The Bodger's Guide to ……..

A 40 Watt power amplifier for 2320MHz using the MRF19085 in a G4BAO 1296MHz board

Introduction

This article describes how I made a useful 13cm Power Amplifier using internally matched 1900MHz devices and a G4BAO 1296MHz PA PCB (as described in June 2009 RadCom). (Reference 1)

With the need to improve efficiency of Cellular Phone base stations there has recently been a number of PCS1900 Amplifiers around the surplus market. A number of articles such as that by WA2AUU (Reference 2) have been published on modifying these amplifiers.

These amplifiers often contain the MRF19XXX series of 1900MHz internally matched devices, normally a non- starter for other frequency ranges due to the internal matching. That said I love a challenge and was encouraged by WA2AUU's results with the MRF19125 and my own bodging of some MRF19100 modules from a Lucent PKLAM amplifier. We both got reasonable gains and output power albeit at lower efficiency.

Let the Bodging begin!

I was therefore encouraged to "do something" with the eight, ex-equipment MRF19085 devices I'd been given a while back, and having more 1296 boards than 1296 devices, I decided to try and re-engineer a few boards for 13cm.

With a bit of Smith charting and creative swiping from the Freescale application notes for 1900MHz, I managed to get a reasonable idea of the matching networks required. A read of reference 3 will give you some idea what is involved in this

As a rule, most of these SHF LDMOS designs use a "Fat line" (4-6 ohms) of slightly longer than a quarter wavelength on the input and a shorter one on the output to transform the very low impedances of the device closer to 50 ohms. Trimming can then be done by adjusting the length and a small capacitor to ground at the 50 ohm end.

The G4BAO 1296MHz board has a 0.29 wavelength line (at 2320MHz) on the input and a similar length on the output. After much tweaking of the amplifier I surprisingly ended up with a good match with the input line unaltered and maximum output by widening and shortening the output line.

Preparing the blank PCB

Track modifications

The PCB requires a larger cut-out for the device, some removal of copper, (best carried out with a VERY sharp scalpel) and the addition of tuning tabs.
In Figure 1 below, track removal is shown in black, added copper tape in orange and the cut out is shown in white.

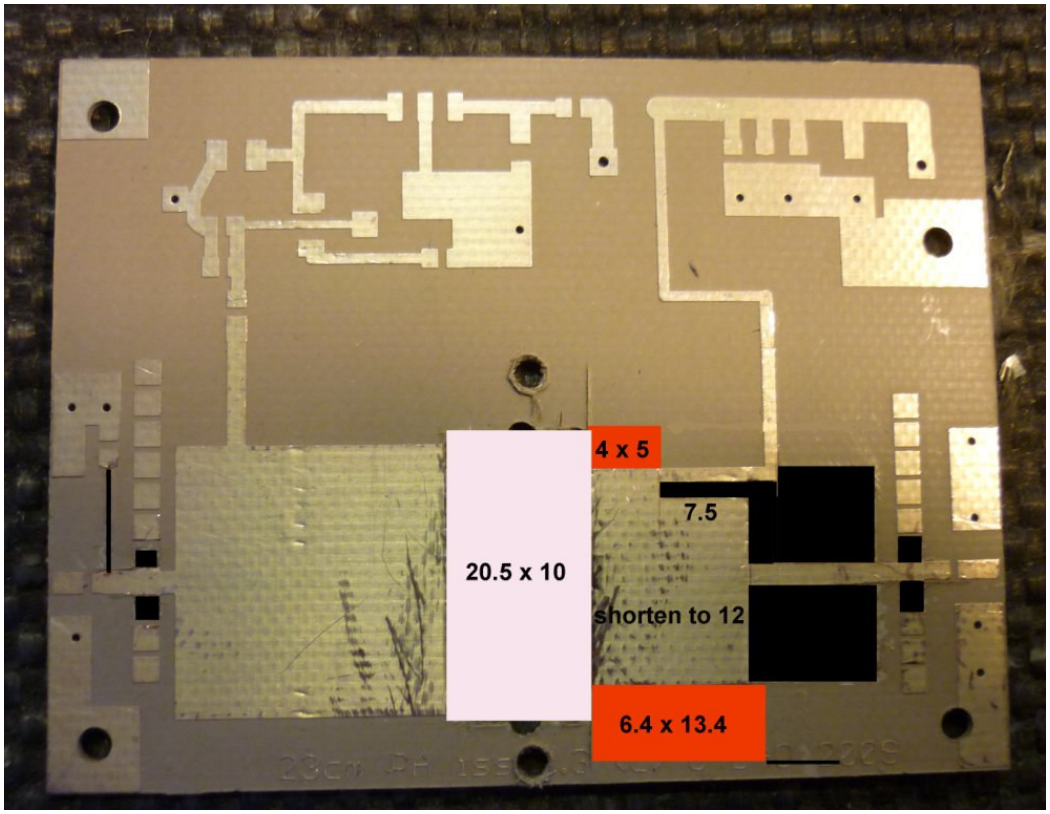

Figure 1 board changes

Attaching the device

As the MRF19085 is a flanged device without bolt holes, it needs to be clamped to the heatsink, and the flange electrically connected to the PCB ground plane. This is achieved by soldering a piece of thin copper tape to the ground plane, under the device as in Figure 2. This also acts as a heat transfer mechanism between the device and the heatsink, so no heatsink compound is needed.

If you use adhesive copper tape, make sure that you remove all of the adhesive from under the device with a suitable solvent.

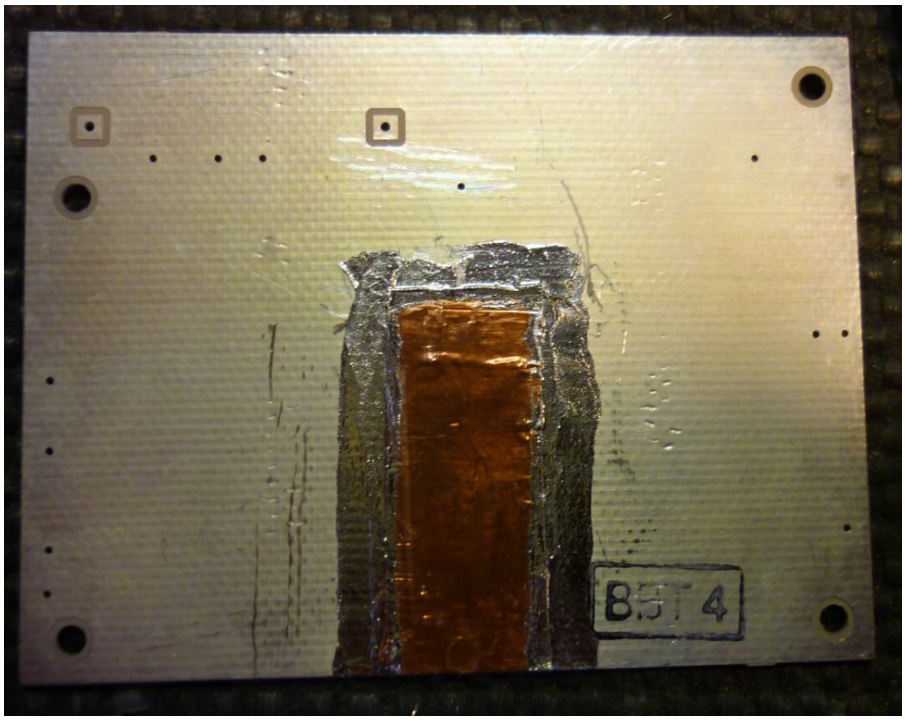

Figure 2 copper tape under PCB

To shorten the drain feed line, a "capacitor" made from adhesive copper tape is attached as shown in Figure 3. The dimensions of the "capacitor" are not too critical and can be estimated from Figure 3.

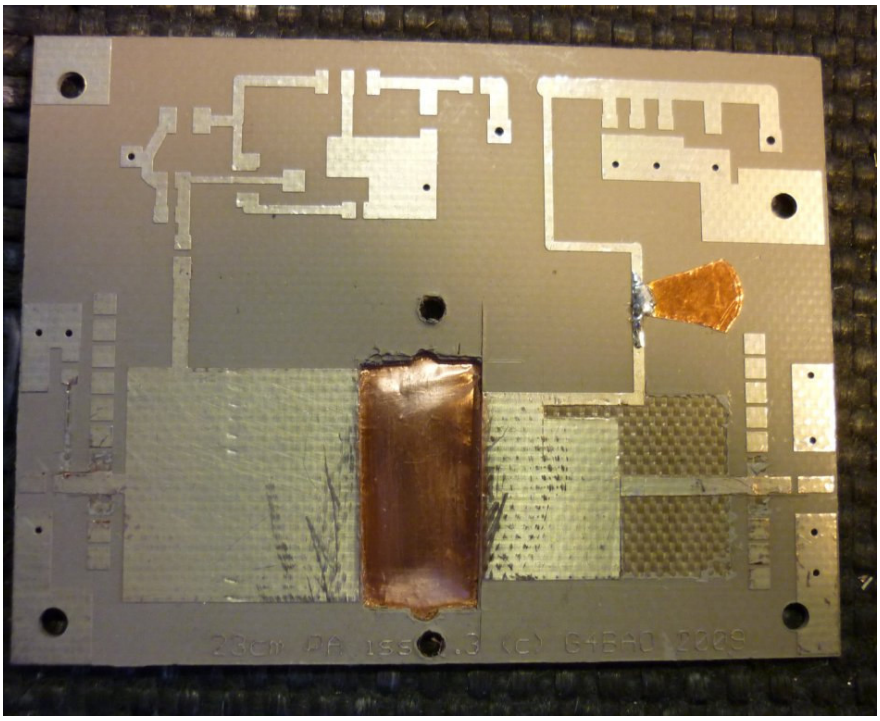

Figure 3 copper tape and added "capacitor"

Circuit changes

The final amplifier circuit differs from the 1296MHz board only in that all the tuning tabs are removed, the output capacitor is changed to a 10pF ATC700, the input capacitor to a 47pF ATC600 and 0.9pg Gigatrim is placed on the input just after the input capacitor. A higher value of gate resistor (1.8K) was used.

Device clamping

Figure 4 shows the assembled amplifier with the home made device clamp manufactured from thick walled fibreglass tube. This construction has the advantage that it is "springy" when tightened down, but take care not the over-tighten as you will crush the tube. Due to the temperature over the device the clamp must be a either fibreglass or (ideally) a thermosetting plastic such as PTFE.

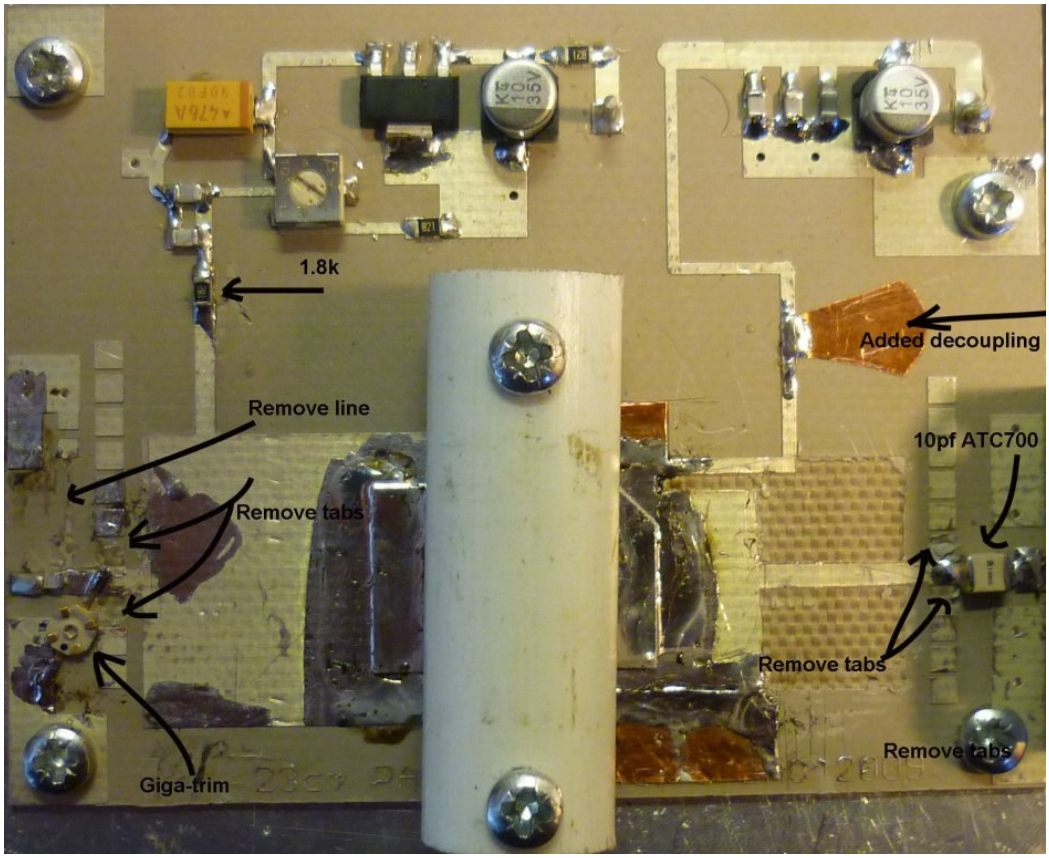

Figure 4 component changes and device clamp

Representative test results

These figures are measured on Amateur test equipment which does not have a current calibration certificate. They should be treated as a guideline only, and no performance guarantees are given or implied.

Quiescent drain current Id_q was set to 1 ampere for all the tests.

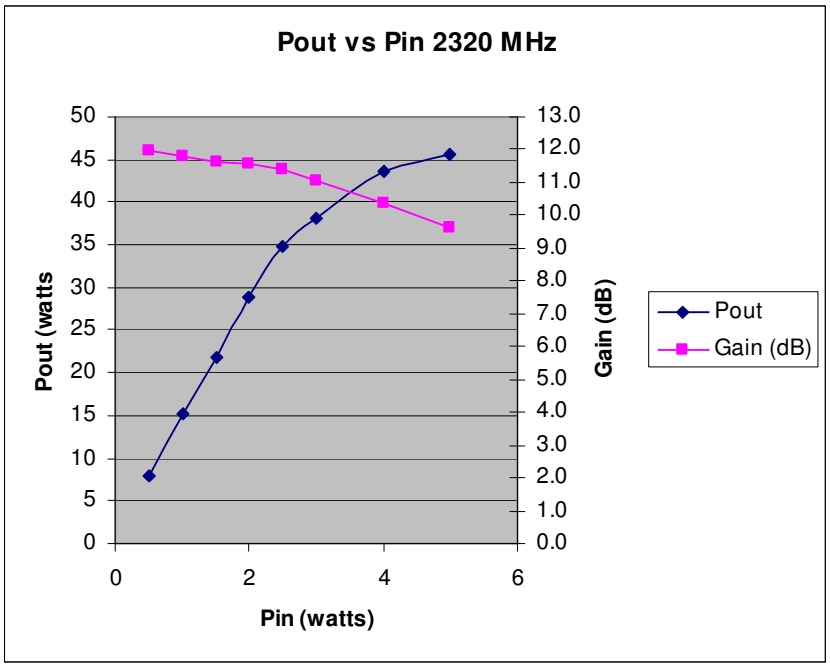

Figure 5 Power out vs Power in and gain

Gain varies between boards, but you can expect between 10 and 12 dB depending on how carefully you build it.

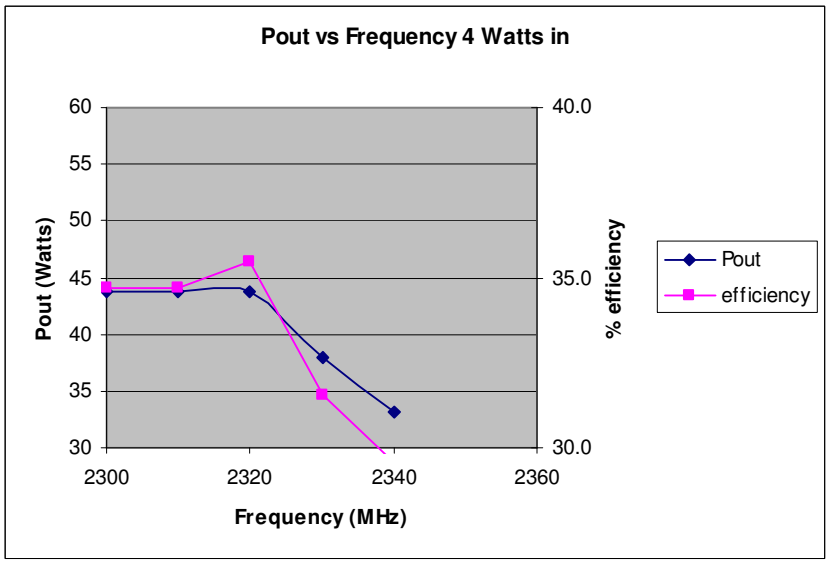

Figure 6 Power out vs frequency and efficiency

Efficiency is quite poor but acceptable for Amateur use, the device drawing up to 5 Amps at 28 volts at full power.

Input tuning is quite sharp, and when tuned to 2320MHz power drops off quickly above this frequency, I have not tried to optimise the design for 2400MHz

Heat sinking requirements

As the efficiency is only around 35- 45% (see test results) significant heat sinking and a fan is required to keep the device cool.

I tested the amplifier on a 100x 200x 40(fins) mm heatsink and it needed forced air cooling with a 120mm fan underneath the fins.

References

1. Dr J C Worsnop G4BAO - "A 45 watt Amplifier for 23cms" - Radcom June 2009
http://homepage.ntlworld.com/john.g4bao/Files/a45w_amplifier_for_23cm.pdf

2. R. L. Frey – WA2AAU "70 Watts Cheap on 2304 MHz Modifying a 1900 MHz PCS Amplifier for 2304 MHz" - Eastern VHF/UHF Conference April 22, 2006
http://www.mgef.org/amps/presentation/AMLpa6_C.pdf

3. Dr J C Worsnop G4BAO – "The Bodger's guide to LDMOS Power Amplifiers"- UK Microwave Group RAL round Table 2009
http://homepage.ntlworld.com/john.g4bao/Files/G4BAORAL09.pdf