23cm LDMOS Power Amplifier – Assembly notes

This kit contains the components required to build a G4BAO 23cms Power amplifier as described in the June 2009 Issue of RadCom, and includes any updates since publication. Note that in the original article, the component sizes for C8 and C11 were transposed. This document is correct for the issue 1.1 PCB.

Antistatic precautions

Note that the LDMOS power FET device fitted to the PCB is still susceptible to static damage until the board has been assembled. Do not remove the tinfoil from the PCB without wearing an antistatic wrist strap or at minimum before having first touched something grounded.

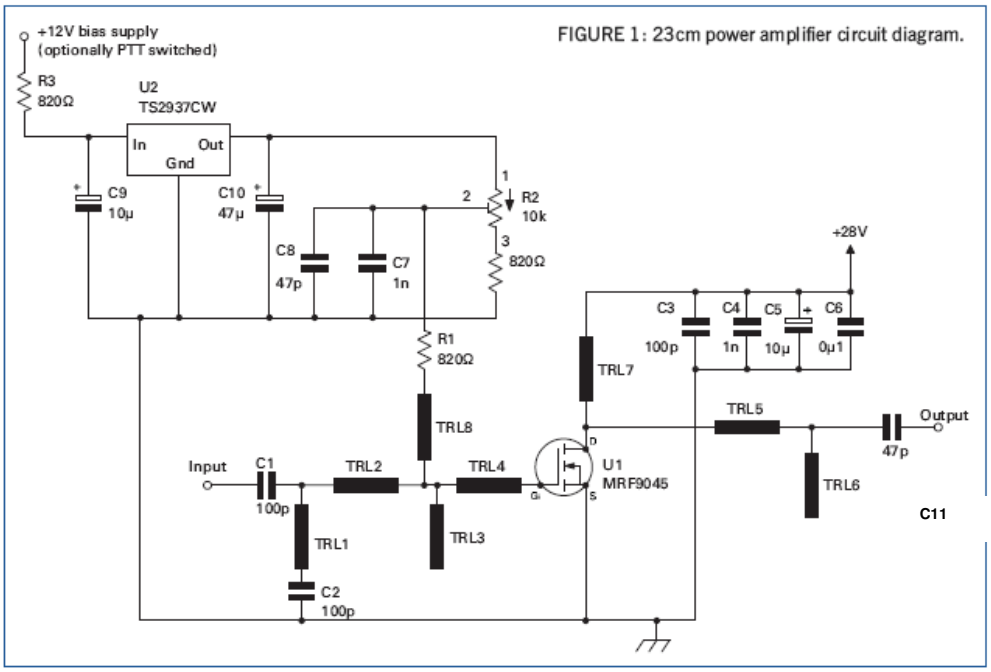


FIGURE 1: 23cm power amplifier circuit diagram.

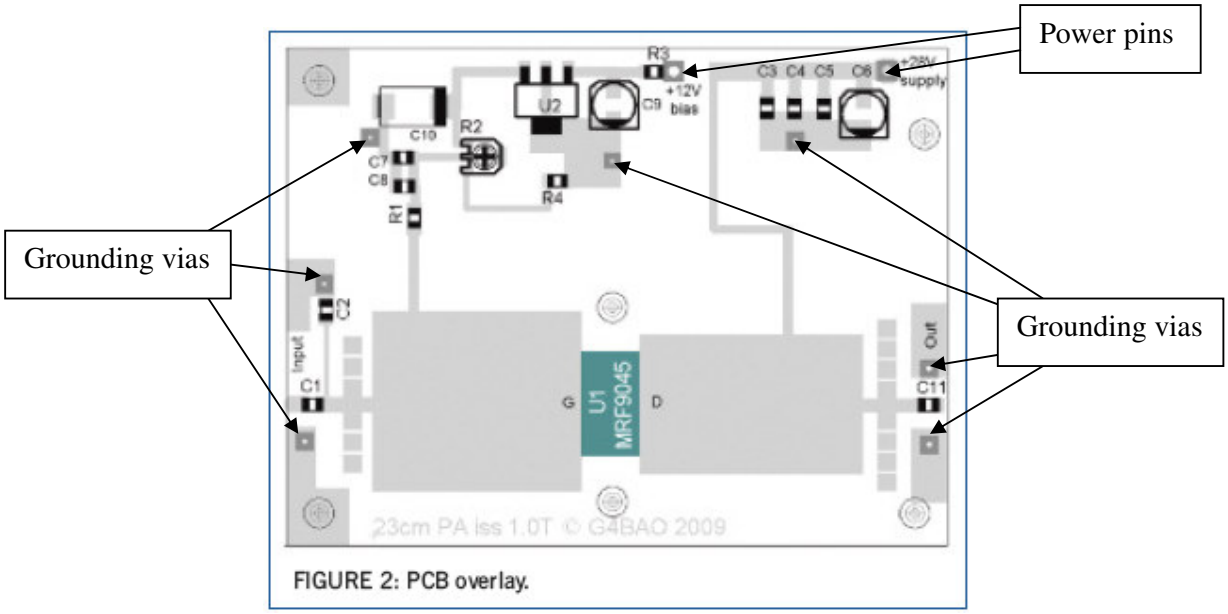


FIGURE 2: PCB overlay.

Component list

Component	Value	Type	Identifier
R1, R3, R4	820ohm	SMD 0805	Red
R2	10k	SMD preset	The only preset in the kit!
C1, C2, C3	100pF	Np0 ceramic 0805	Black and white
C11	47pF	Np0 ceramic 1206	Black and clear plastic
C8	47pF	Np0 ceramic 0805	Green
C4, C7	1nF	Np0 ceramic 0805	Orange
C5, C9	10uF 35V	SMD electrolytic	Silver can. Black bar is negative
C6	100nF	X7 ceramic 0805	No marking
C10	47uF 16V OR 10V	SMD Tantalum	Yellow case. Red bar is positive OR Black case, silver bar is positive
U$1	MRF9045	LDMOS power	Attached to PCB
U$2	TS2937CW	SMD 5V regulator	Manufacturer's mark
PCB pins	Qty 2	PCB pins	For +12 and +28Volt supplies
Wire	100mm	24SWG tinned copper	For grounding vias and tuning.

Check that all the components are present in the kit, and email john@g4bao.com immediately if there is anything missing.

Tools

Use a small temperature controlled, earthed soldering iron, and thin (28swg) solder.
A pair of small sharp side cutters
Small SMD tweezers

Assembly

Remember throughout assembly that the FET is already fitted to the board so observe antistatic precautions.
The Teflon PCB material is softer that the usual FR4, so do not to bend the PCB once the components are fitted as this can crack the components

1. Fit the +12 and +28Volt pins, soldering top and bottom. Take great care to ensure that you do not bridge the solder to ground, especially underneath.
2. Fit the seven grounding wires through the vias soldering top and bottom. Note that your board may already have some BUT NOT ALL of the vias fitted as part of my board test procedure. Make sure that all 7 are fitted
3. Link the all the input and output tuning tabs.
4. Check for shorts to ground on the +12 and +28volt pins and stick a small piece of insulating tape underneath them as the solder bulge puts them close to the heatsink when bolted down
5. Fit the two resistors R3 and 4. **DO NOT FIT R1 YET!**
6. Fit the eight 0805 ceramic capacitors C1-4, C6, C7, C8, C11.
7. Fit the Preset R2
8. Fit C5, C9 and C10.
9. Fit the 5V regulator.

Initial check

RE-CHECK THAT YOU HAVE NOT FITTED R1 YET. If you have, remove it and place it to one side for later!

Be careful, R2 has no "stops" so rotates through 360 degrees and can "jump" from 0 ohms to 10k if you rotate it past its minimum value. Also turning the pot ANTIclockwise INCREASES the Bias current/voltage

Check for shorts to ground on the +12 and +28Volt pins

Set R2 to the centre of its travel and apply +12 volts to the 12volt pin, and ground to the ground plane and measure the voltage at the + end of C10. It should read 5 volts +/- 0.2.

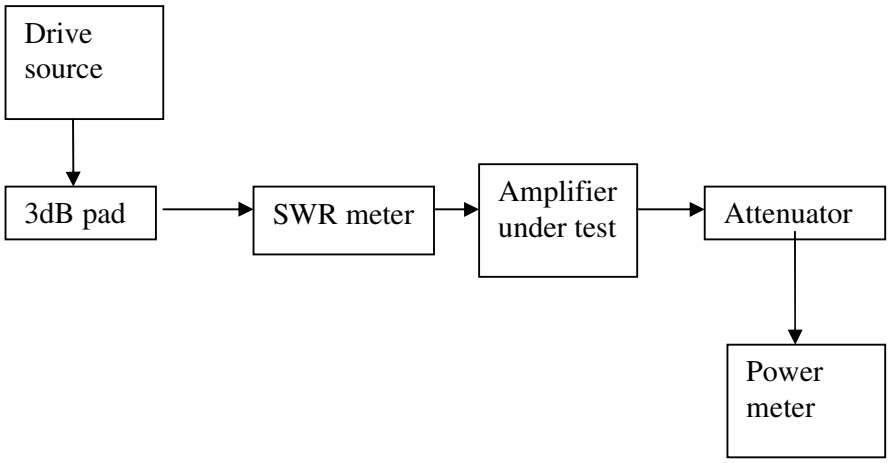
Measure the voltage at the junction of C8 where it connects to R1. It should be 2.7V +/- 0.2.

Rotate R2 clockwise until the voltage is at minimum. Measure the voltage at the junction of C8 where it connects to R1. It should be 0.4V +/- 0.2.

Leave the preset at this setting and remove the 12 volt supply. **Fit R1**.

Recommended Test equipment

Equipment	Example
1.3GHz SWR meter	Bird Thruline or Diamond SX1000
Drive source with adjustable power from 0.5 to 3W	Transceiver/ transverter plus 3dB attenuator
RF power meter and attenuators to measure up to 50Watts	HP 435A, HP436 plus 30 dB attenuator. Bird Thruline or Diamond SX1000 plus 50Watt dummy load.



Assembly notes

Where possible align the PCB in its final box to minimise tuning errors due to proximity of the box sides effecting tuning.

Use only M2.5 pan head screws, do not use washers, do not be tempted to drill the holes bigger and use M3 or the heads will short to the matching lines.

Bolt the assembled board and heat spreader to a large heatsink and if possible, in its box. If possible, solder the edges of the ground plane and the topside grounds near input and output to the tinplate box.

Note that the heat spreader is NOT flush with the bottom of the PCB. Make sure that when you bolt the PCB down, you put enough washers under the PCB mounting holes so that you don't bend the board. The board can be tested with just the heat spreader bolted down if necessary.

Alignment

The input and output matching tabs are split so that you can lengthen or shorten them by bridging them with the 24SWG wire, if necessary. Start with all the tabs linked for maximum length, and remove one section of link wire at a time with the side cutters and soldering iron when tuning, leaving the PCB track in place so you can revert back if necessary.

Connect the input from your 1.3GHz transmitter to the amplifier input via a suitable 23cm SWR meter. (Bird Thruline, diamond SX1000) Connect the amplifier output to a power meter/ dummy load capable of dissipating at least 50Watts. If you are using "flying coax leads" to connect rather than a box and connectors, there should be NO braid tail, not even 1mm. Use thin PTFE coax so that the inner does not melt and solder the braid directly to the convenient ground point close to the input and output pads. Connect the drain to 28 volts via an ammeter on the 1 amp range. Connect the gate bias supply, starting with minimum volts on the gate and VERY carefully increase the gate voltage (remember, ANTI clockwise) until the device begins to take drain current. This onset is very sharp, so be very careful, as the drain current can easily swing up to many Amperes if you are not. Set the drain current to 350mA +/-5mA. This may rise by some 50mA as the device warms up, this is normal. Switch off both supplies and then switch the ammeter to the 10 Amp range. Switch back on.

Check all your connections take a deep breath and apply 0.5 watts drive. Check the input VSWR. It should be better than about 1.7:1. Remove one section of one input tab at a time until the VSWR is less than 1.7:1 and check the output power and current. Once you have minimised the VSWR, trim the output tabs in the same way for maximum power and efficiency. Turn up the drive in 3dB steps to 2 Watts and check that the power increases about 3dB each time until it saturates. As you approach the correct output match, you will find that the amplifier saturates at a higher power. Trim the output tab and repeat until you get the maximum output power with around 3 amps drain current. It goes without saying, I hope, that you disconnect both the drain and source bias supplies before you trim the tabs. Remove the gate bias before the drain supply; reconnect the drain supply before the gate bias.
When all is well, for an **input of 3 Watts maximum**, you should expect **an input VSWR of 1.5:1**, an **output power of between 35 and 45 Watts** and a **drain current of around 3 Amperes.**

Fault finding

There are only few components on the board, so there is little to go wrong, and fault finding is relatively easy. If you fail to achieve something close to the values in the previous paragraph, carefully inspect all your solder joints, and check that you have not cracked or damaged any of the surface mount components or the Power FET. If you can get access to a microscope to do this, all the better! Recheck the bias current with no drive (standing current) It should not have changed by more than about 50mA. Measure the gate voltage and it should be in the 2.7 – 3.5 volt range. If the standing current has changed by more, and you cannot reset it to 350mA, chances are you have blown the device!