Construction project:

16-channel UHF Remote Control – 1

Here is part 1 of the description of a complete remote control system which offers features rivalling commercial units, but at a fraction of the cost. The system can be used to remotely control many different appliances such as alarms, central locking systems, door openers and much more. It features 16 channel operation, a range in excess of 200 metres, easy construction, high security and an expandable design. We start with the transmitter...

by BRANCO JUSTIC

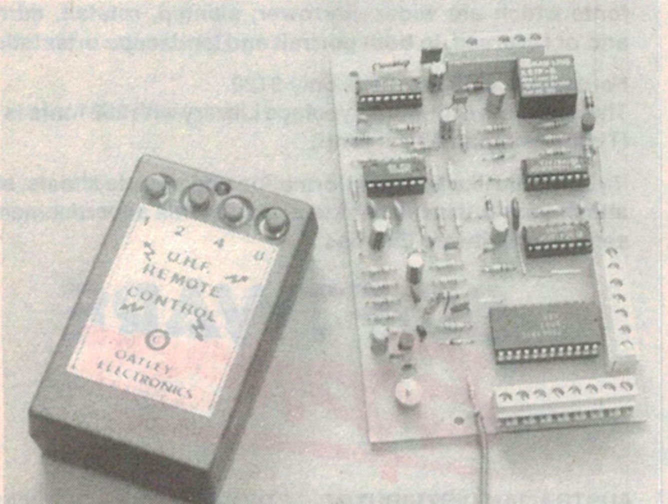
Over the next few months we will present a complete UHF remote control system, intended for applications such as remote switching of alarms, appliances – in fact anything needing remote control on-off operation.

The system features a 16-channel transmitter that can control one or more receivers, which in turn operate up to four, 4-channel relay/indicator PCBs.

The whole project is designed to be both flexible and inexpensive, and the choice is yours as to how sophisticated the final result is. For example, a receiver using only 2 channels could be installed in a car to allow remote activation of the car alarm and/or operation of a central locking system. Another receiver, also operating from the same transmitter, could be installed in your house to control lights, door openers, appliances and so forth.

Maybe you just want bedside on-off control of the TV, or perhaps activation of the house alarm that you forgot to set before bedtime.

Because the system has 16 channels, a house alarm could be arranged into 'zones', allowing the various detectors to be activated independently; a feature not normally found on commercial wireless controlled alarm systems. The system is tamper-proof, has nearly 5 million user selectable codes, providing high security combined with simple construction and low cost. What more could one ask for?



The transmitter and the associated receiver module. The receiver will be described next month.

System details

The complete system starts with a 16 channel UHF transmitter, fully described in this article. Next month the receiver/decoder will be presented, followed later by the 4 channel relay-indicator board and how to interface it to the devices being controlled.

Because many readers may not want full 16 channel operation, the relay board has been kept to 4 channels only, to minimise cost and complexity. If you want to use all 16 channels to operate 16 independent devices, you simply expand the system up to its maximum of four relay boards. Alternatively, a number of receivers (up to 4), each with one 4 channel relay board can be used; versatility that should solve any typical remote control situation.

The system has numerous features, many of which are not found on commercial systems. Foremost is ease of construction and alignment, made possible by printing the important frequency determining inductors on the PCB pattern. Equally important is the security of the system. As already mentioned, the unit has lots of codes – 4,782,969 to be exact, which should be daunting enough in itself. However, today's hi-tech criminals have been known to employ sophisticated scanners that simply

cycle through every possible key combination of a particular alarm system. Although it may take quite a few hours for such a scanner to crack the code for this system – maybe enough time to attract attention to the miscreant, that's only the first hurdle.

Incorporated in the receiver is circuitry that can be used to activate an alarm if the first correct code is not followed by the remaining code in a limited time. How's that for a tamper-proof system?

The transmitter is battery powered, as would be expected. However, the receiver also consumes a very low standby current, and can also be battery powered. The main power consumption is in the relay board, but provision for powering dual coil latching relays has been made if battery powered operation is required for the whole system. This type of relay only consumes power while changing state; otherwise it requires no power. However, for each of the relays supplied with the kit from Oatley Electronics, a current of 30mA is required.

Typically, a complete receiver/4-channel relay board combination can be powered by most types of 12V AC-DC unregulated plug-packs.

The operation of the unit can be selected to either pulsed or toggle mode. In pulse mode the selected relay operates while the transmitter pushbutton is held. Toggle mode allows a relay to be turned on with a pulse, then off with a following pulse. If desired, an audible signal from a buzzer can be used to indicate each time any one of the channels is turned on or off; a short beep for ON, a long beep for OFF. Typically, the range for reliable operation is 200 metres or more, depending on conditions.

Regular readers may also remember, or have built, the single channel UHF remote switch presented in January 1987. If you don't require the 'tamper-proof' feature, the alarm channel of the system being described here can be used as a 17th channel, (with far less code combinations) in conjunction with the January 1987 transmitter. More details on this will follow when the receiver is presented.

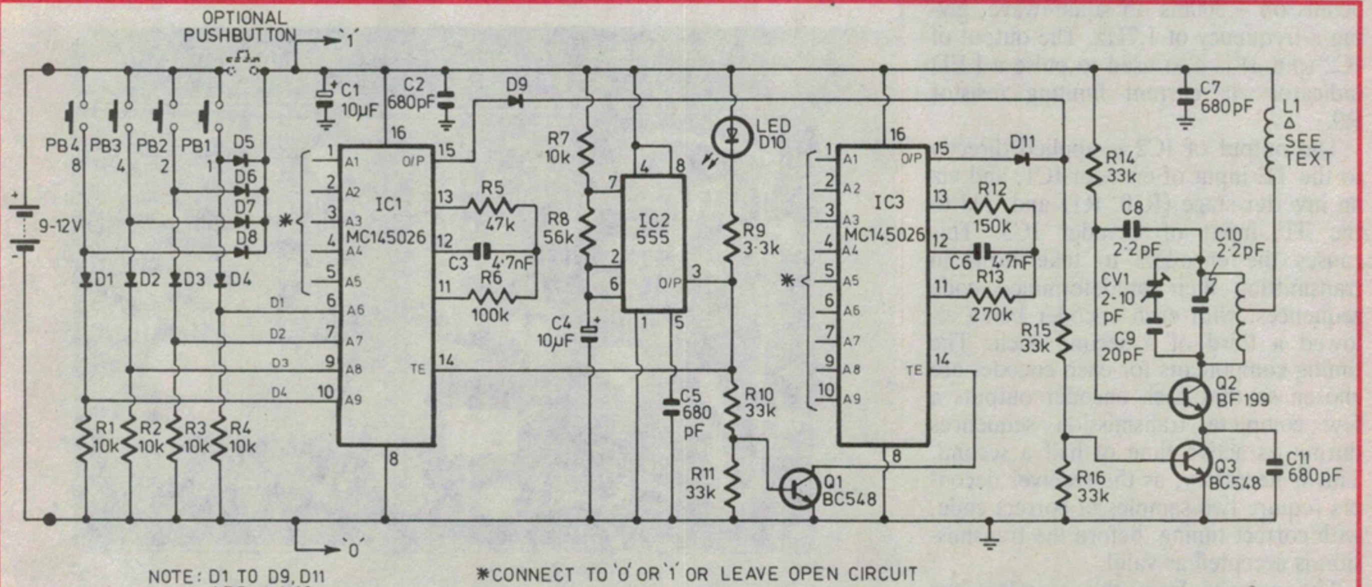
Transmitter circuit

The encoding section of the transmitter is based on the Motorola MC145026 IC. This device was used in the January 1987 UHF remote switch, where it was used to provide 13122 possible code combinations and single channel operation.

The transmitter being described here uses two of these ICs to obtain a security code which has almost 5 million combinations, transmitted in conjunction with a 4 bit data code determined by the status of the pushbuttons. The data is only passed to the output of the receiver if the correct code precedes it.

Timing components R5, C3, R6 and R12, C6, R13 determine the rate of the code sequence transmission for IC1 and IC3 respectively. The timing components used in the receiver's decoder section are chosen to match the transmission rate. If the delays are different, the receiver would not accept an otherwise valid code.

The particular codes generated by the encoders (IC1 and IC3) depend on the states of their address lines (A1-A9). These lines can be connected to the supply line ('1'), ground ('0') or left open circuit (O/C). Note however that the last four address lines (A6-A9) on IC1 are treated as data lines (D1-D4),



The transmitter circuit diagram. The unusual arrangement of the trinary encoders, ICs 1 and 3, allows nearly 5 million user selectable codes. IC2 alternately activates the encoders and drives the LED indicator when the unit is transmitting.

as the information on these lines depends on the status of the pushbuttons. With the pushbuttons pressed, the lines are connected to the supply ('1') via isolating diodes D1-D4. Otherwise, when the pushbuttons are released, they are grounded ('0') via resistors R1-R4, allowing up to 16 possible binary codes, depending on which buttons have been pressed.

Individual pushbuttons can be treated as individual channel controls; CH1 to CH4, or in a binary combination. More on all this, however, when the receiver is presented.

For the purposes of describing the circuit's operation, we will assume that pushbutton 1 (PB1) is pressed. Under these conditions, power is applied to the circuit via isolating diode D5, and address line A6 (pin 6 – IC1) is pulled to a logic 1. If IC1 was now enabled by applying a '0' to pin 14 (TE), it would continuously send out a code sequence at pin 15, dependent on the A1-A5 inputs (soldered links), followed by the data on the A9-A6 inputs as set by the pushbuttons – currently equal to the binary code 0001. Similarly, if encoder IC3 was enabled (TE = '0'), it would also send out a code sequence selectable by the soldered links at its address inputs, A1-A9.

However, these ICs are alternatively enabled by the 555 timer IC2, which is connected as an astable multivibrator. The frequency of operation is mainly determined by R8 and C4, set to give a 300ms on – 300ms off squarewave, giving a frequency of 1.7Hz. The output of IC2 (pin 3) is also used to pulse a LED indicator via current limiting resistor R9.

The output of IC2 is applied directly to the TE input of encoder IC1, and via an inverter stage (R10, R11 and Q1) to the TE input of encoder IC3. This causes the encoders to take turns in transmitting their predetermined code sequences, with each encoder being allowed a third of a second each. The timing components for each encoder are chosen so that each encoder outputs a few complete transmission sequences during its active time of half a second. This is necessary, as the receiver decoders require two samples of correct code, with correct timing, before the transmission is accepted as valid.

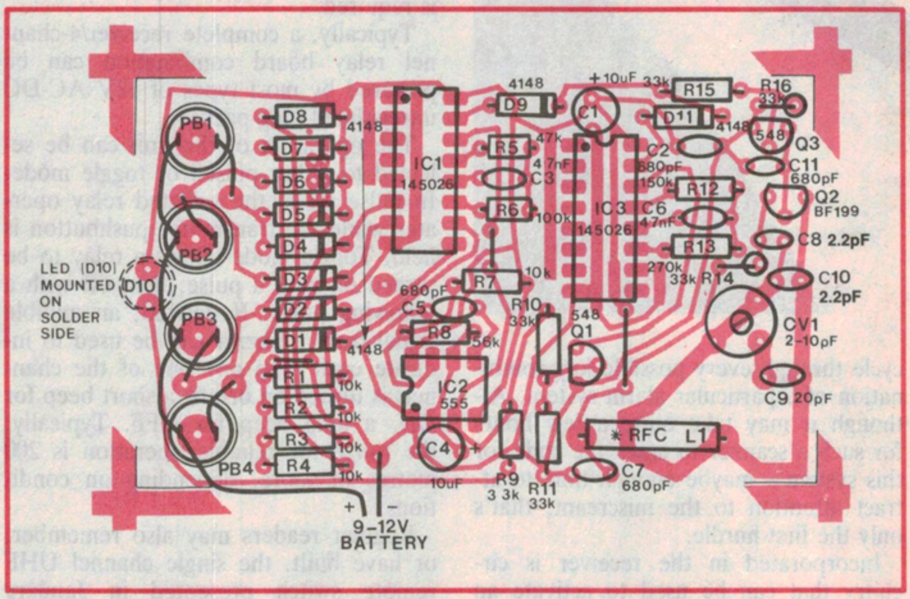
The outputs from the encoders are connected via isolating diodes D9, D11 and resistor R15 to the base of the switching transistor Q3. This transistor simply provides a ground return for the UHF oscillator, and therefore switches the oscillator on and off in synchronism with the code sequences.

Transistor Q2 and its associated components make up a Hartley oscillator whose frequency is adjusted to 304MHz by means of trimmer capacitor CV1 and C9. The total capacitance of CV1, C9 and C10 in conjunction with the printed inductor (PCB pattern) make up the resonant tank circuit, while C8 provides the necessary feedback and the RFC (L1) partially isolates the stage from the power supply.

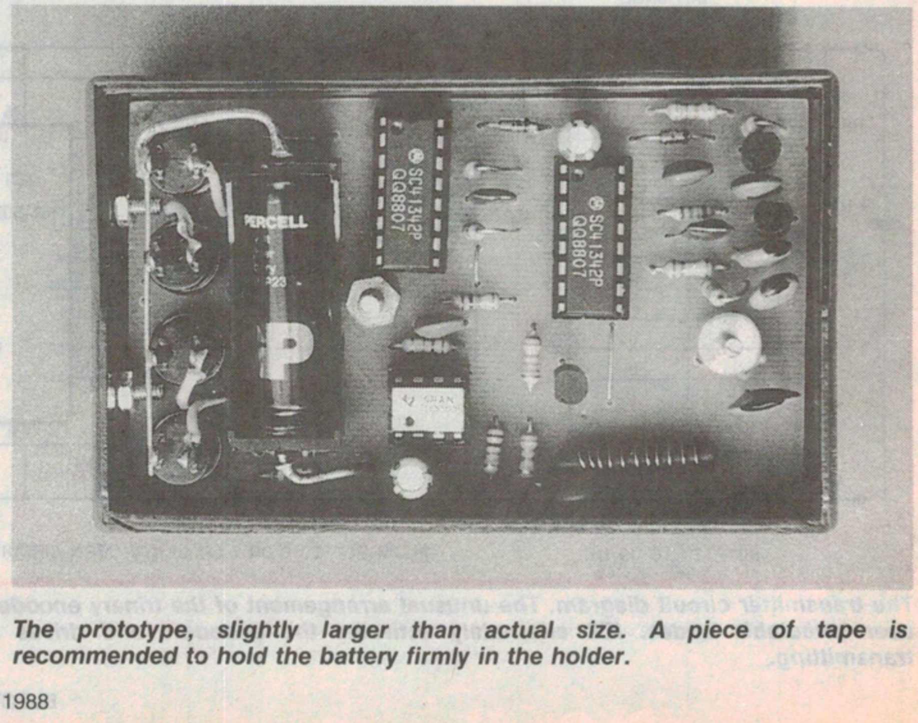
Making the transmitter

A complete kit of parts for this project is available from Oatley Electronics. The kit is complete (as per prototype photograph) and also includes the 12V battery.

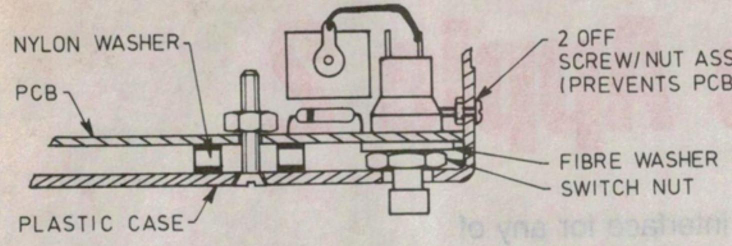
Before assembling the PCB, use the blank PCB to locate the hole positions on the plastic case for the 4 pushbuttons, the mounting screw and the LED indicator. Once located and marked, carefully drill these holes to a size that allows each pushbutton and the LED to project through the case. Countersink the hole for the mounting screw, being



The layout for the transmitter. The battery holder sits over the row of diodes D1 to D8 and is supported by its connecting wires.



The prototype, slightly larger than actual size. A piece of tape is recommended to hold the battery firmly in the holder.



To make sure the PCB doesn't flex when a pushbutton is pressed, fit two stop screws in the end of the case as shown.

careful not to drill the countersink right through the plastic!

The inductor L1 (RFC – value not critical) is made by winding 10 turns of the supplied enamelled copper wire on the small cylindrical ferrite core. The turns should be equally spaced to occupy the full length of the rod, and a dab of glue applied to prevent the core from moving within the winding. The supplied wire can be soldered without scraping off the insulation, and we recommend that the ends be tinned before the inductor is finally mounted on the PCB, as the tinning process takes a few seconds.

Next, mount and carefully solder all the components on the PCB, with the ICs last. Watch particularly for correct orientation of the diodes, transistors, ICs and electrolytic capacitors.

Finally, attach the battery holder to the PCB using solid copper wire (1mm) connected between both ends of the holder and to the PCB. The holder sits above the row of diodes, and the positive end connects to the push-buttons' common rail. It may be necessary to place a cable tie around the battery holder to ensure that the battery does not shake loose during use. Also, to prevent the PCB flexing when the push-buttons are operated, drill the case and fit two screw/nut combinations as shown in Fig.1.

Testing & adjustment

The frequency of the oscillator should already be very close to the allocated frequency of 304MHz, thanks to the use of printed inductors. However fine tuning using a frequency counter is recommended.

To enable the oscillator to run continuously for this adjustment, a wire link can be inserted between the cathode of D8 and the positive supply rail (positive battery terminal). The frequency counter should be loosely coupled to the output tank circuit, and the trimmer capacitor C9 adjusted with a non-metallic screwdriver so that the frequency counter shows 304MHz.

By 'loose coupling' here we mean fitting a small 1-turn loop of insulated hookup wire to the end of the counter's lead, and holding this loop just near enough to the tank circuit's printed inductor to produce reliable readings.

Note that a functional transmitter should cause interference when placed very close to the antenna terminals of a TV set, or when next to the ferrite antenna of an AM radio. But because the power output of the transmitter is around 9 microwatts, it will not cause interference in normal use.

For now, there is little more that can be done until the receiver is presented. It still remains to code the transmitter, which should be done in conjunction with coding the receiver, as the two have to match.

The supplied circuit boards for both the transmitter and the receiver have all the address lines left open-circuit, allowing initial testing of the transmitter-receiver combination to be undertaken prior to coding – as both codes, by default, are the same.

The final code you select, from the millions available, is achieved by setting each address line (A1-A5 for IC1, A1-A9 for IC3) to either a logic 0 (ground), a logic 1 (supply), or by leaving it open-circuit. Note that the MC145026 chips regard an open-circuit on the address lines as quite distinct from either a logic 1 or logic 0 – giving three possible input levels.

However, it is strongly recommended that the code you wish to use be applied after the receiver has been built, and correct operation has been confirmed. And that can all happen next month...

PARTS LIST - TRANSMITTER

1 PCB coded OE88T
1 plastic case - 31mm x 55mm x 90mm
4 push button switches (normally open)
1 12V lighter battery holder
1 ferrite former (for RFC)
Enamelled copper wire, screws, nuts, hook-up wire.

Resistors

All 1/4W, 5%: 1 x 3.3k, 5 x 10k, 5 x 33k, 1 x 47k, 1 x 56k, 1 x 100k, 1 x 150k, 1 x 270k

Capacitors

2 2.2pF disc ceramic
1 20pF disc ceramic
4 680pF disc ceramic
1 2-10pF trimmer
2 4.7nF metallised polyester
2 10uF 16VW low leakage electrolytic

Semiconductors

10 1N4148 signal diodes
1 red LED
2 BC548 transistors
1 BF199 transistor
1 555 timer IC
2 MC145026 trinary encoder ICs
