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, particularly the feedback modification, Rf, Cf and Lf. Note that in the original article, the component sizes for C8 and C11 were transposed. Also the names of C5 and C6 have been transposed on the layout diagram. Looking at the board with the 28V pin to the top right, from left to right it goes in increasing value, C3 100pF, C4 1nF, C6 100nF, C5 (electrolytic) 10uF. **This document is correct for PCBs purchased after November 15th 2015**.

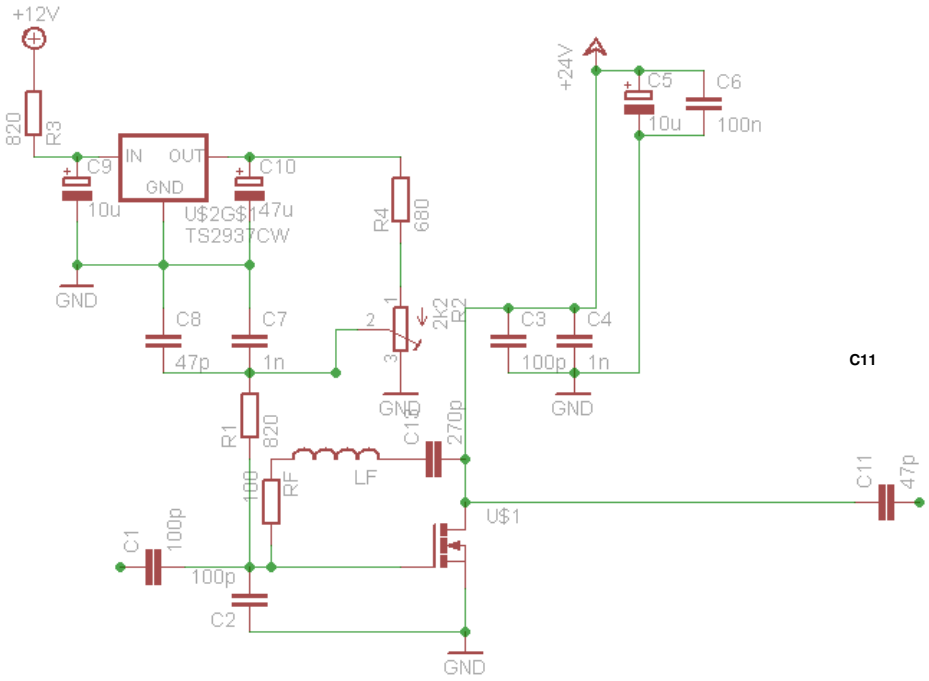


Figure 1 Circuit diagram

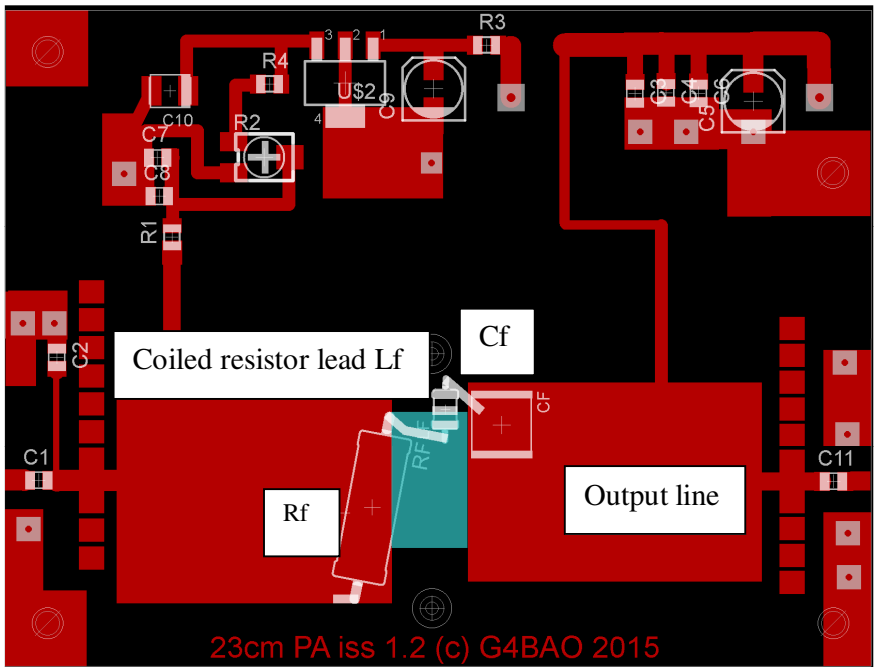


Figure 2 PCB layout

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.

Component list

Component	Value	Type	Identifier
R1, R3	820	SMD 0805	Red
R4	680	SMD 0805	Brown
R2	10k	SMD preset	The only preset in the kit!
Rf	100 ohm	2 Watt carbon film	Wire ended non- SMD part
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	22 to 47uF 16V OR 10V	SMD Tantalum	Yellow case. Red bar is positive OR Black case, silver bar is positive
Cf	270pF to 1nF	AVX RF cap	271 large cube
Lf		2 turns of resistor Rf lead on 2.5mm mandrel	Part of Rf
U$1	MRF9045 or similar	LDMOS power	Attached to PCB
U$2	78M05	SMD 5V regulator	Manufacturer's mark
PCB pins	Qty 2	PCB pins	For +12 and +28Volt supplies
Wire	100mm	24SWG tinned copper	For 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
For best results, always use the preferred Schuberth tinplate box and follow the assembly notes carefully.

To fit the recommended standard Schuberth box, you just need to "nick" the two diagonal opposite corners of the board to accommodate where the box sides overlap internally.

1. Fit the +12 and +28Volt pins, soldering top and bottom. They are a tight push fit in to the holes. Take great care to ensure that you do not bridge the solder to ground, especially underneath.
2. Link the all the input and output tuning tabs. Refer to Fig 3 showing how to do this. Put a small blob of solder on all tabs first then tin the end 2mm of the link wire and solder it between the tabs. Then trim the wire off with a sharp scalpel. Do this for each pait of tabs and the input/output lines.
3. Check for shorts to ground on the +12 and +28volt pins Fit the two resistors R3 and 4. **DO NOT FIT R1 YET!**
4. Fit the eight 0805 ceramic capacitors C1-4, C6, C7, C8, C11.
5. Fit the Preset R2
6. Fit C5, C9 and C10.
7. Fit the 5V regulator.
8. Fit the feedback components RF and Cf as described below
9. Stick a small piece of insulating tape underneath the supply pins, as the solder bulge puts them close to the heatsink when bolted down.

Use exactly the same layout as shown in Photo 1 or poor results will be obtained.
Stand the AVX capacitor "on it's end" and solder the bottom to the output line first. Tin the other end. The resistor comes ready trimmed and should fit between the input line and the top of the capacitor. Solder the resistor short leg down first, then carefully bend the "coil" end such that it touches the unattached end of Cf. Make sure that the coil lead stays touching the capacitor, and does not "pull" on the end of the capacitor after soldering as it could break it once soldered. You can then solder it to the unattached end of Cf.

Make sure that the coil turns are not shorted, and that neither the capacitor nor the coil shorts to ground, the screws or the PA transistor.

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 with R2, it is possible to increase the bias enough to destroy the device Turning the pot clockwise 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.

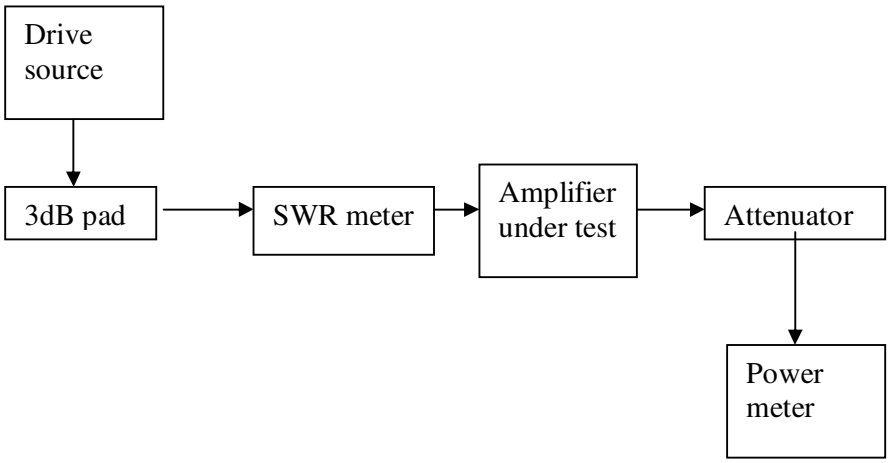
Measure the voltage at the junction of C8 where it connects to R1. It should be 2.3V +/- 0.2.

Rotate R20 anticlockwise until the voltage is at minimum. Measure the voltage at the junction of C8 where it connects to R1. It should be 0.0V +/- 0.2.

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

Recommended Test equipment

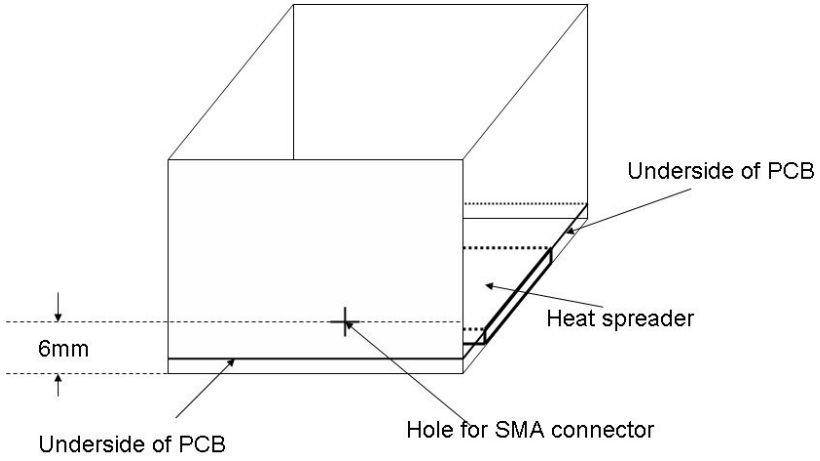
Equipment	Example
1.3GHz SWR meter	Bird Thruline or Diamond SX1000
Drive source with adjustable power from 0.5 to 3W	Transceiver/ transverter plus 3dB attenuator
RF power meter and attenuators to measure up to 50Watts	HP 435A, HP436 plus 30 dB attenuator. Bird Thruline or Diamond SX1000 plus 50Watt dummy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



Assembly notes

If you are mounting the PCB in the recommended tinplate box, make sure that the tabs for the input and output connectors do not short to the box. If so trim them back 0.5mm with a very sharp scalpel

Where possible align the PCB in its final box to minimise tuning errors due to proximity of the box sides effecting tuning. If using the recommended the Eisch/G3NYK boxes, the PCB should be fitted such that the bottom of the heat spreader plate is flush and level with the bottom of the box sides. This allows the whole box and PCB assembly to be bolted flat on a heatsink using the two screws through the heat spreader. I've found that no other fixings are needed. Solder the edges of the ground plane and the topside grounds near input and output to the tinplate box completely round the ground plane side. The two SMA connector centres should be mounted 6mm up the box sides to allow for the SMA plugs to be screwed on. The SMA centre spills should be connected to the PCB with the shortest length of 0.5mm copper wire possible.



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

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 a soldering iron when tuning, leaving the PCB track in place so you can revert back if necessary.

Note that you should link the pads as shown in Figure 3 linking the tuning pads and only remove them with a soldering iron. **Do not be tempted to link them the "wrong" way and remove them with side cutters or you may damage the PCB.**

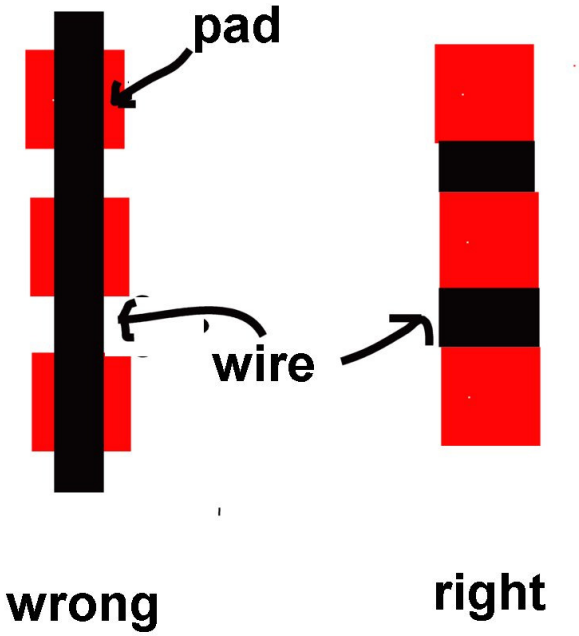


Figure 3 linking the tuning pads

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, 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. **Note that you may not have to remove ANY Tabs.** 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 2 Watts maximum**, you should expect **an input VSWR of 1.5:1**, or better and an **output power of between 35 and 45 Watts** and a **drain current of around 3 Amperes.** Some boards may produce more than this power but operation above 45Watts is not recommended.

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!

Low output power but the correct current could be due to a damaged (cracked) output capacitor C11
A poor input VSWR could be due to a damaged (cracked) input capacitor C1, or poor termination of the PCB input pad.