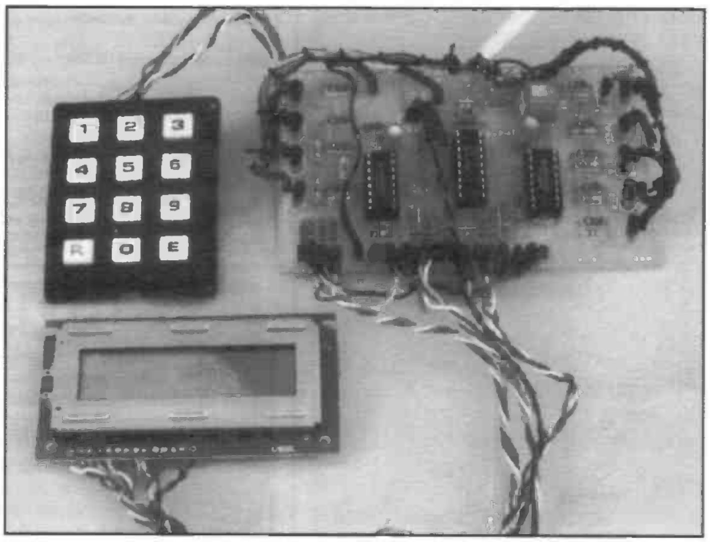
PMR RADIO CONTROLLER KIT

Bob Howlett G6RHB describes a comprehensive PMR radio controller kit based on the PIC16C58 microcontroller chip

This circuit has been developed in answer to the problem of controlling synthesised PMR radios without having to relate a list of frequencies to a list of extraneous thumb switch numbers. In addition a synthesiser having 8 input lines is generally capable of 256 channels, whereas thumbwheel switches only provide 100 channels.

A setup mode allows selection of 2m, 70cm, 12.5 or 25kHz spacing and type of keypad used. An LCD display provides status information such as current frequency, whether or not repeater shift is invoked and TX/RX.

The PMR's original keypad, or any multiplex type of keypad is used to provide direct frequency entry, along with other control functions. Finally there is an automatic transmit lock to prevent accidental radiation in out of band frequencies, and a battery backup to retain initial operating setup, last used frequency, etc.



The PMR Contoller kit has a keypad allowing selection of band and channel spacing. Plus a LCD display to provide status information

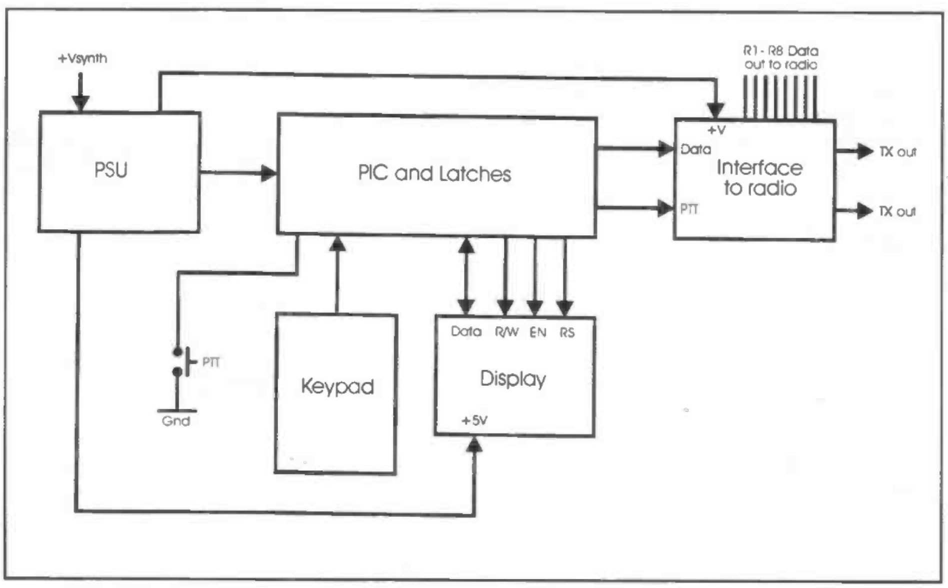


Fig.1: PMR Controller block diagram. The circuit consists of 5 basic blocks.

PRINCIPLE OF OPERATION

The frequency synthesiser used in radios requires an 8 bit binary input 'word or byte' to select the operating frequency; if no input is applied, ie. 00000000_2, then the operating frequency will be the synthesiser base frequency, in our case either 144.0 or 432.0MHz. If the radio has 12.5kHz spacing, then an input word of 00000001_2 will give an operating frequency of

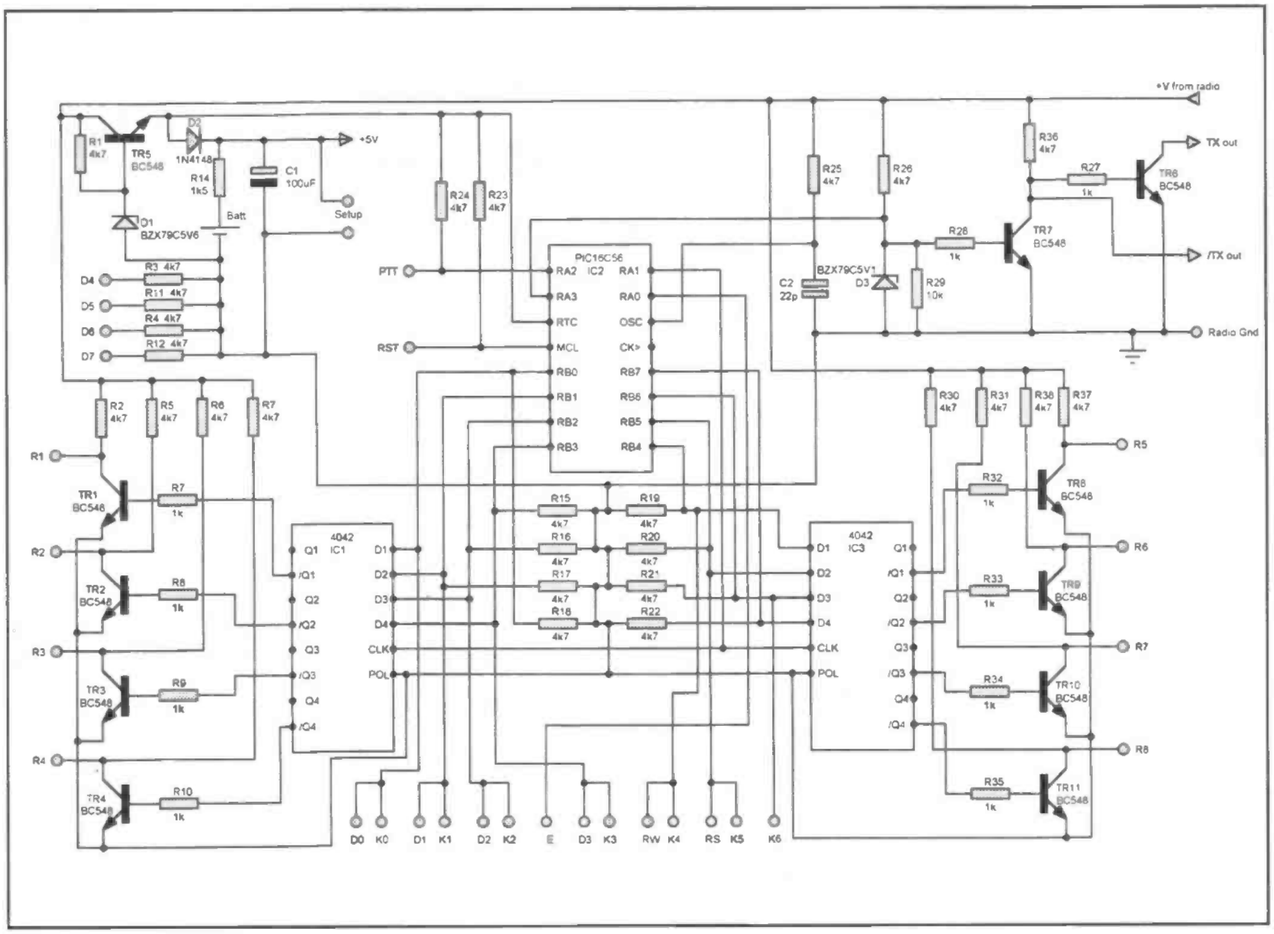


Fig.2: Circuit diagram of the unit

144.0125MHz, or in the case of a 25kHz radio 144.0250MHz, and an input word of 11111111_2 will give an operating frequency of 147.1875, or 150.3750MHz for 12.5 and 25kHz spacings respectively. From this it can be seen that by applying a binary word between 00000000_2 and 11111111_2 any frequency between 144.0 and either 147.1875 or 150.3750 may be obtained. The controller featured here has an upper frequency limit of 147.1875MHz in either 12.5 or 25kHz modes.

The controller described in this article uses a PIC microcontroller (computer on a chip) to decode what we input via the keypad, display it on the LCD display and output the required binary code to the synthesiser. Because all the clever stuff is done by the PIC the circuit becomes very simple, requiring just three chips and a few transistors and diodes for power supply conditioning and interfacing to the synthesiser and PTT.

CIRCUIT DESCRIPTION

The circuit consists of 5 basic blocks (Fig.1), the power and memory backup supplies, the PIC and latches, interfacing to the synthesiser, keypad and display. We will deal with each block individually, refer to the circuit diagram (Fig.2).

The power supply: D1, Tr5 and R1 form a voltage regulator to supply 5V for the digital part of the circuit. D1 is a 5.6V Zener diode, which along with R1 sets the voltage at the base of Tr5 to 5.6V; when a load is placed in the emitter circuit the voltage at Tr5 emitter will be held at 5V due to the 0.6V bias required by the transistor. This is true regardless of the current drawn through the transistor, within reason! R14 provides a charging current for the memory backup battery B1, and D2 prevents current from the battery from being applied to the reset and oscillator of the PIC when the unit is switched off. C1 is a 5V supply decoupling capacitor and C3 provides decoupling for the 8.5V or Vsynth line. The interface section is fed directly from the voltage applied to the unit, this ensures that the binary signal sent to the synthesiser is of the correct level. Consequently the controller should be powered from the radio's synthesiser supply, usually around 8.5V.

PIC and Latches: The PIC (IC2) requires certain signals and supplies in order for it to function. These are an oscillator input which is fed from R25 with C2 to ground, and a reset input which is fed by R23. The reset pin is brought out to a testpin on the board to facilitate a manual reset by Momentarily shorting to ground. The RTCC input is not required in this circuit, and is taken direct to the +5V line. The supply to these two inputs is removed while the unit is switched off; this saves power and resets the processor every time the radio is switched on. The +5V supply to the PIC is maintained by the battery B1 in order to preserve the RAM contents of the PIC. The battery voltage, when fully charged is about 3.6V which is well within the tolerances quoted by the PIC manufactures with regard to memory retention. R24 is a pull-up resistor for the RA2 input (PTT) of the PIC. R15 to R22 are pull-down resistors for the 'data bus'. IC1 and IC3 are 4 bit latches; these hold the binary control 'word' for the synthesiser.

Synthesiser and PTT interfaces: TR1-TR4 and TR8-TR11 are common emitter DC amplifiers to bring the 5V outputs from the latches to 8.5V or Vsynth. R2, R5-R10 and R13 along with

R30-R35, R37 and R38 are the associated load and current limiting resistors for the 8 amplifiers. R3, R4, R11 and R12 are pull-down resistors for the unused display lines. TR7 is a DC amplifier which provides a complimentary TX o/p, i.e. /TX (not TX). R36 is the load resistor for this amplifier, R26 and R29 are it's bias resistors. D3 is a 5.1V Zener diode; this protects the PIC from the potentially damaging Vsynth wich is applied via R26 to the RA3 input (output in this case). TR6 is the TX out amplifier which is fed via current limiting resistor R27 and uses the radio's PTT line as it's load, ie. it pulls the normally high PTT line low for TX.

Display: The LCD display used is the Hitachi LM016L; this is a two line, 16 character per line display with all the decoding built in. It is fed with ASCII from the PIC via bits 0-3 of the 'data bus' and used in 4 bit 2 instruction mode.

The keypad: There are generally two types of 12 key multiplex keypads in use, and these are either arranged as 4 rows of 3 keys, or 3 rows of 4 keys. Either type may be used.

CONSTRUCTION

For those who wish to make their own PCB, the PCB track and silkscreen layouts are given in the accompanying diagrams (Figs 3 and 4), although owing to the small size and spacing of some of the tracks, it is advisable to buy the PCB or have it made by a professional PCB manufacturer.

Start by fitting sockets for the chips, followed by all the resistors and capacitors, paying attention to the polarity of the two electrolytics. Veropins can be fitted next to all the external connection points; this makes for easy connection, and protects the PCB as only one soldering operation is performed on the tracks during the life of the unit. The discrete semiconductors are fitted next; ensure that D1 and D3 are the correct value and the right way round - a mistake here *will* irreparably damage the PIC.

Next fit the battery, again make sure it is the correct way round. Now connect the keypad according to the diagram (see Fig.5); note the two types of keypad and be sure to identify the

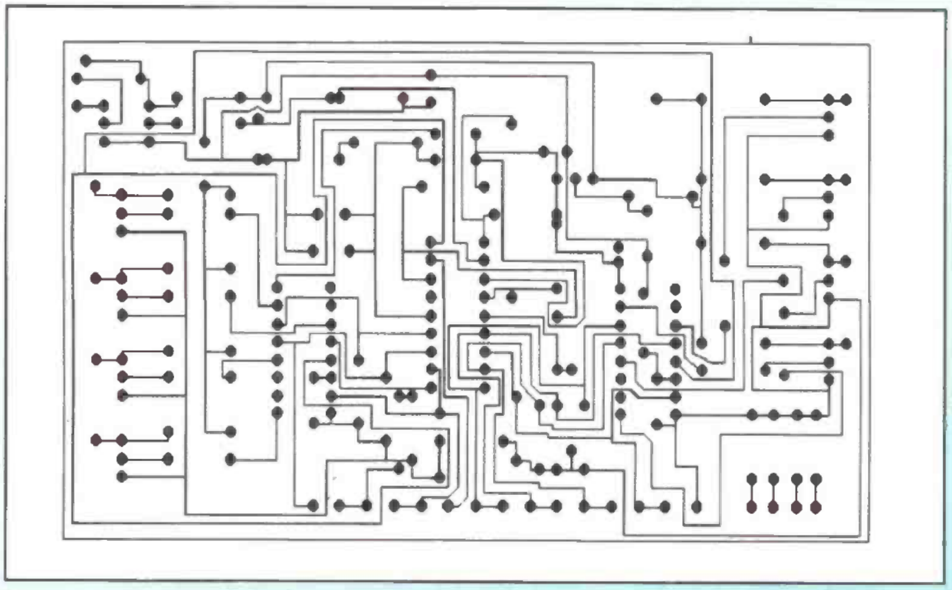


Fig.3: PCB foil pattern (full size)

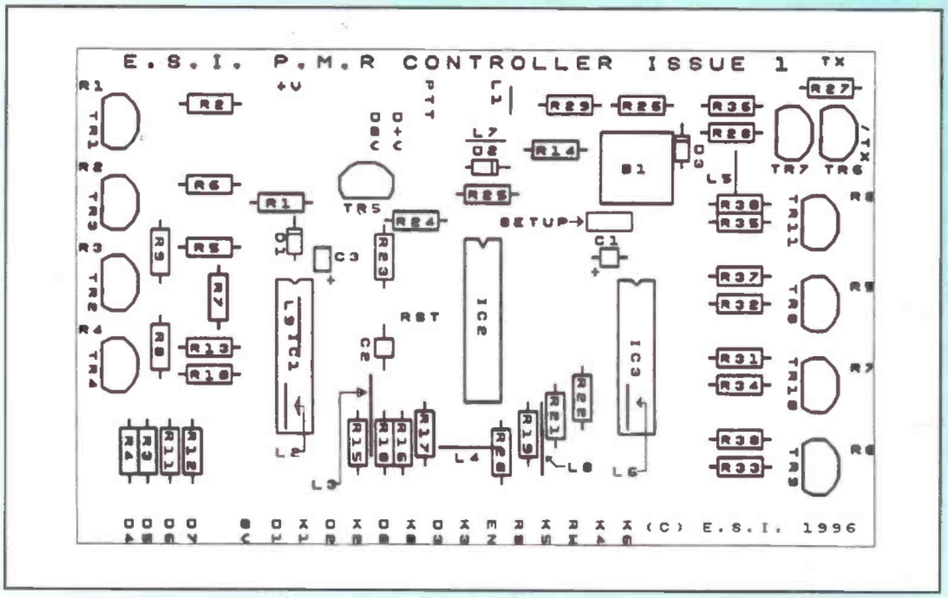
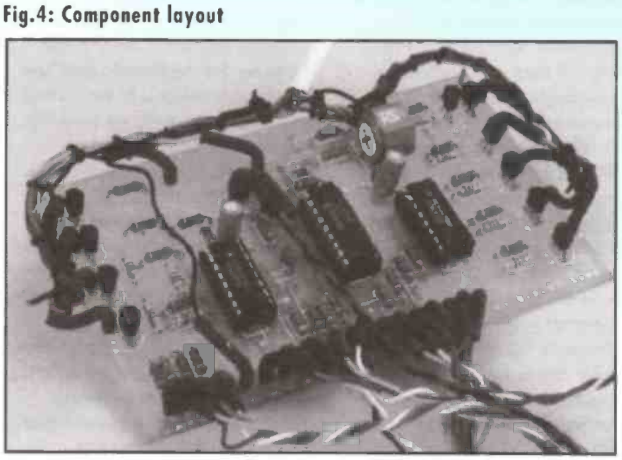


Fig.4: Component layout



one you plan to use - it is important to wire this correctly. The display can be connected next (see table). It is advisable not to connect the +5V to the display until the PCB has been tested, see later.

The display is ESD sensitive and must be handled accordingly. Refering to the keypad connection diagram, connect the keypad to the PCB, K0 on the keypad connects to K0 on the PCB, K1 to K1 etc. Both types of keypads are shown as matrices, where the lines cross represents the connection made when the key is pressed. The button marked 'R' is the repeater shift button and the one marked 'E' is the enter button

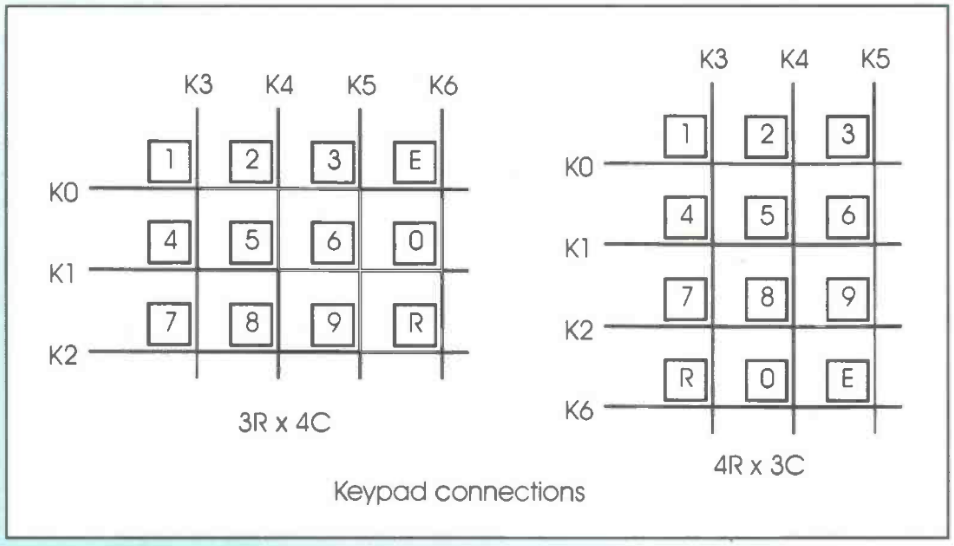


Fig.5: Keypad connections

TESTING

Now that the unit has been built it can be tested before connecting it to the radio. Apply a DC voltage of about 8 or 9 volts between the +V connection point and 0V and measure the current - it should be about 15mA; if excessive current is observed switch off and check for shorts. Measure the voltage on pin 16 of IC1, this should be 5V, as should the voltage on pin 2 of IC2. If all is well power down and fit the three IC's; these are static sensitive and the usual ESD precautions should be used.

The +5V to the display is now connected, and the unit powered. The display should come to life and display the message 'ESI PMR CONTROLLER'; if it does not, momentarily short the two pins marked 'setup' together, followed by shorting the reset pin briefly to 0V. In some cases it will be found that the unit will not work if the battery is completely discharged. If you have difficulty, leave the unit powered for 10 minutes or so to allow the battery to come up, then repeat the reset procedure. If all is well the display will next show the setup screen after a short delay.

Select 12.5kHz by pressing 1 on the keypad. The display will now ask for 2m or 70cm, select 2m by pressing 1. Finally select the correct type of keypad when prompted. The display should now show 144.0000MHz and RX. Using a Logic Probe supplied from +V, test the R1 to R8 outputs; these should all be 'Lo'. Next test the /TX output - this should be 'Hi'.

Key in 147.1875 and press enter (the decimal point is entered automatically). The display should change to reflect this. Now used the Logic Probe again chech R1 to R8 - this time they should all be 'Hi'. Next key in 144.0000, press enter and short the PTT input to 0V; the display should show TX and /TX output should be 'Lo'. Remember that if the displayed frequency is out of band the /TX will not respond to the PTT input, neither will the display. Finally press the RPT key - the display should now show RPT in the bottom left corner; if you now short the PTT input to 0V the displayed frequency should read lower by 600kHz while the PTT is 'Lo'. This completes the testing and the unit can now be fitted to your PMR radio.

CONNECTION TO PMR RADIO

The prototype unit was used with Storno 5000 series radios. Remove the PROM board and connect the controller. The synthesiser connections for these radios are shown in Fig.6. Pin 1 on the synthesiser plug is +Vsynth, pin 2 is bit 0 (LSB) and pins 3 through to 9 correspond to bits 1 to 7. Pin 14 is PTT.

For other types of radio, first identify the synthesiser connections (the ones your Prom is connected to). If you don't know which pins correspond to which bits, select a known frequency with the thumbwheels and measure the synthesiser connections with the Logic Probe, ie. 145.500MHz will be 01111000 for a 12.5kHz radio, and 00111100 for a 25kHz radio. The leftmost bit, i.e. MSB, is B8 and the rightmost bit, ie. LSB, is B1. These correspond to R1 (LSB) through R8 (MSB) connections on the controller PCB.

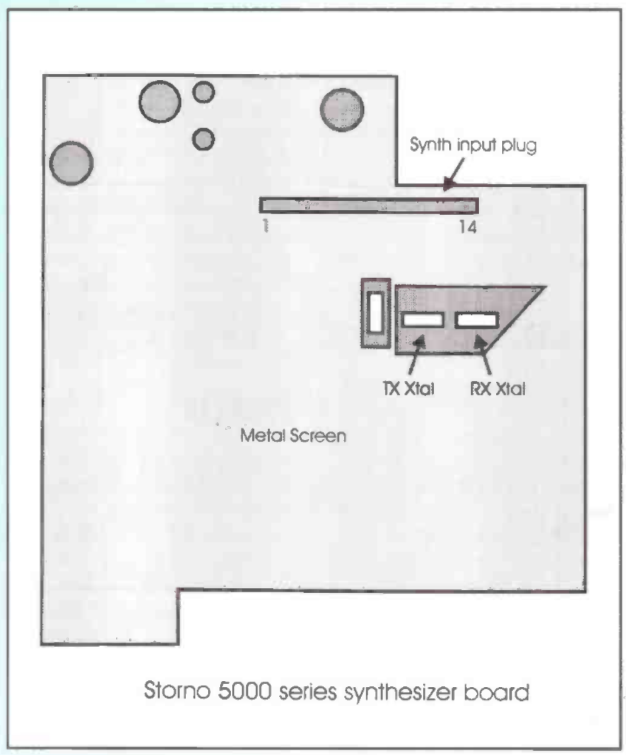


Fig.6: Storno 5000 synthesiser board connections

Using this method it is possible to identify bits 1 to 8 of the synthesiser input. Measure the voltage on these pins whilst they are 'Hi' - as mentioned earlier it is usually about 8 to 9V but may differ between makes. Whatever the voltage is you will probably find that it is the same as the supply voltage on the radio's synthesiser board - this is the supply you should use to power the controller. If no convenient place is found to tap off this supply you should try to find a supply as close to this as possible, since this is the voltage that the synthesiser expects to 'see'.

Finally locate the radio's PTT input - this is usually normally 'Hi', active 'Lo', ie. short to 0V for TX; if this is so connect this to TX out on the controller board. Should it be the opposite way round connect it to /TX out on the controller board. Connect the PTT pin on the controller to the PTT on your microphone (this is active 'Lo'). This completes the connections and the unit can now be built into the PMR case and put into service. It is a good idea if a frequency counter is available, to check that the radio does actually transmit on the frequency shown on the display, just to be on the safe side.

The use of a Logic Probe mentioned above is recommended if one is available; a multimeter can be used to check these levels, but a Logic Probe will confirm that signals are within the limits of 'Lo' or 'Hi'. With a multimeter you will have to decide whether this is in fact the case, since a 'Lo' is not exactly 0V and a 'Hi' is not exactly +V.

IN USE

The controller is very user friendly. After the initial setup has been performed the display will show frequency, TX or RX, and if repeater shift is selected 'RPT' will be shown in the bottom left corner. To change frequency simply key in the required frequency, if an error is made the display will automatically return to the last frequency used. If the whole frequency is keyed in, ie. 145.5000 (the point is entered automatically) then there is no need to press enter, but if only part of the frequency is to be changed, ie. 144.2500 changed to 145.2500 then just enter the first three digits and press enter, ie. 145enter.

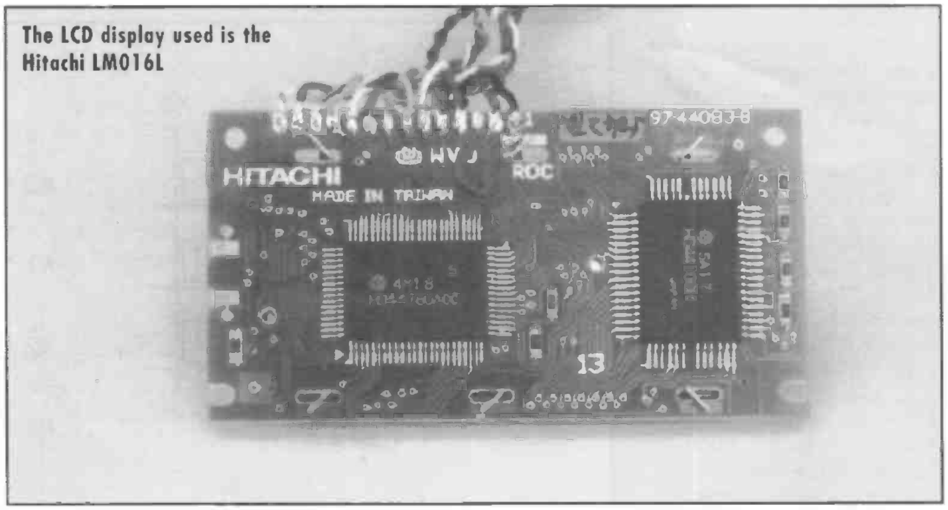
Pressing the 'R' key toggles repeater shift on and off. When the radio is switched off the controller will retain it's settings for about 1 year. Every time the radio is switched on, the controller displays the message 'ESI PMR CONTROLLER' for about eight seconds then displays the current frequency. If the repeater shift is on and the frequency is such that a 600kHz shift would put it outside the range of the synthesiser, then when the PTT is pressed no shift will take place.

FINALLY

A pre-programmed and tested PIC16C58A chip, plus ready-made PCB, as used in this article, are available from GWM Radio in Worthing. The PIC chip is priced at £20.00 and the PCB at £9.99. (see their advert elsewhere in this issue for contact details).

The displays are available from Maplin Electronics and Farnell. The battery from RS Components Stock No. 593-552

Any further queries regarding this project should be addressed to the author, Bob Howlett, 319 Kingston Road, Ewell, Surrey KT19 0BP, enclosing an SAE if a reply is required.



The LCD display used is the Hitachi LM016L

PARTS LIST:

Resistors; All 0.25W Carbon, or 0.6W Metal film

R1-R6, R11-R13, R15-R26, R30, R31, R36-R38	4.7k
R7-R10, R27, R28, R32-R35	1k
R14	1.5k
R29	10k

Capacitors;

C1, C3	100µF 16V electrolytic
C2	22pF disc ceramic

Semiconductors;

TR1-TR11	BC548 or equivelent
D1	BXY79C5V6
D2	1N4148
D3	BXY79C5V1
IC1, IC3	4042 Cmos
IC2	PIC16C58A *(see text)*
Display	Hitachi LM016L
Battery	3.6V 11mAh. PCB mounting

Miscellaneous;

Two 16 pin DIL sockets
One 18 pin DIL socket
Thirteen Veropins
PCB
12-key matrix type keypad

Display to PCB connections

Display	1	2	3	4	5	6	7	8	9	10	11	12	13	14
PCB	0v	+5v	+5v	RS	R/W	E	D4	D5	D6	D7	D0	D1	D2	D3