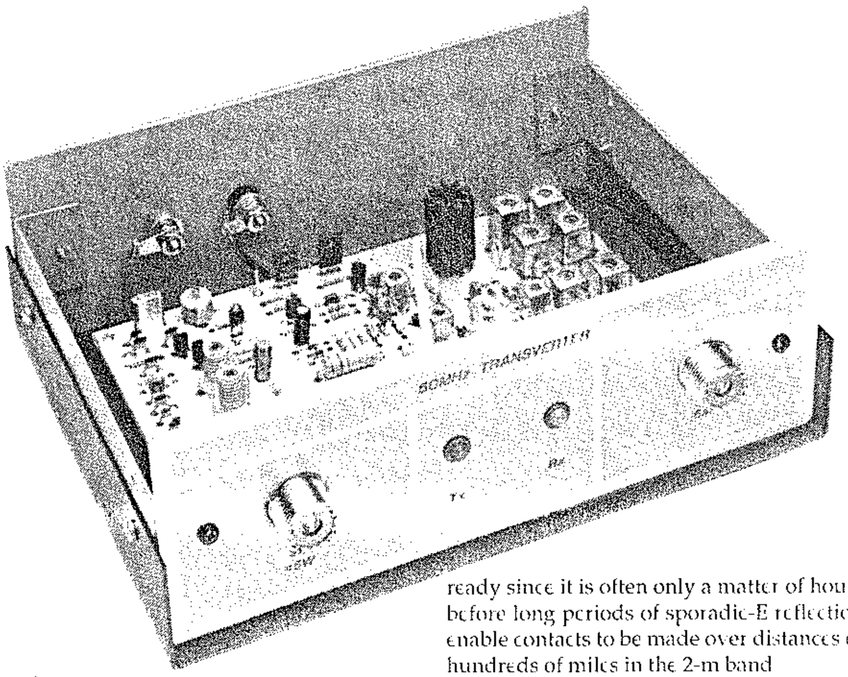
6-METRE BAND TRANSVERTER

Although it has been in use for over ten years in the UK, the 6-metre (50 MHz) band has recently gained a lot of attraction since the PTT authorities of a number of continental European countries including France, Holland, Belgium and Germany have, after a faltering start, issued the first few hundred 6-metre licenses to die-hard home brewers. The author invites you to partake actively in the growing 6-m activity. As shown in the 'specs' box on this page, the present transverter has quite a few distinct advantage over earlier designs that have appeared in the radio amateur press.

Pedro Wyns, ON4AWQ



MAIN SPECIFICATIONS

- **P-I-N-diode Rx/Tx switching; no relays**
- **Packet/Amtor compatible**
- **Output power approx. 1.5 W at 2 W input power (peak effective levels)**
- **Sensitivity approx. 0.2 µV for 20 dB SINAD**
- **VOX/ALC output**
- **Tx hang time set by user**
- **Ready-made inductors for easy construction and adjustment**
- **Eurocard-size PCB (10×16 cm)**

SITUATED at the low end of the VHF band, the amateur radio frequency segment between 50 and 52 MHz has some very exciting propagation characteristics. Thanks to atmospheric reflection, transcontinental radio contacts using very low powers have been made 'on six'. Radio amateurs working on the VHF and UHF bands know that the reception quality of signals from VHF Band-1 (48-68 MHz) TV transmitters can rise within minutes from very poor to quite acceptable. This often happens in the summer and early autumn, when there are temperature inversions in certain layers of the atmosphere. In the UK, where the VHF-1 band is no longer used for TV broadcast services, it is common practice among VHF radio amateurs to monitor the field strength of certain Dutch and Spanish TV transmitters. First, the syncs are audible, then the pictures seem to arise from the noise. The next thing to do is get the logbook out and the rig ready since it is often only a matter of hours before long periods of sporadic-E reflection enable contacts to be made over distances of hundreds of miles in the 2-m band.

A quite different type of propagation, TEP (trans-equatorial propagation), carries 6-m signals across the oceans, reaching stations thousands of miles away. Contacts have been made between European radio amateurs and stations in Rhodesia, South Africa, Namibia and Brazil, using CW on six metres.

In Europe, equipment for the 6-m band is mostly of the home-brew type, although Japanese 'black box' transceivers are starting to become available. The 6-m band is not crowded, and equipment being mostly experimental with modest transmit power, there is a certain distinction in being QRV on six.

From two to six and vice versa

The word transverter is an acronym for transmitter-converter. The circuit described here transposes received signals in the 6-m band to the 2-m band (144-146 MHz; in the USA: 144-148 MHz), while the transmit signal of the 2-m rig is transposed to the 6-m band (50-52 MHz; in the USA: 50-54 MHz). Basically, a transverter is a linear bidirectional mixer connected to an RF input stage and an RF power amplifier. Take a look at the block diagram in Fig. 1. When the transverter is in the receive mode, signals picked up by the 6-m antenna are passed through a filter before they are amplified by T4. Via an electronic RF switch based on p-i-n diodes, the 6-m signal arrives at the LO (local oscillator) input of a mixer. This may appear unusual, but it should be borne in mind that the LO and IF (intermediate frequency) inputs of the mixer are electrically interchangeable.

A local oscillator (LO) chain consisting of a quartz oscillator and two multiplier stages supplies a signal of 94 MHz to the IF input of the mixer. The up-converted 2-m signal is taken from the RF connection, and fed to the 2-m transceiver.

When the 2-m transceiver is switched to transmission, its RF output signal is rectified to control the electronic Tx/Rx (transmit/receive) switch based on T7-T10. The Tx LED lights, and the transverter is switched to

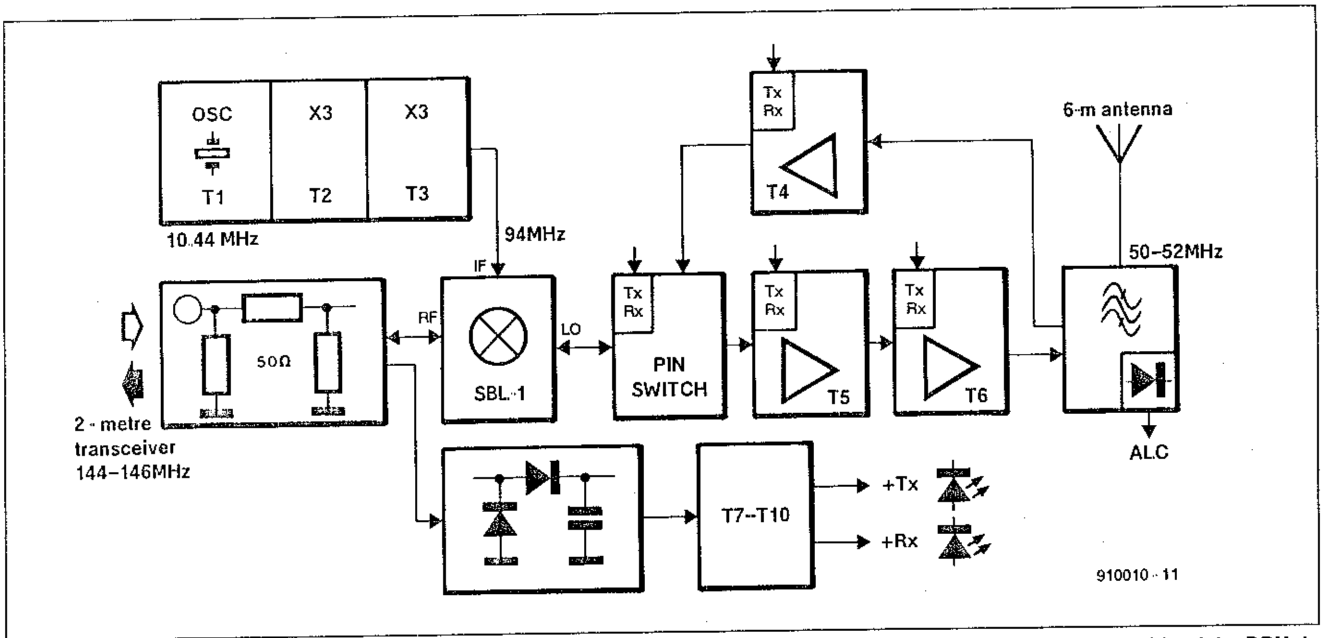


Fig. 1. Block diagram of the 6-m transverter. Not shown here for the sake of clarity is an L-C filter at the transceiver side of the DBM. In receive mode, this section forms a series filter tuned to 144 MHz. In transmit mode, it forms a 50 MHz notch. The switching is effected with a VHF p-i-n diode

transmit mode. The 2-m signal is first attenuated before it is mixed with the 94 MHz LO signal. The mixer output frequency, 50 MHz (with the 2-m rig tuned to 144 MHz), is fed to the input of an amplifier, T5. Then follow the RF power stage and the antenna filter. A signal rectifier in the output filter provides an ALC function or a simple RF signal level meter that may be used to monitor the transverter's output power. The 'hang' time of the Tx/Rx switcher may be adapted by the user to individual requirements.

The input and output impedance of the transverter are 50 Ω. The circuit is powered from a 12-V supply, which makes it suitable for mobile use.

Look: no relays!

The circuit diagram of the transverter, Fig. 2, follows the block schematic quite closely. At the heart of the circuit is a Type SBL-1 double-balanced mixer (DBM) from Mini Circuits Laboratories. This is a 7-dBm-LO, 1-dB-RF DBM for use up to 500 MHz. The SBL-1 is familiar to most VHF radio amateurs as it is used in many home made converters and transverters. An equivalent of the SBL-1, the IE500, may also be used in this circuit. An excellent discussion of DBM operation and selection criteria is given in Ref. 1.

Receive mode

Let's assume that the transverter is in the receive mode and start the description of the circuit diagram with the 94-MHz local oscillator chain. In the lower left-hand corner of the diagram we see a Colpitts-type quartz oscillator based on T1 and a 10.44 MHz quartz crystal X1. The oscillator operates with the crystal resonating at its fundamental frequency. An overtone oscillator running at 94 MHz was found less suitable here in view of the required stability and tuning capability. The output signal of the oscillator is multiplied by three to give 31.32 MHz at the collector of T2. A further tripler, T3, supplies the LO end frequency of 94 MHz at a power of about 10 mW. Via a short length of 50-Ω coax, the LO signal is fed to the SBL-1 (Mix1) which mixes it with the 50 MHz signal supplied by the receive amplifier, MOSFET T4.

Since the Rx supply line is at about +11 V, diode D4 is forward biased, while its Tx counterpart, D5, blocks. This 2-way p-i-n switch provides a high degree of RF isolation between the output of the receive amplifier, T4, and the output of the transmit amplifier, T5, ensuring that the switched-off circuit does not load the active circuit.

The RF signal picked up by the 6-m antenna is taken through a 50 MHz bandpass filter before it arrives at the G1 (gate-1) terminal of T4. The two antiparallel diodes, D1 and D2, form a clamping circuit that protects the MOSFET input and at the same time function in the Tx/Rx switching (remember, the RF power transistor, T6, is switched off because the +Tx supply line is at virtually 0 V). The amplifier based on T4 guarantees excellent sensitivity in the 6-m band, and has ample gain to compensate the mixing loss in the DBM. At the output of the receive amplifier, C31 forms part of a matching network that works in the both the transmit and the receive mode, while components R21 and C30 are used to bias the p-i-n diode.

The 94 MHz LO signal mixed with the amplified 50 MHz signal yields 144 MHz at the RF connection of the DBM. The 144-MHz signal is filtered by a series L-C network, C48-C49-L18 to bypass the transmit attenuator, before it is fed to the input of the 2-m transceiver.

Transmit mode

When the 2-m transceiver is switched to transmission, its RF output signal is rectified by D9-D10-C47. Consequently, transistor T8 is turned off so that T10 is turned on. The Tx LED lights, and the Tx supply line in the circuit is at about 11 V, while the +Rx line is at about 0 V. The +Tx voltage causes p-i-n diode D11 to conduct, which detunes the L-C series network and causes it to act as a 50-MHz notch. The 144-MHz CW or SSB signal is applied to a 50-Ω dummy load and attenuated by R32-R33 to give a suitable driving level for the DBM. Since the LO signal is permanently present, the IF connection of the DBM supplies the heterodyne frequency of 50 MHz. Diode D5 conducts, and the mixer output signal is applied to an amplifier stage based on MOSFET T5. This driver supplies an output power of about 40 mW to the RF power transistor, T6. The MRF237 used in this position is a VHF power transistor from Motorola. To ensure that the device operates linearly, its quiescent current is set to about 75 mA. The RF stage has an output power of up to 1.5 W, depending on cooling and the transistor characteristics. The quiescent current can be measured as a voltage across the 10-Ω supply resistor, R25. The typical voltage on R25 will be around 1 V.

A twelve-pole pi-type elliptical low-pass filter based on adjustable inductors is inserted between the RF amplifiers and the antenna connection. This filter has an additional notch, L15-C40, to trap the second harmonic (100 MHz).

The diode detector based on D7 and D8 may be used for output power level monitoring, adjustments or ALC (automatic level control) applications. The latter function however requires the two diodes to be reversed. The output may also be used to provide a basic RF power indication. The transverter has ample output power to drive a 6-m linear amplifier. The use of high power in the 6-m band is not advocated, however,

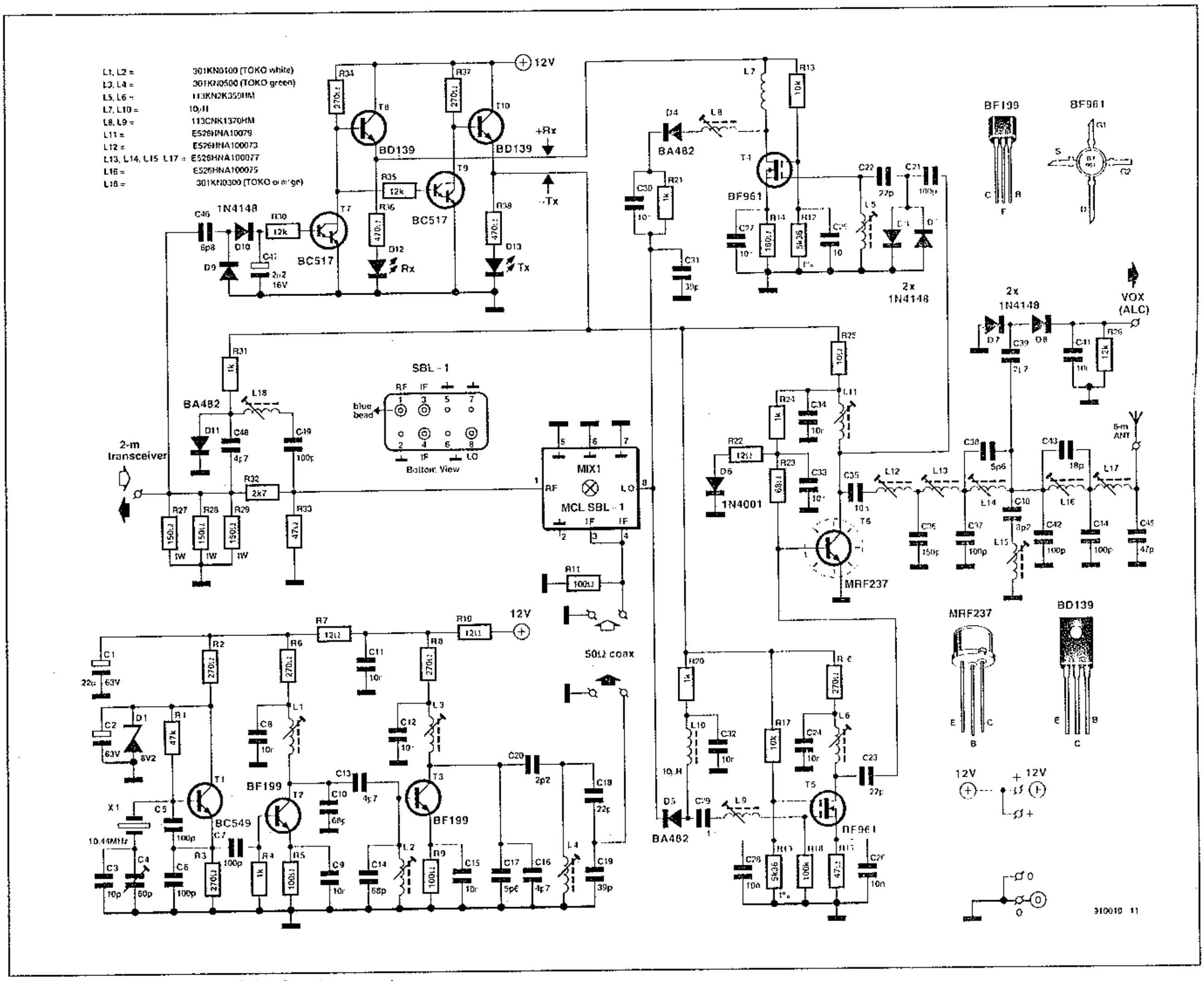


Fig. 2. **Circuit diagram of the 6-m transverter.**

and constructors should observe the maximum permissible EIRP level stated in their license In practice, the 1 5 to 2 watts or so furnished by the transverter will scrape the EIRP limits when a directional antenna is used, say, a five-element yagi with 10 dB gain Do not spoil the experimental character of the 6 m band by using excessively high power levels QRP is much more fun!

Tx/Rx switching

It will be noted that the circuit is totally solid-state, i e., the dreaded transmit/receive relay does not come into play All Tx/Rx switching is performed by p-i-n diodes, whose short response time allows the transverter to be used for Packet Radio and Amtor, where Tx/Rx switching is computer-controlled Note however, that your licence may not allow these communication modes on six The 'hang time' of the electronic Tx/Rx switch is determined by the 2 2 µF capacitor, C47 You may want to change this value to meet your individual requirements

Construction

The transverter is best built on the double-sided printed circuit board shown in Fig. 3 The complete circuit is accommodated on this Eurocard-size (10×16 cm) board which has a pre-tinned copper ground plane at the component side to ensure screening and decoupling of the RF signals Since ready-made inductors are used, the construction is really quite straightforward A few points must be noted, though.

Start by fitting the capacitors, resistors and diodes All parts must be fitted with the shortest possible terminal length Grounded component terminals must be soldered to the ground palne at the component side of the PCB Proceed with mounting the RF power transistor, T6 Experienced constructors may solder the case of this transistor flush to the copper screen at the component side of the board (see Fig 4) If you are less confident of your construction skills push the transistor firmly on the PCB surface, and solder the three terminals at the track side only Remember that the case of the MRF237 is connected to the emitter so that any direct contact between it and the ground plane is perfectly all right Soldering the MRF237 to the board makes for minimum stray capacitance and optimum cooling, which helps to ensure the stability of the RF power stage Carefully remove the solder resist mask locally with a sharp knife Next pretin the area Remove excess solder and solder resin with the aid of desoldering braid and alcohol Push the transistor firmly in place, and solder the rim on the case to the pretinned area Solder as quickly as you can, and go all around the case. The solder joint should be smooth If you have reason to believe that your solder iron is not powerful enough to do this job quickly, pre-heat the transistor with the solder bit until it is so hot that you can just pick it up and fit it on the board The MRF237 **must** be fitted with a heat-sink preferably of the type shown in the photograph of the prototype Never test the transverter without a heatsink fitted on the MRF237: the destruction of this fairly expensive device will be imminent.

Fit the mixer on the board, noting its orientation from the circuit diagram and the indication on the component overlay Push the device flat on the PCB surface, and solder all eight pins at the track side.

Next, mount the inductors. There are quite a few and the type numbers can be confusing so make sure you fit each of them in the right position The screening cans are soldered to ground

The last components to be mounted are

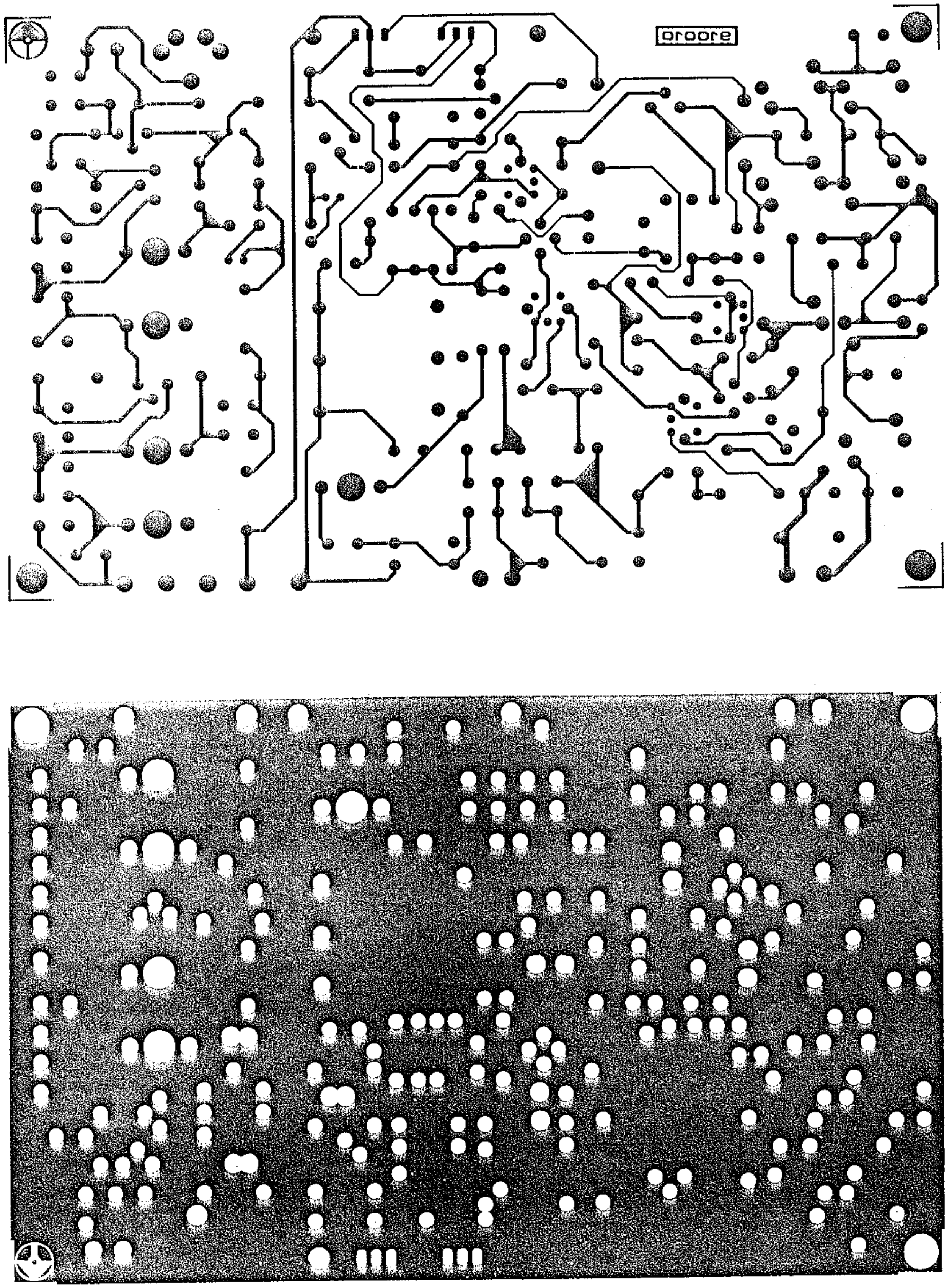


Fig. 3a. Double-sided printed-circuit board for the transverter.

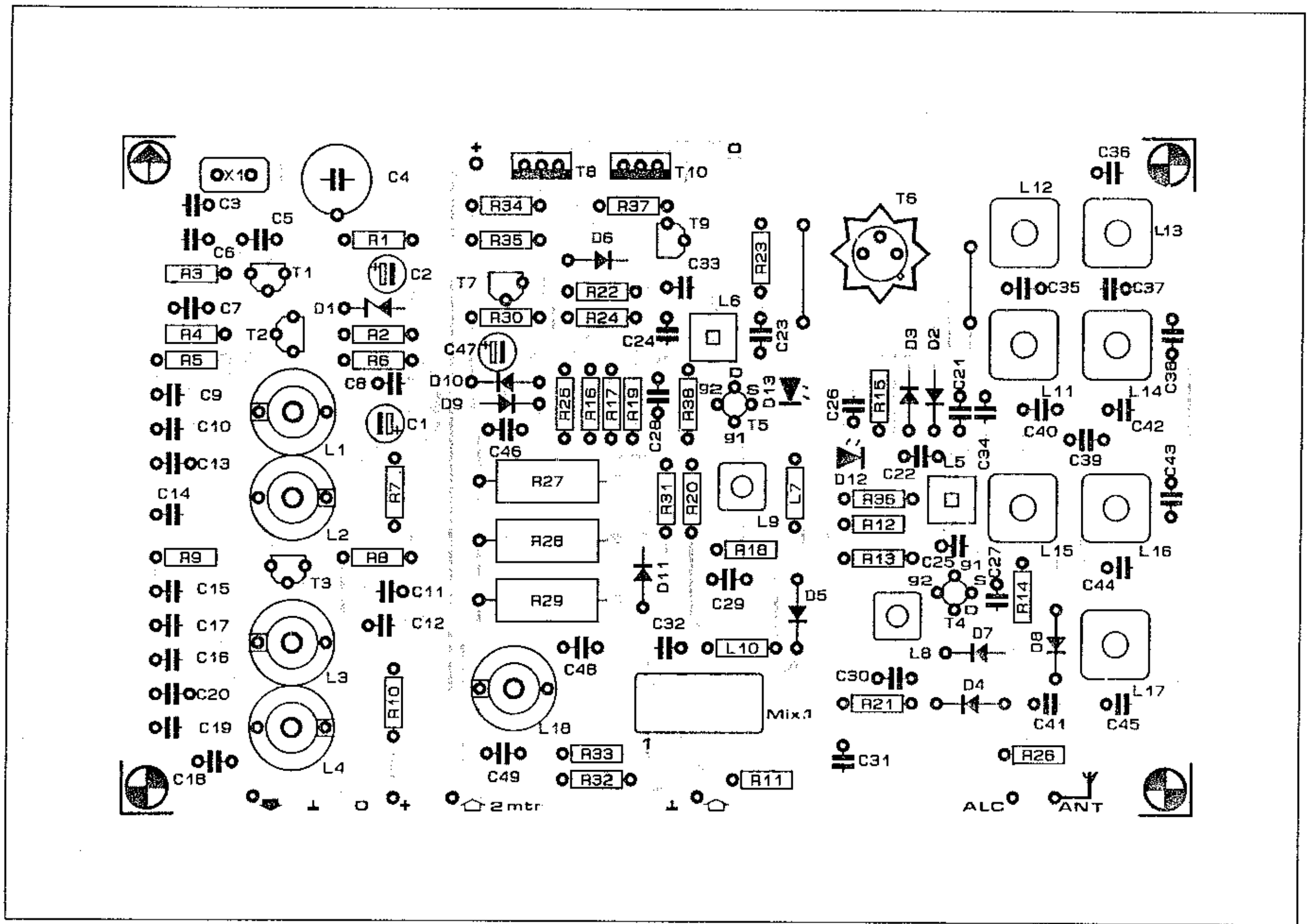


Fig. 3b. Component mounting plan

COMPONENTS LIST

Resistors:

1	47kΩ	R1
5	270Ω	R2;R3;R6;R8;R16
2	270Ω 0.5W	R34;R37
5	1kΩ	R4;R20;R21;R24;R31
3	100Ω	R5;R9;R11
3	12Ω	R7;R10;R22
2	5kΩ36 1%	R12;R19
2	10kΩ	R13;R17
3	150Ω 1W	R27;R28;R29
2	47Ω	R15;R33
1	100kΩ	R18
1	68Ω	R23
1	10Ω	R25
3	12kΩ	R26;R30;R35
1	180Ω	R14
1	2kΩ7	R32
2	470Ω	R36;R38

Capacitors:

1	2µF2 25V tantalum	C2
1	22µF 63V radial	C1
1	2µF2 16V radial	C47
1	60pF trimmer	C4

Ceramic capacitors:

1	10pF	C3
8	100pF	C5;C6;C7;C21;C37;C42;C44;C49
16	10nF	C8;C9;C11;C12;C15;C24-C28;C30;C32-C35;C41
2	68pF	C10;C14
3	4pF7	C13;C16;C48
2	5pF6	C17;C38
3	22pF	C18;C22;C23
2	39pF	C19;C31
2	2pF2	C20;C39
1	1nF	C29
1	150pF	C36
1	8pF2	C40
1	18pF	C43
1	47pF	C45
1	6pF8	C46

Inductors:

2	301KN0100 (white)	L1;L2
2	301KN0500 (green)	L3;L4
2	113KN2K359HM	L5;L6
2	10µH choke	L7;L10
2	113CNK1370HM	L8;L9
1	E526HNA100079	L11
1	E526HNA100073	L12
4	E526HNA100077	L13;L14;L15;L17
1	E526HNA100075	L16
1	301KN0300 (orange)	L18

(All inductors from Toko Inc.)

Semiconductors:

1	8V2 0.4W zener diode	D1
6	1N4148	D2;D3;D7-D10
3	BA482	D4;D5;D11
1	1N4001	D6
1	green LED	D12
1	BC549	T1
2	BF199	T2;T3
2	BF961	T4;T5
1	MRF237 (Motorola)	T6
2	BC517	T7;T9
2	BD139	T8;T10
1	red LED	D13
1	SBL-1 (Mini Circuits Laboratories)	Mix1

Miscellaneous:

1	10 444 MHz quartz crystal	X1
1	heatsink TO-39 style for T6; length 25 mm	
1	printed-circuit board	910010

Coax cable RG174/U

Note:
The author can supply a number of components for the transverter, including the DBM (IE500 or SBL-1), the 10.444 MHz quartz crystal and all inductors. For further information, contact
Pedro Wyns ON4AWQ, Mechelsesteenweg 13, 2220 Heist-op-den-Berg, Belgium
The majority of components for the transverter are available from
Bonex Ltd, 12 Elder Way, Langley Business Park, Slough, Berkshire SL3 6EP. Telephone: (0753) 49502. fax: (0753) 43812.

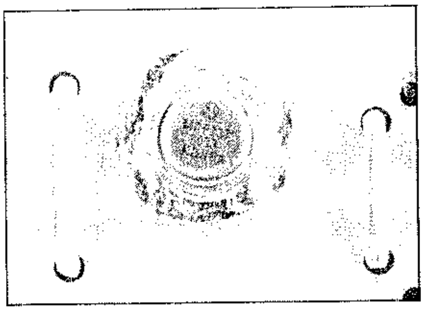


Fig. 4 Not for the faint-hearted: soldering the case of the MRF237 straight to the PCB ground plane

the transistors. While the BF199s BC517s and BD139s will pose little problems, pay attention to the MOSFETs. Do not remove the BF961s from their protective packaging until they are due for mounting. Aluminium kitchen foil is fine for storing these devices. Leave them on the foil while you run a thin, short wire around the transistor body, connecting the four terminals. Next, bend the terminals as required, and insert them in the PCB holes. **Check the orientation of the MOSFETs: the terminal with the tab at one side is the source. Also note that T1 is fitted upside down, i.e., its type indication faces the PCB.** Solder the terminals of the MOSFET before removing the shorting wire.

Inspect the board carefully for incorrectly fitted parts and bad solder joints. Next, connect a short piece of RG174U (dia 3 mm) coax cable between the output of the LO chain and the IF input of the mixer. Two pairs of solder terminals are available for this connection. Finally, note that the local oscillator section of the board may be cut off to function as a separate module.

The completed board (see Fig. 5) is fitted in a metal enclosure. The size of our prototype is 200×150×70 mm (W×D×H). The Tx and Rx indicator LEDs are best fitted on the front panel, with short wires connecting them to the board. UHF-style (Amphenol SO-239) sockets are used for the 2-m and 6-m connections. Use short lengths of RG58 or similar 50-Ω coax cable to connect the sockets to the appropriate PCB terminals. The screening must be connected at both ends of the cable. At the side of the socket, this means that you may have to use a solder lug.

The power supply is best connected via a chassis-mount plug of the type used on mobile transceivers. These plugs have two insulated pins, and connect to a screw-type cable socket. Both items are commonly available as spare parts from amateur radio retailers. It is recommended to insert a 2.5 A fuse in the positive supply line to the transverter.

The ALC output is optional, and since there appears to be no standard for this connection, any suitable combination of a plug and a socket may be used to carry the signal to other equipment.

Adjustment

The transverter is adjusted in steps as described below. First, however, build the RF signal detector shown in Fig. 6. This circuit is used to probe the RF signal levels at various locations in the circuit. The moving-coil meter may, of course, be formed by your multimeter set to the most sensitive current range. The preset in the detector, P1, is adjusted depending on the signal level measured. To adjust the inductor cores, you will also require a gate dip meter and a plastic Allen key. **Never** use a screwdriver or a metal Allen key to adjust the inductor cores.

Local oscillator chain adjustment

1. Connect the probe to the hot side of R4 (1 kΩ), and check for oscillator activity.
2. Tune the gate dipper to 31 MHz, hold it close to L1, and adjust the inductor for maximum reading.

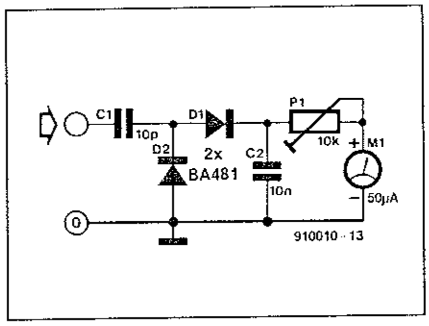


Fig. 6 Circuit diagram of a simple RF signal level meter used during the adjustment of the transverter.

3. Tune the gate dipper to 94 MHz, hold it close to L3, and adjust L2 and L3 for maximum reading.
4. Repeat steps 2 and 3.
5. Connect the RF probe to the hot side of R11 (100 Ω).
6. Adjust L3 and L4 for maximum reading. Check that the LO frequency is 94.00 MHz. If not, adjust C6.

Tx chain adjustment

7. The green LED (Rx) should light. Short the collector of T7 (BC517) to ground. The green LED goes out, and the red LED (Tx) comes on. Measure the voltage across R25 (10 Ω). This should be between 0.75 and 1 V. Remove the core from L9.
8. Connect a dummy load/power meter or an antenna to the 6-m output. Apply a continuous power of 100 to 500 mW to the 2-m input.
9. Adjust inductor L6 for maximum output power.
10. Adjust inductors L11, L12, L13, L14, L16 and L17 for maximum output power. Repeat steps 9 and 10.
11. Adjust inductor L15 for minimum signal at 94 MHz (use an FM radio for this adjustment).

Rx chain adjustment

12. Remove the short at the collector of T7. Connect an RF signal source to the 6-m input. Alternatively, ask a nearby ham to transmit a test signal on six. Tune the 2-m receiver to the test signal. Adjust L5, L8 and L18 for best reception. If necessary, gradually reduce the level of the test signal.

This completes the adjustment of the 6-m converter. The absolute maximum 2-m input power to the transverter is 5 W. In most cases, however, the maximum output power of about 2 W will be achieved with 2.5 W or less on 2 m. Switch the 2-m transceiver to SSB or CW, connect your 6-m antenna, and away you go. You are now QRV on six! International calling frequency: 50.110 MHz. ■

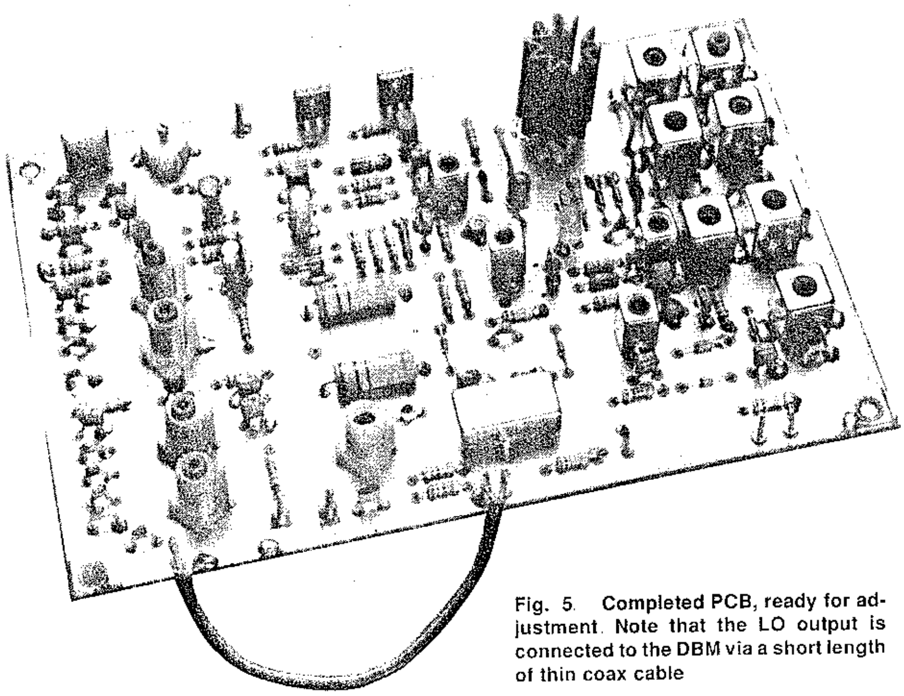


Fig. 5. Completed PCB, ready for adjustment. Note that the LO output is connected to the DBM via a short length of thin coax cable.

Reference:
1. RF/IF signal processing handbook. Published by Mini Circuits Laboratories, P.O. Box 166, Brooklyn, New York, U.S.A.