Technical Feature

Pic 'n' Mix Digital Injection System

*Part 3, by Peter Rhodes, BSc, G3XJP**

IN THIS PART the circuit diagram and PCB layout for the display board is described, together with some construction notes and the complete project components list.

KEYPAD

THE KEYPAD IS a low cost 4-row by 3-column switch matrix, designed for push-button phones. The software polls the keypad periodically, looking for key presses. It does this by driving each row low in turn. For each row, it then tests each column, looking for a low; and if one is found, the column/row intersection defines which key is pressed. The key press is de-bounced in software, since the contacts rapidly make and break for up to 5ms - and without this facility, the average key press would otherwise be interpreted as about 20 successive identical key presses.

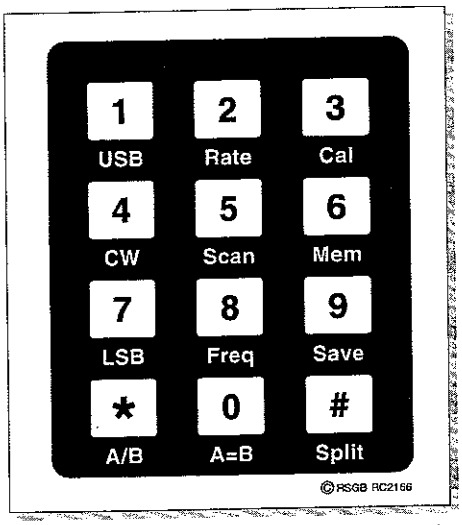
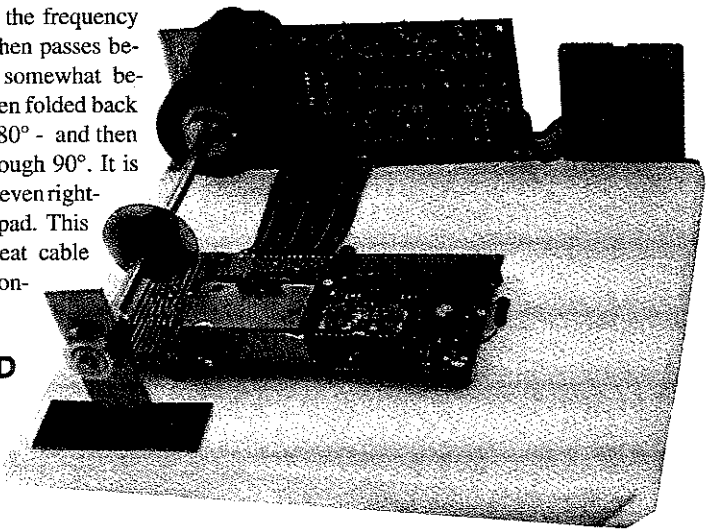


Fig 9: Keypad overlay for reproduction, 47mm wide by 57.5mm high.

The keypad needs an overlay to give a better feel of the alternative meaning of the keys in this application. **Fig 9** may be copied at size and glued over the keys, the digits having been first cut out with a sharp knife.

The keypad is connected to the display board via some 7-way ribbon cable. You need a cable routing which brings the top lead from the display board to the most right hand connector on the keypad.

Fig 10 shows the best way to achieve this. The cable is routed across the front of the display board beneath the frequency display and LEDs. It then passes behind the keypad and somewhat beyond it. The cable is then folded back on itself - ie through 180° - and then folded downwards through 90°. It is then made off onto the seven right-most pads on the keypad. This process produces a neat cable run with the correct connections.



DISPLAY BOARD DESCRIPTION

REFERRING TO **Fig 11**, the display element itself comprises three double-digit 7-segment common anode displays. They were chosen because they are large and make for comfortable viewing. Their segments are all wired in parallel.

It is traditional to drive 16 character back-lit LCD displays in this sort of application. The cost would be comparable (for a one-off), power consumption noticeably less and the software complexity about the same, albeit totally different in nature. I preferred the LED approach, since I find the LCD character size just a little small for comfortable viewing.

The display digits are multiplexed; that is, only one digit is lit at any one time, and all are lit in turn (rapidly and frequently) to provide flicker-free viewing. The software controls the multiplexing process and devotes as much time to repainting the display as circumstances permit.

In operation, IC12 decodes RA0, 1, 2 to determine which one digit is being addressed - driving one of the PNP switches TR5-TR10 to handle the digit current. At the same time, IC11 decodes a BCD input on RB0, 1, 2, 3 to determine which segments to light; and in addition RA3 is pulled low for a decimal point. By rushing round each digit in turn and by executing the entire sequence often enough, the human eye sees a continuous 6-digit display.

Do not be tempted to substitute a different BCD to 7-segment decoder chip, since the software relies on the behaviour of the 'LS47 for BCD values greater than 9 to achieve leading zero suppression.

Data is clocked into the latch IC13 as an 8-bit serial word - and the outputs are updated by a latch pulse on RB5. These bits drive low current (2mA) LEDs (D4-D11) directly via current limiting resistors R41-R48. D4 and D5 are green LEDs, the others red. This gives a strong visual clue when you are operating 'split'.

The seven lines to the keypad are routed through the display board for convenience. They could equally be taken directly from the DDS board, provided some means is found to mount the series resistors R49-55. The resistors are there to prevent potential short-circuiting of the PIC I/O lines, in the event that two or more keys are pressed simultaneously.

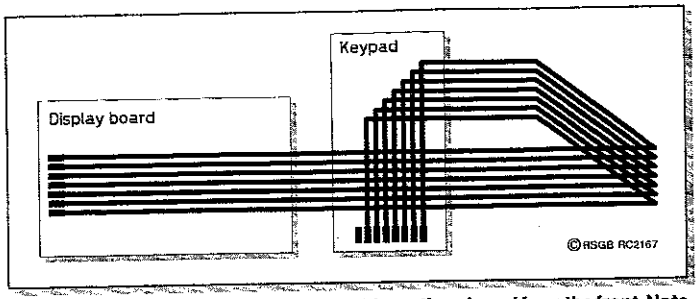


Fig 10: Display board to keypad ribbon cable routing viewed from the front. Note that of the eight connectors on the keypad, the extreme left one is not connected.

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DISPLAY BOARD CONSTRUCTION

THE PCB LAYOUT is shown in **Fig 12**. The rear tracking is somewhat complex around the display IC sockets. A perfectly acceptable but less purist approach would be to bring these pins and those of IC11 out onto small pads and then hand wire all the segments to the 7-segment decoder using Vero wire.

Other common anode devices, including single-digit ICs and those with pins on the vertical edges could easily be substituted with simple changes to the PCB - or again, by using Vero wire.

The status LEDs may be tacked onto the board but without shortening their leads for commissioning purposes.

When inserting ICs or IC sockets onto the

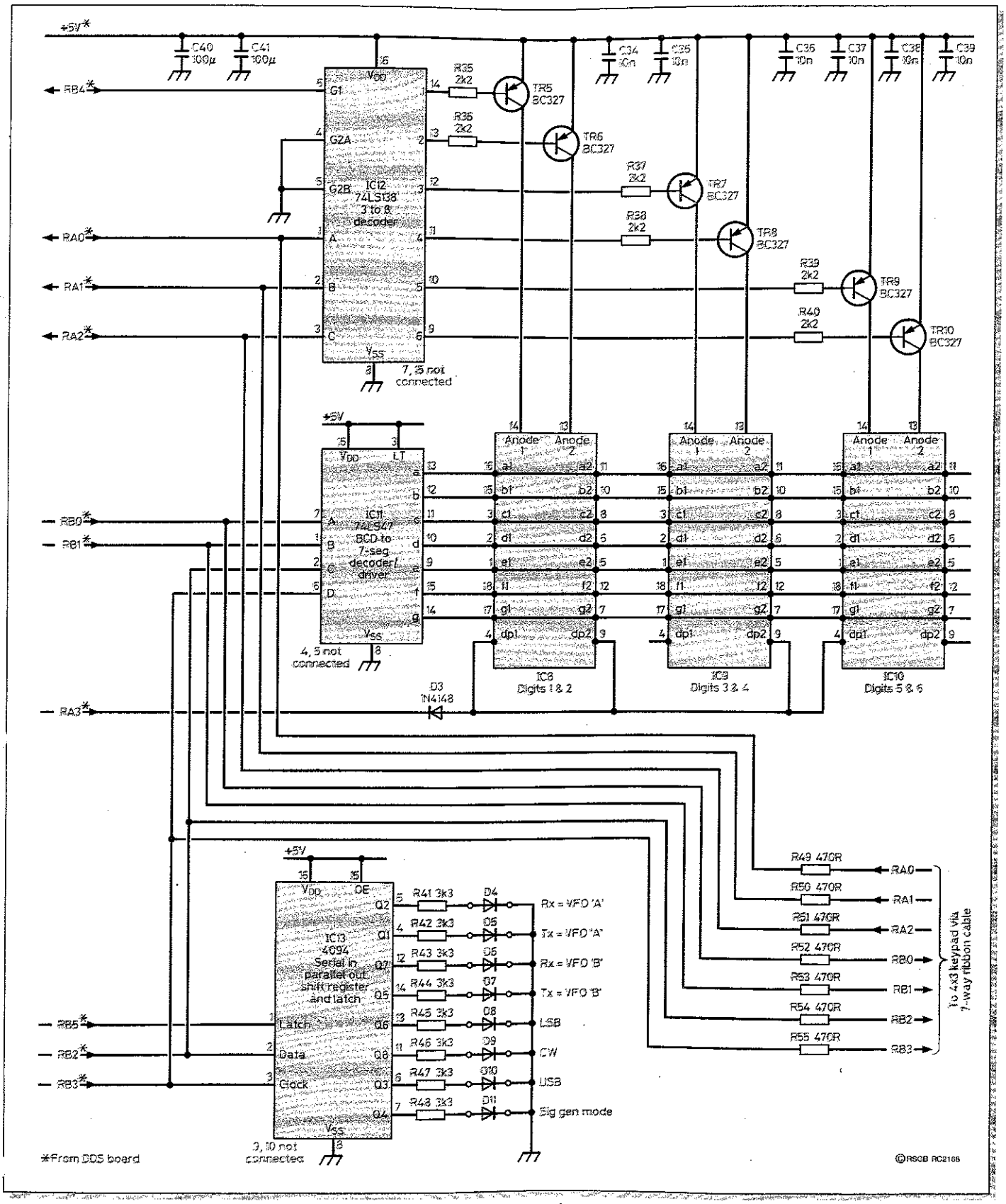

Fig 11: Display board circuit diagram. Note that the segments of all the display ICs (8, 9, 10) are wired in parallel except for some decimal points which are never used and which are not connected. The eight 3mm status LEDs, D4-D11, are soldered on the display board, but physically mounted in holes in the front panel.

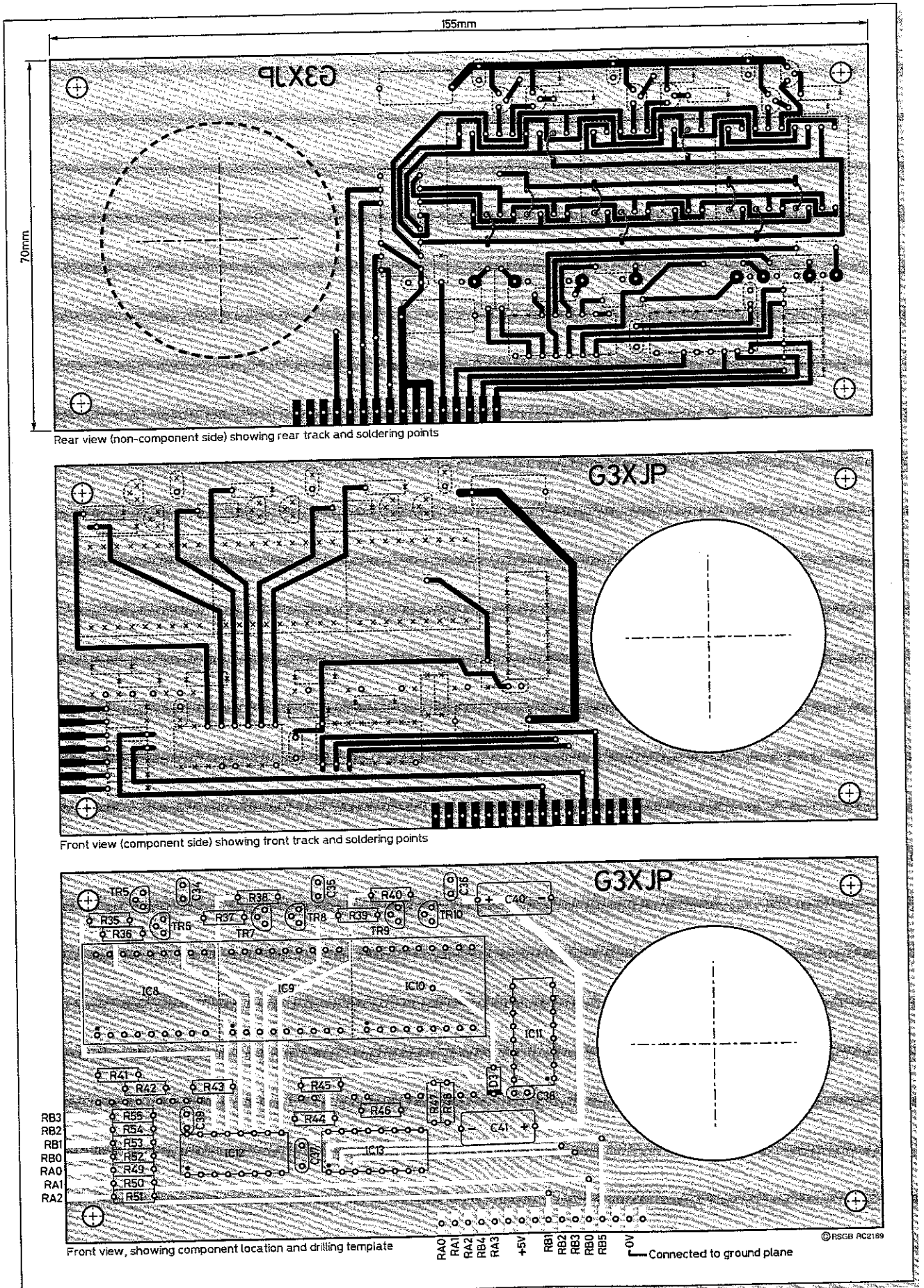

Fig 12: Display board PCB drawn for production as described in the text. The ground plane is not shown, since all of the board (both sides) is ground plane copper except where removed to let in the tracking. Holes on the front and rear track views shown as an 'x' are not soldered on that side of the board. They should be lightly countersunk. Holes shown as an 'o' are soldered to either the track or the ground plane. All holes are 0.7mm dia. The front panel LEDs (D4-D11) are not shown. They solder to the pad and ground plane pairs in a horizontal line about half way up the rear view. Nine short wire links are shown as red lines on the rear view.

COMPONENTS

Resistors - all 1/8-1/4W, 5-10%, except R33

R1, R9, R17, R27-31	100R
R2	330R
R3, R4	10k
R5, R14, R20, R21, R23	1k
R6	220R
R7, R8, R22	4k7
R10	200R
R11	180R
R12, R15	56R
R13, R49-55	470R
R16	5R6
R18	3k9
R19	560R
R24-26	270k
R32	47k
R33	10R, 2W
R35-40	2k2
R41-48	3k3

Capacitors

TC1, TC2	2-22pF min film dielectric trimmer
C1	1nF feedthrough
C2, C4, C5, C11-14, C17, C18	1nF disc ceramic
C3	10µF, 16V radial electrolytic
C6, C24, C28	22pF ceramic plate
C7	68pF ceramic plate
C8, C9, C40, C41	100µF, 10V axial electrolytic
C10, C16, C19-23, C34-39	10nF disc ceramic
C15	470µF, 16V axial electrolytic
C25	3.3pF ceramic plate
C26	33pF ceramic plate
C27	8.2pF ceramic plate
C29, C30	15pF ceramic plate
C31, C32	47pF ceramic plate
C33	100pF ceramic plate

Semiconductors

D1	LD271 IR diode
D2, D3	1N4148
D4, D5	3mm low current LED (green)
D6-D11	3mm low current LED (red)
IC1	78L08
IC2	7805
IC3	16C84-04/P or 16F84-04/P (in socket)
IC4	AD9850BRS
IC5	HLC2705
IC6, IC7, IC13	4094 (no sockets)
IC8-10	2-digit common anode 7-segment LED, Maplin FA01B (green) or BY66W (red)
IC11	74LS47 (socket optional)
IC12	74LS138 (no socket)
TR1	2N2222A
TR2	J310
TR3	2N3866 with small heat sink
TR4	BC108
TR5-10	BC327

Inductors

L1	5 turns 22 SWG on ¼in dia, ½in long, tap 1 turn from earthy end
L2	5 turns 22 SWG on ¼in dia, ½in long, centretap
L3	1µH axial choke
L4	0.68µH axial choke
T1	8 bifilar turns 32 SWG on FT37-43

Miscellaneous

2-sided PCB	see text for dimensions
4x3 Keypad	Maplin JM09K
7-way 0.1in pitch ribbon cable for above	
1-off 32- pin DIL turned pin socket (0.6in)	
1-off 28-pin DIL turned pin socket (0.6in)	
Mount display ICs on above and cut off unused pins	
Display optical filter	3.5in x 1in approximately
1-off 28-pin DIL turned pin socket (0.6in)for DDS assembly	
1-off 28-pin DIL turned pin socket (0.6in) to mount DDS assembly on mother board	
1-off 18-pin DIL turned pin socket (0.3in) for 16C84	
1-off 14-pin DIL turned pin socket (0.3in) for 74LS47 (optional)	
Shaft encoder disc (see text)	
Knob to mount encoder disc, approximately 1in skirt dia, drill right through	
Tuning knob, flywheel, shaft & bushes/bearings	Your choice!
18-way ribbon cable to Tx/Rx (optional)	
16-way inter-board ribbon cable (optional)	
12V DC input connector (optional)	
RF output connector (optional)	
18-way host connector (optional)	
X1	approximately 110MHz (see text)
X2	4MHz

board with this form of PCB construction, insert them only far enough to give a useful tail on the back of the board. Specifically, avoid bridging tracks or earthing pins on the component side of the board via the shoulders on the pins.

SUPPLIERS

THE MAJORITY of the components were purchased from JAB Electronic Components, PO Box 5774, Great Barr, Birmingham B44 8PJ. Tel 0121 682 7045. The significant exceptions are the keypad, IC8-10, D1, D4, D5, D6-D11 and TR1, which are available from Maplin.

The PIC 16C84 (IC3) can also be obtained from Maplin at a one-off price of £8.90 - if you want to write your own software. I will be happy to supply the PIC ready programmed with the features described in this article, an acetate disc for the shaft encoder and a paper overlay for the keypad for £15, on receipt of an SAE.

For bushes and bearings, much can be recovered from scrap potentiometers or variable capacitors. Failing that, model shops are a good source.

The AD9850BRS DDS chip can be purchased through any Analog Devices distributor who will sell small quantities. There may be a long lead time. The price will depend on delivery and payment methods. I used Kudos Thame Ltd. 55 Suttons Business Park, Reading, Berks RG6 1AZ. Tel 0118 935 1010. ♦