G3WDG017 1.3GHz 20W PA

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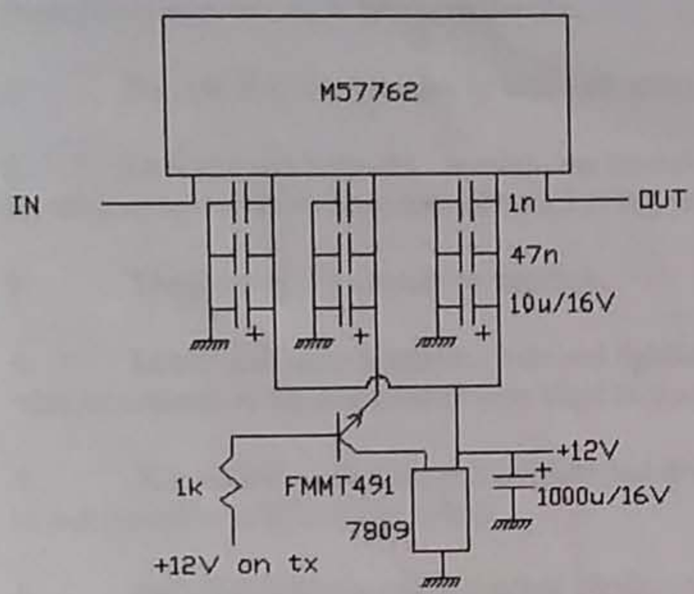
WDG017 20W 1.3GHz PA Beta Test Notes

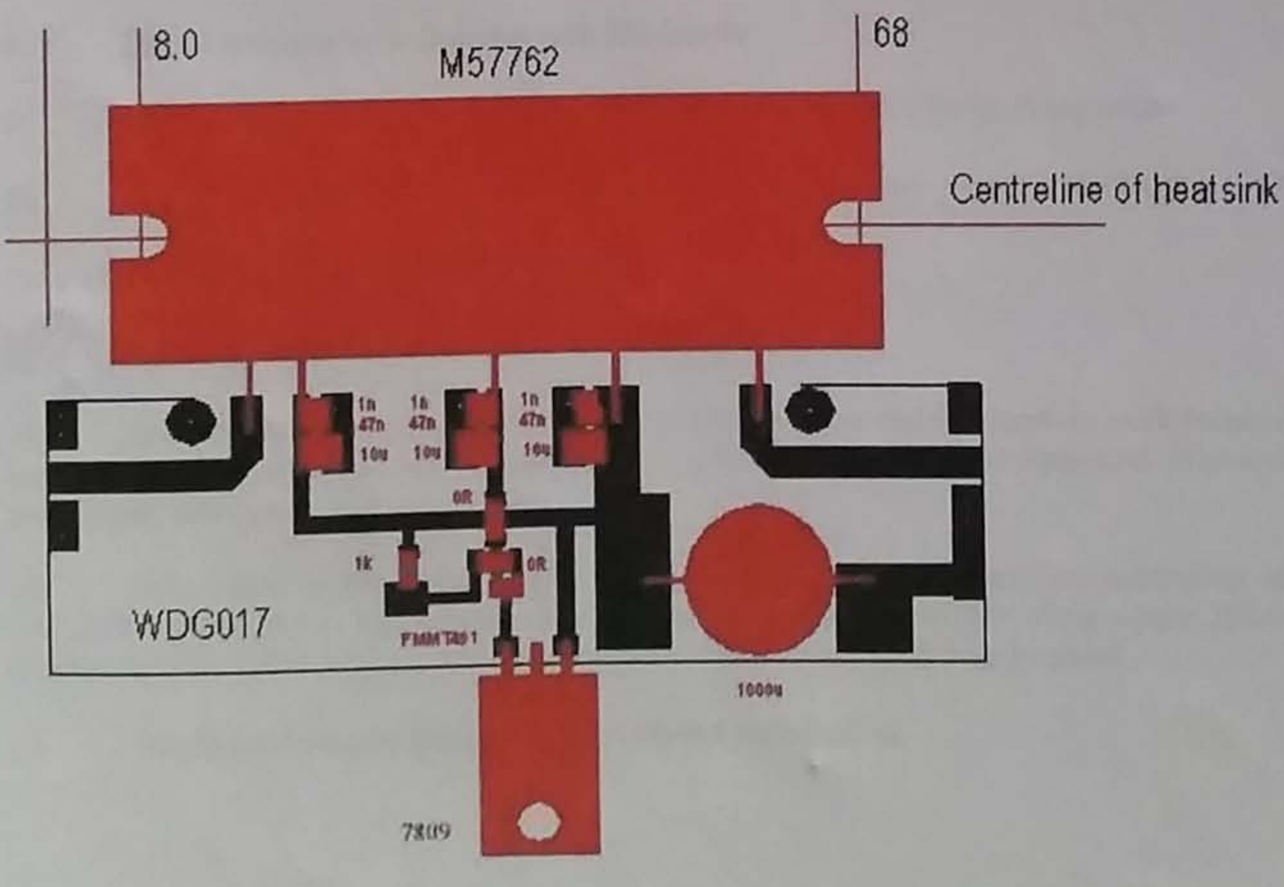
The WDG017 20W PA uses the well-proven Mitsubishi M57762 power module which is designed to cover the whole 1.3GHz band. The power seems to peak around 1260MHz, and the module still works very well at 1296MHz.

The WDG017 employs a transistor switch to enable the PA to be shut down during receive periods, to save energy and lower the heatsink temperature.

The circuit diagram of the PA is shown below:



The layout is shown below.



PRECAUTIONS AND RECOMMENDATIONS

GENERAL

Mitsubishi RF Power Modules for mobile radio applications have high reliability and good performance, as they are designed and manufactured under strict quality control. However, the reliability of semiconductor devices is remarkably affected by usage conditions such as circuit constructions, mounting method, environments, etc.. In order to keep high reliability and obtain good performance when using Mitsubishi RF Power Modules, the following important points concerning maximum ratings, handling, etc., should be noted before use.

1. MAXIMUM RATINGS

Maximum ratings of the RF Power Modules are defined by the "Absolute Maximum Ratings" shown in separate specification sheet. Maximum ratings should not be exceeded in any circumstances, even momentarily. If a device is operated in excess of the absolute maximum ratings, the device may immediately be degraded or destroyed. Futhermore, in designing an electronic circuit using RF power Modules, it is necessary to note that the maximum ratings of the devices should not be exceeded even if external conditions are changed.

2. NORMAL OPERATING VOLTAGE

Normal operating voltage is 12.5~13.8 volts for Mitsubishi RF Power Modules, because they are designed for mobile radio applications. The regulated 9 volts is recommended for the base biasing voltage of the modules for linear power amplifiers (for SSB).

3. THERMAL DESIGN

In order to keep high reliability of the equipment, it is better to keep the module temperature low. The case temperature of the module, when operated standard conditions, is lower than 90°C under all severe ambient temperature, recommend normally 60°C.

4. MOUNTING and HANDLING

4-1 When the module is mounted on to a heat sink of a equipment, thermal compound to get good heat sinking should be applied between the module's fin and the heat sink. Following thermal compound for good heat sinking is recommended.

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4-2 When mounting a module to the circuit, do not apply excessive stress to the terminal leads or the fin. In particular, if there are some foreign objects between the module and the heat sink, or if there are some burrs or rising on the surface of the heat sink, it may happen that the substrate of the module will crack or break due to excessive stress from screwing the module on to the heat sink. Therefore, the surface of the heat sink in contact with the module must be as flat as possible.

When screwing a module to the heat sink, torque screw is recommended as 5 to 6kg-cm when using ϕ3mm screws.

4-3 For soldering, the major precautions are as follows:

1) Flux;

Roles of flux are to remove oxidized layer on the object, and prevent from oxidation during heating or lowering surface tension on the objects. Rosin flux, which is less corrosional and highly insulative, is recommended.

2) Soldering temperature:

The temperature of the lead soldering should be lower than 260°C and shorter than 10 seconds, or lower than 350°C and shorter than 3 seconds.

3) Cleaning after soldering.

The recommended solvent for cleaning the residual flux is the Ethyl Alcohol. Trichlene type solvents should not be used.

4-4 When the module is screwed after soldering the terminal leads to the circuit board, excessive stress is applied to the leads. Therefore, please solder the terminal leads to the circuit board after screwing the module to the heat sink.

4-5 If the module falls onto a hard surface, it will be damaged by mechanical shock and can no longer be used.

4-6 To obtain good stability and electrical performances, it is necessary to take precausions concerning the earth potential of the module. As the fin is the ground terminal, the fin should be connected to the ground of the set completly in RF condition.

4-7 The values of input VSWR and output VSWR of the module indicated in the specification sheet are guaranteed when the input and output leads are straight and these leads are connected to the load 50Ω within 10mm length. If the device is mounted under different conditions from these mentionedabove, the performances, such as output power and efficiency, may be degraded due to the impedance mismatch. In order to reform such an impedance mismatch, please set the additional matching circuits to get good impedance matching.

5. VOLTAGE SUPPLY

The modules have 2 or 3 terminals for DC power supply. If these terminals are combined without RFC (Radio Frequency Choke), or if each terminal is not bypassed with the condenser, parasitic oscillation occasionally may occured. Therefore, the DC Power Supply Terminals should be combined with RFC, and each terminal bypassed with the condensers (10μF and 4700pF in Paralel).

The first stage transistor of the module even for FM is operated in class AB. When excessively high voltage is applied to the first stage DC Power Supply Terminal, the first stage transistor may be destroyed due to current runaway. Therefore, the first stage supply voltage must be controlled, not exceeding 17 volts DC.

Precautions using Mitsubishi RF Power Modules

Many stations are using RF power modules very successfully, but on occasions there have been problems where modules have failed or degraded. The most likely cause for this is overheating, particularly where modules are driven hard or are operated continuously. The extract reproduced below may be useful regarding this and other general precautions.

It is important to ensure that the heatsink surface is flat and free from burrs, and that the heatsink is adequate to dissipate the heat generated by the module. Also note that Mitsubishi recommends the use of thermal grease to improve the heat conduction from the module. Mitsubishi states that the temperature of the module flange should not exceed 90C or irreversible damage may occur. We have recently had occasion to dismantle a degraded M57762 and found a cracked chip capacitor in the output network and some fried thick-film resistors, so this may well be true!

Under high drive conditions, the M57762 module, used by many stations on 1.3GHz, may dissipate over 40W of heat. The heatsink specified above may not be large enough for continuous use. Also note that for optimum operation, the heatsink should be mounted with its fins vertical so that air can flow freely and achieve optimum cooling. Measurements show that mounting the heatsink flat with the fins downwards will increase the thermal resistance by as much as 50%!

It has been found that as supplied the modules are slightly bowed, which means that the centre of the heatsink may run considerably hotter than it does at the ends, near the mounting screws. Measurements with a thermocouple have shown that centre of the module flange seems to run some 20-30 degrees hotter than the heatsink to which the module is bolted, suggesting that the heatsink itself should not be allowed to run hotter than about 60C. The temperature of the flange near the mounting screw only runs 10 degrees or so hotter than the heatsink and may lead to an optimistic view of the temperature of the flange where it really matters!

A suggestion to prevent operation continuing if the heatsink gets too hot is to use a bi-metallic thermal switch bolted to the heatsink to shut down the module if the heatsink gets too hot. Once the heatsink cools, the switch resets automatically and the PA can be used again (and the overs kept shorter!). Suitable switches are available from Farnell and RS at relatively low cost. If there is sufficient interest, these could be stocked by the Microwave Committee Components Service (eg a 50°C NC type which could be connected in series with the T/R line or power supply to the module).

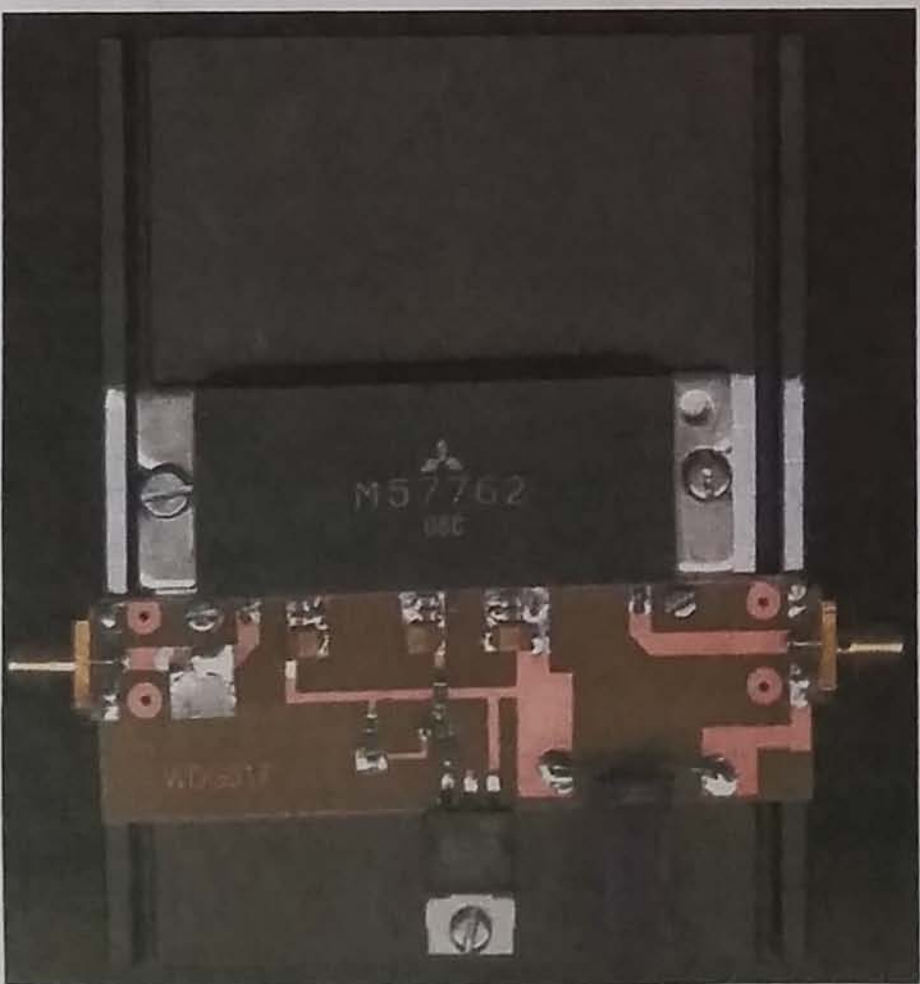
Forced air cooling of the heatsink is worth considering it temperature rise is a problem. Various small fans are available quite cheaply these days (eg computer cooling fans). This is an excellent suggestion for situations where air can move freely around the PA.

It is recommended to shut down the PAs on receive. This can be done by removing the 1k resistor and applying +12V on transmit via a 470R resistor to the pad previously connected to the bottom end of the 470R resistor. On receive, the lack of a voltage effectively shuts the module off.

SMT Kit Contents

7809 9V regulator (1)
1000uF electrolytic (1)
1nF chip capacitors (3)
47nF chip capacitors (3)
10uF chip capacitors (3) - bar end is +ve
470R chip resistor (1) - replaces 1k shown in circuit diagram and layout diagrams
0R chip links (2)
FMMT491 smt transistor
solder for SMT parts (1)

Photo of completed unit



16. Reassemble pcb to heatsink and fit connectors. Solder connectors to ground strips on track side of board using decent sized iron. If you have only a small iron, preheat the heatsink to 150C approx and while hot make the solder joints.

17 Mount other components including the module to pcb.

Testing and using the PA

Apply volts, apply drive and you should have output! Performance of one of the prototypes at 1300MHz is shown below. The data sheet for the M57762 quotes an absolute maximum supply voltage of 17V, and that the device should survive a 16:1 VSWR with a 15.2V supply at 18W output power. For most applications, a supply voltage up to 14V is recommended. If equipment is available to measure the input VSWR, a small improvement may be possible by adding a tuning tab to the input line (see photo below).

Vcc=12V

Pin (dBm)	Pout (dBm)	Pout (W)	Gain (dB)	Icc (A)
no rf				0.66
20.0	37.67		17.67	2.24 (small signal operation)
24.2 250mW	40.95	12.5	16.75	3.25 (1dB gain compression)
27.0 500mW	41.96	15.7	14.96	3.85 (near compression)

Vcc=13V

Pin (dBm)	Pout (dBm)	Pout (W)	Gain (dB)	Icc (A)
no rf				0.68
20.0	38.47		18.47	2.39 (small signal operation)
24.3	41.72	14.9	17.42	3.48 (1dB gain compression)
27.8	42.86	19.3	15.06	4.27 (near compression)

Vcc=14V

Pin (dBm)	Pout (dBm)	Pout (W)	Gain (dB)	Icc (A)
no rf				0.70
20.0	39.05		19.05	2.45 (small signal operation)
24.5	42.5	17.8	18.0	3.70 (1dB gain compression)
28.6	43.8	24.0	15.2	4.69 (near compression)

Vcc=15V

Pin (dBm)	Pout (dBm)	Pout (W)	Gain (dB)	Icc (A)
no rf				0.67
20.0	39.2		19.2	2.50 (small signal operation)
24.8	42.98	19.9	18.2	3.87 (1dB gain compression)
28.2	44.06	25.5	15.9	4.74 (near compression)

Construction

The original prototype was constructed using a commercial heatsink as the chassis. The heatsink measured 80 x 100 x 30mm (Farnell 738-906) and the construction notes refer to the use of this heatsink. Other prototypes have been built on a 6mm (or 0.25") thick aluminium plate as the chassis. This has some advantages, in that any heatsink out of the junk-box can be used (provided it is big enough!), or the plate may be water-cooled. In these cases the plate chassis is just screwed on to the main heatsink. Also, most aluminium plate is easier to work than the metal used to make heatsinks, which tends to be rather soft, and there is no need to scrape off the anodising (a rather tedious operation!). Please note that for continuous operation, the Farnell heatsink referred to above may not give sufficient cooling. Please refer to the precautions section below for more details.

1. For 1W PA, cut heatsink to size (45 mm). 18W PA uses full size heatsink.

2. Drill and tap holes for securing the module to the heatsink. Refer to assembly diagrams for location of holes. Drill 2mm and tap M2.5 (1W), drill 2.5mm tap M3 (18W).

3. Temporarily, fit module to heatsink.

4. Locate pcb onto heatsink - refit and tighten module screws so that pcb aligns to edges of heatsink without under/overlap and module pins align to tracks on pcb.

5. Temporarily, sellotape pcb in place and drill through holes in pcb either side of RF lines partway in to pcb (to make drill location holes).

6. Drill through heatsink in marked places 1.6mm diameter and tap M2. Drill carefully, with lubricant, to avoid breaking drill. Also tap with lubricant.

7. Open holes previously drilled through in pcb to 2mm dia.

8. Fit pcb temporarily to heatsink with M2 screws.

9. Locate voltage regulator and drill 2.0mm hole and tap M2.5 for its fixing screw

10. Locate connectors and drill/tap heatsink for retaining screws. Use 2 x M2 if using SMA types.

Skip 12-14 if using plated through hole pcb

12. File ends of heatsink to allow clearance for ground pins

13. Drill through grounding holes in rectangular pads near module leads to mark heatsink (6 places) and drill these out a few mm into the heatsink to sufficient diameter (4mm suggested) to give clearance to ground pins and associated solder fillet).

14. Fit veropins to pcb, heads on groundplane side, cut to leave about 1mm protruding on pcb side, and solder to both sides. File excess solder off heads on groundplane side. Keep solder fillet within confines of blind relief holes or scrape off excess so board still sits flat on heatsink.

15. Scrape anodising off heatsink under pcb and module area.