatively fast switching speed of IC1 results in a "clean" and fast version of the input signal appearing at its output.

A drive signal of only a few milliamps is available at the output of IC1 pin 6, and transistor TR4 is therefore needed to boost the output current to a level that will drive the infra-red l.e.d. D2 properly. Resistor R10 limits the l.e.d. current to about 70mA, but due to the pulsed and intermittent nature of the signal the average output current is far less than this.

The current consumption of the circuit as a whole is about five milliamps, and as the unit will normally be left running for long periods it is essential to use a fairly high capacity battery. In theory, each set of six HP7 size batteries should have an operating life of about 400 hours, but due to the low current consumption the actual life span is likely to be substantially greater than this.

In normal use switch S2 is set to the position shown in Fig.3 so that the output of the unit is connected to infra-red l.e.d. D2. When initially testing and setting up the unit it is useful to set S2 to the other position so that the output signal is directed to l.e.d. D3.

As D3 is a visible red l.e.d. it enables the user to determine whether the output of the unit is at the correct standby state (with D3 switched off). This also makes it easy to adjust preset VR1 to a suitable setting.

The red l.e.d. D3 will visibly flash when the unit receives a signal from the remote control handset, and this enables the user to determine whether or not the unit is operating correctly. Resistor R11 provides additional current limiting that protects D3 from excessive currents during the setting up process.

CONSTRUCTION

The main circuit is constructed on a piece of stripboard which measures 37 holes by 17 copper strips using the component layout shown in Fig.4. The underside view of the board, giving details of breaks in copper tracks, is also provided. Construction of the board follows along the normal lines and should not provide any problems.

The TL071CP op.amp used for IC1 is not a static-sensitive component, but it is still a good idea to fit it in a holder. Infra-red diode D1 is specified as a TIL100 in the components list, but any similar component should work equally well.

In component catalogues diodes of this type are not necessarily sold under a particular type number, but are sometimes advertised as an infra-red diode for remote control applications. A Maplin "Infra-Red Diode" is used in the prototype, and Fig.4 is correct for this component. Other infra-red diodes might have different encapsulations or leadout configurations.

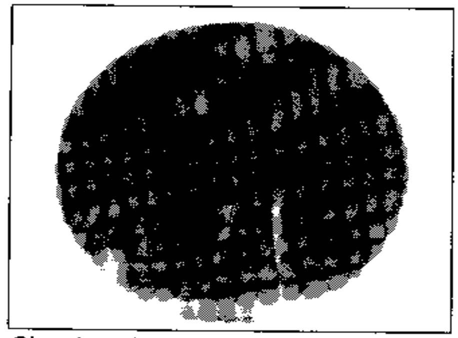
Mylar capacitors have long leadout wires that can be formed to accommodate a wide range of lead spacings, which makes them a good choice for C3, C5, and C7. It could be very difficult to fit other types of capacitor into this layout. Similarly, C4 and C7 should be miniature ceramic plate types, since other types are not likely to fit properly into this component layout.

A medium size plastic box or instrument case will comfortably house everything. The only slight complication is that a window is required for the infra-red diode to "look" through. With the specified diode the large flat surface is the one that must be aimed towards the window.

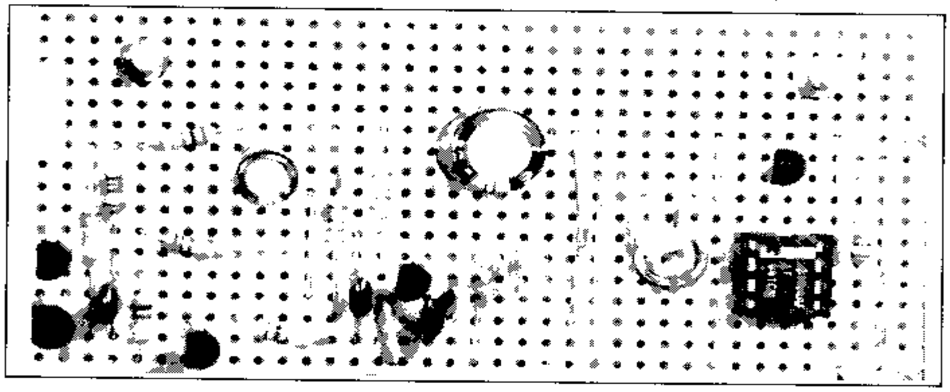
It is best to cut a fairly large window of about 20mm to 25mm in diameter, and to position the circuit board so that D1 is quite close to the cut-out, see photographs. The unit will then have a wide angle of view instead of the "tunnel vision" that would be obtained if D1 is mounted well back from a small cut-out. A piece of transparent plastic is glued in place behind the cut-out.

The screened connecting cable is fitted to the main unit via a 3·5mm jack plug wired to the cable, and a matching jack socket SK1 mounted on the rear panel of the main unit. Alternatively, the cable can simply be hard wired to the circuit board.

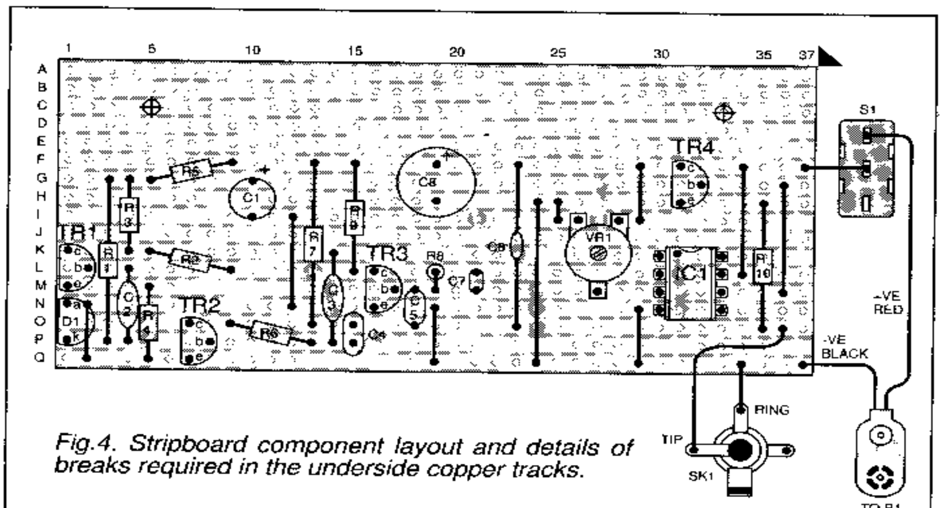
The cable does not carry a high frequency signal, and any screened audio cable of reasonable quality will suffice. It



Site the photodiode close behind the "window" to avoid any "tunnel vision" effect.



Completed stripboard component layout.



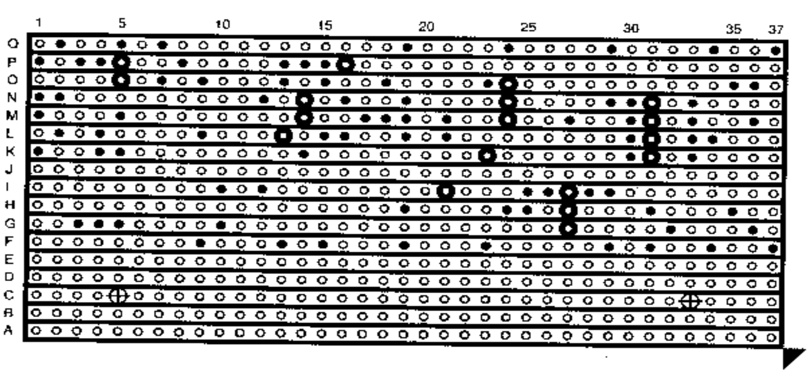


Fig.4. Stripboard component layout and details of breaks required in the underside copper tracks.