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Simple Car Burglar Alarm
Multi-channel remote control to build

Eight-channel IR remote control

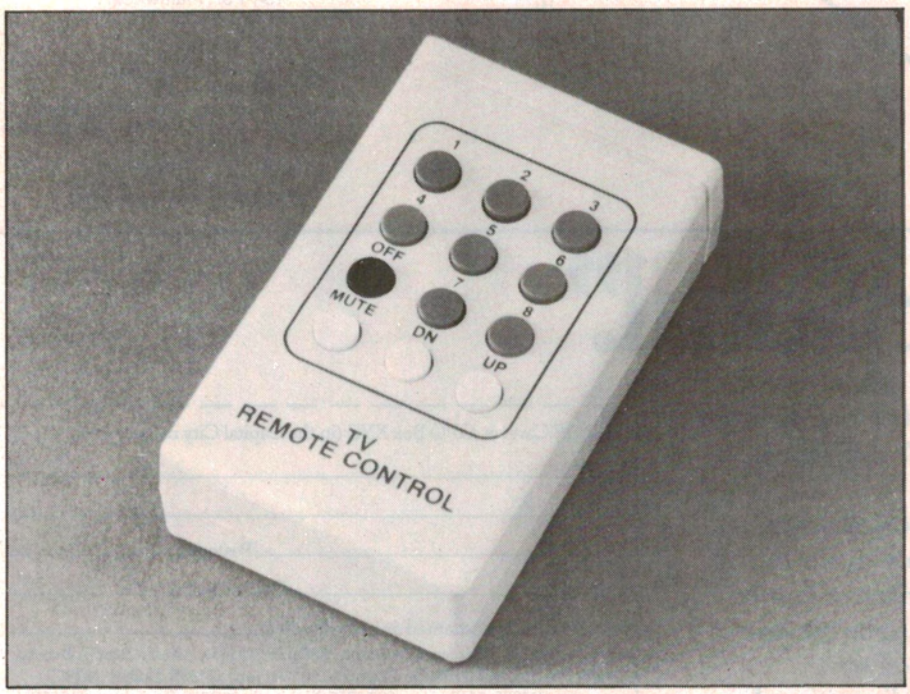
Ever wanted to fit remote control for your TV set, CD player, VCR, cassette player or even your model railway? Or do you have appliances or machinery which would be safer or more convenient if operated by remote control? Up to eight separate functions can be switched with this infrared remote control and you can add power on/off, muting and volume control.

by JOHN CLARKE

The remote control system to be described could be added to a pushbutton TV set which presently does not have the luxury of remote control. Alternatively, if mains-rated relay switching is added, it could be used to control appliances such as lamps, alarms, heaters and so on.

Model railway enthusiasts can build the circuit in a number of versions and use it to control points and signalling on a track layout.

Basically, the remote control unit can operate any device which is normally controlled with momentary or change-over contacts. This includes solenoid-operated cassette players, CD players, pushbutton TV sets, some machinery and models.



The project can be used to provide full remote control for a TV receiver. This version of the transmitter uses the smaller of the two optional plastic cases.

The remote control comprises a small hand-held battery-powered infrared transmitter and an accompanying receiver unit. The receiver is mains powered and can be built with a minimum of components to provide remote control of up to eight functions with momentary or latched relay contacts. The addition of the full complement of components allows control of on/off, muting and up and down volume.

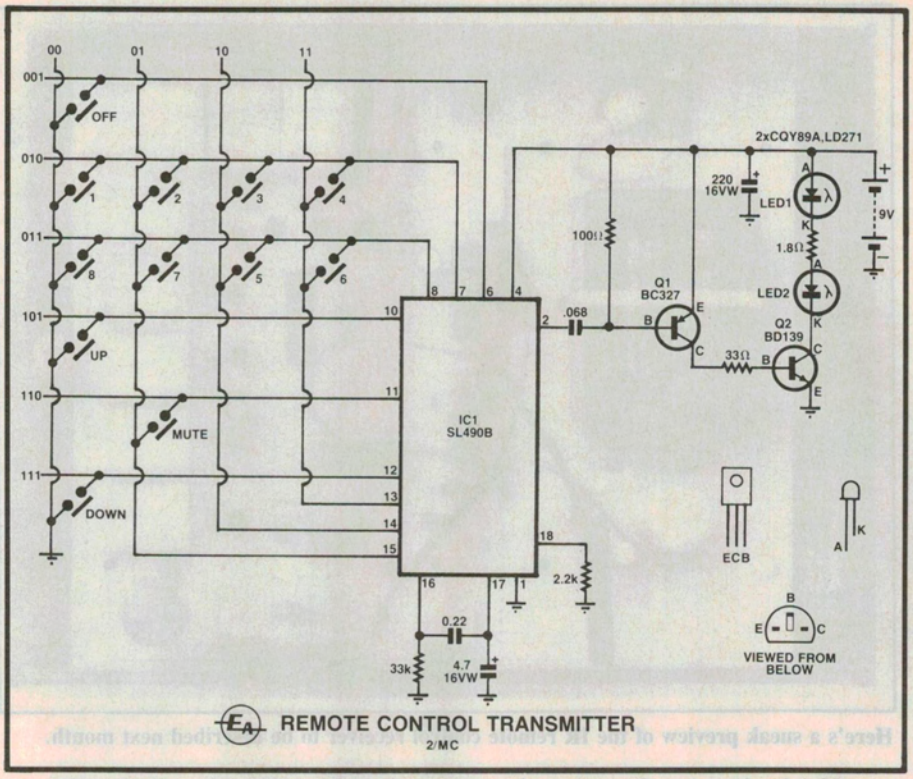
The transmitter can include up to 12 switches to enable the use of all remote control features, or only include those switches that are necessary for the number of functions on the receiver. For instance, only eight switches need be used if the receiver is built to control eight outputs only.

Operation of the remote control relies upon a coded signal which consists of pulses of infrared light. The receiver uses an infrared diode to detect the transmitted IR light. The resulting pulsed waveform is applied to a decoder IC which provides an output to select the function determined by the transmitter. Outputs are relay contacts which have the advantage of complete isolation of each output plus the choice of normally open or normally closed contacts.

A choice of decoders provides for either latched (ie, stays on after being selected) or momentary contact relay outputs. The latched output decoder can be one of two types. One type simply is a 4-bit output suitable for selecting each of the eight relays. The second type has the 4-bit output plus a separate output for mute and volume control.

If momentary contacts, volume and muting are all required then two decoders are required.

The volume control output is a current source which can be used to directly control volume on DC volume controlled TV sets or via a Light Dependent Resistor. The LDR connects across the volume control potentiometer



The transmitter circuit. IC1 delivers a series of pulses to drive the two infrared LEDs.

and provides complete isolation from the receiver circuit.

Circuitry

The transmitter circuit comprises one SL490B integrated circuit (IC1), two transistors, two infrared (IR) LEDs and a few resistors and capacitors. The IR LEDs transmit a pulse position modulation (PPM) 5-bit code whenever one of the switches is pressed.

We have used 12 of the possible 32 separate code commands available with the SL490B. Connections for the switches are arranged in a matrix form from pins 6 to 15 and ground. The code for each matrix line is shown on the circuit. This means that switches 1 to 8 have codes from 01000 to 01111, while the Up, Mute and Down switches have codes 10100, 11001 and 11100. The OFF switch sends the code 00100.

The transmitter circuit is actually very similar to and compatible with the remote control for the Playmaster Stereo AM/FM Tuner (described in the July 1986 issue of EA). The 8-channel keys and the on/off key would therefore operate the tuner memory, up/down tuning and AM/FM selection. The Mute and the Up and Down volume controls will not affect the tuner.

The transmit code output is at pin 2 of IC1, which is AC-coupled via the 0.068μF capacitor to the base of transistor Q1. This produces a 15μS current pulse each time pin 2 goes low. The 100Ω resistor at the base of Q1 ensures that Q1 is off after each 15μs pulse. Q2 is driven by Q1 via a 33Ω resistor which in turn drives the IR LEDs with the short high current pulses.

The PPM rate of transmission is set by the 33kΩ resistor and 0.22μF capacitor. Filtering for the internal 4.5V supply of the SL490B is provided by the 4.7μF capacitor connected between pin 17 and the 0V line.

Power for the transmitter is derived from a 9V battery while a 220μF capacitor across the supply provides the high current surges required when the IR LEDs are pulsed on. The standby current of the circuit is less than 10μA.

Receiver circuitry

IR diode D5 is the detector for the transmitted IR signal. It is connected across the differential input stage of IC2 at pins 1 and 16. The differential input stage provides for rejection of common mode noise from the diode and connecting leads.

Following this is a gyrator and four gain stages (all inside IC2). Each of these has a low frequency roll-off below 2kHz to effectively reject any 100Hz signals picked up by the receiver diode. The 6.8μF, 47μF, 0.015μF, 0.033μF and 0.0047μF capacitors at pins 2, 3, 15, 5 and 6 respectively are used to provide this roll-off.

A 0.15μF capacitor at pin 8 filters the output from an internal peak detector which measures the final output at pin 9. The resulting signal is used to automatically control the gain of the first three amplifier stages.

The input to an internal regulator at pin 12 is supplied via a 220Ω resistor to reduce the supply voltage and is filtered with the 22μF capacitor. Supply decoupling between the sensitive input circuitry and the output circuit is via the 47Ω resistor and 0.33μF capacitor.

After amplification in IC2, the received signal is sent to the input of IC3 and/or IC5. These devices convert the received serial stream into a 4-bit parallel code. (This means that they can only decode 16 of the possible 32 codes from the transmitter).

Both decoders contain an internal oscillator and this is at pin 2 for IC5 and pin 1 for IC3. The 0.027μF capacitor and series connected 22kΩ resistor and 50kΩ trimpot provide the reference frequency for each of the decoder ICs. In

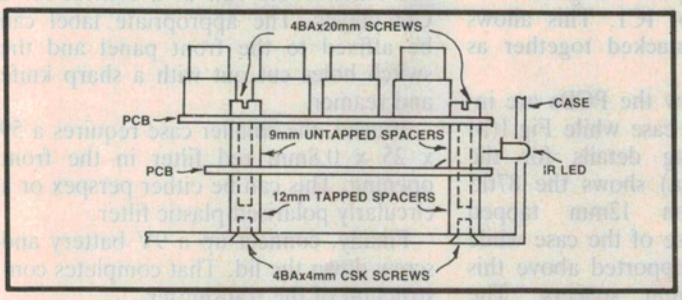


Fig.1a: this diagram shows how the two transmitter PCBs are installed in the larger case. The IR LEDs protrude through holes drilled in one of the end panels.

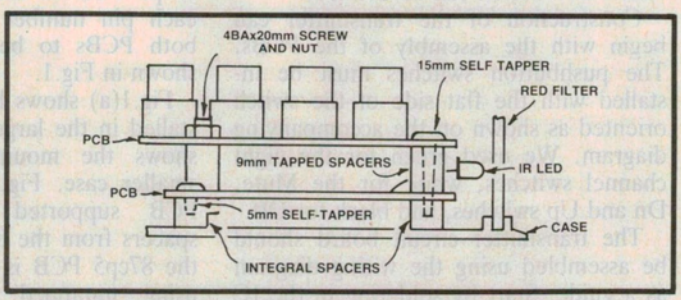
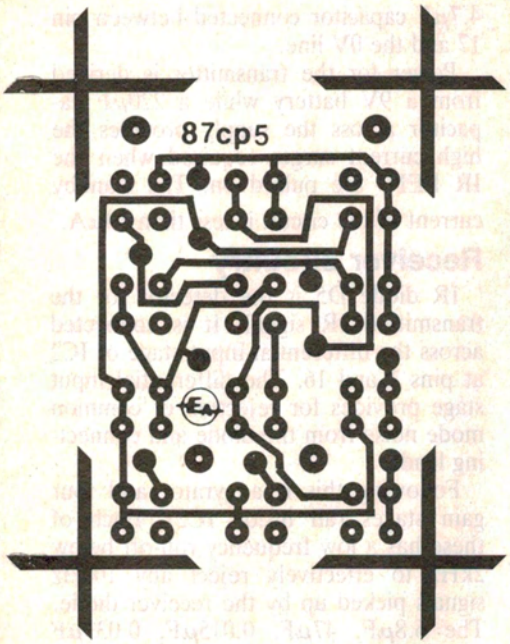
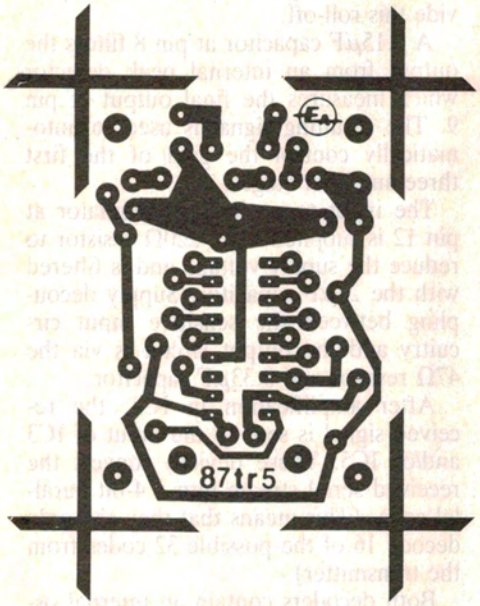
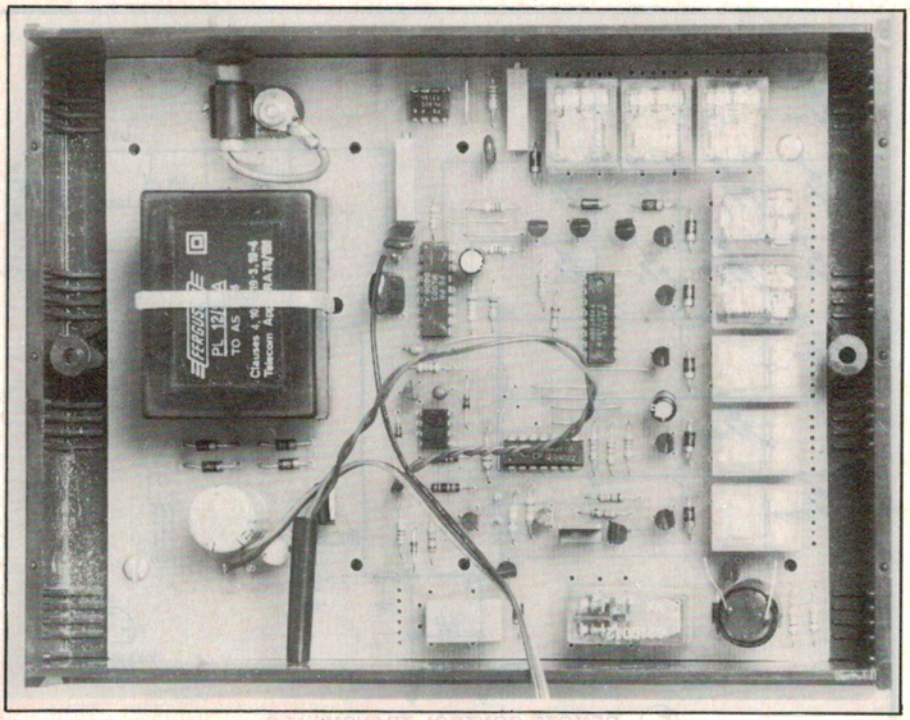


Fig.1b: PCB mounting details for the optional smaller case. In this version, the IR LEDs are positioned behind a red plastic filter.



Above & below: actual size PC artworks for the transmitter.





Here's a sneak preview of the IR remote control receiver to be described next month.

ing the eight channel selections plus Off, Mute, Dn and Up. For those functions not required, the switch associated with that function can be deleted.

Construction of the transmitter can begin with the assembly of the PCBs. The pushbutton switches must be installed with the flat side of the switch oriented as shown on the accompanying diagram. We used green for the eight channel switches, white for the Mute, Dn and Up switches, and black for Off.

The transmitter circuit board should be assembled using the wiring diagram as a guide. Start by soldering in the IC and resistors. Before installing the remainder of the components, it is easier to solder in the wires for connection to the other PCB.

We used a 50mm-long piece of 10-way rainbow cable to do this job. The wiring is at IC1 pin numbers 6, 7, 8, 10, 11, 12, 13, 14, 15 and ground. Note that if the Off, Mute, Dn and Up switches are not used, then wires into pins 6, 10, 11 and 12 are not necessary.

All the capacitors lie side-on to allow the switch PCB to stack on top of this board. The 220μF capacitor is mounted off the edge of the PCB using the leads to support it in this position.

Transistor Q1 is inserted hard down onto the PCB, while Q2 is bent over as shown in the photograph. The infrared LEDs are mounted above the PCB by about 5mm, and their leads bent so that they protrude over the edge of the PCB by about 7mm.

The 9V battery clip can now be soldered in place. Wiring from the 87tr5 PCB is made to the underside of the 87cp5 PCB to the pads designated for each pin number of IC1. This allows both PCBs to be stacked together as shown in Fig.1.

Fig.1(a) shows how the PCBs are installed in the larger case while Fig.1(b) shows the mounting details for the smaller case. Fig.1(a) shows the 87tr5 PCB supported on 12mm tapped spacers from the base of the case while the 87cp5 PCB is supported above this using untapped 9mm spacers. The LEDs protrude through holes drilled in the front face of the case.

Fig.1(b) shows the 87tr5 PCB supported on the integral spacers in the base of the case. The 87cp5 PCB is supported above this using untapped 9mm spacers. The LEDs are positioned so that they are located just behind a red plastic filter. The filter measures 59 x 25 x 0.8mm and is slotted into the front of the case.

Install the PCB assembly in the box and measure the distance from the first row of switches to the front of the box. Use this distance and the front panel artwork to mark out the hole locations in the front panel. Remember to mark out only for the number of switches used.

Drill the holes out carefully with a 4mm drill and ream each hole out to 9mm diameter. Check that the lid will fit without fouling any of the switches.

Two front panel labels have been designed. One will suit if the unit is used as a remote control for a TV set while the other would suit as a control for a CD player. The appropriate label can be affixed to the front panel and the switch holes cut out with a sharp knife and reamer.

If used, the smaller case requires a 59 x 25 x 0.8mm red filter in the front opening. This can be either perspex or a circularly polarised plastic filter.

Finally, connect up a 9V battery and screw down the lid. That completes construction of the transmitter.

Next month we will describe the construction of two versions of the receiver.

IC6 selects one of the eight outputs according to the code at the A, B and C inputs. This switches on the associated transistor to power the accompanying relay. The diode across each relay quenches the back EMF of the coil and prevents damage to IC6 and the associated transistors.

Note that each relay is a double pole double throw type to duplicate the action of double pole switches used in some equipment. For selection of the relays to take place, the INH input to IC6 must be low. Consequently, when IC3 or the ML926 (IC5) is used for selection, the D output is inverted so that the D-bar signal can be applied to the INH input of IC6.

When the ML928 is used for IC5, inversion of the D output is unnecessary since the outputs are already inverted. This also means that the order of relay selection will not comply with the relay numbering designated for the ML926 and ML923 ICs. Instead of being selected sequentially from 1 to 8, the order is 6, 5, 7, 8, 2, 1, 3 and 4.

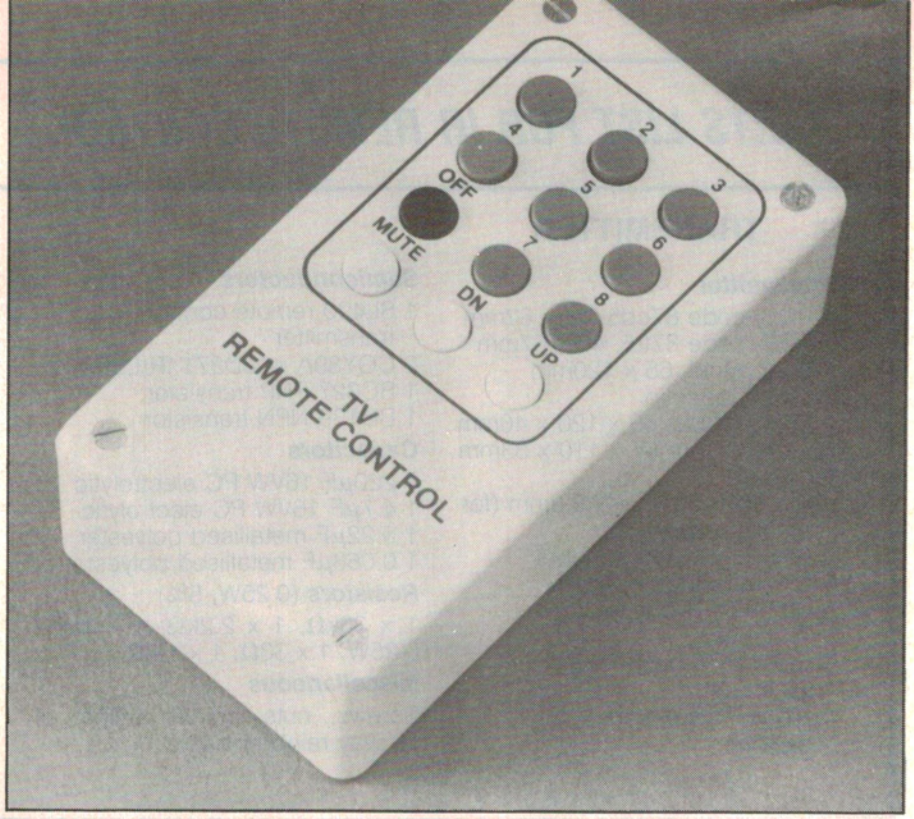
Apart from providing latched A, B, C and D outputs, IC3 has an analog output at pin 10 and Mute control at pin 8. The Mute output goes high for muting and is low otherwise. For each transmitted Mute signal, the output at pin 8 changes state.

The analog output at pin 10 is a current mirror which delivers up to 1.3mA in 32 increments. The down transmission reduces the current while the up transmission increases the current. It takes about three seconds to span the entire current range with the transmitter Up or Down button continuously pressed.

When power is first applied, the RC time constant at pin 17 resets the analog output to 3/8th the maximum current and the muting is reset. The 0.1μF capacitor and 3.3MΩ resistor at pin 7 allows correct operation of the muting and analog steps.

The current output from pin 10 of IC3 is fed to a series resistor string consisting of a 6.8kΩ and 39kΩ resistor, the latter being shunted by transistor Q4. The voltage across Q4 can be used for controlling DC volume controls of TV sets. As an alternative, a Light Dependent Resistor (LDR) provides for a fully isolated volume control that can be substituted for a conventional potentiometer.

This facility is provided by Darlington-connected transistors Q5 and Q6 which are driven from the collector of Q4, via a 39kΩ resistor. Q6 drives two LEDs through 470Ω resistors from the 12V power supply. The LEDs in turn provide light for the LDR so that its resistance changes with the varying current available from pin 10 of IC3.



Alternative version of the transmitter, mounted in the larger of the two standard cases. Leave out the buttons for those functions that you don't need.

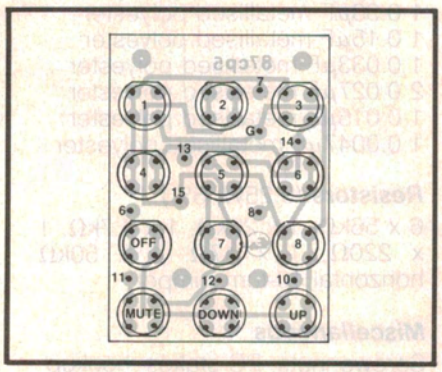
Muting here, muting there

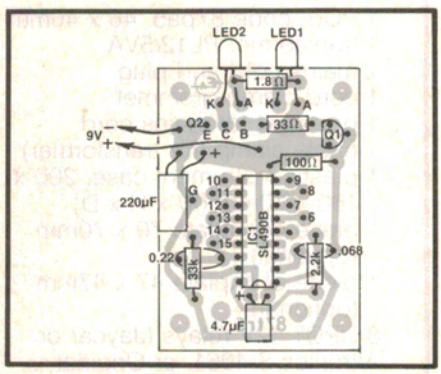
Muting of the current source at pin 10 of IC3 occurs under three separate conditions whenever diode D6, D7 or D8 is forward biased. When this happens, Q4 turns on and shorts the voltage at its collector to ground. This also causes transistors Q5 and Q6 to turn on fully and drive the LEDs to full brightness. This gives minimum resistance through the LDR.

Diode D7 is forward biased when the Mute output at pin 8 of IC3 goes high. This happens under two conditions. It could be in response to a Mute signal from the transmitter or if the transmitter volume down switch brings the output on pin 10 of IC3 to a minimum.

Diode D8 is forward biased for muting whenever the output of IC4 at pin 3 is high. IC4 is a 555 connected as a monostable timer with a timing length of about 240ms. Triggering of the timer occurs whenever the AFC output of IC3 at pin 5 goes low. This occurs for every code transmission from the transmitter which changes one of the eight output relays.

When pin 5 of IC3 goes low it triggers IC4 and sets its output at pin 3 high. For as long as the transmitter switch is pressed the AFC output will supply low going pulses to the base of





Here are the parts layout diagrams for the two transmitter PCBs. The numbers adjacent to various pads correspond to the external wiring points (see also photo page 46).

Q3. This transistor discharges the 2.2μF capacitor to keep the timer output high. When the transmission ceases, the 555 timer output goes low after 240ms and unmutes the circuit.

Finally, diode D6 is forward biased to cause muting whenever transistor Q9 is off. Q9 is switched on whenever the output of IC7b goes high. This occurs in response to an off signal from the transmitter. Relay 9, the power relay, then turns off and removes mains power to the remotely controlled appliance via its normally open contacts.

Consequently, diode D6 is forward biased via the denergised relay 9 coil to provide muting when the power is switched off.

Muting on power off is done so that if a direct DC connection is made between the TV volume control and the DC output of IC3, there is no voltage present when power to the TV is switched off.

Note also that transistor Q7 is switched on and off via IC7a which has a low output when the power relay is off. The IC7a output follows the IC7b output. Thus, Q7 is switched off when the power to the remotely controlled appliance is switched off. Q7 controls the power to the LEDs so that LEDs are not driven during power off and this conserves power consumption. As soon as power is re-applied, the output of IC7a goes high to supply power to the LED driving circuit.

When muting occurs, the drive from D6, D7 or D8, apart from driving Q4, also turns on Q8. This transistor powers the Mute relay RLA10. This relay can be used to switch off the loudspeaker of a TV set, or to switch the volume control potentiometer to provide complete volume cut-off.

LED 5 is connected across the Relay 10 windings to indicate both when the volume is muted and also when the remotely controlled appliance is powered off.

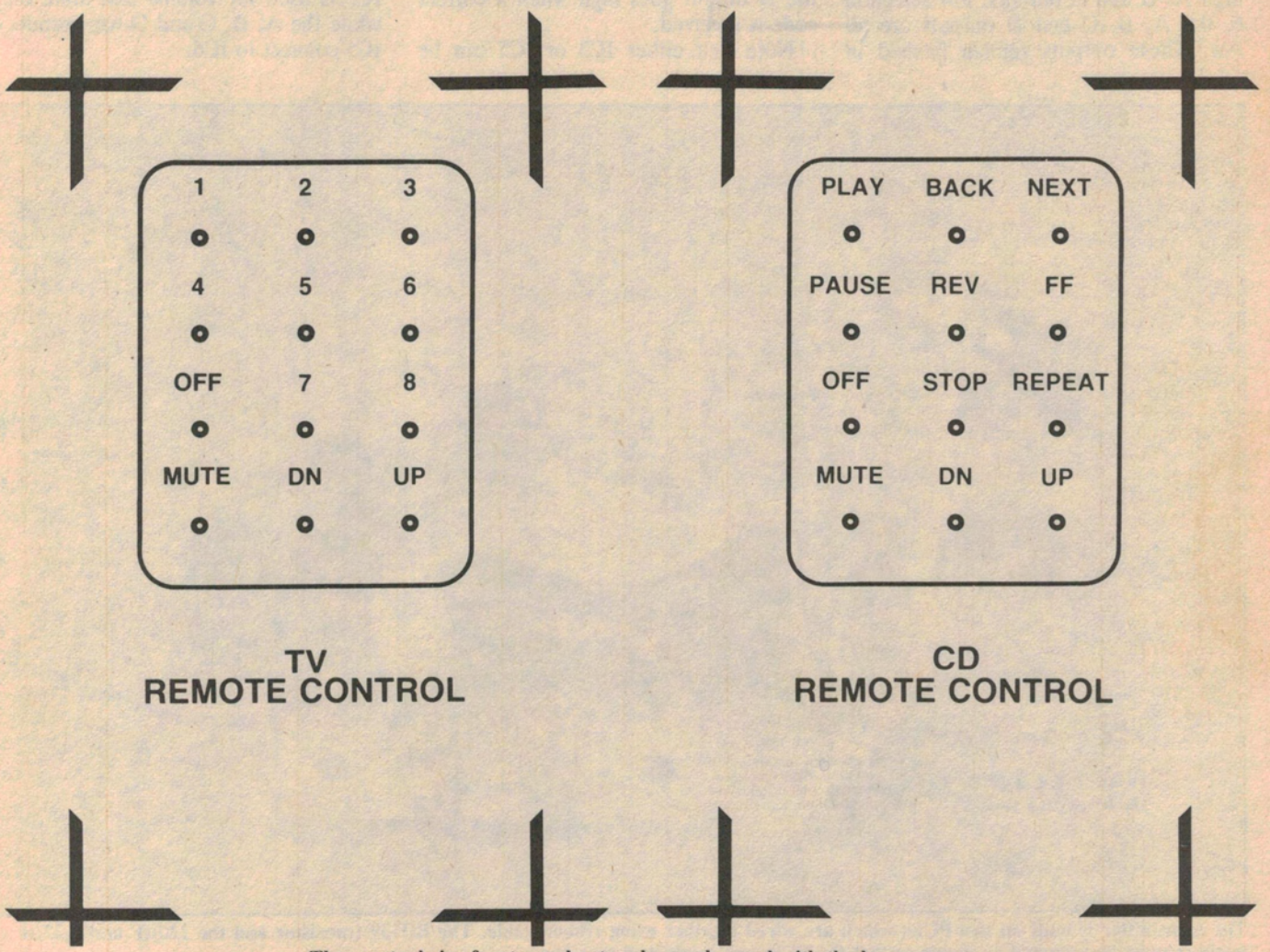
Power for the receiver circuit is derived from a PCB mounted mains transformer which provides 12VAC. This feeds a bridge rectifier, D1 to D4, and a 470μF filter capacitor. The unregulated DC is fed to a 7812 3-terminal regulator to provided a fixed +12V DC output.

Transmitter construction

The remote control transmitter is constructed on two printed circuit boards. One PCB accommodates the pushbutton switches and measures 44 x 62mm (code 87cp5); the other accommodates the remainder of the circuitry and measures 40 x 57mm (code 87tr5).

The transmitter can be housed in one of two cases. The first is a standard plastic case measuring 65 x 120 x 40mm (W x H x D) and available from many kitset suppliers. The alternative is smaller but more expensive, has a 9V battery compartment, and includes provision for a plastic window in the front of the unit. It measures 67 x 110 x 33mm and is available from Hi-Com Unitronics, 7 President Lane, Caringbah, NSW 2229.

The 87cp5 PCB can accommodate up to 12 switches, all of which are required for the full remote control circuit featur-



These actual-size front panel artworks can be used with the larger case.

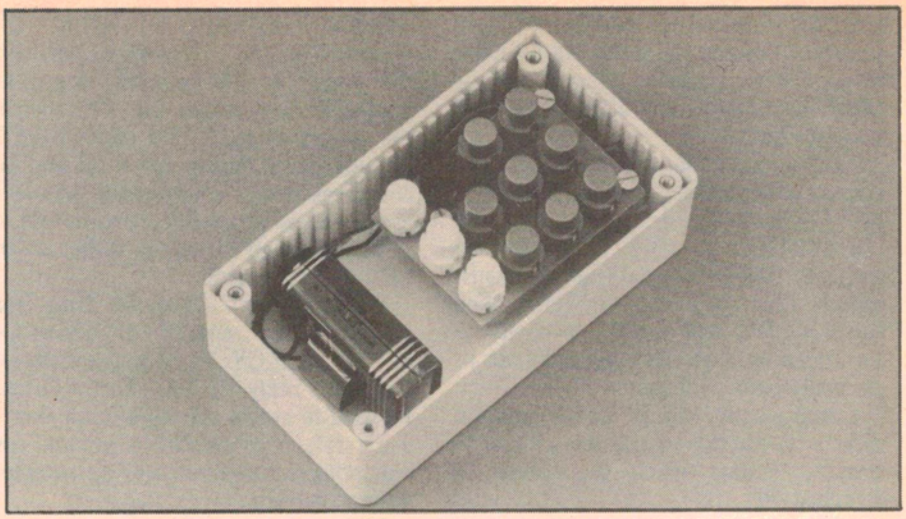
theory, both of these oscillator inputs could be tied together and only one set of oscillator components used. In practice though, we found that this resulted in IC3 not operating.

One of two ICs can be used for IC5, either the ML926 or the ML928. The former provides momentary 4-bit outputs while the latter provides latched 4-bit outputs.

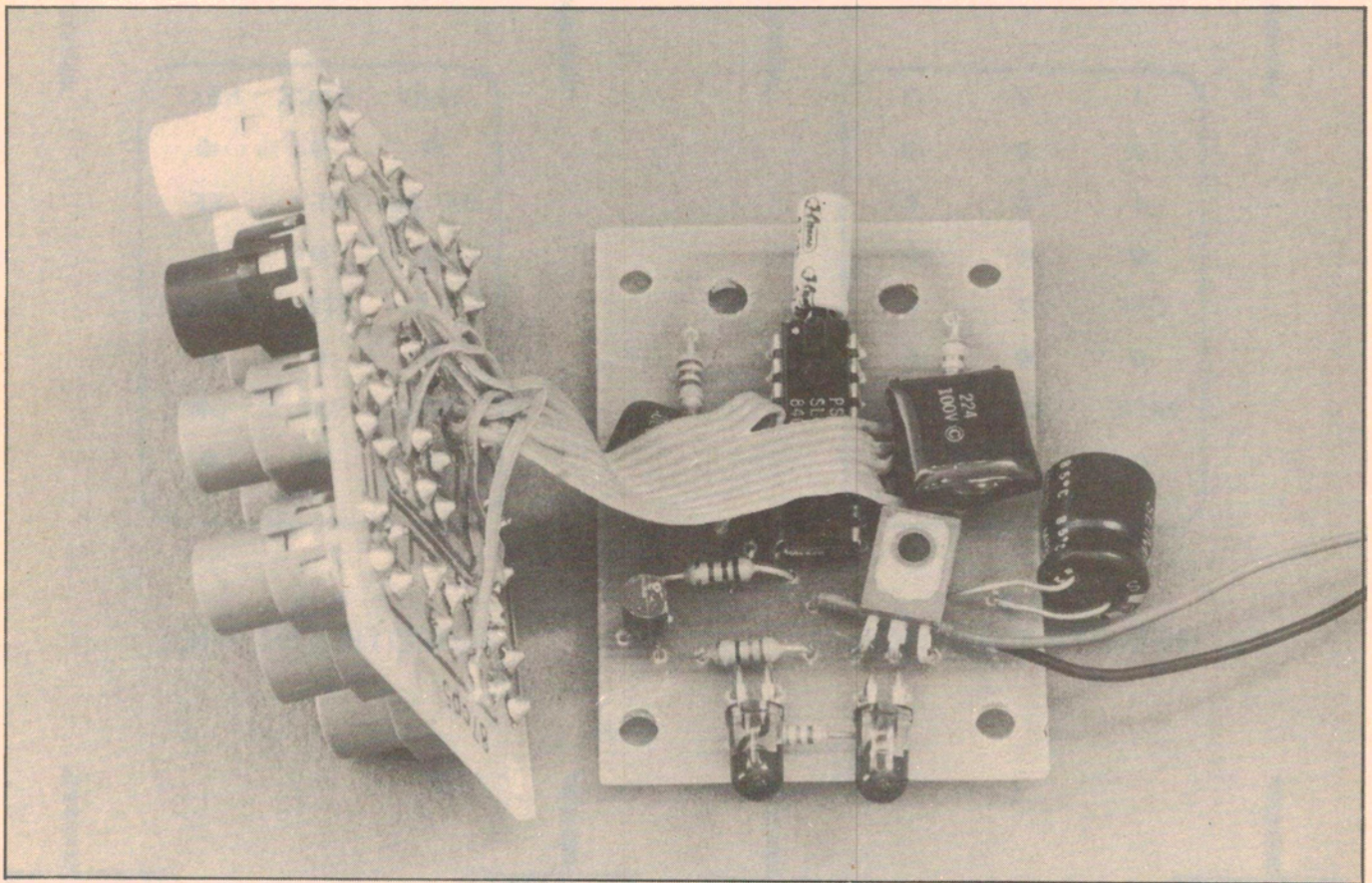
For the ML926 IC, the outputs normally are low until a correct code is received from the transmitter. It responds to the 1 to 8 selections with the D output going high. Reception of selection 1 results in the D output going high and the A, B and C outputs low. For selection 6, A, B, C and D are all high. These outputs are maintained until cessation of the transmitted signal, whereupon the outputs return to zero.

For the ML928 IC, the outputs are initially high until a correct code is received from the transmitter. It also responds to the 1 to 8 selections with the D output going low. Reception of selection 1 results in a low D output and high A, B and C outputs. For selection 6, the A, B, C and D outputs are all low. These outputs remain latched in the state of the last received signal until a new transmission changes the output code. The A, B, C and D outputs for IC3 are latched and have the same logic sense as the ML926. That is, the outputs are normally low at power-on and the D output goes high when a correct code is received.

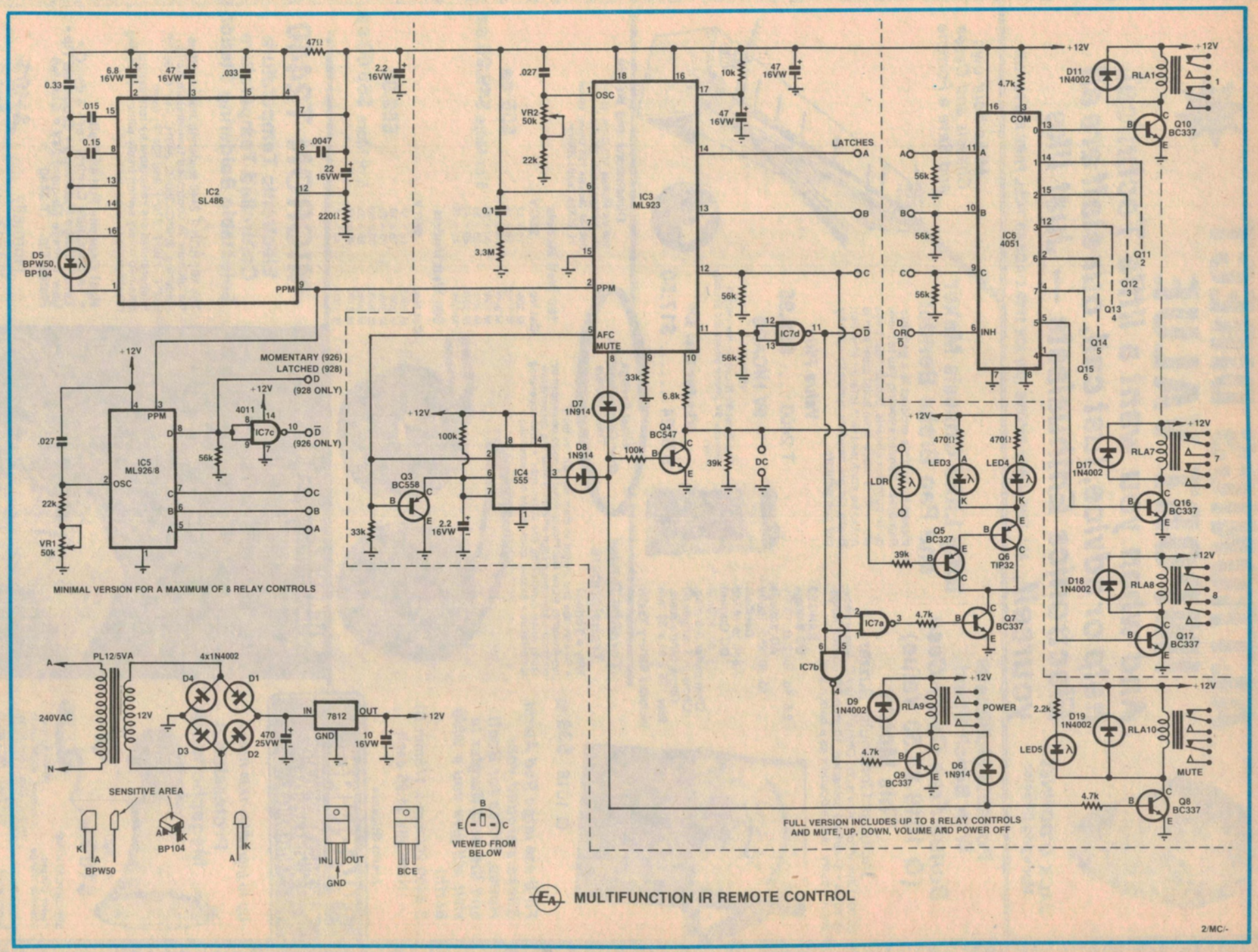
Note that either IC3 or IC5 can be connected to the eight channel demultiplexer (IC6). This is to allow the omission of IC3 when volume control and mute is not required. When muting and volume are required together with momentary contacts for the 1-8 outputs, IC3 is used for volume and mute only, while the A, B, C and D-bar outputs of IC5 connect to IC6.



This view shows the transmitter PCBs installed inside the larger case. The 9V battery is secured by a metal clip.



The transmitter is built on two PCBs which are wired together using ribbon cable. The BD139 transistor and the 220μF and 0.22μF capacitors must be mounted as shown so that the PCBs can be stacked together.


IC2 SL486
IC3 ML923
IC5 ML926/8
IC6 4051
IC4 555
IC7a
IC7b
IC7c
IC7d
D5 BPW50, BP104
VR1 50k
VR2 50k
LATCHES
MOMENTARY (926)
LATCHED (928)
(928 ONLY)
(926 ONLY)
MINIMAL VERSION FOR A MAXIMUM OF 8 RELAY CONTROLS
FULL VERSION INCLUDES UP TO 8 RELAY CONTROLS AND MUTE, UP, DOWN, VOLUME AND POWER OFF
PL12/5VA
4x1N4002
240VAC
7812
SENSITIVE AREA
BPW50
BP104
VIEWED FROM BELOW
MULTIFUNCTION IR REMOTE CONTROL
2/MC/-