Modifying the RW1127 and similar TWTs for 24GHz

Some notes by Brian G4NNS updated after the EME conference.
Issue 1.04

During a visit from Johannes DF1OI he explained how Ulli DK3UC had modified Siemens RW1127 TWTs for operation on 24GHz. Transforming this 2W 12GHz tube to a potential 40W 24GHz tube sounded almost too good to be true, the more so as the modification he described was quite simple. At the EME conference at Wuerzburg I was able to watch Ulli carry out the most delicate part of the conversion and with his help have been able to make these notes. Thank you Ulli !!

Step one is to remove the clamps supporting the SMA barrels at the input and output to provide better access. Tubes in this series have SMA input and output connectors and the structure of the SMA connectors includes impedance matching at the design frequency. The next task therefore is to remove the SMA assemblies. These unscrew but are held with Loctite. To avoid the use of undue force which will destroy the tube, the SMA barrels should be heated with a hot air gun until they turn with minimal force. See Fig 1.

Figure 1

Figure 3

Next, the most delicate operation, is to remove the matching disks from the input and output pins. See Figs 2 and 3.

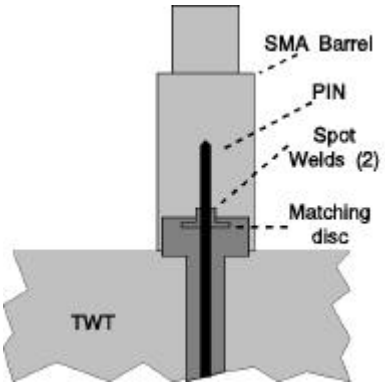


Figure 2

The discs are held in place by (usually two) spot welds on the vertical, tube like, section of the disc (see fig 2). These are filed or ground away to free and remove the disks. If access to the welds is not possible with a file, a small grinding tool on a multi tool such as Dremel can be used. However you do this great care must be taken not to damage the pin or the ceramic. I found a small square “Swiss” file was the best tool for the job. It may be necessary to file or grind away any small obstructions on the pin itself which stop the disc from sliding off easily . The pin should not be cut. It will protrude right through the waveguide. Take great care !

If you plan to use SMA input and / or output you will need to re match these by adding an M2 Nut held in place by a (home made) expanded polystyrene (Styrofoam) “washer” as shown in figures 4 and 5.

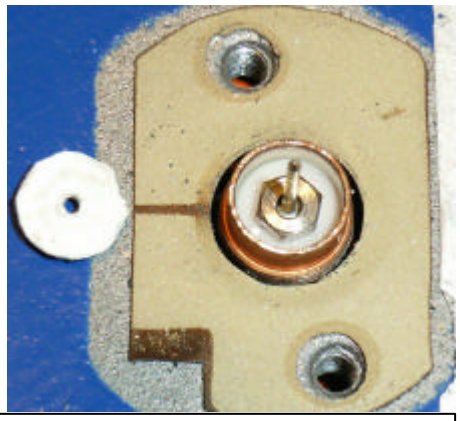


Figure 5

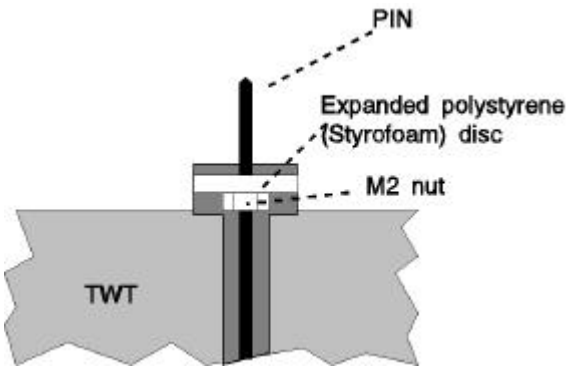


Figure 4

I found that with some tubes this modification helped improve output when applied to the waveguide input modification I will now describe.

My version of Ulli’s modification is based on an early sketch that Johannes had given me during his visit. Ulli has developed a more “professional” modification which is shown in Fig 13. I am sure his works even better than the version I have used. But I have limited access to machine tools and the version I describe is simple to make.

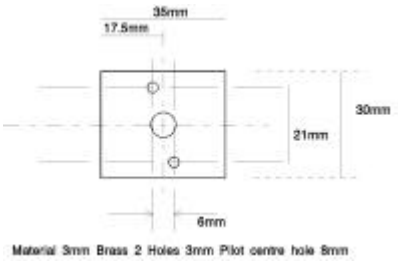
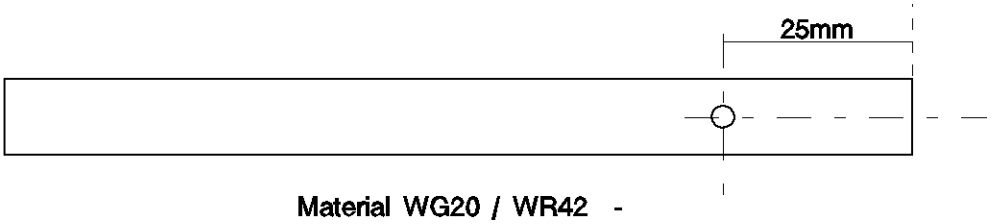


Figure 6

Both input and output require a mounting plate as shown in Fig 6. Note that the 3mm fixing holes may need to be enlarged or moved using a file so that they correspond with those on the tube whilst ensuring that the 8mm hole is concentric with the probe assembly and avoids putting stress on it.

Next, two sections of WG20 / WR42 are prepared as shown in Fig 7. The lengths are not critical. I chose lengths so that the input and output flanges would clear the body of the tube. Note that there is an 8mm hole on the side

nearest the tube and a 3mm hole on the other side. The probe, which should not be cut, passes right through the waveguide and protrudes into the 3mm hole.



Material WG20 / WR42 -
1 pc 110mm o/a 1pc 120mm o/a Pilot hole through both sides 3mm
One side only to be opened to 8mm

Figure 7

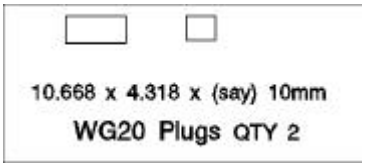


Figure 8

Tight fitting plugs (sliding shorts) are fitted to the end of the waveguide nearest the probe and flanges are fitted to the other ends. The plugs were machined very slightly over size and then lapped very carefully on fine abrasive paper until they were a tight but sliding fit in the waveguide.

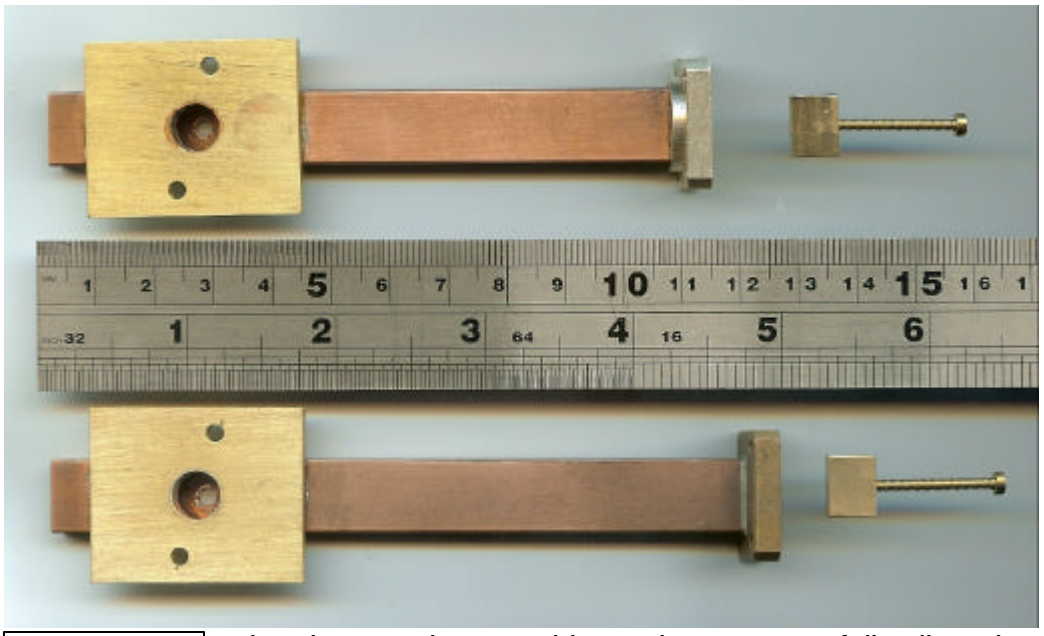


Figure 9

The plates and waveguide sections are carefully aligned. (I used an old 8mm drill to assist with this) and then soldered together. I used a thin layer of solder paste to ensure that good contact was achieved between the waveguide and the plate.
Note:- Plugs fit at the left hand end near the probe NOT as shown in Fig 9.

Figure 10 shows the tube modified with G4NNS's "quick and dirty" version of Ulli's modification while figure 11 shows Ulli's version.

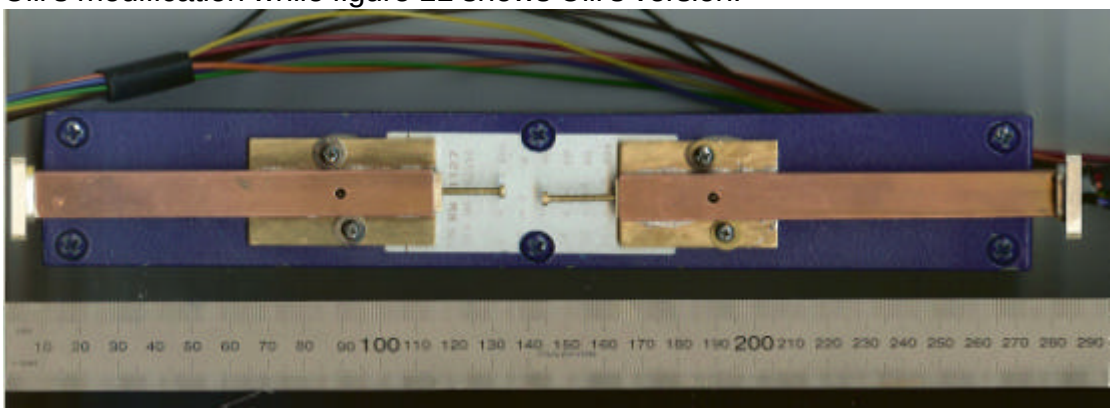


Figure 10

Figure 11

Note that Ulli has used SMA input and waveguide output (Fig 11).

Modification of the RWN32x PSU

The PSU switches should be set for the type of tube you are using according to the table printed on the power supply cover. Additionally it is helpful to drill a hole in the cover to provide access to the Helix adjustment potentiometer which is the right hand one in Fig 12. It will be necessary to adjust the helix voltage for maximum output.

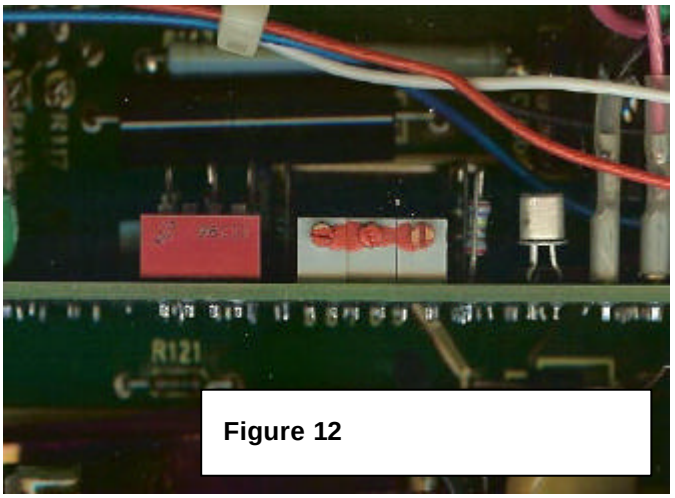


Figure 12

The next modification to the power supply is to short out the Collector 1 current sense. See Figure 13

Remember we are operating the tube in “Ham” mode and not as the manufacturer intended ! Take care.

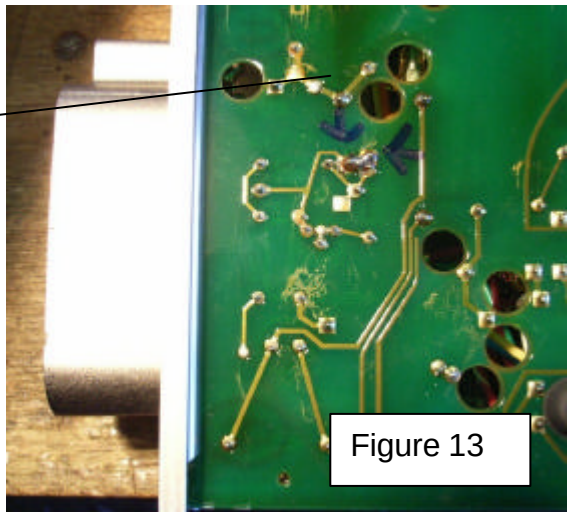


Figure 13

Alignment

Make sure the waveguide is terminated into a good load. I did not have a good load for 24GHz so I used a horn with good return loss pointing out of the open window ! If you do this make sure the arrangement is safe with no one likely to come in the near field. The tube needs a heat sink as power will quickly reduce as the tube heats up, the helix current may become unstable and damage may result. About 0.25 degrees C per watt should be sufficient.

Start alignment with a small amount of drive e.g. 1mW. I used an HP8592L spectrum analyser to monitor the output via a 20dB (waveguide) directional coupler .

Adjust the sliding shorts and helix voltage for maximum output. Increase the drive and repeat the process. Look out for self oscillation. My tube did experience self oscillation but this was traced to a loose SMA at a low level (~-10dBm) input to the driver chain and stopped when the SMA was tightened correctly. Some tubes have been found to be unstable although at the time of writing this I have not yet experienced an insoluble problem with the four tubes I have now tested. Helix current should be in the range 1-2mA for 20-30W output. Do not exceed 2mA.

With approximately 29dBm drive I got between 41dBm and 44dBm output. But I must emphasise that I do not have access to a properly calibrated power meter at 24GHz and I have to estimate the losses in transitions, adapters and short coax to the spectrum analyser which is only specified to 22GHz. But I do have echoes off the moon with my 3.7m cassegrain dish so the power estimate must be somewhere near.

Additional Notes

Ulli DK3UC observes that the noise of these TWTs (RW1127-RW1136) on 47GHz is very strong, so they may work on 47GHz too !

A good indication for the max power output you can expect from the tube is the maximum cathode current specified by the manufacturer and based on an efficiency of 20-30%.

You may be able to get some improvement in the power output by adjusting the G2 voltage which is done using the red slotted “knob” on the outside edge of the Power Supply. But take care to avoid excessive Cathode or Helix current.

Keep the low level stages well away from the TWT output in your final system layout to help avoid instability.

If you are using SMA input you should be sure that your filter has reduced any sub harmonic components to a very low level or you may damage the tube.

If the tube has been unused for a long time it is a good idea to run it with heaters only for a few hours before applying power and drive. Power supply standby mode – no PTT.

PSU Interface and Monitoring circuit.

The RWN32x series power supply provides monitoring of Helix and Cathode current, Alarm indication and reset and a Standby / TX or PTT input. These signals are isolated within the PSU but I provided some additional isolation of the reset, PTT and alarm signals and also buffered the current indicators. I did this mainly because the Helix current indicator provides 1V / mA into 100K and I did not have a suitable meter (20uA for 2mA FSD with 100K). Also I wanted to be able to monitor these signals locally when testing the system on the bench (or perhaps for terrestrial /P operation) or remotely in the shack some 30m cable run from the EME antenna system and the PSU. So maybe my circuit adds unnecessary complications but I include it in these notes in case it helps.

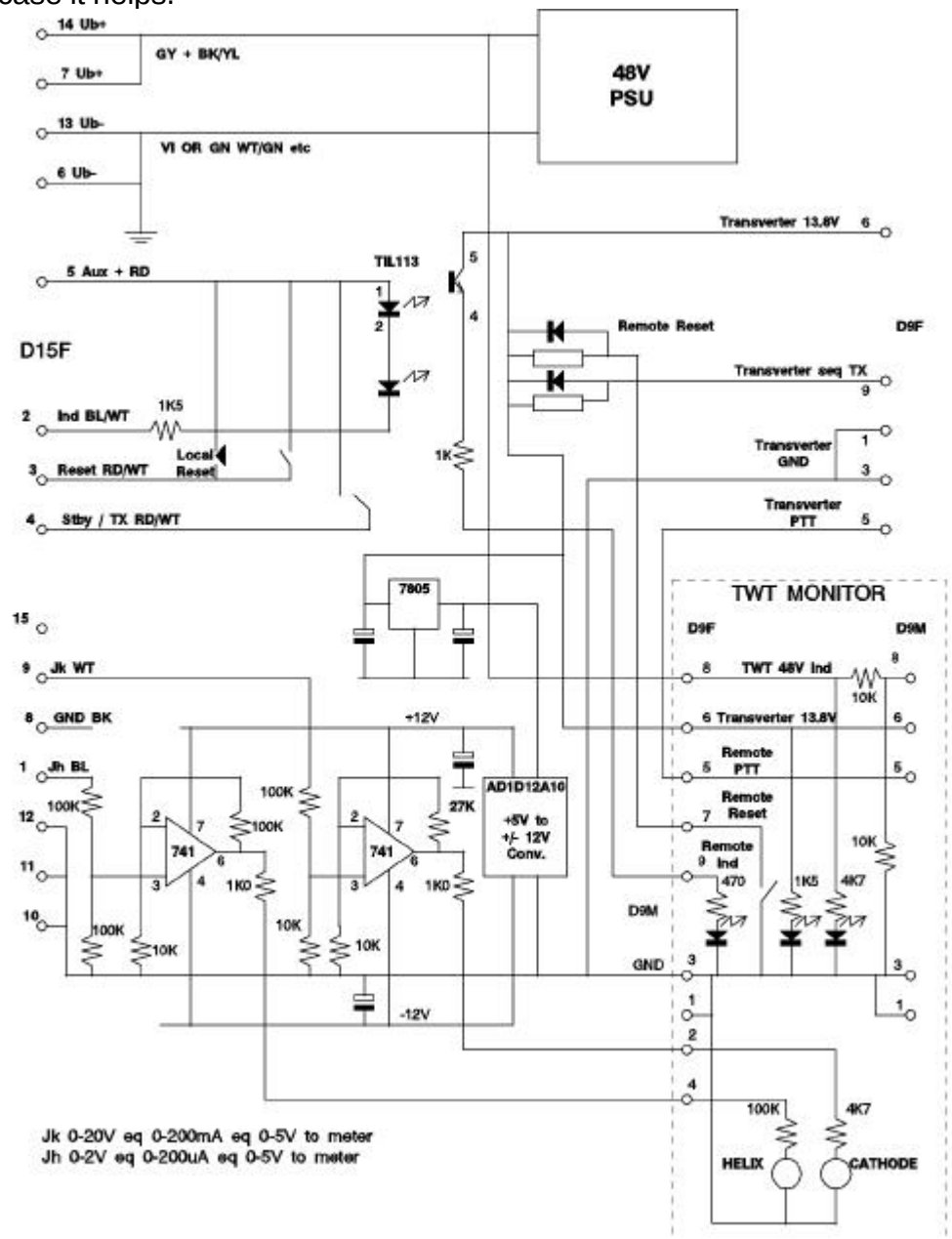


Figure 14

The meters are voltmeters so select series resistors to suit.