Infrared Remote Control

A simple but effective on/off remote control using infrared.

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A few years ago remote controls systems were almost invariably of the ultrasonic variety, but thse days the infrared systems are probably more common. They are generally less vulnerable to spurious triggering, and are less likely to annoy your pets. They can also carry quite complex forms of modulation. Their only real drawback when compared to ultrasonic systems is that the range is usually somewhat less, although for many applications a range of only a few metres is required. This is easily achieved using an infrared systems.

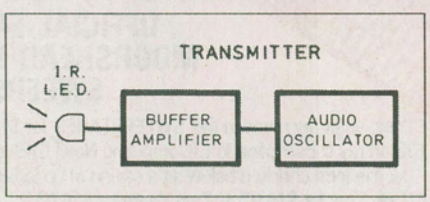
Wiring

This infrared remote control system has been kept as simple as possible so that it can easily be built using perfboard, making it fairly easing for complete beginners to electronics construction as well as more advanced constructors.

Control System

The range of this control system depends on the emitter device used in the transmitter, and is around two to three metres using a wide-angle device, or about four to five metres using a narrow beam type range. The aim of the transmitter must be quite accurate especially when the system is operated close to its maximum range.

The unit provides a basic on/off action where opening and closing a switch on the transmitter results in the contacts of a relay in the receiver switching on and off. The system is suitable for simple remote control applications such as control of a small model car or boat. The equipment could also be used as a broken- beam type sensor for a burglar alarm system.



The System

In theory it is possible to have a DC system, where the signal from the transmitter is detected by a photocell at the receiver, and the photocell drives an amplifier which in turn drives the relay. In practice such a system is unusable, as it provides a totally in-

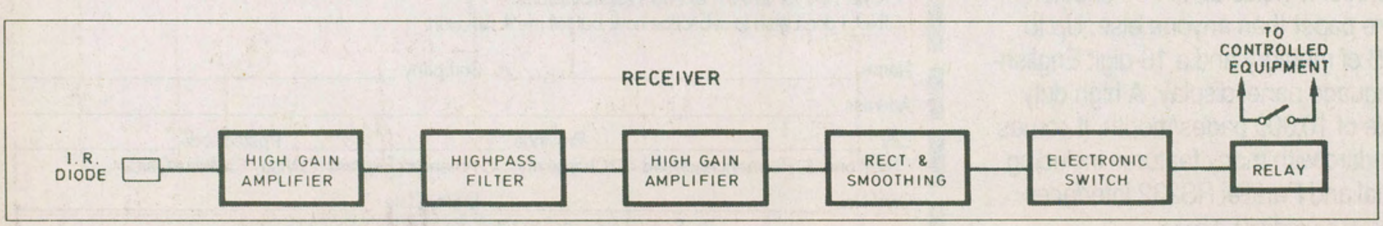


Fig. 1. Block diagrams of the transmitter (above) and receiver.

PARTS LIST

RECEIVER

Resistors

All .25%, 5%

R1 ....22k
R2 ....1M8
R3 ....6k8
R4 ....1k
R5 ....1M
R6 ....4k7

Capacitors

C1,6 ....100u 10V
C2,3......................................22n
C4 ....1u 63V
C5...................................2u2 63V

Semiconductors

TR1,3 ....2N3904 NPN
TR2.......................2N3906 PNP
D1 ....TIL100 IR photodiode
D2,3 1N34 or 1N60 germanium
D4 ....1N914 or 1N4148

Miscellaneous

RLA1 5V or 6V relay with 200 ohm coil or higher, contacts as required
S1 .... SPST min. toggle switch
B1 9V battery or 6 AA cells in holder

TRANSMITTER

Resistors

All .25W, 5%

R1 ....3k9
R 47k
R3 68

Capacitors

C1 ....100u 10V
C2 ....4n7

Semiconductors

IC1 ....555 timer
D1 LD242 high power IR LED (see text)

Miscellaneous

S1 SPST min. toggle or push-button
B1 9V battery

adequate range. Boosting the sensitivity to improve range simply results in frequent spurious operations of the system.

The main problem is that of a certain amount of background infrared signal. This background level could easily be strong enough to swamp the signal from the transmitter.

There is also a problem with the inevitable drift that occurs

in high gain DC amplifiers. An inordinate amount of

readjustment could be needed with a sensitive DC coupled circuit.

Infrared remote control systems normally use some from of pulse signal, and this one is no exception. The block diagram of Fig. 1 shows the basic arrangement of the system.

Transmitter

The basic transmitter signal is generated by an audio frequency oscillator. The exact operating frequency is not important, and anywhere in the upper regions of the audio range will do. Higher frequencies are less than ideal as the photocell and other parts of the unit will operate at less than optimum efficiency at these frequencies. Lower frequencies could make the equipment a bit sluggish in operation, and would make it relatively difficult to combat the background infrared noise.

An LED converts the electrical pulse from the oscillator into pulse of infrared radiation. This component is very much the same as the LED used in clock displays, etc, but its output is just outside the visible-red part of the spectrum and into the infrared zone. It provides no significant visible light output, and does not noticeably glow when activated. In order to give an adequate output level the LED must be driven from the oscillator via a buffer amplifier.

Receiver

The photocell at the receiver is a photodiode. This is a type designed specifically for applications such as remote control systems. It has a spectral response that matches the output wavelength of the LED at the transmitter, and it is a large area device that provides good sensitivity. At least, it provides good sensitivity by photodiode standards.

It still only provides an extremely low level output signal which must be amplified by a considerable amount in order to give sufficient drive to operate a relay. Most of this gain is provided while the signal is still in pulse form, and it is provided by two high gain amplifier stages.

Under most circumstances the background infrared noise level is not a problem. Reasonably constant infrared signals will not affect the unit. It is only those that, like the signal from the transmitter, are amplitude modulated that will interfere with the unit by holding the receiver in the activated state.

The only likely source of such a signal is the 120 Hertz modulated signal

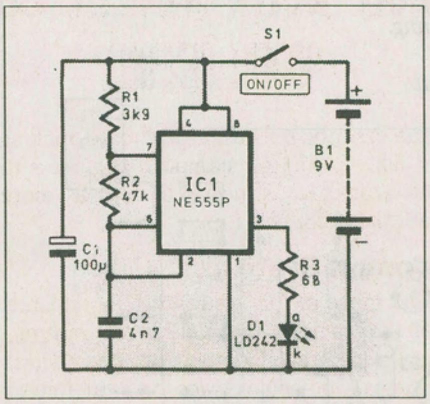


Fig. 2. The IR transmitter schematic.

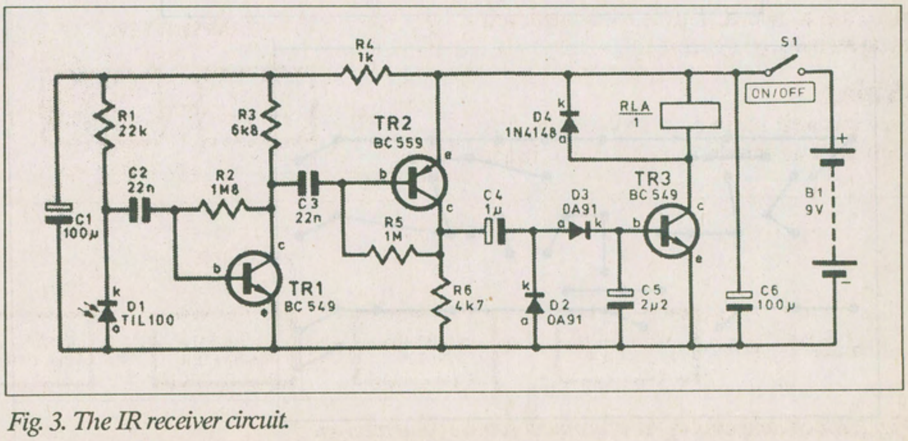


Fig. 3. The IR receiver circuit.

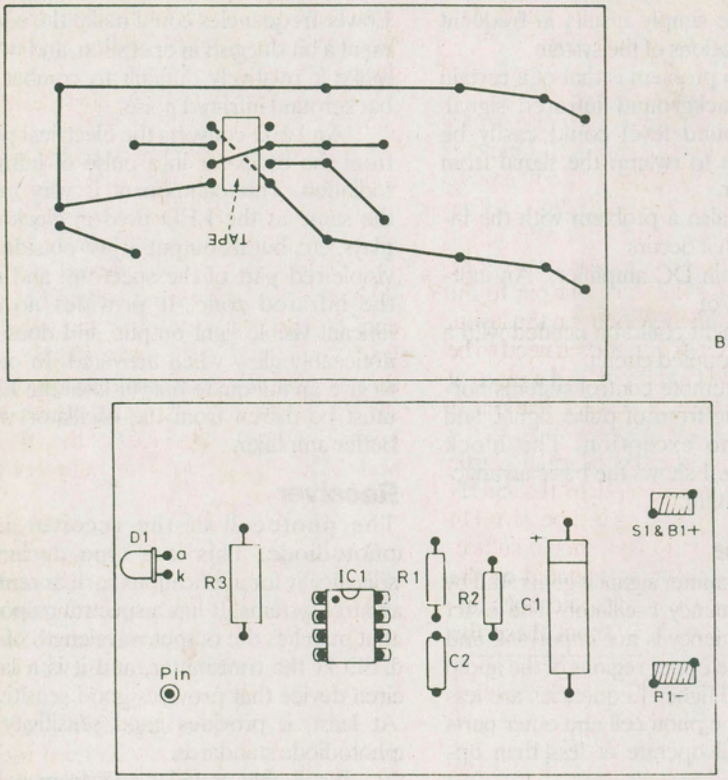
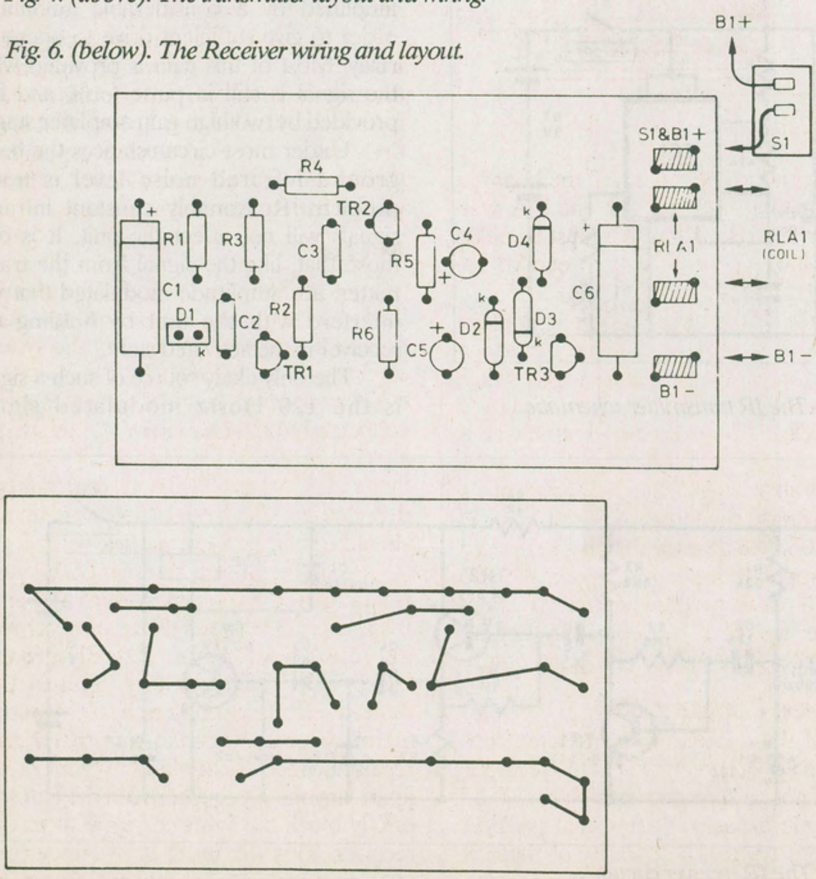


Fig. 4. (above). The transmitter layout and wiring.

Fig. 6. (below). The Receiver wiring and layout.



produced by AC filament bulbs (60 positive and 60 negative pulses per second from the 60Hz mains). As this is at a much lower frequency than the signal from the transmitter, some simple highpass filtering is all that is needed to remove any "hum" picked up by the photodiode from lights.

The output from the second high gain amplifier is fed to a rectifier and smoothing circuit. With a suitable input signal present, the output from the rectifier circuit is a series of positive pulses. These are smoothed to produce a reasonably steady positive DC signal that can drive the relay.

The relay is controlled via an electronic switch that also provides a large amount of DC amplification. This enables the relatively weak output signal from the smoothing circuit to drive virtually any relay having a suitable coil voltage. A relay is merely a switch that is operated by an electromagnet, and its switch contacts are connected in one of the supply leads of the equipment which is to be controlled by the system.

Of course, in the absence of any signal from the transmitter, the output from the second amplifier is only a low level noise signal, and the DC output from the smoothing circuit is inadequate to drive the electronic switch properly. Consequently, the relay (and the controlled equipment) are only switched on when the transmitter is activated.

Transmitter Circuit

The transmitter circuit is shown in Fig. 2, and as will be apparent from this, it uses very few components. It is based on the indispensable 555 timer integrated circuit. In this case it is operated in the standard astable (oscillator) configuration and its output frequency is controlled by timing components R1, 2 and C2. They give an output signal with a markspace ratio of roughly 1:1. In other words, the "on" periods of the LED (D1) are roughly equal to the "off" periods. Resistor R3 controls the output to D1, and it sets this current at a little under 100 milliamps. However, as D1 is switched off for about 50 percent of the time the average LED current is just under 50 milliamps. IC1 has a built-in output stage that enables these relatively high currents to be handled without the need for any external amplification.

Receiver Circuit

The full circuit diagram for the receiver section of the system is shown in Fig. 3. D1 is the photodiode, and it is used here in the reverse bias mode. R1 provides the reverse bias, and normally the current flow through D1 is only a minute leakage current. However, when it receives each pulse of infrared radiation from the transmitter pulse of increased current flows through the circuit. This generates small voltage pulse at the junction of R1 and D1, and these are coupled to the input of the first amplifier by C2.

Transistors TR1 and TR2 act as the basis of the two high gain amplifiers, and these are both common emitter stages. They are AC coupled and use the same basic configuration, but the first amplifier uses an NPN device whereas the second is based on a PNP type. They each provide a voltage gain of more than 40dB (one hundred times). The highpass filtering is obtained by using fairly low values for coupling capacitors C2 and C3. This gives simple two pole filtering, which is adequate for present purposes.

Diodes D2 and D3 are the rectifier circuit, and C5 is the smoothing capacitor. The output of this circuit drives a common emitter switch (TR3) which has the relay coil as its collector load.

When the relay is de-energized a high reverse voltage can be generated across the coil. D4 effectively short circuits this voltage spike and prevents it from damaging any of the components in the unit. C1, R4, and C6 form a supply decoupling network. These prevent low frequency instability due to feedback through the supply lines.

Construction

Details of the transmitter board and small amount of hard wiring are shown if Fig. 4. Equivalent details for the receiver unit are provided in Fig. 5. Start with the transmitter board which is the more simple of the two. Take care to fit C1 the right way around.

With the axial (horizontal mounting) electrolytics the correct orientation is shown by an indentation around the body of the component (which indicates the + terminal. The shorter lead out of D1 in the transmitter is its cathode (k) terminal.

The LD242 gives optimum range but it is quite directional. Reduced range but a wider beam are obtained using an LD241 or a TIL38. Incidentally, some component suppliers sell these LEDs simply as something like "high powered infrared LEDs" rather than by type number; these should also work well.

An indentation at one end of IC1's body enables its orientation to be set correctly. A socket is a good idea for IC1 in case you have to change it. Connections to it will also be easier if they are made via a holder which has quite long pins.

Wiring Up

The wire which carries the negative supply rail must be routed around IC1. One way of keeping this wire in place is to fit a piece of the double-sided adhesive backing material onto the board. As only a single angle in the wire is needed, an easier solution is to add a printed circuit pin to the board at the point indicated on the layout diagram. In fact it does not even need to be a proper printed circuit pin, and a piece of wire trimmed from a resistor leadout is quite adequate.

There are a number of small plastic boxes that can accommodate the circuit board and battery, and an inexpensive 114 by 76 by 38 millimetre type should suffice. The component board is mounted on the base panel using small nuts and bolts, including short spacers. Without these the component will be forced off the board as the mounting nuts are tightened. A window for D1 to look through must be made at a suitable position in one end of the case.

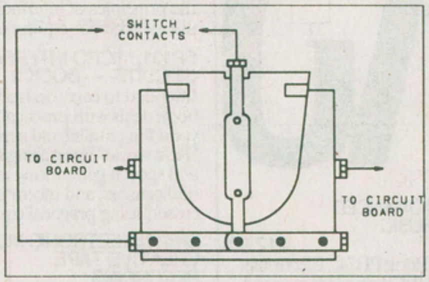


Fig. 6. Typical relay wiring.

If the unit is to be used in an application where S1 will need to be closed for much of the time a miniature toggle switch is the best type to use. Otherwise a push to make, release to break push- button type is better.

An alkaline 9V battery is adequate if the transmitter will only be used in short bursts. If it will be used for long periods, a higher capacity battery such as six AA size cells in a plastic holder is preferable. Note that the use of a high capacity battery might necessitate the use of a larger case.

Receiver Construction

A lot of these notes on transmitter construction apply equally well to the receiver, and will not be repeated here. Some of the electrolytic capacitors are radial (vertical mounting) types. The polarity of these is usually marked by + and - signs on the bodies of the components. D1 is mounted with the large surface that carries the type number (and possibly other markings) facing toward R1.

Note that its sensitive surface is the one opposite this,

and that the output from the transmitter must be directed

towards this side of the device. A window must be in the case adjacent to D1.

Make sure the other diodes are also fitted the right way round. A band at one end of the body indicates the cathode leadout, but these days some diodes have three or four bands. In this case, one band should be broader than the others and positioned right at one end of the diode's body. This is the one that indicates the cathode leadout wire.

The relay can be any type that has a coil resistance of about 200 ohms or more, will operate reliably on a six volt supply, and has contacts of adequate rating for the equipment that the unit will control. Some of the 5V relays designed for use with logic circuits such work well.

If the relay is too large to fit onto the circuit board, it can easily be fixed inside the case. It can either be glued in place using a good quality general purpose adhesive, or small bolts will do the trick.

Although the relay may be capable of handling 120V mains powered equipment, the unit should only be used in this way **if it is built an installed in a fashion that is entirely safe.** Those of limited experiences **should only use Remote Control with low voltage battery powered equipment.**

In Use

As with any projects, give the wiring a final and thorough check before switching on and testing the system. Try the system at close range initially. It can be tested even without having the relay contacts connected to the main item of equipment, as most relays produce a "click" sound as they switch on or off. The maximum range depends on the type of LED used, but should be at least a few metres.

A simple infrared system of this type is strictly a line of sight system, and anything opaque between the transmitter and the receiver will almost certainly prevent the system from working. This is the desired effect in broken beam intruder alarm systems. With the transmitter and receiver space a couple of meters or so apart, anyone passing between the two will briefly block the infrared signal from the receiver. This will result in the relay contacts opening momentarily, which can be used to activate a burglar alarm system. ■