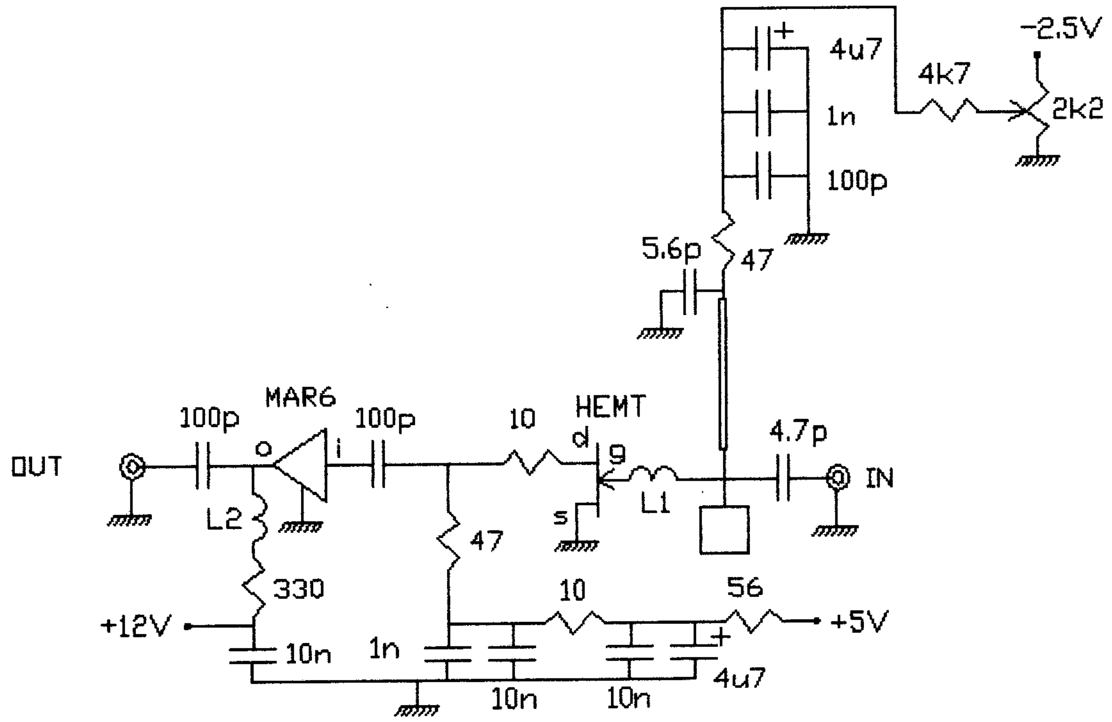
G3WDG025 2.3GHz HEMT Preamplifier

The G3WDG025 preamplifier is a state-of-the-art ultra low noise preamplifier intended for high-performance applications. It uses a well-proven, reliable, HEMT device to achieve a very low noise figure and high associated gain. It is normally built with SMA input and output connectors.

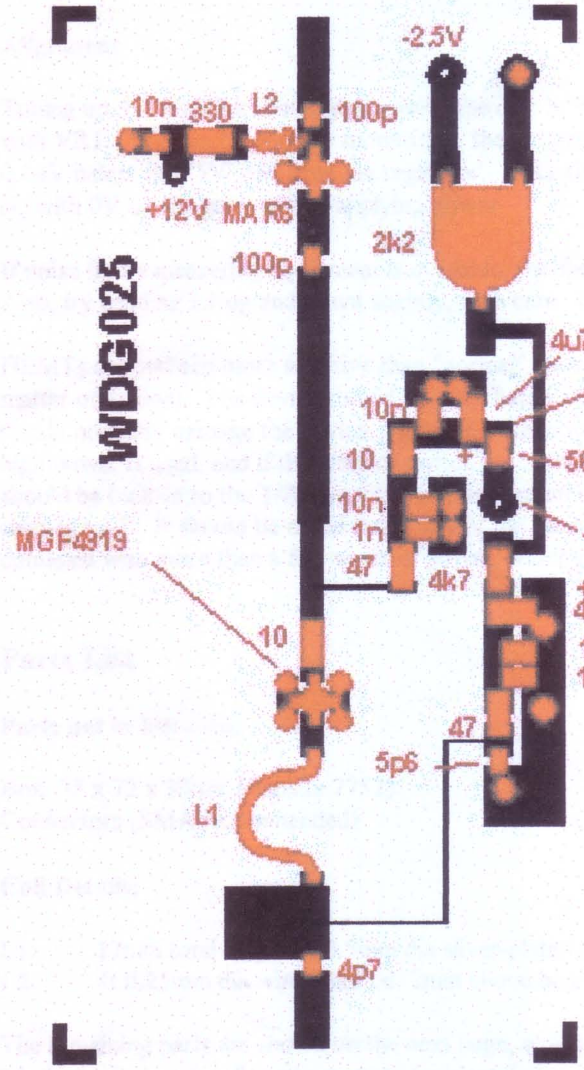
The circuit diagram of the G3WDG025 is given below.



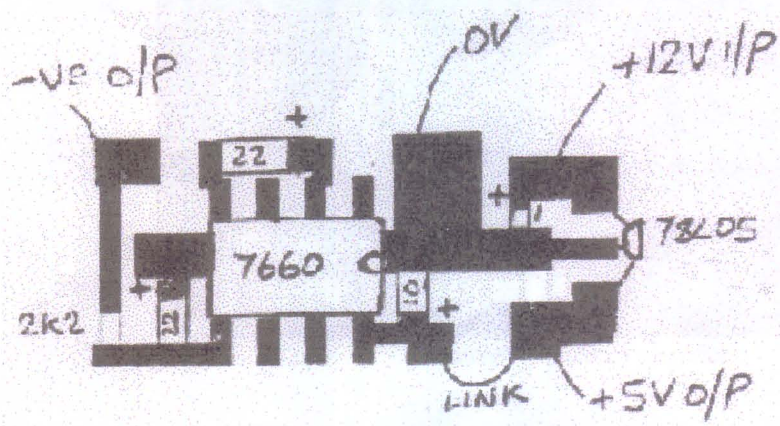
The design is based very closely on DJ9BV's, and offers very high stability, a state-of-the-art noise figure and sufficient gain to overcome the second stage noise figure of all but the worst 2.3GHz receivers.

The circuit diagram includes a MODAMP second stage. This is not intended to be used except in rare cases where very high gain is needed (for example at mast-head if there is very high feeder loss). The modamp is not included in the kit, but may be purchased separately if needed. The gaps in the line for the modamp and one of the series 100pF capacitors should be shorted out, leaving just one of the 100pF capacitors in place as a DC block.

The layout of the board is shown below.



Note that the dc inverter/regulator pcb is mounted on the reverse side. In the kit for this module, all the regulator components are supplied. The layout of the psu pcb is given below.



Construction

For construction information, please refer to Appendix 1.

Alignment

Tuning up the amplifier is straightforward, the only adjustment required is to set the drain current to 15 mA with VR1. This can be done by monitoring the voltage on point X, and setting VR1 to give a voltage 0.84V below the "5V" rail from the regulator. VR1 should be set initially to its fully anti-clockwise position (ie with 0V on the gate) before applying power.

If noise figure measuring equipment is available, try optimising the 2k2 gate bias pot for lowest noise figure. Also, try bending L1 up and down slightly, with care. Usually best NF is with L1 almost flat on the board.

HEMTs are perhaps more sensitive than "normal" GaAs FETs to damage from high RF input levels (this is a matter of debate). The device should be quite happy with at least 1-10mW RF input, but watts of power would probably damage the device. Antenna changeover relays with poor leakage could cause trouble if high power is used, and if the relay or switch has built-in indicators to show when it has changed over, these should be built-in to the T/R switching circuitry as interlocks to prevent the transmitter coming on until the relay is ready. It should be noted that many of the small SMA relays available on the surplus market can be damaged with more than a few watts of power, which might also put the HEMT at risk.

Parts List

Parts not in kit:

Box 35 x 72 x 30mm (tinplate 7752)
Connectors (SMA recommended)

Coil Details:

L1: 17mm total length of 0.5mm dia silver-plated wire. Ends bent down ~1mm.
L2: 4t 0.25mm dia wire 2mm i.d. 2mm above board

The remaining parts are shown on the next page, which may be removed from the booklet and used as a "de-kitting" sheet to allow the parts to be identified and arranged prior to construction.

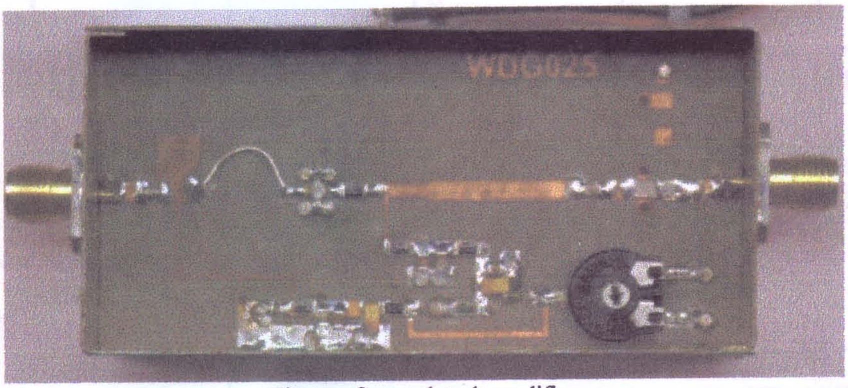


Photo of completed amplifier

Parts list (kit)

100p 3	5.6p 1	1n 2
10n 3	4u7 2	4.7pF 1
4k7 1	2k2 preset 1	47R 2
56R 1	10R 2	330R 1
78L05 1	1U 1	10u 1
22u 2	7660 1	FRE023 pcb 1
RF pcb 1	veropins 18	SMT solder 1
2k2 1	wire for L1 1	wire for L2 1
MGF4919 1	x x	x x

Appendix 1 - Construction

Before starting

As the parts used in this project are quite small, some form of optical aid is recommended unless your eyesight is exceptional! A bench magnifier (some have inbuilt extra lighting) can be useful, although we prefer to use a headband binocular magnifier (eg RS part number 606-989). A good pair of tweezers is also essential. Chip components are hard to find on the average shack floor and can fly an amazing distance if they jump out of the tweezers! A soldering iron with a fairly small tip is also highly desirable, and the use of the correct type of solder is recommended for the SMT parts. The solder supplied with the kit should work well for this.

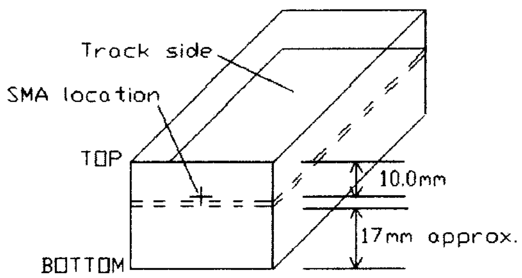
Box and RF PCB preparation

1. Assemble the tinplate box, by placing the side sections in the lids. If necessary, bend the sidewalls to give a good fit with the lids. With the box still all together, solder the outside seams as far as can be done (without soldering to the lids!).

2. Remove the lids and solder up all box seams inside and out.

3. Trim/file pcb to fit box. Generally pcbs are generally supplied slightly oversize and need a small amount of preparation to fit the box. The board should be made a reasonably tight fit in the box, but not so tight that there is any risk of damaging it while putting it into the box. Remove any rough edges from the board which could interfere with later soldering.

4. Scribe a line 10mm from the top edge of the box, as centreline for SMA centre connector pins. Mark out position of connector pins, to align with relevant pcb tracks.



5. Drill holes 4mm diameter for all SMA connector centre pins.

6. Flange mount SMA connectors may be soldered directly to the box by first locating them carefully in position, clamping them with two crocodile clips (one either side of the flange) and then soldering. Alternatively, follow steps 7-10 below.

7. Mark out positions of connector mounting holes using connector as a marking-out jig.

8. Drill connector mounting holes 2mm dia. Deburr using a drill on both sides. It is difficult to reach the inside of the holes with small boxes but it can be done. Filing is not recommended, as areas where the tin plating is inevitably scratched off will be difficult to solder to.

9. Assemble connectors to box with M2 screws and nuts.

10. Solder connectors to box all round using sufficient heat so that the solder flows well and when cool remove fixings. The use of two soldering irons can help! Note: Stainless steel SMA connectors cannot be soldered, and are therefore not recommended.

11 Reassemble pcb into box and check alignment of connector pins to tracks. Remove and refit any connectors where alignment is poor. Remove pcb. Cut connector pins to extend approx 2mm into box.

12. Drill and deburr holes in the box for feedthrough capacitors for power connections. If desired, drill a 1mm hole nearby, to allow a pin to be fitted for the ground connection.

RF PCB Pre-assembly

1. Fit supplied pins into holes in PCB where grounding is required with head of pins on the circuit pattern side (locations are shown on the layout with solid circles on the pads). Solder pins to groundplane side. This is best done by applying solder and soldering iron to the pin and flowing the solder down to the groundplane. Do NOT solder to the heads of the pins on the circuit pattern side at this stage. Trim the pins with sidecutters after soldering.

Assembling the PCB into the box

1. Reassemble the pcb into the box from the bottom side, and push it up against the RF connector pins. Try to get the board "square" in the box, not tilted to any great extent. Tack solder the groundplane in the four corners and recheck the RF input/output tracks are still touching the connector pins.

2. Solder all round the groundplane to the box walls. Two soldering irons may be helpful here also. Make especially sure there is a good joint where the connector are located. This is necessary to ensure a proper low inductance ground path from connector to pcb. It is best not to solder the track side groundplane areas around the preamp to the box wall. The veropins provide adequate grounding on their own.

3. Fit and solder feedthrough capacitor(s) for power connections, and box grounding pin (if used).

Fitting components to PCB

1. Fit chip components as described below, except the HEMT.

2. Fit any wire ended components required (on RF side and/or on groundplane side as specified).

3. Any grounded veropins have not been soldered to during earlier assembly stages should now be soldered, except those required to ground the HEMT source leads.

4. Fit any remaining veropins (power connections etc) and solder to track side.

5. Complete wiring including the FRE023 negative voltage generator pcb.

6. Set the 2.2k pot to about mid-range and power up the unit. Check that drain and gate voltages are present where the FET is to be fitted. If not, troubleshoot as necessary. Power off.

7. Fit the HEMT as described below, taking care it is orientated correctly and observing the static precautions as outlined below.

Fitting chip components

To fit chip components across two circuit tracks or pads, the following procedure should be adopted.

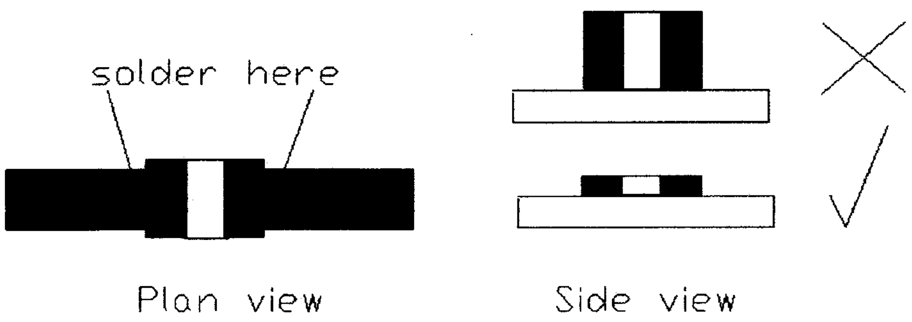
1. Lightly tin one of the tracks or pads. Silver loaded solder is recommended, and is supplied in some of the kits.

2. Locate the chip component and reflow the solder on the tinned track to make a preliminary joint.

3. Solder the other end of the chip to the track to make a good fillet.

4. Resolder the other end of the chip using a little fresh solder.

Note that the standard chip capacitors are mounted flat on the board as shown in the figure. Mounting them at 90 degrees will cause extra series inductance and may result in reduced performance, instability etc. It is recommended to mount resistors with the code letters visible, should later debugging prove necessary!



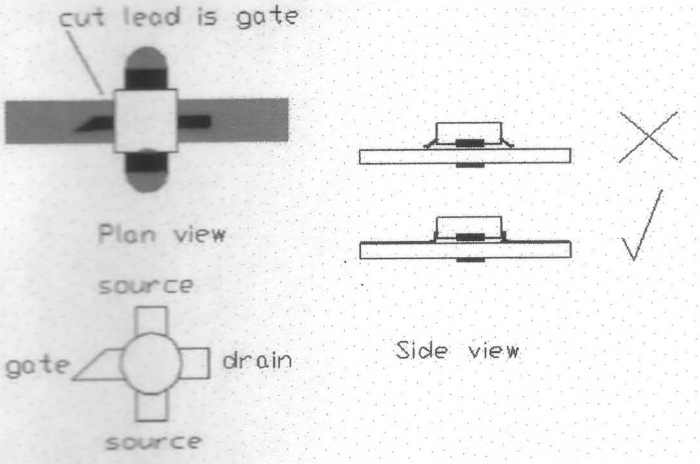
Note, where wire ended components are mounted surface mount style, aim for minimum lead length.

Fitting the HEMT

Before this device is handled, some preparations need to be made to avoid potential damage to the device(s) from static discharge and/or soldering iron leakage. In the case of normal GaAs FETs, it is often possible to get away with no precautions at all and not experience any problems. With HEMTs this philosophy needs to be reexamined. HEMTs are much more susceptible to damage and this is usually not apparent in its DC characteristics, often a disappointingly high noise figure is the only observable consequence. Where devices are supplied as part of kits, the use of these devices is entirely at the constructor's risk. The Microwave Committee Components Service cannot replace damaged devices free-of-charge!!

Damage from electrostatic discharge (ESD) is avoided by never allowing the possibility of the sensitive device having a different potential to any object it touches, including yourself. A simple static-free workstation should be made, such as a sheet of metal to which a wire is attached. The free end of the wire is joined to either a proprietary anti-static wristband worn at all times, or to some form of homemade body contact (such as a wire wrapped round a ring). For safety reasons it is recommended NOT to earth the workstation, and to use a high value resistor eg 100k ohms in series with the wire if using a homemade body contact. The device may than be safely unwrapped and placed on the worksurface.

Source leads are cut short next using sharp sidecutters, to fit between the source pins so that the device is flat on the board.



The last stage in the construction is the installation of the HEMT. The module should be otherwise complete and tested for correct voltages at the ends of the lines where the device is to be connected as noted above. With no power applied to the module, place it on the metal worksurface and connect a wire between the worksurface and the module box. Next, arrange some form of connection between the soldering iron bit and the worksurface, separate from the mains earth. Check that even when hot, there is a low resistance path from the soldering iron tip and the worksurface. It is also worth checking that there is no leakage in the iron by measuring resistance between the tip and the heater connections of the iron, with the iron cold and hot. The device may then be placed in position and its source leads soldered. At the same time, make sure the solder also flows to the grounding pins It is important to avoid touching the gate and drain leads with the iron during this operation. Before soldering the gate and drain the iron should be completely unplugged (retaining the tip-worksurface connection of course).

One assembled into the circuit, devices should be safe. However if for any reason soldering operations are required in the future, be sure to repeat the precautions. The author has damaged devices in the course of developing modules when soldering in tuning stubs and forgetting to connect the iron-worksurface link, and/or unplugging the iron. Some irons claim to have an ESD connection - we would not trust this! ESD damage to a HEMT may not cause it to fail catastrophically. The only sign of damage may be a higher than expected noise figure. No amount of tuning will be able to recover this and the only cure is to change the HEMT!