VHF amateur transceiver

PART 2

by LEO SIMPSON

Last month, we introduced the Commander VHF amateur transceiver and described its circuit operation. This month we conclude with construction and alignment of the unit.

While the circuit of the new VHF transceiver is relatively complex, its construction is reasonably simple and does not require any special assembly techniques. A soldering iron and a screwdriver are virtually all you need. Make sure the iron has a small chisel-shaped bit, for quick and effective soldering.

Most of the circuit components, with the exception of front panel and rear panel hardware, are accommodated on a single-sided printed circuit board (PCB) measuring 162 x 199mm and coded with the Dick Smith Electronics type number ZA1687. The front and rear panels are also made from PCB copper laminate and are soldered at right angles to the main PCB,

The whole PCB assembly fits (and that is the operative word) into a specially designed ABS case which has two interlocking halves secured by four screws. It is a neat and effective assembly.

As can be seen from the photos this month and last month, the front panel has white silk-screened labelling on a black background. This is combined with an attractive set of knobs and other hardware plus a backlit signal/power meter to produce a professional looking transceiver which is every bit as good as expensive commercial units.

Construction aids

All purchasers of this transceiver kit will receive a detailed assembly manual which describes construction on a step-by-step basis. The parts layout diagram comes complete with a grid pattern and you simply insert each part in turn at the grid location and cross it off the parts list.

In addition, the main PCB will be supplied with a screen-printed overlay as published on page 47 of this article (our prototype unit did not have this overlay). The copper side of the board also has a solder mask to reduce the possibility of solder bridges. Finally, to help construction you can use the colour photos in last month's issue as a guide although note that kit versions will differ slightly from our prototype.

Board preparation

Before actually mounting any of the components, a certain amount of work on the PCB is necessary. The first job is to remove a 3mm strip of solder mask from the earth pattern at either end of the PCB. This is best done by masking off each 3mm strip with masking tape and then removing the solder mask using a cotton bud dipped in nail polish remover.

Alternatively, the solder mask can be scraped off using a sharp utility knife.

Constructors should also inspect the board very closely to see if the solder mask has encroached onto any of the mounting holes of the components. Check also that all component holes have in fact been drilled and that there is no evidence of bridging in the copper pattern. None of these faults may in fact be present but it is better to spot them now rather than try and find them when most of the soldering is complete.

It may also be necessary to slightly enlarge the mounting hole for power transistor Q22. This transistor is mounted and soldered on the underside of the PCB and secured by a stud which passes through the board.

Q22 requires a clearance hole of 10mm so that its seating plane can pass right through the PCB and butt up to the aluminium heatsink. More on that later.

PCB assembly

We are now ready to commence assembly of the PCB. Begin by installing the PC stakes and wire links. The wiring diagram on page 48 indicates where most are required. Additionally, PC pins are required as a foundation (4) for the oscillator enclosure and as locating points for the front and rear panels.

The four PC pins for the oscillator enclosure and earth pin for Q21 should be fitted from the copper side of the PCB so that the longest end is through the PCB.

The use of PC pins for the external wiring is optional but we recommend it. PC stakes make it so much easier to disconnect and re-connect wires if that becomes necessary.

There are 13 wire links on the PCB and all except one of these are labelled "LK" on the overlay diagram. The exception is near C158. These two are shown but not labelled on our diagram. In addition, note that one of the links should be insulated (near D33).

With the job of installing the PC stakes and wire links complete, there is now the longer task of installing all the resistors and capacitors. This is where the colour photo of the interior published last month will come in handy. You can use it to cross-check that your resistor colour codes are correct.

Keep those leads short

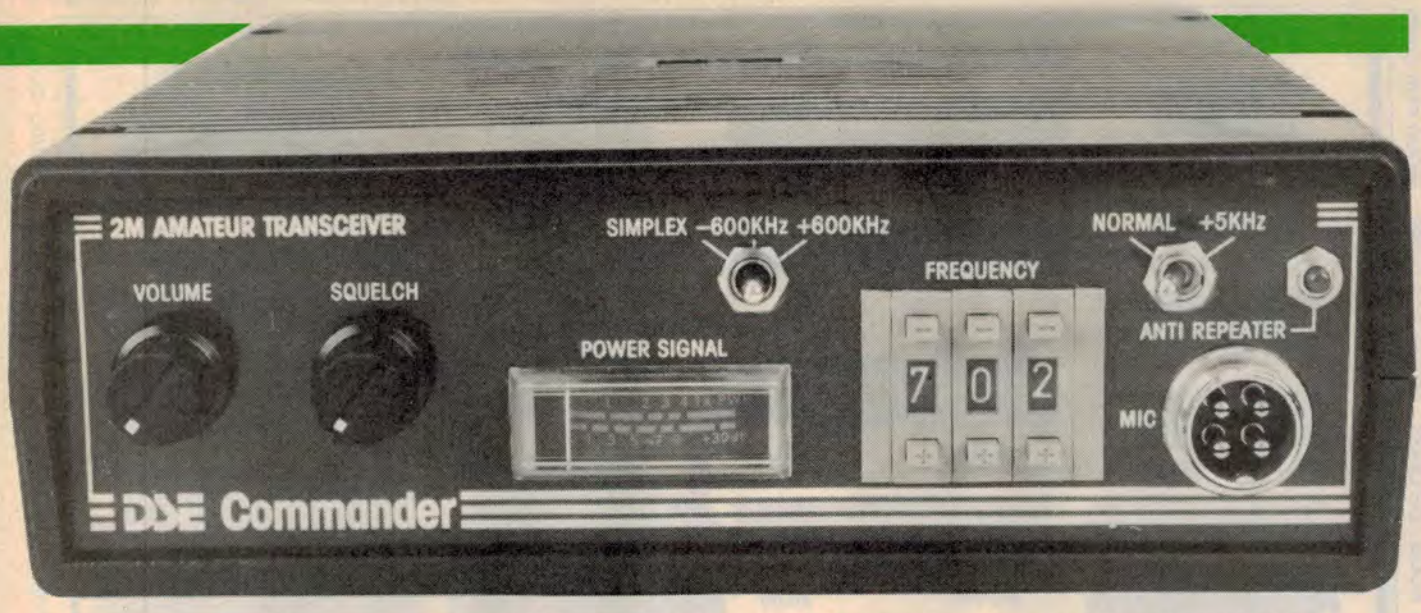
The most important point to remember when installing all these small components is that the pigtails should be kept as small as possible. Because the circuit is working at very high frequencies, any long component pigtails will act as unwanted inductors and play merry hell with the performance.

Quite a few of the resistors have to be stood "on end" to fit them in. When this is done the clearance between the end of the resistor body and the PCB should be around 1mm. It is a good idea to install these vertical resistors with the colour code running down the body. It is easier to check the resistor values in this way.

R111 (100kΩ) should not be installed before FL3 and Q8 are inserted and soldered. It loops over these two components.

Little comment is required with regard to mounting the capacitors except that you must use the capacitor type specified. There are no ifs or buts here. Do not interchange greencaps (ie, metallised polyester) for ceramics or tantalums for normal electrolytics (or vice versa).

C169 is a couple of light duty insulated wires twisted together. The amount of twist is adjusted (sounds very precise,



doesn't it?) during the calibration procedure.

Semiconductors

The semiconductor complement is 33 diodes, 30 transistors and seven integrated circuits. With the total at over 70, it might seem a lot but don't hurry the task to get through it quickly.

Mount the diodes first and again the pigtails should be kept as short as possible but take particular care with the diodes that are mounted "on end". Make sure that the polarity is correct.

Without wishing to labour the point, make absolutely sure about the polarity of diodes mounted "end-on". Remember that once you have soldered and clipped the leads you will not be able to re-use the diode if you find it has been installed the wrong way around.

Pay particular attention when installing diodes D22, D23, D24 and D25. The cathode end of these diodes is indicated by the red band. The yellow and orange bands make up the colour which indicates the 243 type number (ie, red, yellow, orange).

D14 is installed with cathode end up and anode to PCB earth. It is part of the pickup (including "gimmick" capacitor C169) for the meter circuit.

Care is also required when mounting the transistors to ensure correct lead orientation. Double check each transistor against the circuit diagram before soldering it into circuit. All the small signal plastic pack transistors, plus the metal encapsulated TO-18 types (Q6, Q7, Q17, Q25) should be mounted so that the transistor bodies are about 3mm above the surface of the PCB.

In practice, this simply involves pushing the transistors down onto the board as far as they will go without placing undue strain on the leads (and on your fingertips).

The TO-39 metal package transistors, Q20 and Q21, are mounted flat against the PCB. The metal case of Q21 must also be earthed by soldering it to a PC pin which should already have been installed. Clip-on heatsinks are also fitted to Q20 and Q21.

As already mentioned at the start, Q22 is mounted on the copper side of the PCB. It has four brass tabs which are soldered directly to the PCB copper pattern. Make sure it is correctly oriented before soldering.

The integrated circuits require little comment apart from the two that are CMOS. These are IC2 and IC3, the decimal adders, 4560. These should be soldered while the iron has its barrel connected to the PCB earth pattern via a jumper lead. Solder pins 16 and 8 of IC2 and IC3 first, and then the remaining pins.

Inductors

By now you are ready to begin installing the various RF transformers and coils. Ten of these have to be wound by you, the constructor. The necessary details of these are shown in the table on page 43 of this article. The main points to watch here are that you must use the correct gauge of wire for each coil and that the coils are wound exactly to specification.

Note that the hairpin coils L21 and L24 must be dimensioned exactly as called for in the table.

Coils L8 and L11 are supplied already wound and must be installed the right way around. If you closely examine the red plastic former of each coil you will notice that one side of the former has a long vertical rib while the other has a short vertical rib. In the case of L8, the long rib should be adjacent to L6. In the case of L11, the long rib should be closest to Q1, the BD140.

Assembly of the main PCB can now be completed by installing the filters, the four crystals, and preset pots.

Finally, it is necessary to shield the VCO to prevent spurious radiation into adjacent circuitry. Supplied with each kit is a strip of double-sided PCB laminate which should be cut into four 28mm lengths. The four strips are then soldered to the PC pins at the corners of the VCO circuit.

Final assembly

Attention can now be turned to the front and rear panels. These are supplied with the necessary cutouts for all the hardware and assembly is really very straightforward. For example, the frequency selector switch just clicks into place and has its own inbuilt retaining system.

Leave the heatsink assembly and meter off at this stage. Note that R37 (470Ω) is strung between the outside lugs of the volume and squelch pots, as depicted in the wiring diagram.

With the hardware fitted, slip the front and rear panels into their respective mounting slots in the case and mount the main PCB using the four self-tapping screws provided. The PC pins at the front and rear of the main PCB are now soldered to the end panels and the case fully assembled to make sure that everything fits.

Adjust the PCB assembly as necessary, then remove it from the case and run a series of solder fillets between the earth pattern of the main PCB and the end panels. This provides strength and rigidity.

With this done the rest of the assembly can be completed. Install the heatsink assembly for Q22, which comprises a short channel extrusion and a single-sided heatsink for the rear panel. These are secured using screws and nuts supplied with the kit. Finally, complete the wiring according to the diagram on page 48.

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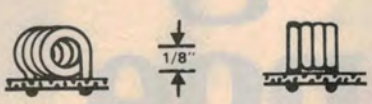
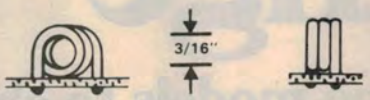
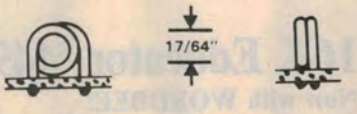
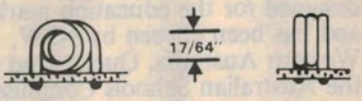
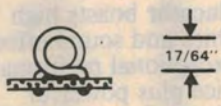
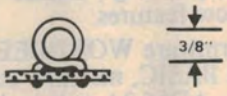
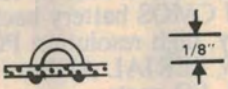
Alignment

This is quite a straightforward process although you do need access to some test equipment: (1) a digital multimeter; (2) a dummy load, eg, DSE cat D-7027; (3) a 5MHz (or better) oscilloscope; and (4) a digital frequency meter.

COIL WINDING DETAILS

L13	25 B&S En/Cu 1/8" (3.2mm) diam. close wound	4T	
L20 L30	18 B&S En/Cu 3/16" (4.7mm) diam. close wound	2½T	
L23 L25	18 B&S En/Cu 17/64" (6.7mm) diam. close wound	1½T	
L27 L28 L29	18 B&S En/Cu 17/64" (6.7mm) diam. close wound	2½T	
L22	18 B&S En/Cu 17/64" (6.7mm) diam.	1T	
L24	18 B&S En/Cu 1/4" (6.4mm) diam.	Hairpin	
L26	18 B&S En/Cu 3/8" (9.5mm) diam.	1T	
L21	25 B&S Tin/Cu 1/8" (3.2mm) diam.	Hairpin	
RFC2	Ferrite bead 25 B&S En/Cu	2T	
RFC3	6-hole ferrite choke 25 B&S Tin/Cu		

Initial settings

(a) set the core of L18 flush with the top of the can;

(b) Set the core of L9 two turns down from the top of the can;

(c) Set the core of L10 one turn down from the top of the can;

(d) Set the slug of coils L8 and L11 one turn down from the top of the former;

(e) Set VR68 to ¼ clockwise rotation.

Voltage checks

Connect the transceiver to a 13.8V DC power supply and make the following voltage checks:

(a) Without switching on the unit, check that the input voltage is 13.8V DC. This voltage can easily be measured between the switch contact on the volume control and earth;

(b) Switch on (without microphone connected) and check for +10V DC at the collector of Q1 (allowable tolerance 0.5V);

(c) Check for +10V DC at the emitter of Q4 (allowable tolerance 0.5V).

Synthesizer alignment

1. Check TP1 (Test Point 1) for 10kHz clock frequency at 6V P-P (approx). Measurement for TP1 can be easily taken from under the PCB at Pin 7 of IC6.

2. Check TP2 (output from L18 offset oscillator) for RF output. Use a sensitive RF probe or test probe as depicted in the diagram below.

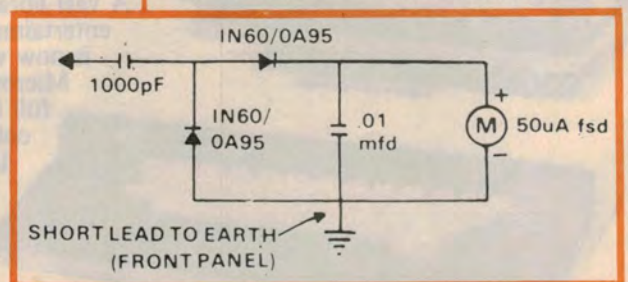
3. With oscilloscope on TP4 (mix down frequency), located at IC16, and the DC meter with the positive probe to TP3, adjust L8 (VCO coil) for 2.5—2.7V at 144MHz.

4. TP4 should show a signal of 600kHz at approximately 2V P-P (simplex — 144MHz). (Minimum level of 1V P-P and maximum level of 2V P-P nominal).

5. Adjust L18 (offset oscillator), for maximum amplitude at TP4.

6. Select 147MHz. The DC volts at TP3 should increase to approximately 5 to 6 volts. The oscilloscope on TP4 will show a level greater than 1V P-P at 3.6MHz.

7. Select 146MHz (simplex). Connect a dummy load to the output. The DC



This probe is required for alignment.

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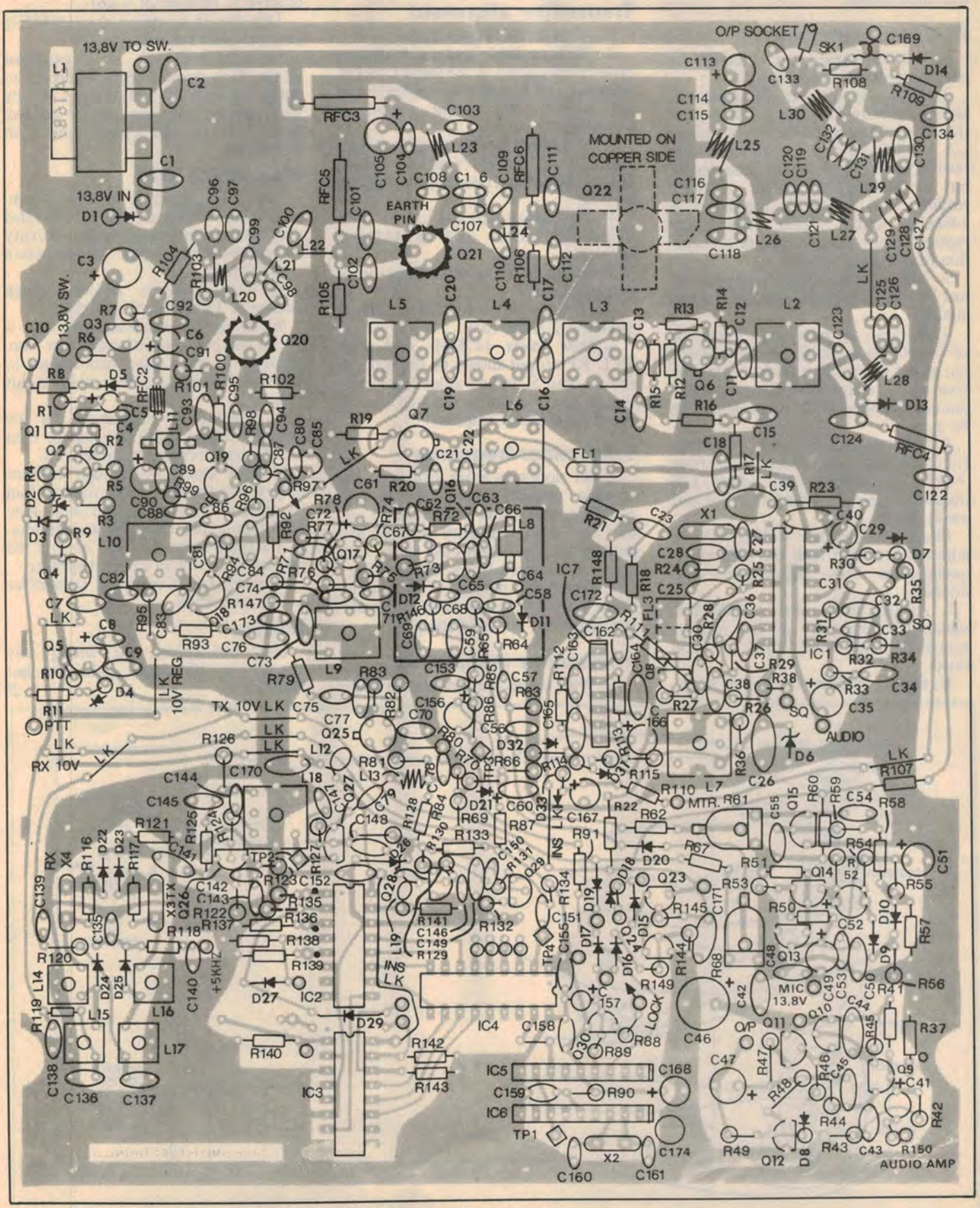

Use this diagram and the wiring diagram on page 48 to assemble your transceiver.

volts at TP3 should be 4—4.5 volts. Now press the PTT button for a short period and adjust VR68 for 4—4.5 volts as measured above.

Receiver alignment

1. With no signal input, adjust L7 for maximum noise in speaker.

2. With suitable signal source (ie, signal generator or a hand-held transceiver held near a radio, etc), adjust L2, L3, L4, L5 and L6 for maximum reading on the signal meter, reducing input as required to obtain ½ scale reading. This should be performed at 146MHz (centre band). Your local repeater, slow morse beacon or propagation beacon can be used.

3. With a known input frequency, adjust L6 and L7 for best sound (best audio quality).

4. With an accurate input frequency of 146.005MHz and the +5kHz switch on, adjust L14 for best audio quality. (A separate 2 metre transceiver using a dummy load and in close proximity can be used).

5. With an accurate input frequency (146.000MHz), now select switch from +5kHz to normal and adjust L15 (receiver frequency adjustment) for best audio quality.

Please note that the +5kHz must be adjusted first, and then the normal frequency, as these adjustments will interact.

6. At this point, with a calibrated signal, the sensitivity of the receiver should be better than 0.5μV for 12dB sinad.

If minor receiver instability is experienced, change R12 from 10kΩ to 12kΩ. This is due to the variation in gain of the RF amplifier, Q6.

Transmitter alignment

1. Align at 144MHz simplex.

2. With a suitable load and frequency counter connected to the output socket, press the PTT button and monitor the input current. RF output should be available.

3. At 144MHz simplex, adjust L9 for maximum RF output. Note that this is a critical adjustment; once adjusted, do not alter it.

4. Then adjust L10 and L11 for maximum RF output (still at 144MHz simplex).

5. At this point, the RF output should exceed 10 watts.

Approximate current drain is 1.9A at 10W and 2.2A at 15W.

6. Now select 147MHz and press PTT. RF output should be the same as that in Step 5, and no adjustment is required. (No tuning is required due to broad band power amplifier).

Transmitter frequency

1. Set normal/+5kHz switch to the +5kHz position. Set frequency to 146MHz, then press PTT, making certain that both frequency counter and dummy load are connected to the output. Then adjust L16 for 146.005MHz.

2. Switch the normal/+5kHz switch in the normal position and adjust for correct frequency (ie, 146.000MHz).

Transceiver modulation

1. With a suitable modulation meter or monitor receiver, adjust VR61 for 5kHz peak deviation. The setting for 5kHz peak deviation should be approximately ½ rotation of VR61.

This should be adjusted at 146MHz simplex (centre of band range).

2. Adjustment of twist capacitor C169: With dummy load connected to output, press PTT and adjust C169 by tightening or loosening turns to achieve 90% FSD on signal/power meter in transceiver.

Waxing the VCO

Once the alignment has been completed, the VCO enclosure can be filled with wax to ensure mechanical stability and prevent microphony. The procedure is as follows:

(a) With 144MHz selected, check voltage at TP3. Note this reading.

(b) Using your soldering iron, melt a liberal coating of transformer wax (supplied) on to the various components in the VCO but do not cover coil L8 at this stage;

(c) When cool, readjust L8 for the voltage reading previously noted; then use the transformer wax to seal L8.

In some cases, where high ambient noise forces the use of high volume from the internal speaker, microphonics may still occur despite the shield and the wax. If this occurs, the best way around the problem is to use an external speaker.

Construction of the VHF transceiver is now completed.

Errata

D18 was shown the wrong way around on the circuit published last month.