Technical Feature

Pic 'n' Mix Digital Injection System

Part 4, by Peter Rhodes, BSc, G3XJP*

IN THIS PART the circuit diagram and PCB layout is provided for the DDS board, together with some construction notes and details for building a shaft encoder.

DDS BOARD DESCRIPTION

REFERRING TO **Fig 13**, the functional blocks comprise a crystal oscillator (the reference clock) feeding the DDS assembly, followed by a low pass filter and buffer. There are two output latches and not least, the PIC which controls operations.

On the input side, the PIC is monitoring the shaft encoder, the PTT line and the keypad.

TR1 is a conventional crystal oscillator, followed by TR2, a common gate buffer. The crystal may be any value in the range 100-125MHz, the higher the better. The exact achieved frequency is trimmed into the software using the calibration process which will be described next month.

The entire oscillator is surrounded by a PCB enclosure formed by the board, four sides and a top. The latter has braid hinges for access - and two holes drilled to allow adjustment of TC1 and TC2. R7 and R8 bias the AD9850 reference clock input to half rail.

IC4, the AD9850, is operated in serial control mode. That is, a pulse stream of 32 data bits and 8 control bits is clocked serially in on the D7 line by 40 corresponding clock pulses on W_CLK. That sequence is then actioned by pulsing FQ_UD high.

The resulting synthesised sine wave appears on the complimentary current outputs IOUT and IOUTB, terminated by R9 and R10. R18 sets the on-chip DAC full scale output current in accordance with the manufacturer's recommendations.

C24-28 and L3, L4 form a 42MHz, 200Ω elliptic low-pass filter, taken from the AD9850 data sheet [4]. R11, R12 form an 'L' pad, to terminate the filter and to match into the base of the driver, TR3. This in turn delivers +7dBm into 50Ω. It is important that Pic 'n' Mix feeds a non-reactive load of about 50Ω, to ensure effective termination of the LPF. The injection port of, say, an SBL-1 mixer is ideal. Being double balanced it also reduces the AM noise floor.

Data is clocked into the latches IC6 and IC7 serially by a sequence of 8 clock pulses followed by a latch pulse. Pulses for other purposes appear on the data and clock lines, but are effectively ignored since there is no following latch pulse.

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These two latches, as well as IC13 on the display board and the AD9850, are updated simultaneously by pulsing RB5 high - which is reserved exclusively for this purpose.

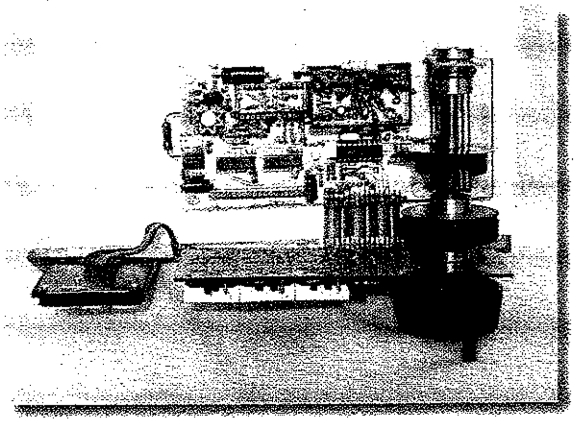
The latch outputs are +5V when true, so you may interface these with transistor switches etc to drive the band switches in your Tx/Rx, switch antennas, etc.

The 'broad band' output goes true if the displayed frequency is not one of the explicitly specified ones. (To be precise, the 10MHz and 1MHz digits are compared). I use this to switch in two relays which short-circuit my Rx front-end and remove all selectivity. This allows me to listen on any HF frequency. Obviously Rx performance is seriously compromised under these circumstances, but for the ability to listen to broadcast stations, frequency standards etc, the price is well worth paying. Equally, if your Rx does not have a front-end for an explicit band you could diode-OR the bit for that band with the broad band bit.

IC3, the PIC, has been covered previously. Its hardware configuration is entirely conventional. The three lines shown as 'Programmer interface' together with R30 and R31 may be omitted if you never have any intention of programming the PIC *in situ*.

D1 is a cheap IR emitter, designed for remote control applications. IC5, the IR detector, is designed for computer mouse position encoding. It has the merit of producing decoded outputs which are very easy (and fast) to handle in software. The 'pulses' output goes briefly low for every dark/light transition. This is used to interrupt the PIC, to handle the consequences. The 'direction' output is a steady level, which reflects the last direction of rotation. The software can therefore test this line at any time pretty well at leisure to determine tuning direction. This is far cheaper on program size than decoding the Gray code outputs produced by many commercial shaft encoders.

TR4 isolates the host transceiver PTT line. The logic on the PTT line can be of either polarity, since the software assumes the initial level at switch-on corresponds to receive. This allows for your not connecting a PTT line if you are running an Rx only. But, if running a Tx/Rx, this line must be connected since the software needs to know the T/R state in order to allow split operation; and for safety reasons, to cancel any scanning operations when appropriate.



CONSTRUCTION NOTES

THERE IS A PREFERRED order for building and commissioning the DDS board, to ensure access and progressive testing. The PCB layout is shown in **Fig 14**.

Build the 110MHz crystal oscillator first. That is, all the components within the screening enclosure (but not the enclosure itself) and omitting for now C1 and C7.

The oscillator components are all surface mounted on islands on the top copper plane. The leads must be cut as short as practicable, consistent with being able to get the soldering iron in. Mount the two coils L1 and L2 last. Fit the tap to L1.

Fit also C15, IC1 and C18, and insert a temporary jumper from the 8V top track to the junction of R1 and C2, to provide power to the oscillator.

Loosely couple a GDO (as a passive detector) to L2 and set the GDO to your crystal frequency. Adjust TC1 for oscillation and peak TC2 for maximum output at the specified frequency. Repeat several times and check that the oscillator fires up from cold.

Next, fit the inter-plane wire links (ie some old component leads), which are either under the PIC socket or between it and the edge connector.

Fit IC2 and solder its tab to the board. Fit C8-C10, R23 and R33. This completes the +5V rail distribution. Check for shorts, apply 12V and verify +5V is available on the top track busbar under the shaft encoder detector - second track from the left. If it is getting this far, all the several crosses from top to bottom track are verified.

Fit, in order, C29, C30, TR4, R22, R32, R26, R25, D2.

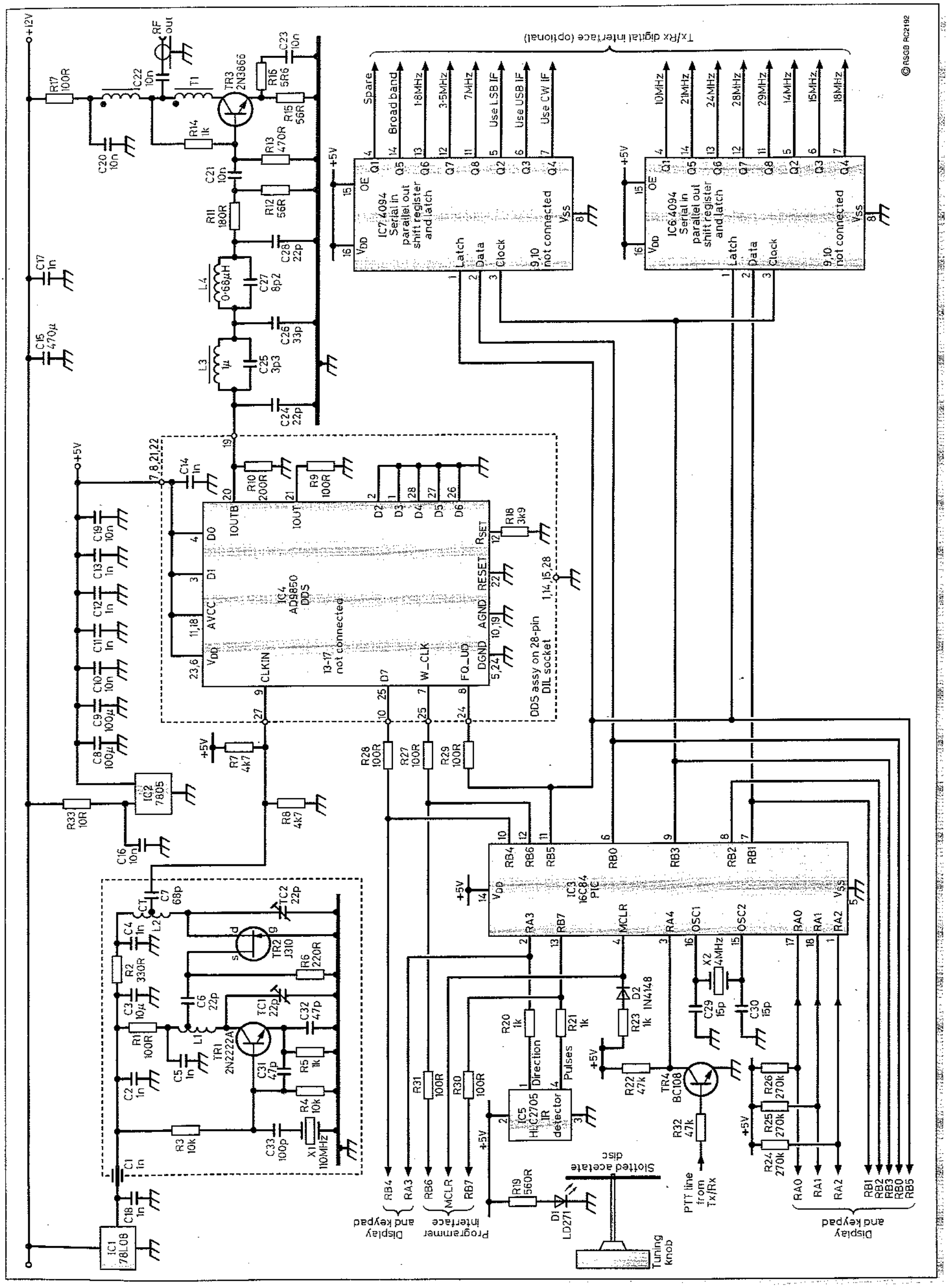


Fig 13: DDS board circuit diagram. IC4 and its associated components are mounted on a 28-pin DIL socket to form the DDS assembly. This plugs into a 28-pin socket on the main board.

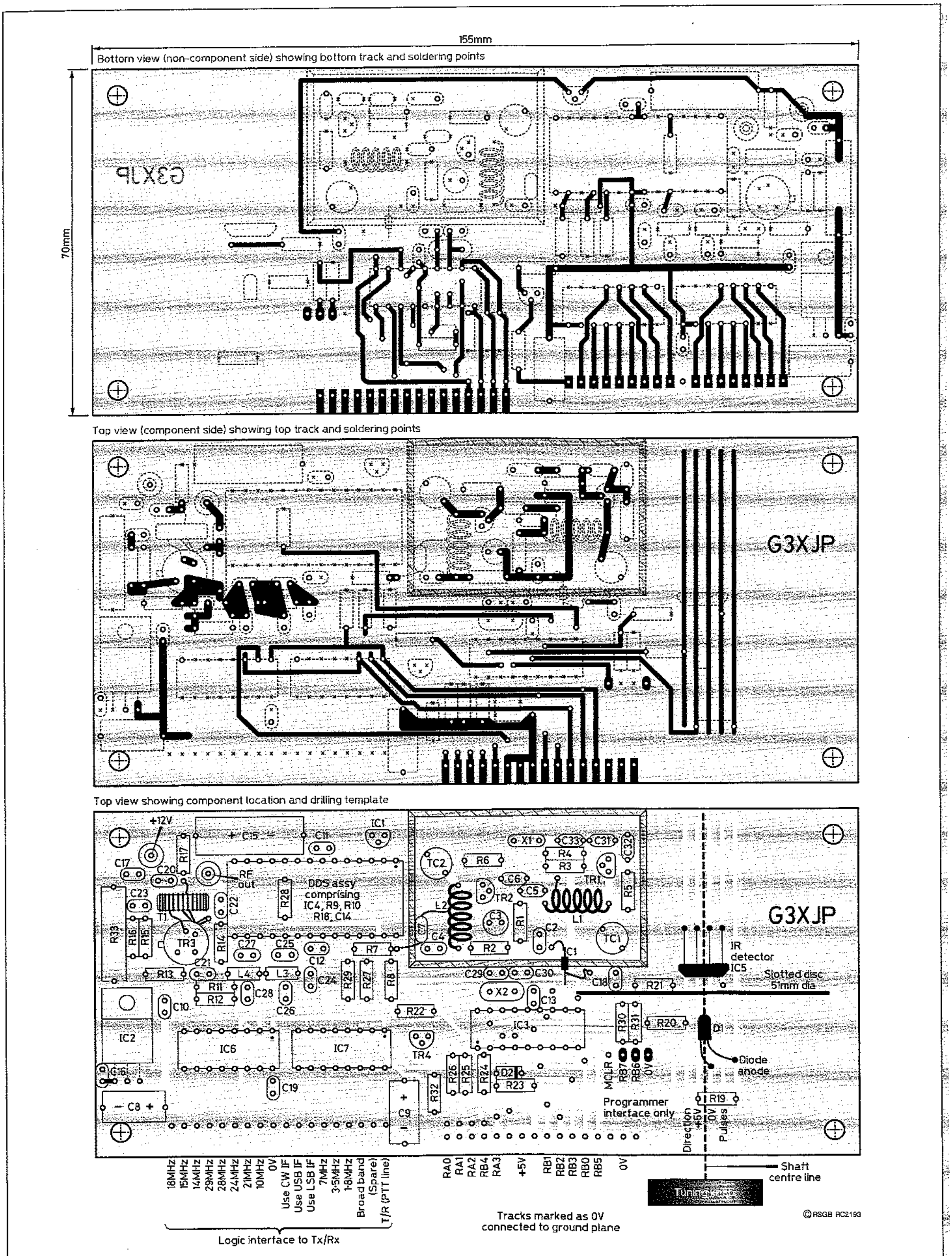


Fig 14: DDS board PCB drawn for production using same conventions as Fig 12. All holes are 0.7mm dia except 3 leads from IC2 which are 1mm. Ref oscillator is screened by PCB enclosure. C7 uses its leads to connect from tap on L2, via hole in enclosure to top track. C1 is connected to track via short jumpers. IR detector/diode and disc shown for mounting at 90° to display board.

Check again the links under the PIC socket (IC3), your last chance, and fit the socket. Now fit R24, C13 and X2.

Now surface mount all the components in the low-pass filter and buffer amplifier. Fit TR3 last and its heat sink last of all.

Temporarily fit C7, one end to the top track shown, the other forming the centre tap on L2.

Solder IC5 and D1 to the board without shortening their leads and adjust them so that they are about 1cm apart. Fit the socket ready for the DDS assembly, but do not insert the assembly itself at this stage. Mount all other components except C1. Insert IC3 in its socket.

Build the display board and link it to the DDS board. Check all the inter-board leads for any shorts to earth and for any shorts to any and every other such lead.

Apply 12V and your display should initialise to 80m and the Rx='A', Tx='A' and LSB LEDs should light. This all verifies that the PIC is working - as well as the Display board. At this stage there is, of course, no actual RF output.

A screwdriver passed between IC5 and D1 from left to right should produce a decrease in indicated frequency - and vice versa right to left.

Wire up the keypad and check that all keys work - as well as the status LEDs.

Verify +5V on the DDS assembly socket and check for any shorts or bridges on all connected pins.

Finally, and only if everything else is working, insert the DDS assembly, monitor for RF output from the board and apply power. Look for RF around 12-13MHz.

All being well, Key '83' to give signal generator mode. The RF output should change to 80m and the status indicator LEDs should correspond.

Fit the screened compartment around the 110MHz oscillator, drilling holes for C1 and for one of C7's leads to pass through. This compartment must be made from 2-sided fibreglass board, since both its screening and thermal conductivity properties are needed. Fit a top, drilling holes for adjustment of TC1 and TC2. Secure the top using some internal braid hinges.

Re-peak TC1 and TC2 for clean, stable output of some known frequency - and specifically ensure the output is not at a multiple or sub multiple of that frequency.

Fit the shaft encoder. Adjust its disc, IC5 and D1 so that the disc runs just not touching IC5. The position of D1 is less critical (actually, none of it is very critical). It needs to be a about 1cm away from the disc. Note that in bright incident light, the shaft encoder will not work reliably and may produce no or apparently random pulses. It is easy - but less than useful - to end up with a device which produces an output frequency proportional to the number of passing clouds!

Fit IC6 and IC7 last of all, since their operation is independent of the rest of the board.

You do not need the PTT line connected for testing purposes, but should do so before starting serious operational use.

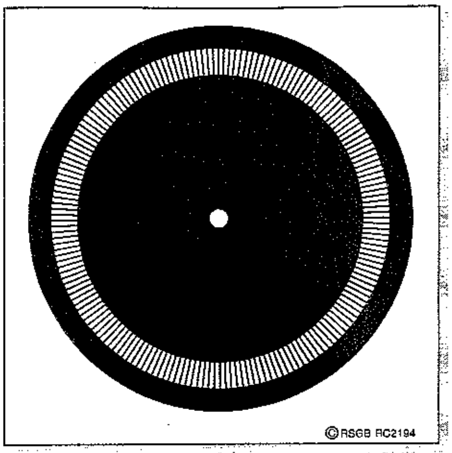


Fig 15: 180 slot encoder disc, 51mm dia, for reproduction on acetate film.

If there is evidence of multiplex noise in your receiver, fit a 1000µF electrolytic from the junction of R33 and IC2 to earth. Multiplex noise is characterised by disappearing completely in sleep mode [73].

If there are occasional musical notes, these may be reduced by fitting three further decoupling capacitors (as well as C14), one in each corner of the DDS assembly from the 5V power plane to the ground plane. Use two 10nF and a further 1nF, with the shortest leads possible.

SHAFT ENCODER

THE SHAFT ENCODER assembly comprises a tuning knob, a length of shafting, some bearings, a flywheel and an encoder disc. You will also need some means of taking out any end-float on the shaft. I was fortunate in that Jack, G3XKF, turned up some beautiful brass fittings for me. Don't skimp on the mechanics here as the 'feel' of the tuning knob is important to pleasurable operation. At the very least, the assembly must spin freely with no binding.

I borrowed a flywheel from an old cassette recorder and drilled it out to take the shaft. Because of the software flywheel, you don't need much physical mass here, but some inertia is needed to smooth the turning rate. A heavy tuning knob may be sufficient. Mine is loaded with lead caps off wine bottles, thereby doubling the pleasure. While on the subject of tuning knobs, one with a finger hole or a turning (tram) handle is best.

The software has been tuned for an encoder disc with 180 spokes. Since the detector emits a pulse for every dark/light transition, this gives a natural tuning rate of 360x10Hz = 3.6kHz per rev, a rate which is speeded up or slowed down by the software as appropriate.

Fig 15 shows the disc I used, which may be reproduced at size onto acetate film (by your local copy shop). Ensure the 'spokes' reproduce black with as much contrast to the 'slots' as possible. Glue it carefully onto an old knob with the toner side away from the detector to avoid scratching. Drill the knob right through first and ensure the disc is properly centred by spinning it (slowly!) on a shaft before the glue has fully set.

Long parallel tracks are provided on the DDS board, to give flexibility in mounting position. The actual configuration will depend on whether the DDS board is mounted parallel to or at right angles to the display board.

NEXT MONTH

THE FEATURE CONCLUDES with the calibration process and details of user operation.

REFERENCE

[4] 'CMOS, 125MHz complete DDS Synthesiser', Analog Devices, Rev 0. ♦

RadCom Helplines FOR MEMBERS

● Graeme, G3GGL, Secretary of the Eddystone Users Group (EUG) seeks to acquire the **callsign G3EUG** for the club. It was issued in 1948 to B Hutchings of Walthamstow, who had moved to Thundersley, Essex, by 1965, when the license lapsed. Consent of the former licensee (or next of kin) is required to release the callsign. Any clues would be gratefully received. G3GGL, QTHR. Tel: 01299 403372.

● Stephen, G0PQB, is looking for information on the **Realistic** (Tandy) **19-310** speaker/mic for hand-held transceivers. G0PQB, QTHR. Tel: 0181 953 2164.

● Tony, G8CKK, is looking for circuit diagrams and information on the **Microwave Modules T432/144R** 432MHz transverter. All costs covered. G8CKK, QTHR. Tel: 0117 967 7922.

● Frank, G3XWZ, would like to obtain a spare drive wheel for an **Eddystone 730/4** receiver. G3XWZ, QTHR. Tel: 01623 643355.

● Julian, GW0FPY, urgently requires circuit diagrams of the **Racal RA1772** receiver, especially the power supply section. GW0FPY, QTHR. Tel: 01248 681782.

Helplines is a free service to members. Requests for help are published in the order they are received. We regret it is not possible to provide an undertaking of when any submitted request will be published.