MODIFYING THE M/A COM 10GHz “WHITEBOX” RF MODULE (CENTRAL BASE STATION) FOR AMATEUR USE

by Peter Day, G3PHO

The Microwave Associates 10GHz RF transverter module was originally designed, during the 1980s, for use in a datacomms repeater system in the band 10.500 to 10.680GHz. A complete system includes the RF assembly described in these notes, together with a phase locked Local Oscillator and its external 5MHz reference, a 3dB power divider for the LO as well as a very comprehensive power supply, alarm and monitor board. The whole system was mounted in a substantial, waterproof white box, suitable for location out-of-doors.
In commercial use the system employed a receive IF of 135MHz and a transmit IF of 70MHz.

The Central Base station system differs to its “slave” or Sector Transceivers in that it has the added advantage of a two stage, low noise RF preamplifier, or LNA, in the receiver as well as a 1 watt o/p PA in the transmitter. The latter is a separate module needing some 200-300 mW drive to produce approximately 1 watt output.

The following notes detail modifications to the RF transverter module <u>only</u>. This module measures 19.2cm x 12.7cm x 7,5mm, including lids. Attached to the top lid is a small box containing circuitry that produces the necessary bias and supply voltages for the several GaAsFETs in the transverter module. This circuitry is essential and on no account should one attempt to operate the transverter without these supplies being present.

<u>First of all you should familiarise yourself with the basic layout of the module:</u>

Refer to Figure 1:
This shows the layout of the 10GHz RF sections, transmitter and receiver. The local oscillator (this would be 10224MHz for the 10GHz amateur band if a 144MHz IF were to be used) supplies some 60 to 80 milliwatts to a 3dB splitter (housed in a separate milled box). The splitter or divider then supplies 30 to 40mW to both TX and RX local oscillator inputs. SMA connectors are used for this purpose. Input, output and interstage sections are protected by means of ferrite isolators. It is wise to retain these if the various GaAsFETs are to be given protection from the effects of poor VSWRs during testing and setting up.

On the TX side, the LO drive is fed to a ring mixer, along with 144MHz RF and the resultant 10.368GHz signal is passed through a dual cavity, post mixer, filter where the LO and image frequencies are substantially reduced, leaving the required 10.368GHz signal to be amplified by two x2 stage GaAsFET RF amplifiers. The final output varies from unit to unit but the writer has measured 360 milliwatts at the TX RF output SMA connector.

The RX LO feeds a double image rejecting ring mixer via a relatively long length of 50 ohm stripline. No further filtering is required here. The mixer receives external 10GHz signals via a low noise amplifier which uses NEC GaAsFETs type NE710 and NE700. Typical Noise Figures achieved at the input connect are usually around 2.5dB and this can be substantially improved upon (ie down to 1dB or less) by the addition of an external HEMT preamplifier.

M/A COM 10GHz "WHITEBOX" RF MODULE (CENTRAL BASE STATION)

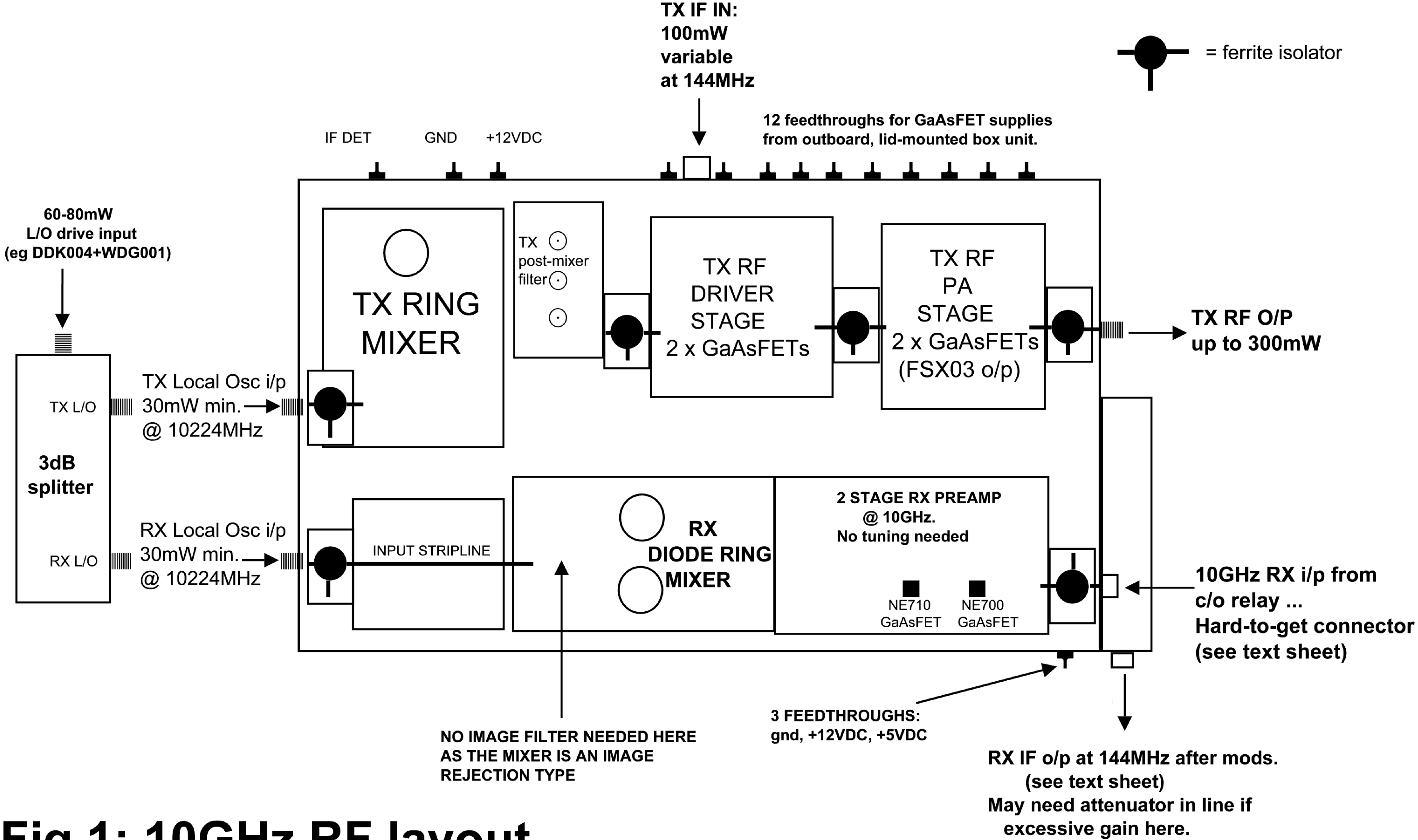


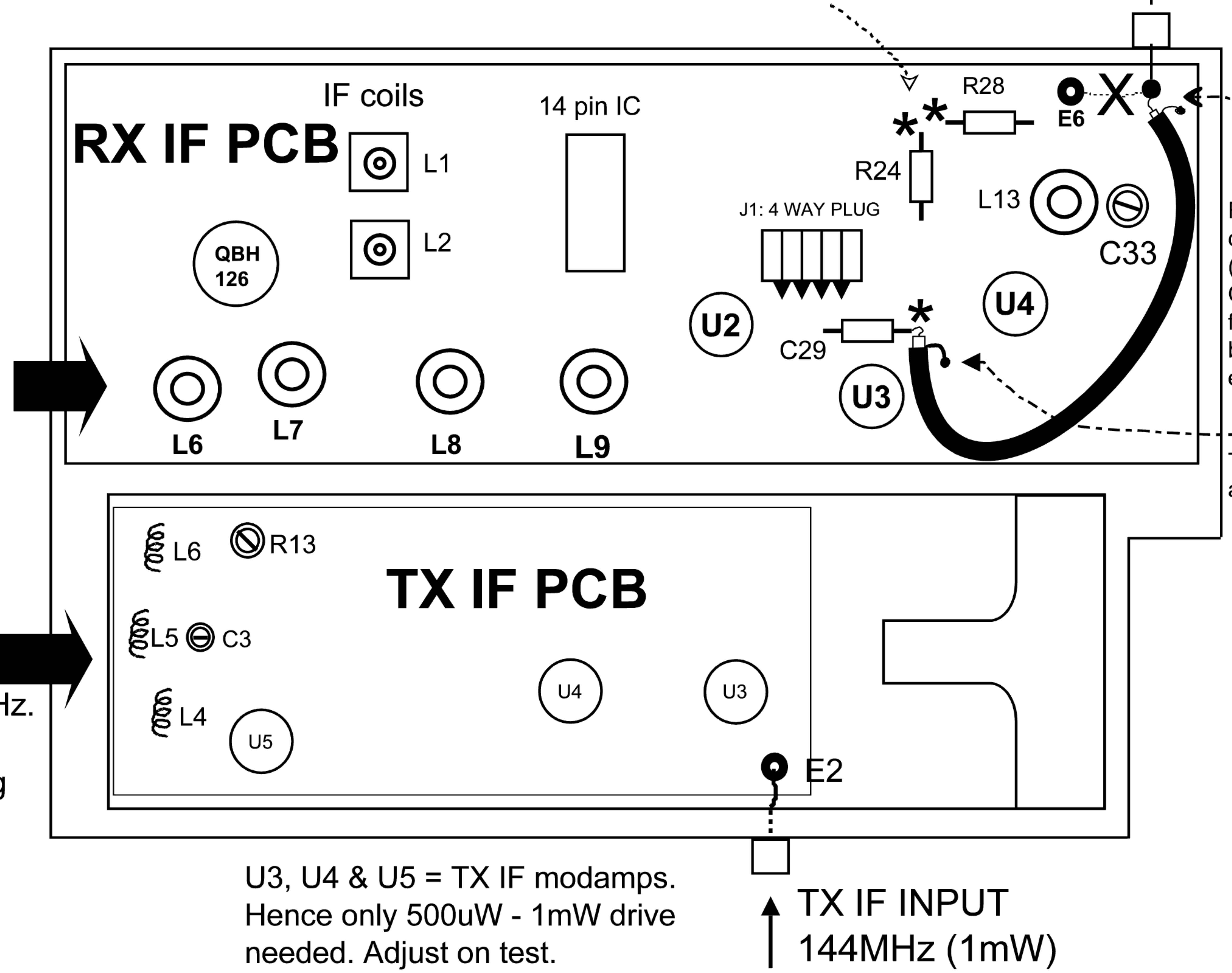
Fig.1: 10GHz RF layout

M/A COM 10GHz "WHITEBOX" RF TRANSVERTER MODULE
TX and RX IF PCBS (LOWER SECTION OF MILLED BOX)

Cut C29, R24 and R28 leads where shown, close to pcb

RX IF OUTPUT @144MHz

Retune L6 to L9 for maximum signal o/p into a 144MHz receiver. Use a marker or signal generator set to 10368.00MHz



Remove link between E6 and output connector. Solder thin 50 ohm coax (eg RG174) between o/p socket and C29 (whose right leg has been uplifted from the pcb by cutting it close to the board. Ground the coax outer at both ends by soldering to pcb groundplane.

This modification renders U3, U4, L13 and C33 redundant.

L4,5,6 may need shortening to resonate on 144MHz. Try squeezing together or shorting out a turn on each. **DO NOT ADJUST C3 OR R13**

U3, U4 & U5 = TX IF modamps. Hence only 500uW - 1mW drive needed. Adjust on test.

TX IF INPUT 144MHz (1mW)

Fig.2

Figure 2:
This shows, an a condensed form, the main features of the TX and RX IF sections which are located in the underside compartments of the transverter module. Both these parts of the module are constructed on standard printed circuit board, unlike the RF boards which are of high quality Duroid type.

The RX IF pcb contains a Hybrid input circuit and preamplifier fed by the ring mixer diodes. The received signal is subsequently amplified by some 40 to 50dB in a chain of three modamps. There is far too much gain here for amateur purposes. The modifications detailed below deal with this quite effectively.

Similarly there is a lot of gain in the TX IF circuit. If the circuit is used unmodified only -3dBm or so of 144MHz drive is required but this can vary from unit to unit.

Connectors:
All but one of the connectors used in this transverter module is readily available from such sources as RadioSpares, Farnell or at the many amateur radio rallies held throughout the UK each year. The RX front-end input connector is another matter though! It is a specific OSM connector which the writer has not been able to obtain from the usual sources. Microwave Associates UK quoted almost £40 in the mid 1990’s for a single matching connector! As a result some typical amateur “D.I.Y” was called for (see modification details later). However you may be fortunate in obtaining your transverter module complete with its WG17 to OSM transition as the original system was fed by a waveguide filter. If so, it is possible to make up an extra WG17 transition (to SMA connector) that can be bolted back-to-back with the one supplied. In this manner the TX/RX antenna changeover can then be done by means of a 10GHz coaxial relay.

A second, VHF relay, is also needed to change IF input from TX to RX.

Power Supplies:
The complete system originally had a complicated power supply with interlocking warning and monitoring features. To power the transverter module alone, all that is needed is a supply providing +12VDC at up to 1 amp and -5VDC at say 100mA. A bias board, housed in the small box attached top the transverter lid, then produces the required bias voltages for the various semiconductors in the trasnmitting section of the module. (see Figure 6).

The receive section has its bias supplies derived from the 14 pin IC and 2N3904 transistor found on the RX IF board. (see Figure 7).

Note the many feedthrough terminals found on the sides of the module. It is essential that all these are connected correctly, the -5V being active on both TX and RX. However, for full protection of the RX LNA GaAsFETs it is suggested that the +12V supply at the feedthrough next to the RX IF OUT socket be switched off during transmit. A suitable 12V relay can easily do this via the PTT arrangement used for send/receive. Make sure that the -5V is left ON at all times.

Fig. 3: MAKING A D.I.Y OSM CONNECTOR

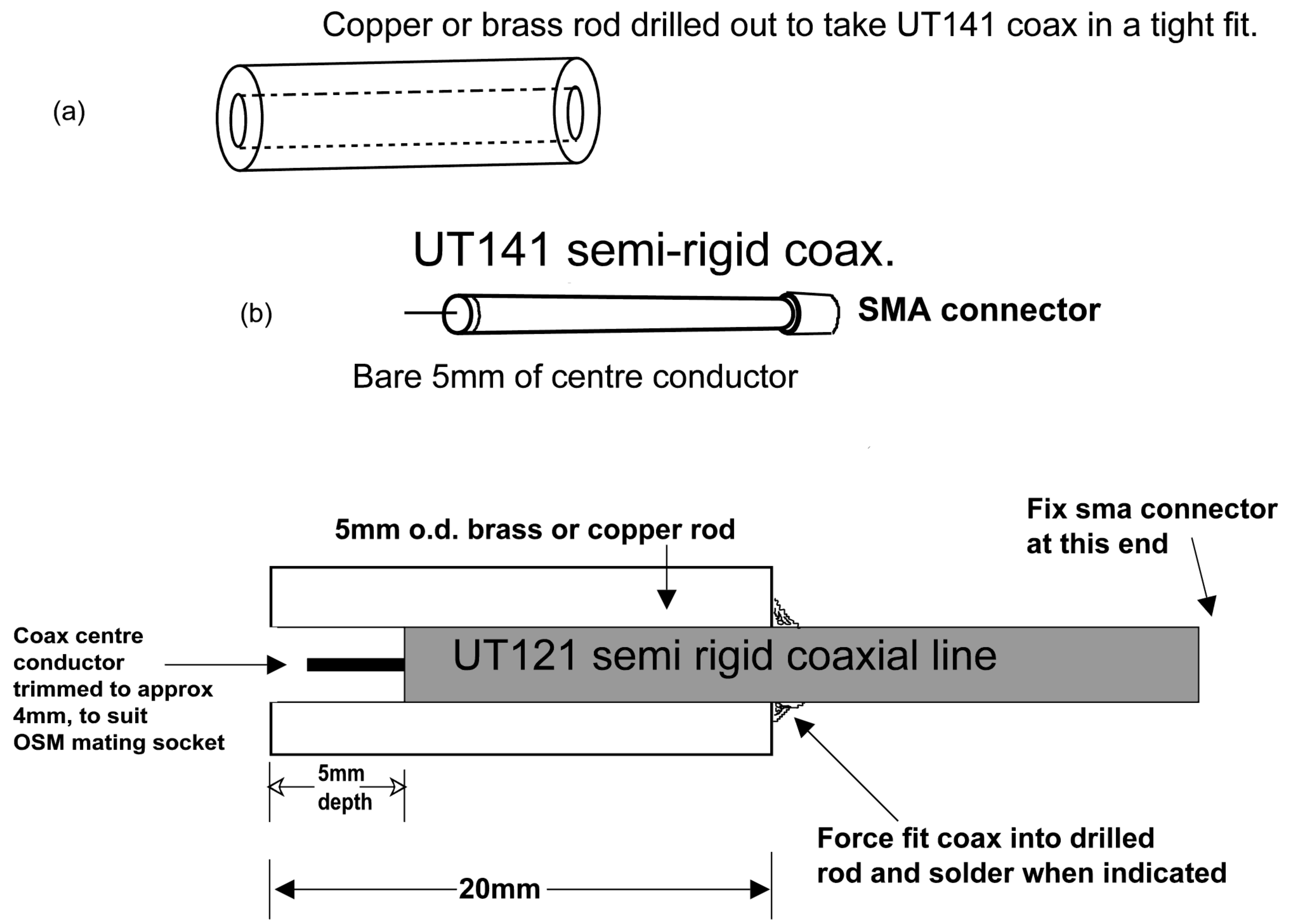
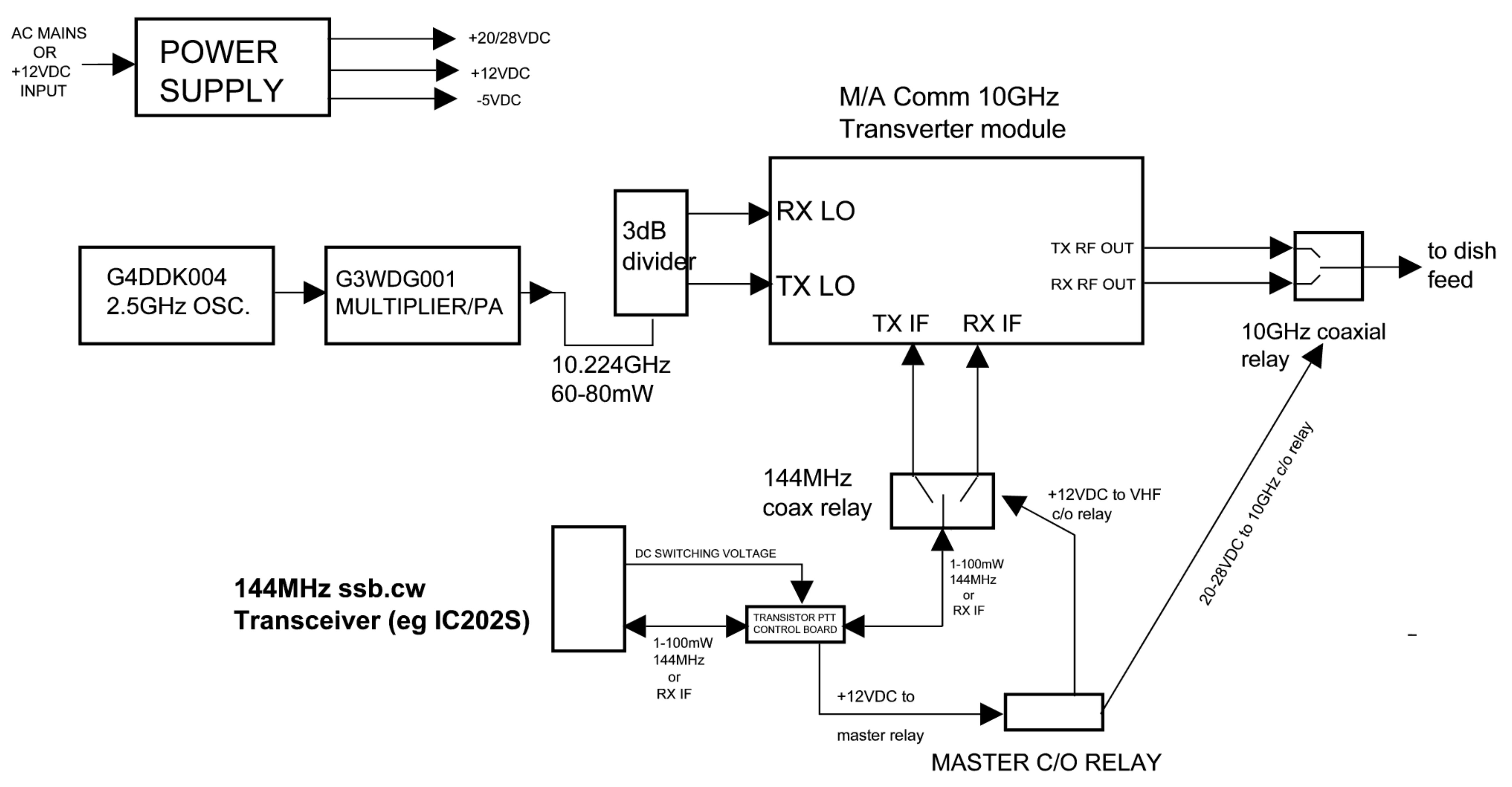


Fig. 4: 10GHz SYSTEM



THE MODIFICATIONS

[1] LOCAL OSCILLATOR:

If the original local oscillator is available it will need a new crystal and some measure of realignment to get it onto 10.224GHz. There are several published articles on how to get these so-called “brick oscillators” onto the amateur bands, the best being found in past copies of the ARRL’s Microwave Update Proceedings.

Otherwise, it is a matter of building one’s own stable crystal oscillator. Highly recommended and easy to build is the G4DDK004 2.4GHz oscillator module driving a G3WDG001 multiplier/amplifier to 10.2GHz. With care, this combination can achieve the required 60 to 80mW of 10.224GHz drive required. For better stability, it is suggested that the 106.5MHz crystal used in the DDK004 module is fitted with a Murata Posistor crystal heater and that the crystal is specified for the temperature characteristic of the heater (say 40 deg C).

If the 3dB divider module does not accompany your transverter module you have a problem but it is not to difficult to overcome. You can either switch the 10.224GHz LO between the TX and RX LO inputs, using a second 10GHz coaxial relay OR construct your own power divider. The latter is best done on RT Duroid pc board. (see Figure 5) It may be possible to make a “bodge” divider by using an sma T-connector is you can find one and then using equal lengths of semi rigid + sma connectors for each LO port. A waveguide 16 divider is possible but is of course physically larger than a connectorised one.

[2] TX & RX IF PCBs (Lower section of the Transverter module)

For setting up both these IFs, it is assumed the local oscillator is connected and operating correctly at a minimum drive level of at least 30mW per LO port on the transverter and at a frequency of 10.224GHz.

The TX IF used by the writer is 144MHz: **(refer to Figure 1 and 2)**

To line up the transverter on TX:

a) Connect a microwave power meter to the TX RF output socket. The power meter should be capable of reading several hundreds of milliwatts (ie a 100mW head with suitable coaxial attenuators). Better still would be to connect the TX RF output to a spectrum analyser (via suitable attenuators).

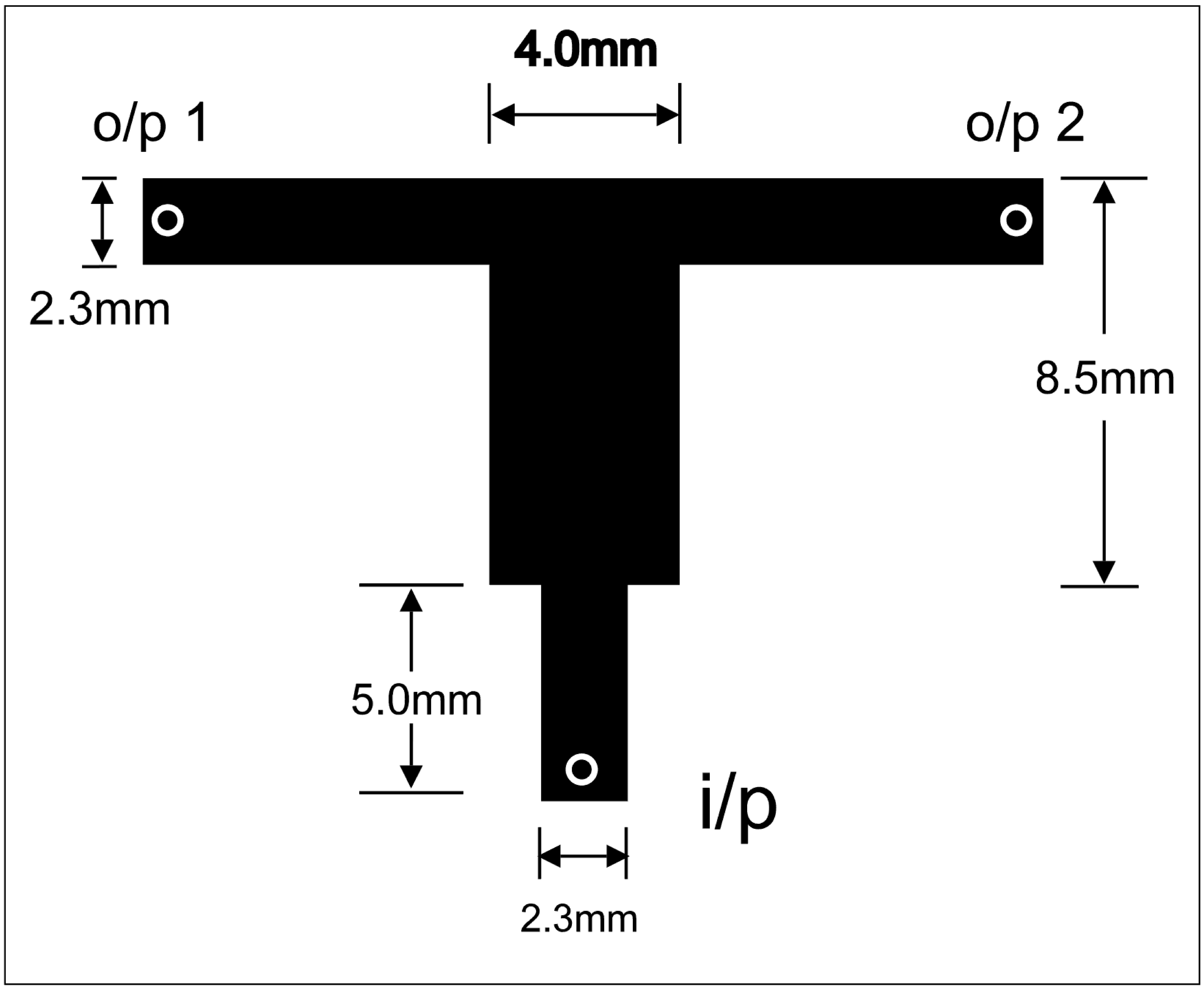
b) Feed a few milliwatts of 144MHz, through a variable attenuator, into the TX IF input socket and, with a bit of luck, the power meter and/or spectrum analyser should indicate output at 10.368GHz. The TX IF strip employs three modamps, producing a lot of gain at this stage!

c) Using a suitable allen key, adjust the two outer screws in the TX post mixer filter for maximum RF out at 10.368GHz, consistent with minimum output at 10.224MHz.

If you have a 10GHz wideband receiver you can adjust this filter without having 144MHz drive applied. Just listen for the 10.224GHz signal in the wb receiver and adjust the filter for minimum signal. This will get you “into the ball park” so that final tweaking can be done with 144MHz drive applied. Adjust the centre screw after peaking the two outer ones. Repeat the process several times for best results.

3dB stripline power divider for 10GHz

Figure 5



Material: RT Duroid 5870

Solder sma connectors at tip of each line

Design frequency = 10.224GHz but should still work at 10.368GHz

d) 144MHz drive should be adjusted for maximum 10.3GHz output. The air wound coils L4, L5 and L6 on the TX IF pcb (see Figure 2) can be adjusted for maximum output by squeezing the turns together or by shorting out a turn or so on each. This circuitry will work up to about 120MHz . The writer found that 144MHz drive easily passed through the circuit to mix with the 10.224GHz LO. The amount of 144MHz drive will vary from unit to unit. Adjust until an further increase at 144MHz produces no further increase in 10GHz o/p. Then back off the 144MHz slightly.

No further adjustments are needed to the TX section as the PA is broadband enough to work at 10.3GHz. Final power output should be at least 200mW and maybe as high as 350mW.

The <u>RX IF</u> is a different matter. **Refer to Figure 2**.

a) The RX IF output port should be disconnected from its original post E6. Turning to C29, cut its lead close to the pc board so that the right hand leg of the capacitor can be carefully lifted clear of the pcb. A length of thin, 50 ohm coaxial line (eg RG174) can then be soldered to this cut lead, the other end being soldered to the centre pin of the RX IF output connector. The outer braiding of the coax can conveniently be grounded to the pcb groundplane at each end of the line.

b) Cut R24 and R28 as shown in Figure 2. This effectively disables two of the high gain modamp stages in the RX IF chain.

If modifications a) and b) are not done, the RX IF gain is in the order of +50dB, far too much for an IF receiver such as an IC202 or FT290 !! The modifications bypass two gain stages and reduce current drain on the power supply in the process.

c) Connect the RX IF output port to your 144MHz receiver. Apply 10.224GHz local oscillator drive at a level of 30 to 40mW to the RX local oscillator. The RX RF input connector can be left unterminated if so desired. Using either a calibrated 10GHz signal generator, a low level crystal-controlled signal source at 10.368GHz or a harmonic of a lower microwave frequency (eg a few tens of milliwatts of 1296MHz driving a simple diode multiplier), tune the IF receiver for a signal at 10.368GHz. Close coupling of the signal source to the RX input may be needed here. Once it is heard, adjust the cores of L6, 7, 8 and 9 on the RX IF board (Figure 2) for maximum S meter reading on the 144MHz receiver. Coils L1 and L2 can also be peaked. The writer found the cores of all these coils needed to be wound outwards by a number of turns.

Coil L13 and capacitor C33 need no adjustment as they have effectively been removed from the circuit by the modifications described in b).

These modifications leave one IF modamp in circuit. If the gain is still excessive, as indicated by a high standing noise level on the 144MHz receiver S-meter, there are two courses of action open:

1. Add a suitable in-line attenuator between the coax line installed in the unit and the RX IF output connector, OR
2. Cut R23 to render modamp U2 ineffective and connect the coax line to a two link insulated link winding over L6 (the writer has not tried this but it should work!)

No modifications are need for the LNA. The RX NF should be around 2.5 to 3.5dB.

[3] Making a DIY OSM Connector for the RX RF input port

The RX input port needs an expensive, hard-to-get matching connector. The writer fortunately has a matching WG17/OSM transition. If this is not available it is still possible to make a suitable connector, using no more than a 2cm length of 5mm brass or copper rod and a longer length of .141" semi-rigid coaxial line, terminated at one end with a standard SMA connector. **Figure 3** illustrates the general idea. It is important to make the brass or copper rod section a firm fit into the OSM receptacle on the transverter module. A short mounting strap could also be fashioned to enable the whole assembly to be bolted down to the wall of the module, using the two holes found either side of the OSM connector.

INTERFACING THE TRANSVERTOR MODULE TO THE 144MHz TRANSCEIVER

To make this unit operate as a complete 10GHz system, you will need a coaxial change-over antenna relay, connectorised with SMA, and rated to at least 10GHz. There are several types available on the surplus market. Dynatech and Transco types will work up to 18GHz. Most of these are 28V DC types but will operate on 20 volts. Expect to pay around £30 to £45 for one of these relays, depending on the source!

Another, VHF coaxial type, will be needed to change the 144MHz transceiver from the TX IF input port to the RX IF output port.

A third relay will be needed to switch the positive supplies to the two GaAsFETs in the receive LNA if these devices are to be given maximum protection during transmit periods. Remember to leave the -5V supply connected at all times!

These three relays will be operated by a transistor relay keying circuit when the microphone PTT is operated for transmit. The keyer circuit works on the basis of there being a positive DC voltage at the antenna port of the receiver (in the receive state for an IC202 or the transmit state for an FT290MkII).

A suitable power supply will need to generate +12V and -5V for the transverter and +20 volts for the 10GHz relays, the other relays being +12VDC types. If 3 terminal regulators and/or voltage step-up ICs are used in the PSU it is very important to bypass their input and output terminals with the recommended values of tantalum or electrolytic capacitor. Low ESR types are highly recommended for use with the step up ("switcher") ICs.

Figure 4 shows a complete 10GHz station based on the M/A Comm transverter.

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