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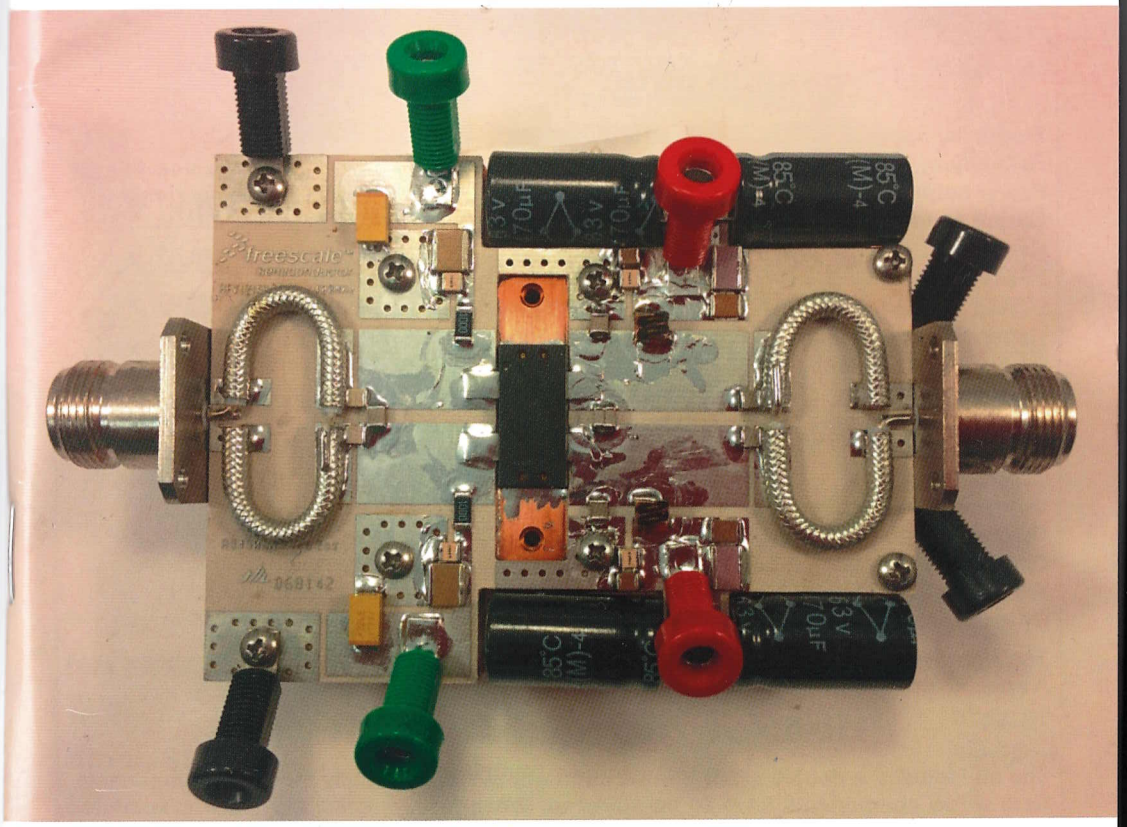
400 W SSPA for 23 cm



by W7FSL

Magazine for Amateur Radio on VHF/UHF and Microwaves

Modifications for the MTRU UMTS PA module from HUAWEI for usage on 13 cm (2320 MHz)

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The MTRU UMTS PA module from HUAWEI is available from several sources (Ebay, surplus dealers) for under 100 Euro, the PA board alone for even less.
This power amplifier original specification was for 2110-2170 MHz and 50 W CW power output, at a lower supply voltage of 20 V. The modified amplifier will be powered with 28 V, supplied via the MOLEX socket of the unit. The PCB of this power amplifier appears in two revisions: QWD1DA50 ver. B and QWE1DA51 ver A. This article describes the adaptation of the PCB labeled QWD1DA50 ver. B. See Fig.1. The final stage consists of two MRF6S21140H LDMOS transistors [1]. It is preceded by a driver using the MW6IC2240N [2] and an SXA389BZ MMIC [3].

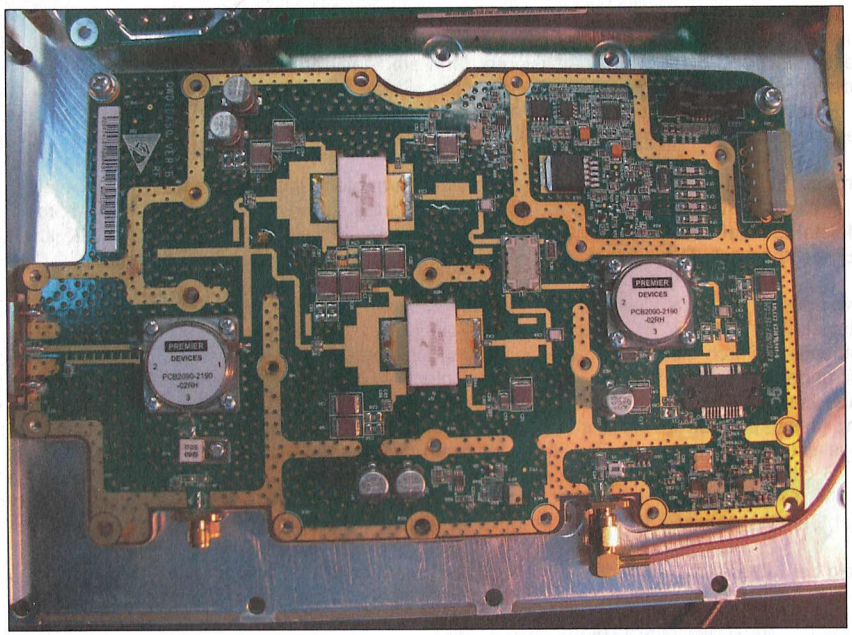


Figure 1: MTRU UMTS PA from HUAWEI, QWD1DA50 ver. B, before modification

There are circulators between the MW6IC2240N driver and the final transistors and also on the PA output. It is not known how broadband they are (they have never been measured) and, in the case of the output one, what power they are able to handle. Thus the output circulator should be replaced by a PCB with a 50 Ohm microstrip track (on a microwave laminate) or short piece of semi-rigid cable UT141 (or similar).
In the first case the track width (w) can be calculated with the software AppCAD [4]. The results for several teflon laminates are:

- Rogers Ultra Lam 1250 ε_r=2,5 H=1,2 mm -> w=3,4 mm;
- Rogers RT/duroid ε_r=2,33 H=1,57 mm -> w=4,6 mm;
- Taconic TLC-32 ε_r=3,2H=0,76 mm -> w=1,8 mm;
- ε_r=2,5 H=0,76 mm -> w=2,1 mm;
- ε_r=2,8 H=1 mm -> w=2,6 mm;
- ε_r=3,1 H=1,5 mm -> w=3,6 mm.

Because of the proximity of the PCB mounting bolts, the track cannot be too wide.

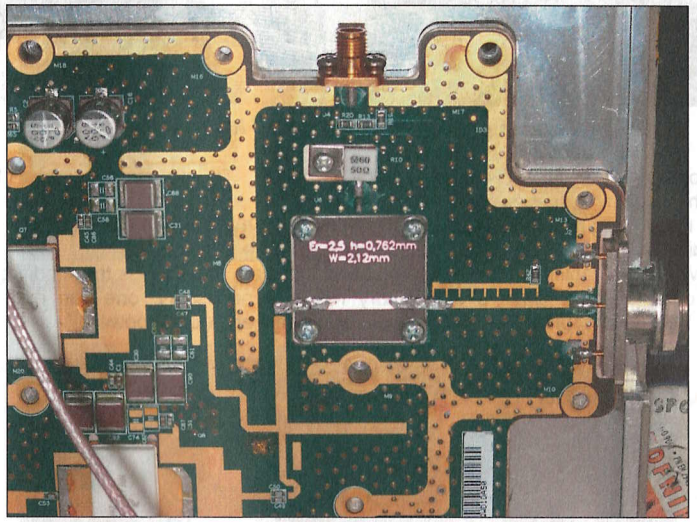


Figure 2: PCB with 50 Ohm track inserted instead of the output circulator

Two control wires have to be soldered to the socket J6. They are for the PTT (pin 6) and the supply for the SXA389BZ (pin 9). While transmitting the PTT should be connected to +12V to +28 V. The proper supply voltage for the SXA389BZ is provided by the MIC29302 voltage regulator, which should not be connected to 28 V, because its maximum input voltage is 26 V. Pins 6 and 9 can be connected together and controlled by a 12 V PTT signal, taking into account the current of 120 mA.

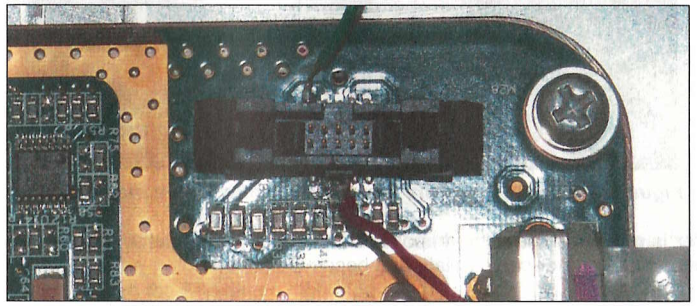
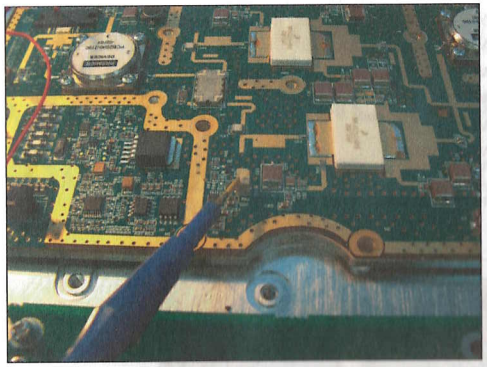
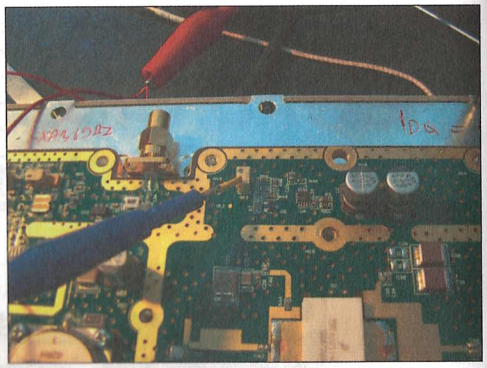


Figure 3: Socket J6

Next the quiescent currents of the output transistors are set. For this the potentiometers RP3 and RP4 are set to minimum, then a 28 V supply (through an ammeter) is connected and the 12 V PTT applied. The measured current should be about 520 mA (from the MW6IC2240N driver). Adjust the potentiometer RP3 to get a current of 520+1200 =1720 mA (1200 mA quiescent current for Q7), similarly, by adjusting RP4 try to get 1720+1200 =2920 mA (1200 mA quiescent current for Q8).





Figures 4 and 5: Potentiometers RP3 and RP4

Now proceed to modify the output transistor matching circuits. Try to make the same changes for both transistors. At the beginning, prepare two pieces of thin copper sheet with the dimensions 12x8 mm. They will be used to modify the gate matching circuits. Solder these sheets as shown in figure 7. The output circuits are modified by cutting part of the PCB track (see figure 7).
At the time of writing, 4 amplifiers have been modified this way. In all cases the modifications applied to the input and output circuits gave a satisfactory result. If necessary, one can experiment with the matching of the MRF6S21140H driver and get even more gain and output power.

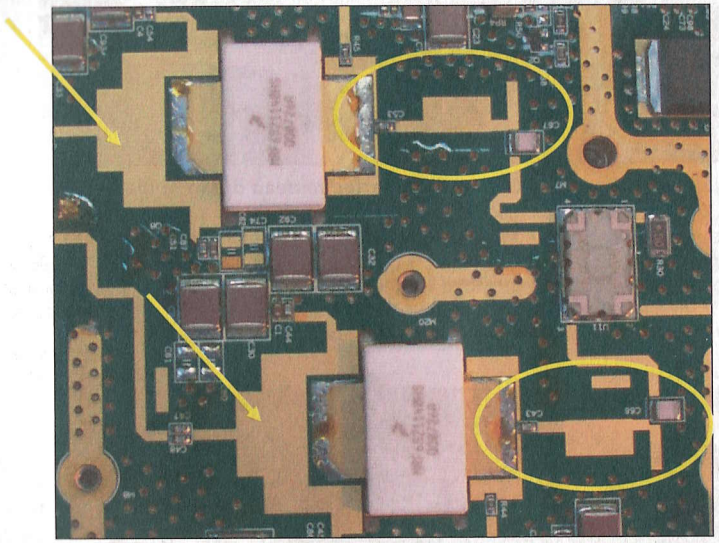


Figure 6: Output transistors matching circuits before modifications

Now the amplifier is ready for operation. Important: When the PA is operating the upper shield must be attached, otherwise the amplifier can oscillate and become unstable.

Results

- Output power P_{1dB}, when supplied with 28 V: 170-180 W
- Max. current: 17 A
- Gain for P_{1dB}: 43-44 dB (drive power 6-8 mW)
- Input SWR: 1.35:1

One of the modified amplifiers delivered 200 W output power at 2 dB gain compression. No tests were carried out to obtain higher power due to the current limiting of the power supply used.

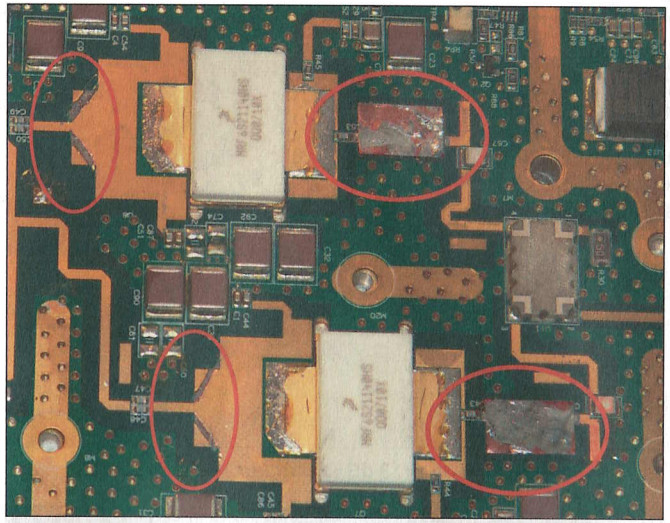


Figure 7: Output transistor matching circuits after modifications, the gates are on the left

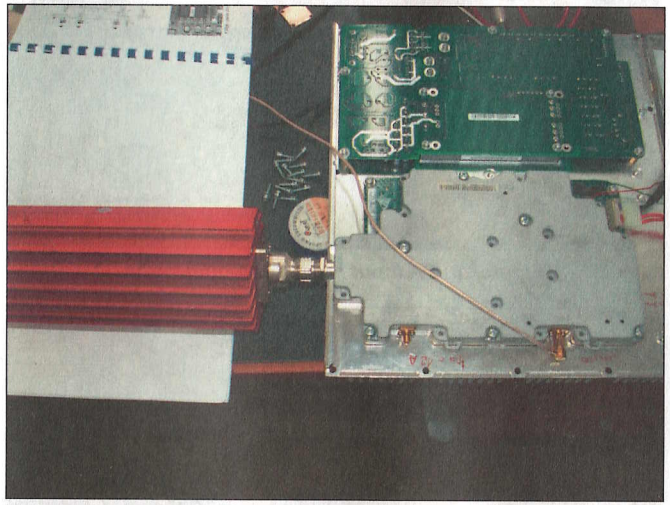


Figure 8: PA during tests: shield attached, driven by 13 cm DJ6EP transverter, 30 dB/200W attenuator at the output

The power amplifier must not be overdriven, because of the risk of damage to the SXA389BZ and/or resistor R30 (50 Ohm, near the hybrid coupler U11).
There is the possibility to drive the PA using a higher power, by not using the SXA389BZ pre-driver. To do this, desolder (best to use a hot air soldering iron) the SXA389BZ, the 3 dB attenuator U1, the coils L1 and L3 and the capacitors C34, C35 and C36 (see Figure 10). At the SXA389BZ location, first cut off the middle pad ground connection (see figure 11). Then connect the pads of U1, C34, C35 and the SXA389BZ together with a 1.5mm wide copper foil.

After this modification, it is of course not necessary to supply the pin 9 of socket J6, only the PTT signal on pin 6 is needed. After removing the SXA389BZ the PA needs 100 mW (20 dBm) of drive. The gain is about 32 dB, the output power is the same (170-180 W) and the input SWR is 1.5:1

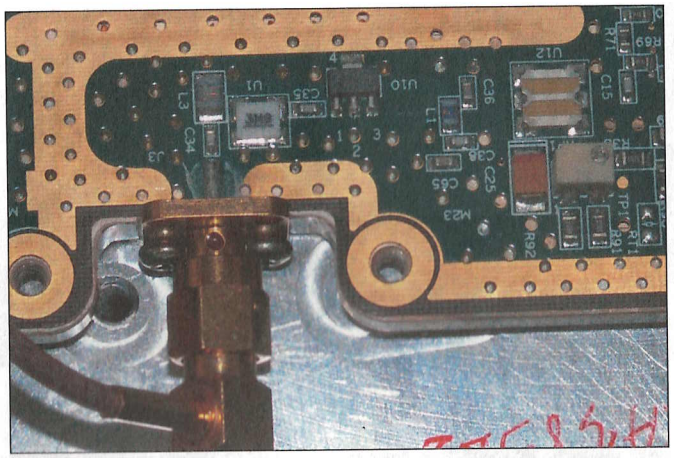


Figure 9: PA input: 3 dB attenuator and SXA389BZ

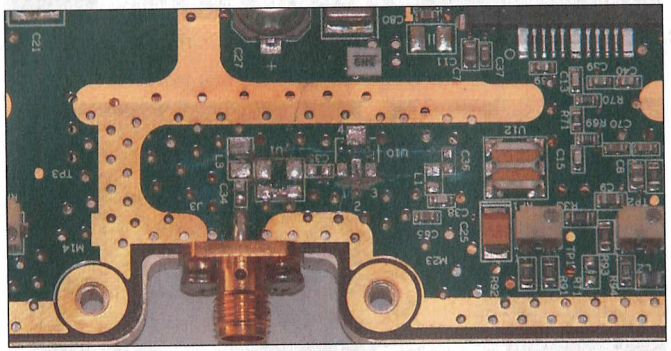


Figure 10: PA input ready for modification

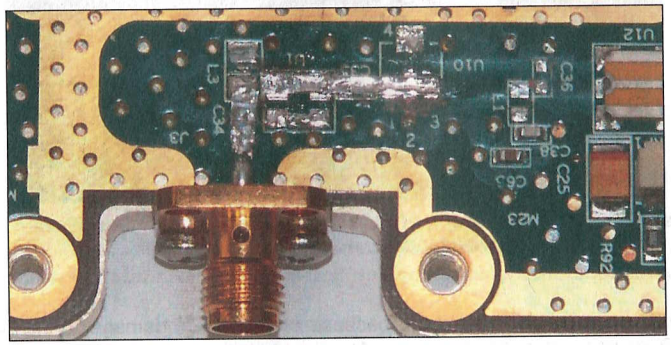


Figure 11: PA input after modification

Summary

The idea of this modification was to complement the popular 13 cm DJ6EP transverter with a solid state power amplifier, allowing to successful operation on Tropo or EME.

During tests it has been found that the configuration Transverter - Attenuator - PA is better than directly connecting the transverter with reduced power output directly to the PA. In the transverter output spectrum a 2176 MHz signal due to LO leakage was observed. This was -46 dB at P_{out}=9 dBm, while at

P_{out}=20 dBm the was more than -60 dB. An alternative to using an attenuator is to remove the SXA389BZ and drive the PA with a power of 20 dBm.

When working for long periods heating up of the PA decreases the output power. Therefore, for example when using the amplifier to operate digital modes, better cooling should be supplied. The advantage of this module is the repeatability of the adaptation and its simplicity. One does not require a complex microwave workshop. An important factor is also the small size of the amplifier module: 25cm x 14cm x 3cm. The original box of the power amplifier (and DC/DC converter) can be used, after removing the superfluous receiver part, to build in a transverter and possible switching circuitry, making an integrated, compact unit. Unfortunately, the standard casing of DJ6EP transverter is too high to fit without modifications inside.

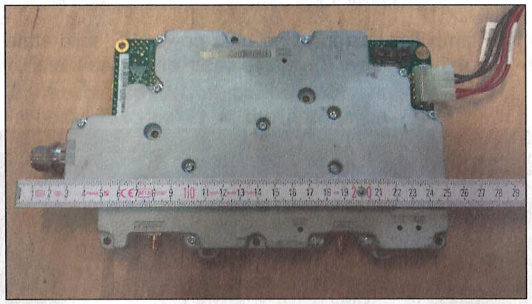


Figure 12: PA module without the casing (heat sink)

DC/DC converter

In the complete module there is a unit containing a DC/DC converter PAF500F48-28 [5]. The technical specifications of the PAF500F48-28 are:

- Input voltage 36-76 V (nominal 48 V at 12,1 A),
- Output voltage 28 V (adjustable 16,8-30,8 V).
- Output current 18 A (for 28 V)

Currently the authors are working on a modification in order to be able to use this converter. Please ask the authors for results, if you are interested.

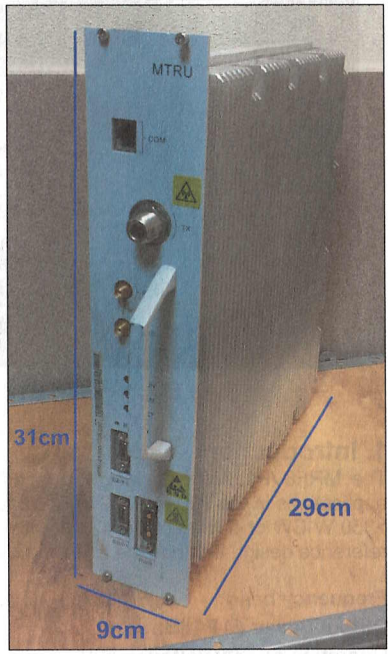


Figure 13: The MTRU module with the outer dimensions (weight 7kg)

References

[1] http://cache.freescale.com/files/rf_if/doc/data_sheet/MRF6S21140H.pdf
[2] http://cache.freescale.com/files/rf_if/doc/data_sheet/MW6IC2240N.pdf
[3] http://www.rfmd.com/store/downloads/dl/file/id/29266/sxa389bz_data_sheet.pdf
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