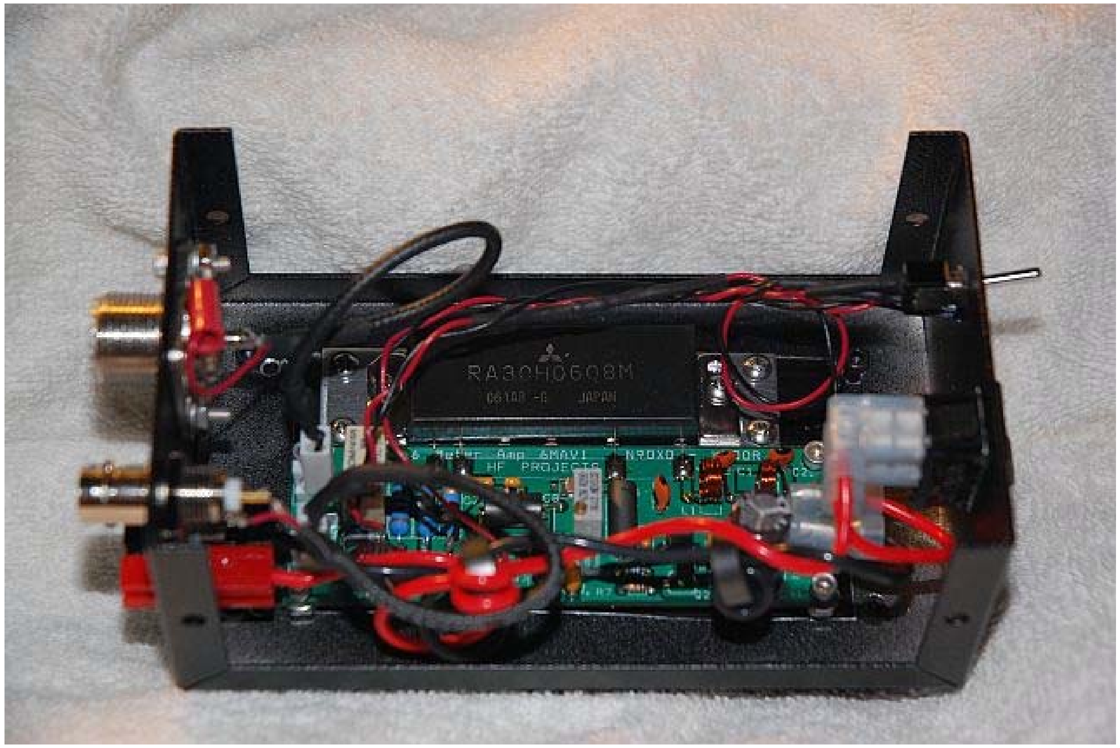


HF Projects
6 Meter VHF Packer Amplifier
Project Manual

Manual version 1.1, September 5th, 2009
http://site.hfprojectsyahoo.com/vhf_packer_6m_amp

Table of Contents

1 Introduction

1.1 Description

This project will provide you with an excellent source of fun, interest and skill building challenge. In the end you will have a compact 30 watt linear amplifier for use with QRP 6m transmitters, which can be powered from a 12 volt DC supply. The design is a good balance between output power, physical size and battery power consumption. The completed amplifier will reward the builder with a clean, more powerful output signal from a 6M QRP transmitter.

The product uses the Mitsubishi RA30H0608M RF mosfet module mounted on a heat sink. (http://www.mitsubishichips.com/China/common/cfm/ePartProfile.cfm?FILENAME=ra30h0608m.pdf). This 30-watt RF MOSFET Amplifier Module is designed for 12.5-volt mobile radios that operate in the 66- to 88-MHz range on SSB, CW and FM modes.

1.2 Features

- All parts, circuit board, case and heat sink provided
- 50 ohm resistive pi network input: 1W drive = 30W output
- Filtered Anderson Power Pole DC Input: 12VDC @ 6.2A
- Low Pass Filter on-board; Filtered RF Input and RF Output
- Bypass / Operate Switch with TX LED
- COR – Carrier Operated Relay
- Size: 5.25 x 3 x 3 inches ; Weight is less than 1 pound
- Accurate Drill templates provided for easy case fabrication
- Construction manual provided on a CD

2 Procedure

The basic concept to building this amplifier is to prepare the chassis, the cables, the circuit board and the amplifier board (in that order) and pretest them before final assembly and final testing. This manual is thus organized with this concept in mind and consists of distinct chapters for each module assembly process:

1. Introduction
2. Procedure (this chapter)
3. Chassis Fabrication
4. Cable Assemblies
5. Circuit Board Construction
6. Install Circuit Board and Amplifier Assembly
7. Testing Procedures
8. Operating Procedures

2.1 Preparation

The most important preparation step is to read this manual before assembly. This will familiarize you with the project, its circuitry, building requirements and components. You should also do an inventory of parts. In the unlikely event that you appear to have missing parts, duplicates or wrong parts please first double check for the parts in *all* bags, recheck the inventory and if you appear to still be missing parts please contact the project organizer (mailto:vstamps@comcast.net).

2.2 Faults

It is a fact that 90-95% of problems with completed electronics projects are due to either component misplacement or soldering faults. We cannot stress highly enough the importance of reading the manual thoroughly, double checking component installation before soldering and then good soldering technique in order to have a working amplifier at the end of this project. Other builder faults are active component damage due to over-heating and damage to circuit board pads and tracks caused by faulty de-soldering, too high a wattage of soldering iron or carelessness. It is very rare indeed to have initially faulty components or printed circuit boards (PCBs).

2.3 Soldering Technique

- use a 12-25 watt soldering iron with a clean, non-corroded, well-tinned, fine tip
- keep the tip clean by frequently rubbing it along a wet sponge
- keep the tip tinned with a thin film of solder

- ensure all circuit board pads and component leads are clean (not a problem with this project because boards and components are new)
- insert the component in the holes associated with the component outline. Bend the leads at a 45 degree angle to hold the part in place
- ensure the soldering iron tip is at its working temperature and is in contact simultaneously with both surfaces to be soldered (the pad and the component)
- let the contact zones heat before applying only electronics grade rosin cored solder (usually 3-6 seconds will do)
- apply the solder to the two surfaces (not the iron tip) and only enough solder to coat both surfaces
- ensure that the joint does not move after you remove the soldering iron tip and until the solder has solidified (approx 5-7 seconds)
- clip the leads very close to the circuit board surface
- check that the resultant solder joint is shiny, in perfect contact with pad and wire and has a concave upwards appearance
- if not, renew the solder joint by reheating and reflowing the solder joint with the tip of the soldering iron
- special care for toroid coils: the toroids and inductors you will wind and solder in this project use enamel coated magnet wire. You must remove this insulation coating at the ends of the wires prior to soldering. Two techniques are: 1) use a small butane cigarette lighter to burn off the insulation material or 2) take a large drop of hot solder on your soldering iron tip and run the wire end through the hot solder blob to remove the insulation (this may not work with low wattage irons). Other methods such as using sandpaper or a razor knife will work but you may damage the wire or the toroid windings if you are not careful.

- **Desoldering**: we recommend using desoldering wick. This thin flexible copper braid heats rapidly, sucks up solder well and is inexpensive. (Solder suckers are difficult to hold in place and the solder may re-solidify before you are able to press the suck button). To use desoldering wick (braid) heat the wick first before applying any heat to the joint, lay the wick over the joint and put the tip of the iron on the wick. It will take a second or two to heat up, but once it is hot you will feel the wick slide and you should then see the solder flow into it. You probably won't have to repeat this step. Once a section of wick is filled with solder, it is used up and must be cut off the rest of the braid. Since the wick comes on a spool, all you need to do is cut off the used sections and take some more off the spool.

2.4 Suggested Tools

- 12-25 watt electronics soldering iron with stand and sponge
- electronics grade solder
- de-soldering braid and/or de-soldering pump or bulb
- fine needle nose pliers, small fine wire cutters, wire stripper
- multi-meter, test leads
- small nutdriver set, English
- 50 ohm Dummy Load

Also, the following tools are needed to fabricate the chassis:

- 3/8 inch wood boring bit[1]
- 5/8 inch wood boring bit
- 7/32 inch drill bit
- 5/32 inch drill bit
- 1/8 inch drill bit
- 1/16 inch drill bit for pilot holes
- Nibbler tool for cutouts
- Hand drill and/or drill press
- Small and medium flat file

Tools necessary for Testing:

- Multi-meter capable of measuring volts, ohms and amps.
- LCR meter for testing low pass filter (other methods possible if you don't have this)
- Dummy load, 50 ohms for output testing (capable of 50W)
- Dummy load, 50 ohms to terminate the input (BNC 50 ohm plug)
- Current measurement test cable (to make life easy)
- 12V source for testing (a small battery is ok)

Nice to have (but not necessary tools):

- GC/Waldom W-HT1821 crimp tool (for blue flag terminals)
- West Mountain Radio Power Pole Crimpers
- Wire strippers, Klein Tools 11046
- Molex Crimp tool EDP# 11-01-0185; ENG# CR2262C (22-30 AWG)
- Heat Gun for shrink tubing

2.5 Component Installation

For each component and throughout this manual, our word *“**Install**”* generally means:

[1] A wood boring bit works well when drilling through soft aluminum and makes a nice neat hole.

1. Pick the correct part to start with – in the assembly notes that follow you will get a complete description of the part to install. You must find this part using the “Bill of Materials” for the specific module you are constructing. This parts list is located at the end of this document (see the Table of Contents). Parts will be located in their appropriate module bag.
2. Insert the component into the correct PCB position. Refer to the appropriate PCB component outline diagrams and follow the text.
3. Orient it correctly, following the PC board outline. This is vital for active components, electrolytic and tantalum capacitors and diodes. Also, it is good practice to mount resistors and capacitors in identical orientations (for resistors normally read color code left to right in same direction as the silkscreen on the PC board). This makes component checks easier.
4. Install all low profile components first: usually resistors, capacitors, diodes, then electrolytics and active components. The text will normally guide you to the most efficient method of what to install when.
5. Resistors, capacitors, relays and connectors should be mounted flush with the board.
6. Bend the wires of the components at the bottom side slightly outwards in order to hold the component in place for soldering.
7. Solder as per techniques described above.
8. Trim excess wire leads.
9. Mark off each installation step in sequence as you complete it, in the box provided (e.g. ☑).

The usual sequence of assembly is to place all the small resistors and capacitors first. The order given is by position on the board. Generally, the flow is from upper left to lower right to aid you in locating the next component. Sort all the resistors by component value from left to right. You may wish to use a strip of scotch tape on a scrap of paper and slip a lead of the resistor under the tape. Use your ohm meter and resistor color code (see end of this document) to identify each of the small resistor values. Group the same component values together and then follow the text procedure exactly. A parts placement diagram is provided at the end of each module assembly section for reference.

2.6 Board Cleaning

PCB cleaning is recommended after soldering all components. This removes residue that might provide a conduction path at high frequencies and subvert the overall frequency response of the filters. TechSpray Blue Shower is a good product and is available from Mouser Electronics. Use the spray in a well ventilated area (e.g. outside) to remove solder flux from the board. Follow directions on the can.

3 Chassis Fabrication

3.1 Template Procedure

- ❑ Ensure your printer is set for “no shrink” so that no distortion of scale occurs upon printout.
- ❑ Print out 2 copies of the drill templates (one to read the other to use). See Illustration 1 as an example.
- ❑ Cut out the top and end panels and tape. Put the box back together again for strength.
- ❑ Using the heat sink plate (rectangle, approximate size of cutout) as a straight edge, score the outline with a hobby knife or straight-edge razor blade to mark the outline.
- ❑ Use a chassis-punch to mark all the holes for drilling.
- ❑ Mark all three sides of the chassis for the cutouts or holes to drill.
- ❑ After you cut through the paper, remove the rectangle cutout and place a piece of scotch tape over the cutout.
- ❑ Score the outline again to leave a tape outline of the area to be removed.
- ❑ Drill small 1/16 inch pilot holes at all hole locations. Drill all holes before removing the drill template as it very hard to see the marks.
- ❑ Remove the drill template. You will be left with tape outlines to help you see the cutout area clearly.
- ❑ Drill a 3/8 inch hole in the center of the larger cutouts. Use a couple adjacent ¼ inch holes on the smaller cutouts and file large enough diameter to accept the nibbler tool.
- ❑ Use the Nibbler tool to cut close to the edge of the scribed line of the cutout.
- ❑ Use a file to finish up the cutouts to dimension.
- ❑ Install the chassis switch components into the cutouts. Use a file to achieve the final dimension necessary to install the component. It is important to note that the two terminals should be oriented towards the outside for proper switch logic.
- ❑ Precisely attach the drill template for the heat sink plate (rectangle piece). Center punch and drill the 6 holes starting with a small drill bit diameter and graduate to the final bit size. Remove rough edges so the plate will mount flat against the heat sink. A ¼ inch drill bit rotated by hand will clean up the edge.
- ❑ Trial fit the heat sink plate on the heat sink into the chassis. The heat sink plate should be parallel to the heat sink edge and spaced about 0.05 inch from the edge.
- ❑ Align the amp module mounting holes in the heat sink plate with the tapped holes in the heat sink. This is of primary importance.
- ❑ Apply a thin even layer of thermal grease between the heat sink plate and heat sink. Use four 4-40 x 5/16 inch screws to attach the heat sink plate to the heat sink.
- ❑ Attach four Jack screws to the four holes that will be the board mounting location.
- ❑ Trial fit the heat sink into the chassis. File the length or width of the slot as necessary to achieve fit.
- ❑ Elongate a hole, if necessary (to compensate for fabricating tolerance variation). Side pressure with the hand drill can make small adjustments for better fit.

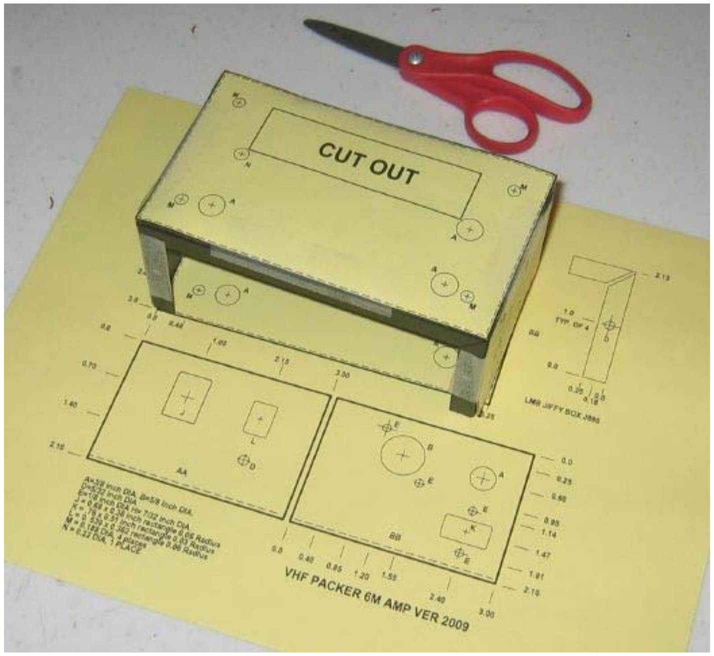


Illustration 1: Preparing the templates for chassis fabrication

3.2 Bottom Cover Fabrication

- ❑ Cut out drill template for bottom cover. Tape to the bottom of the case.
- ❑ Chassis punch four holes. Drill pilot holes.
- ❑ Drill 7/32 inch diameter holes. Use a large bit on the inside to de-burr the holes.
- ❑ Attach four rubber feet into the holes.

3.3 Chassis component mounting

- ❑ Attach the heat sink assembly to the case. Use four 4-40 x 5/16 inch screws with lock washers. (You should already have the two switches mounted in the case).
- ❑ Attach the power pole connectors using 4-40 x 3/8 inch screws, lock washers and #4 nuts. The extra screw length helps with assembly.

- ❑ The Power Poles have a mounting convention to properly mate with a power pole cable. View from outside the box, the red housing should be on the left with the metal contact in the bottom quadrant. The black housing is physically combined with the red housing.
- ❑ Place the top power pole retainer piece first, loosely attached with a 3/8 inch length 4-40 screw, lock washer and nut. Insert the power pole retainer into the metal retaining tab. Tighten up the mounting screw. Install the other screw, power pole retainer, washer and nut. Even up the hardware and tighten. We will insert the wire later.
- ❑ Attach the SO239 connector with two sets of 4-40 x 3/8 inch screws, lock washers and #4 nuts. The flange is placed inside the enclosure.
- ❑ Attach the BNC connector. Use a ½ inch wrench to tighten securely to the case.
- ❑ Trim the LED length to 6 inch. Install two crimp terminals to the ends of the wires. Insert the LED through the chassis. Slip the crimp terminals into the housing. The red lead will ultimately plug into the square pad at the D3 connector on the circuit board.

4 Cable Assemblies

4.1 Power Cable Assembly

- ❑ Cut the red wire to make a 7 inch length. Crimp a Power Pole terminal to one end and a blue flag terminal to the other end. Plug in on a power switch tab.
- ❑ Trim the black wire to make a 7 inch length. Crimp a Power Pole terminal to one end and a blue flag terminal to the other end. This wire will connect to the circuit board when installed.
- ❑ Insert the wires into the power pole housing. It is important that the connector tab be fully inserted for proper assembly. Use a small flat blade screw driver to push on the back end of the terminal with the terminal inserted in the housing. You should hear a click when the mating ends of the terminals join together.
- ❑ Trim the remaining red wire to 3 inch. Crimp a blue flag terminal to each end. Plug in on a power switch tab. This wire will connect to the circuit board when installed.

4.2 RF Cable Assembly

- ❑ Cut two four inch lengths of RG174 coax. Remove the insulation ¾ inch from the wire end. Thread four ferrite cores over each wire.
- ❑ Comb out the braid and twist into a pig tail. Trim the pig tail to ¼ inch. Tin the wire at the tip.
- ❑ Cut six ½ inch lengths of the black shrink tubing. Place over the four ferrite cores in the middle of the wire and heat shrink to hold in place.
- ❑ Locate the black hook up wire. Cut four 2 inch lengths. Strip ¼ inch insulation from each end. Tin one end of each wire.
- ❑ Solder one end of each black wire to the ends of the cable.
- ❑ Place a ½ inch length of shrink tubing over each end of the cables. The black wire should be formed so both the black and center conductor are the same length. Heat shrink the tubing.

- ❑ Crimp a terminal pin to one end of each cable. Crimp a terminal pin to same end of the coax center connector.
- ❑ Insert the terminal pins into the connector housings. The coax center pin will plug into the circuit board at the square pad position.
- ❑ Tin the wires at the other end of the two cables.
- ❑ Solder the red ring terminal to the black lead of one of the cables. This establishes this cable as the RF Output cable. The other cable is the RF Input cable.
- ❑ Solder the RF Output cable to the SO239 connector. The red ring terminal is placed under a SO239 mounting screw. See Illustration 2.
- ❑ Solder the RF Input cable to the BNC connector. Make sure the ground connection is not a cold solder joint. See illustration 2.

Illustration 2: Completed RF cables.

4.3 Switch Cable Wiring

- ❑ Cut two 6 ½ inch lengths of hook up wire. Strip ¼ inch insulation from each end. Tin the wires on one end.
- ❑ Attach crimp terminals to the unsoldered end of each wire. Insert into a 2-pin housing.
- ❑ Solder the other end of each wire to the Bypass/Inline switch.

5 Circuit Board Construction

5.1 Install Capacitors

- ❑ C5 47pf
- ❑ C2 18 pf
- ❑ C4 100 pf (101)
- ❑ C1 5.6pf
- ❑ C14 .01uF (103)
- ❑ C3 56 pf
- ❑ C15 .01uf (103)
- ❑ C12 .68uf (684) (observe polarity)
- ❑ C9 1nf (102) same as 1000 pf
- ❑ C6 1nf (102)
- ❑ C10 .01uf (103)
- ❑ C13 .01uf (103)
- ❑ C7 .1uf (104)

5.2 Install Resistors

- ❑ R5 10K BRN, BLK, ORN 1/8W
- ❑ R6 402 Blue body 1% 1/8W
- ❑ R7 10K BRN, BLK, ORN 1/8W
- ❑ R8 1K BRN, BLK, RED 1/8W
- ❑ R4 jumper
- ❑ R3 100 1W (measure)
- ❑ R1 68 1W (measure)
- ❑ R2 100 1W (measure)

5.3 Install Connectors

- ❑ J1 2 pin friction lock header

- ❑ J2 2 pin friction lock header
- ❑ D3 2 pin friction lock header
- ❑ SW1 2 pin friction lock header
- ❑ TEST 2 pin header

5.4 Install ICs, Transistors, Diodes and Relay

- ❑ U1 78L05
- ❑ Q2 2N3906
- ❑ Q3 2N5089
- ❑ D2 1N5711 (observe polarity stripe)
- ❑ D1 1N4007 (observe polarity stripe)
- ❑ K1 Relay, 12V DPDT (solder 1 pin, reheat and align, solder all pins)

5.5 Install Other Components

- ❑ L4 Ferrite Tube (use a wire from component clipping)
- ❑ L3 Multi-hole Ferrite
- ❑ C8 .68uF surface mount (684) Tin 1 pad. Place component and solder. Solder other lead
- ❑ J3 Tab Solder 1 pin, reheat and align, solder other pin
- ❑ J4 Tab Solder 1 pin, reheat and align, solder other pin
- ❑ VR1 POT 200 ohm (adjustment screw aligned with square pad) Turn pot fully CCW (no stop)
- ❑ C11 680uF (observe polarity)

5.6 Fabricate and Install T1

- ❑ Cut a 15 inch length of #24 AWG wire
- ❑ Fold in half and thread ferrite core on the wire.
- ❑ Hold core between thumb and fore finger with the wires pointing up
- ❑ Grasp the wire under your fore finger wind 13 turns on the core.
- ❑ Wind 12 turns with the remaining wire for a total of 26 passes through the core.

- ❑ Trim the ends to 3/8 inch. Remove the insulation on the wire (file, Dremel tool, etc.)
- ❑ Tin the leads and insert into holes 1 and 4 (upper right square pad and lower left round pad) and solder.
- ❑ Insert a 1 inch length of insulated wire (small insulated bus wire) through the center of T1 and attach to holes 2 and 3 (upper left, lower right) and solder.

5.7 Fabricate and Install L1 and L2

- ❑ Cut a 5 inch length of #24AWG enamel wire. Scrape the last ¼ inch to remove insulation and tin the ends. Wrap the wire tightly around a ¼ inch drill bit to form an air coil. Form the leads and solder into L1 position.
- ❑ Cut a 4 inch length of #24AWG enamel wire. Scrape the last ¼ inch to remove insulation and tin the ends. Wrap the wire tightly around a ¼ inch drill bit to form an air coil. Form the leads and solder into L2 position.

6 Install Circuit Board and Amplifier Module

6.1 Install Circuit Board

- ❑ Attach circuit board to case using four 4-40 x ¼ inch black screws. Place the shorter locking lug terminal under the screws at upper left and upper right. These will be soldered to the amp module lug terminals when the amp module is installed.
- ❑ Plug in RF In cable to IN. Keep coax tight and next to RF IN connector.
- ❑ Plug in RF Out cable to OUT. Route cable to be under SO239 connector.
- ❑ Route LED wires below power cable down the length of the case and plug into D3 location.
- ❑ Route switch cable in the same manner as the LED cable.
- ❑ Plug in the power cable to J3 and J4. The plus (red) lead connects to J3. The minus (black) connects to J4.

6.2 Install Amplifier Module

- ❑ Read the RA30H0608M data sheet located at the end of this document and heed the warning concerning handling and operation.
- ❑ Attach four TO220 Thermasil pads on the heat sink surface of the Amp Module
- ❑ Ensure you do not bend the leads of the device.
- ❑ Solder the leads only after the module and circuit board are mounted and in their final resting place.

- ❑ Clip ¼ inch off the length of the four pins attached to the amp module.
- ❑ Apply a thin coat of thermal grease under each mounting wing of the amp module
- ❑ Place the amp module on the heat sink plate. Place a lug locking terminal on each 4-40 x 3/8 inch mounting screw. Screw until just tight but not cinched down yet.
- ❑ Position the lug locking terminal to contact the lug locking terminals mounted on the circuit board.
- ❑ Firm up the screws a bit more and solder the lug locking terminals together.
- ❑ Tighten the amp module mounting screws firm.
- ❑ Amplifier module connections on the circuit board are pins 1-4 (left to right)
- ❑ Solder pins 1, 2 and 4 to the circuit board and isolate pin 3 with small of paper between the pin and the circuit board. We will attach pin 3 to the 12V in a later step after initial check out has been completed.
- ❑ See Illustrations 6, 7 and 8 regarding completed and assembled amplifier chassis, boards and module.

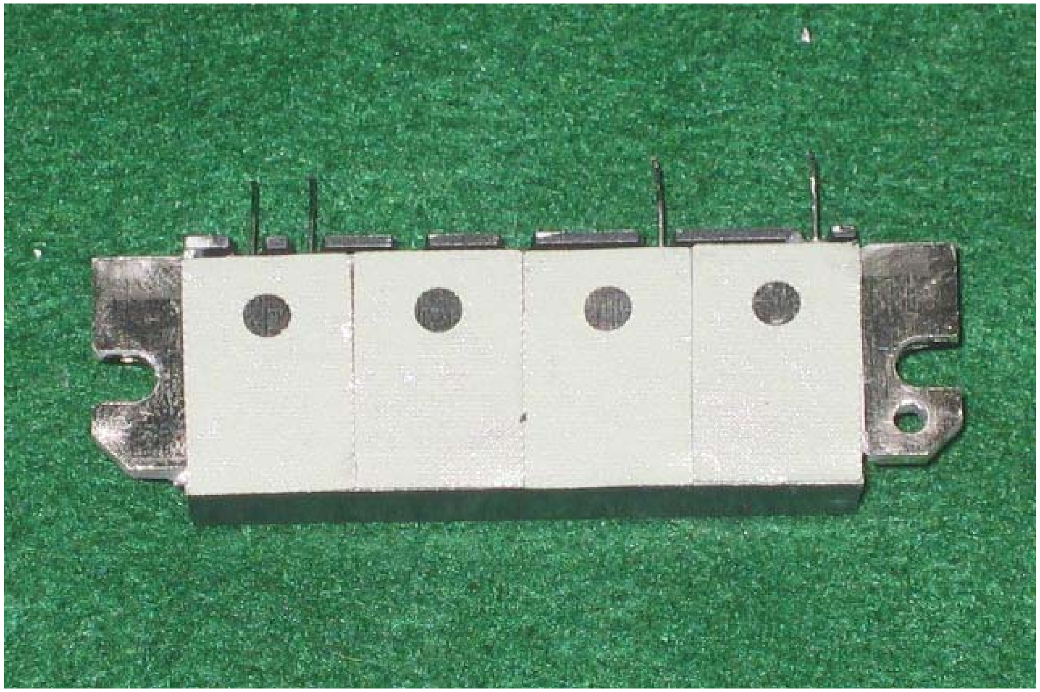


Illustration 3: Thermalsil™ III is .152mm (0.006") thick and grey green in color. A finely woven glass cloth provides the thinnest possible matrix for enhanced thermal resistance.

7 Testing Procedures

7.1 Initial Checks

- ❑ Connect a multi-meter to measure ohms on the DC input (power pole connectors). The resistance should be in the high megaohms. A typical is greater than 5Meg ohms with the power switch ON.
- ❑ Connect a multi-meter to measure volts. One lead to ground (case). Place the positive lead on pin 2 of the amp module. This is the BIAS pin.
- ❑ Turn power on. The voltage on pin 2 should be zero volts.
- ❑ Attach a jumper to the TEST jack (use an small alligator clip for this purpose).
- ❑ Reading should be about 3.2 VDC.
- ❑ Rotate the pot clockwise a few turns and observe that the voltage begins to rise. This will confirm the adjustment circuit is functional and the pot is installed correctly.
- ❑ Disconnect from power. Remove the paper insulator and solder pin 3 to the circuit board.

7.2 Setting Bias Current

- ❑ Configure the multi-meter to measure current. Place the meter in the circuit to measure the current. A typical configuration would be to place the meter in series with the positive DC Volts lead to the amp from the power source.
- ❑ Set the meter to measure DC AMPS.
- ❑ Turn on the amp. The current reading should be zero amps. There will be an initial small surge current that quickly drops to zero.
- ❑ Jumper the TEST jack. The current will be approximately 36mA.
- ❑ Operating the amp in SSB mode requires setting the bias current to 0.7A. For FM or digital modes, set the bias current to 0.5A.
- ❑ Connect a 50 ohm load to the OUTPUT and INPUT. Failure to terminate may result in oscillation and high current.
- ❑ Turn the pot slowly clockwise and set the BIAS current. No oscillation or erratic behavior should be observed.

7.3 Filter Circuit

The low pass filter is designed to band stop frequencies above the 6 meter band with notch filters for the 2nd and 3rd harmonics.

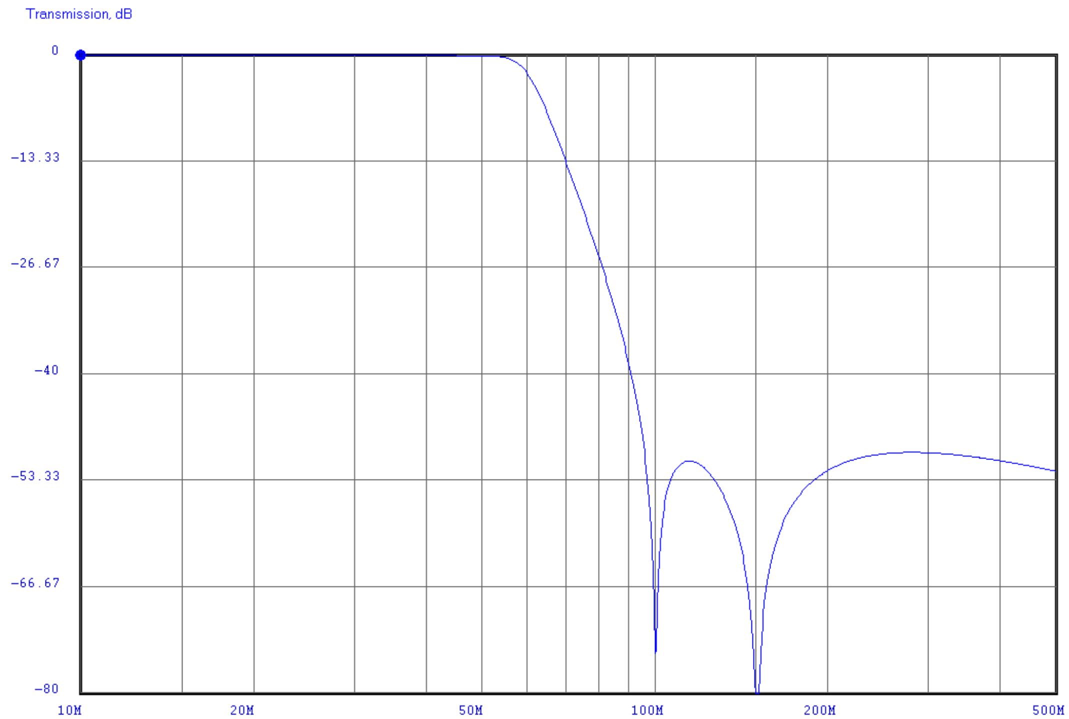


Illustration 4: Low Pass Filter characteristics.

7.4 Alignment of L1 and L2

- Alignment of the low pass filter is done by squeezing or pulling L1 and L2 - but only one at a time (see Illustration 5 below). Adjust L1 until the dip is at 150 MHz and similarly for L4 on 100 MHz. The inevitable attenuation in the pass band should not be affected by the tuning of L1 and L2. Otherwise there is something seriously wrong with the coils. If you do not have the necessary instruments to align the filter apply a small but known signal level at 50 MHz and measure it before and after the low pass filter. The maximum attenuation should not exceed 10%.

- ❑ Building the filter and L1-L2 according to the directions in this manual shouldhave your inductance will be reasonably close to the schematic values listed.

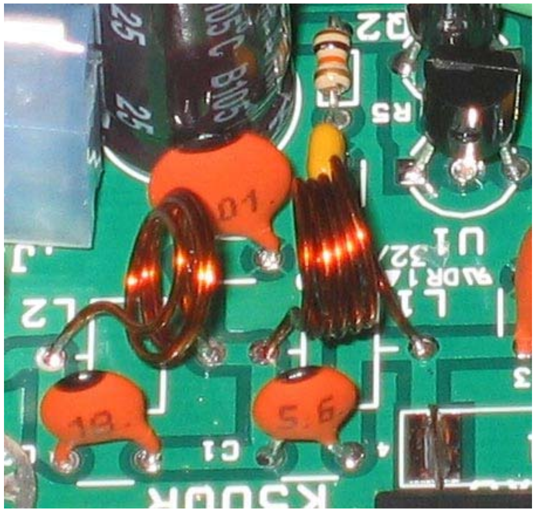


Illustration 5: L1 and L2 low pass filter.

7.5 Power Output Test

- ❑ Attach a Power Out/SWR Meter to the RF Output.
- ❑ Attach a dummy load.
- ❑ Attach a transceiver set to only 1 watt drive on 6M to the RF Input.
- ❑ Monitor the DC Current with a multi-meter set to the AMPs.
- ❑ Connect a 12VDC Source capable of delivering 10A.
- ❑ Momentarily put the transceiver into TUNE (CW signal):
    - ❑ RF Power Out should be about 30W
    - ❑ SWR should be 1.0:1
    - ❑ DC Current should be about 6A

Illustration 7: Front panel controls.

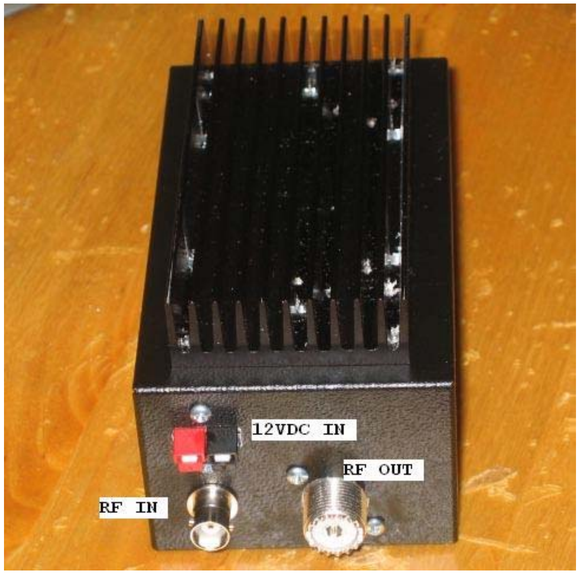


Illustration 6: Rear panel controls.

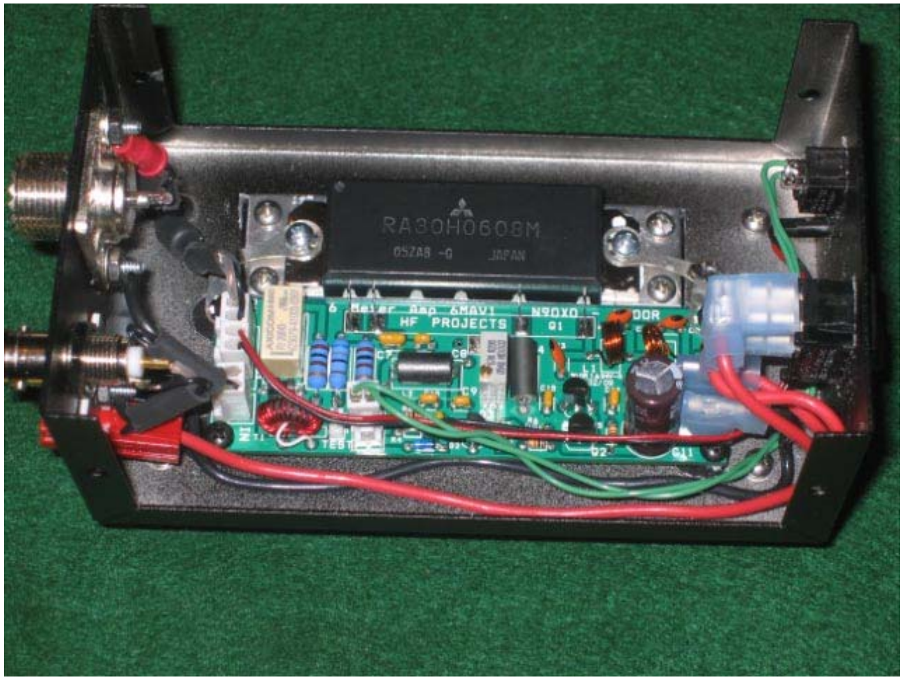


Illustration 8: Inside view of completed amplifier.

8 Operating Procedure

Connect a fused 12VDC source to the amplifier Power Pole inputs. Tune your antenna with the front panel switch in BYPASS. Operate QRP with the switch in BYPASS. Place a meter to measure SWR in series from the RF OUT to the SWR meter and Antenna. The Transceiver driving the amp will see a 50 ohm load and a low SWR when driving the amp with the switch in OPERATE. The TX light will light when a sufficient RF signal triggers the carrier operated T/R switch.

Do not exceed 1W of RF drive. The standby current is very low (less than 1 mA). The transmit current will peak about 6A. Do not attempt to operate with the RF Output connector not connected to an antenna or dummy load. If your power exceeds 30W, you should take steps to reduce power out by either reducing drive or lowering the applied DC Voltage. Enjoy!

9 Schematic, Parts List, Templates and Module DataSheet

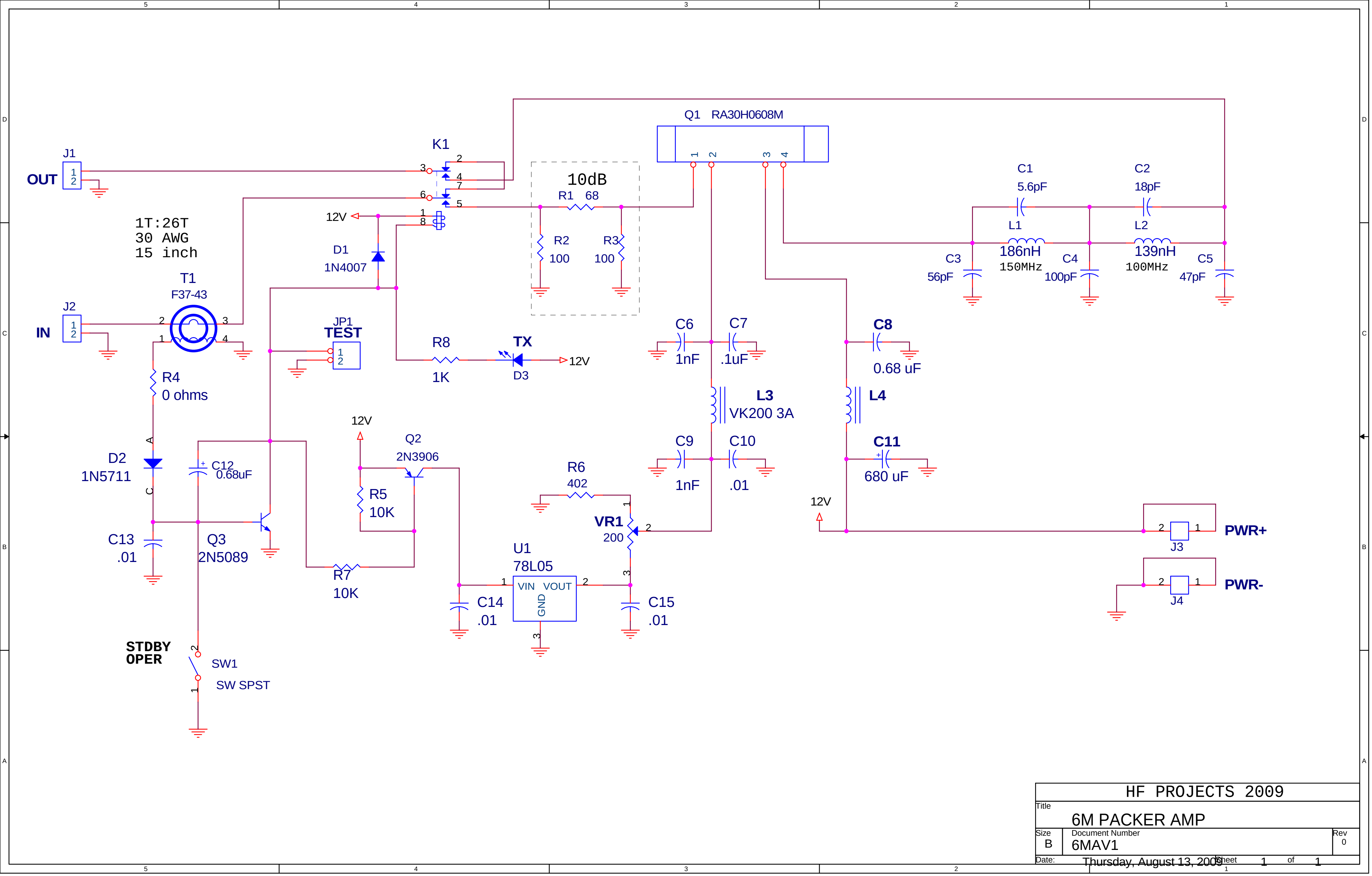
Follow on below.

			6M PACKER AMP Revised: Thursday, Aug 13, 2009		
Item	**Quantity**	**Ref**	**Description**	**Part Number**	
1	1	C1	Capacitor 5.6pF 500V 5.6pF NPO	140-500N2-5R6C-RC	
2	1	C2	Capacitor 18pF 500V 18pF NPO	140-500N5-180J-RC	
3	1	C3	Capacitor 56pF 500V 56pF NPO	140-500N5-560J-RC	
4	1	C4	Capacitor 100pF 500V 100pF NPO	140-500N5-101J-RC	
5	1	C5	Capacitor 47pF 500V 47pF NPO	140-500N5-470J-RC	
6	2	C6,C9	Cap 1000pf Kemet Conformally Coated Radial Ceramic Capacitors 100V X7R 80-C315C102K1R ; Vishay	80-C315C102K1R	
7	1	C7	Capacitor .1uF Cap, 0.1uF 100V 10% X7R SR201C104KAR AVX	Mouser 581-SR201C104KAR ; Allied stk 881-0447	
8	1	C8	Capacitor 0.68 uF SMD Cap Cerm .68uf 10% 25V X7R 1206 AVX 12063C684KAT2A	581-12063C684K Mouser	
9	4	C10,C13, C14,C15	Cap, .01uF SR151C103K AVX 100V 10% 581-SR151C103K AVX 100V 10% 1C10X7R103K050B Vishay	Mouser 581-SR151C103K; Allied stk 507-0210	
10	1	C11	Capacitor, Al Electrolytic; 680uF; 25VDC; +/-20%; Radial; 10.0mmDia.; 20.0mmL; 32VDC	613-0280 687KXM025M	
11	1	C12	Capacitor 0.68uF 10% 35V	80-T350A684K035	
12	1	D1	Standard Recovery Rectifier 1000V 1A Standard (Subminiature case) ON Semiconductor 1N4007	Mouser 863-1N4007G	
13	1	D2	Diode, Schottkey 1N5711 STM Electronics	Allied 248-0563	
14	4	J1, J2,D1,S1	Header .100 K.K. Friction lock 2 CKT	Molex 538-22-23-2021	
15	2	J3, J4	KeyStone Electronics .25 PCB TAB 032TPBR	Mouser 534-1287	
16	1	K1	Relay, 12VDC Non-latching Single coil P2 Tyco Electronics/ Axicom V23079A1003B301	FUTURE 1-1393788-1 TYCO	
17	2	L1,L2	INDUCTOR 24AWG fabricated		

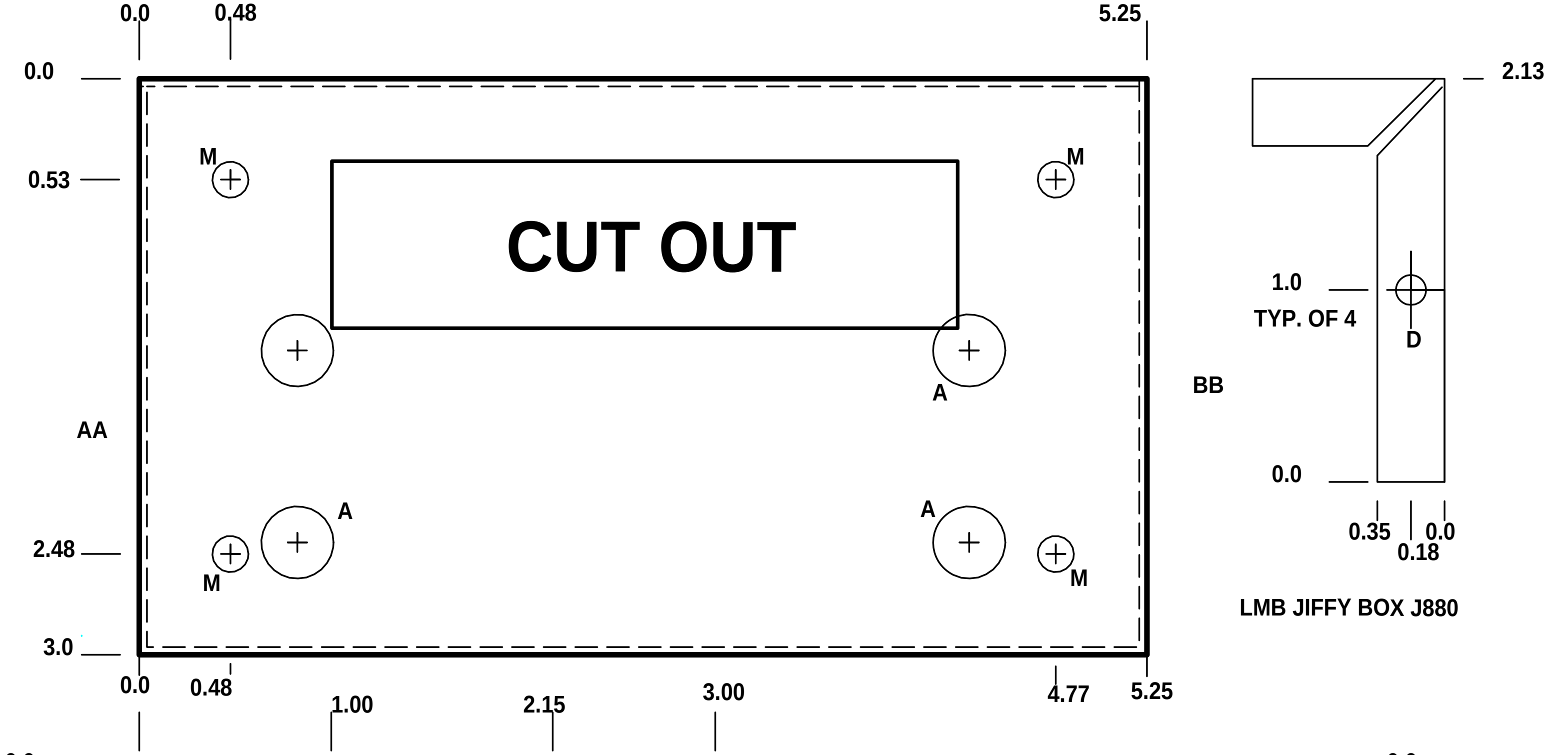
18	1	L3	Inductor VK200 3A	Inductor VK200 3A	
19	1	L4	Ferrite Bead EMI/RFI Supressors & Ferrites Fair-Rite EMI Shield Beads Z=94ohms @ 10MHz Fair-Rite 2673021801	Mouser 623-2673021801	
20	1	Q1	Amplifier Module RA30H0608M	68-88MHz 30W 12V	
21	1	Q2	Transistor 2N3906	625-2N3906	
22	1	Q3	2N5089 Small Signal Transistors NPN Gen Pur SS Central Semiconductor 2N5089	610-2N5089 Mouser	
23	1	R1	Resistor 68ohms 5% Tol	281-68-RC	
24	2	R2, R3	Resistor 100 ohm 5% Tol	281-100-RC	
25	1	VR1	Potentiometer 200 3/8" 200 ohms Sealed	67WR200LF	
26	1	R8	Resistor 1K 5% 1/8W Carbon Film XICON 299-1K	299-1K-RC	
27	2	R7,R5	Resistor 10K 1/8W 1% Metal Film 1% 50PPM XICON 270-10K-RC	Mouser 270-10K-RC	
28	1	R6	Resistor 402ohms 1%	270-402-RC	
29	1	T1	Toroid, FT37-43		
30	1	U1	5V Regulator, Fairchild 512-LM78L05ACZ	Mouser 512-LM78L05ACZX	
32	1		Switch, Rocker; SPST; 16 A @ 125 VAC, 10 A @ 250 VAC; 125/250; On-None-Off	Allied 676-0031 DA102J12S215HQF	
33	1		Circuit Board	HF Projects	
34	1		HeatSink, AAVID 646903B04600	Norvell 646903B04600	
35	1		HeatSink Plate	HF Projects	
36	1		Case Metal Enclosures BOX Black finish	Heeger LMB model J880	
37	8		Crimp Terminal MOLEX 538-08-50-0114	MOLEX 538-08-50-0114	
38	4		Locking Ramp Housing 2P	MOLEX 538-22-01-2027	
39	4		AMP Faston Terminals FLAG RECP 16-14	571-35201332	
40	1		3M Insulated Terminals RING 22-18 AWG 4 11-4S-P	517-2204A	
41	1		Wire 14AWG RED 11"		
42	1		Wire 14AWG BLK 8.5"		
43	2		Red 1327 Power Pole Connector	803-0108	
44	2		Black 1327G6 Power Pole Connector	803-0100	

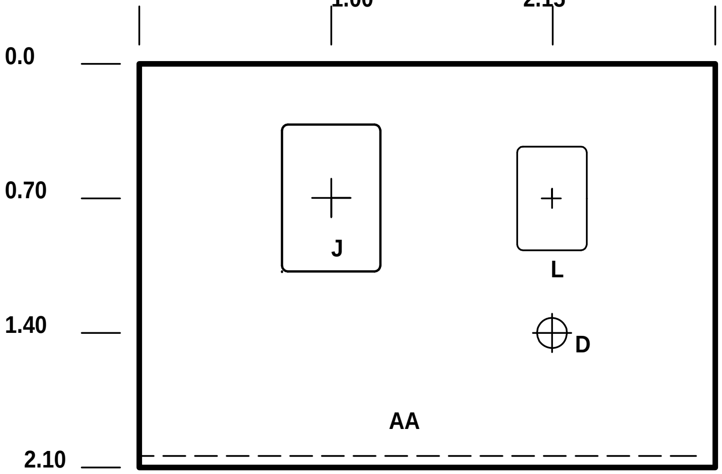
45	4		Contacts, 30A 1331BK Power Pole	803-0125	
46	1		Power Pole Plate Set 1462G1	803-0160 1462G1 ST/2	
47	4		Screw 4-40 x 1/4		
48	6		Screw 4-40 x 3/8		
49	2		Nut #4		
50	2		Washer #4		
51	1		Connector, BNC R.A. JACK 50 OHM Emerson CP1094AST	Allied 716-1094	
52	1		Coaxial Connector, UHF, Female Chassis Mount Emerson	25-7350	
53	1		LED Red Snap-In	Allied 558-0101-007F	
54	4		Foot, Black elastomer; fits all LMB enclosures	Mouser 537-F2	
55	1		Switch, Rocker, ULTRA Miniature, ON-OFF, NO LEGEND Mfr's Part#: PRK22J5BBBNN	Allied Stk#: 908-0065	
56	1		VERT PCB HDR 2P .1 K.K.	Mouser 538-22-03-2021	
57	1		hookup wire 8 inch black		
58	1		hookup wire 15 inch any color		
59	8	T1	FT23-77 Core		
60	2		Coax RG174, 6 inch		
61	4		Screw, 4-40 x 5/16		
62	1		24AWG Enamel wire 9 inch		
63	1		30AWG Enamel wire 16 inch		
64					
65	1		Heat Shrink, 1/4 inch 602-221V014-4 6 inch	Mouser	
66	4		M/F Spacer 0.187 Keystone 7228 Jack Screws, Length 0.250; No Hardware	Allied 839-0994	
67	2		Lug, Locking Tinned #4 Keystone 903 Terminal; Lockwasher; 0.120 in.; 3/32 in.; 7/8 in.; 0.018 in.; 5/16 in.	Allied Stk#: 839-2389	
68	2		Lug, Locking Tinned #4 Keystone 908 Terminal; Lockwasher; 3/32 in.; 5/8 in.; 0.018 in.	Allied Stk#: 839-2380	
69	4		532-53-77-4ACG TO-220 THERMASIL III	Mouser	

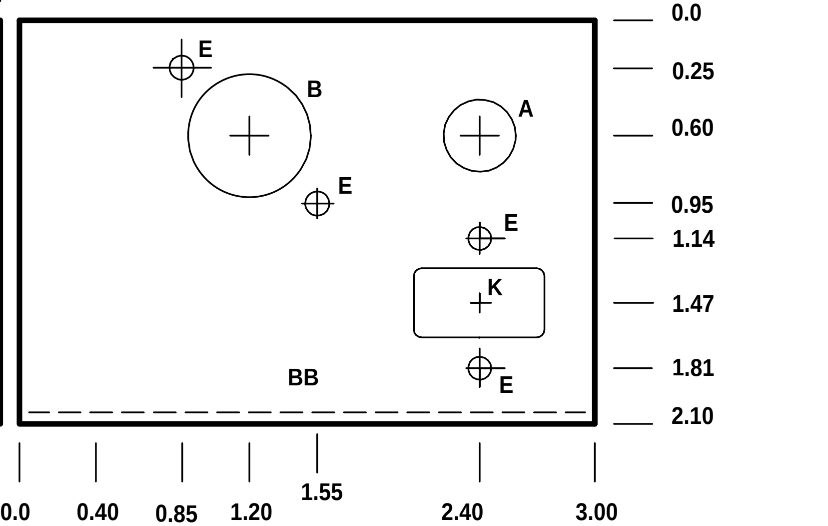
70	1		Heat Transfer Compound; Silicone; white paste; .14 oz x 100 pkts MG Chemicals 860-4G	Allied 661-0145	
71	1		Sequential Serial Number	Techiant LLC	



Q1 RA30H0608M
K1
J1
OUT
10dB
R1 68
12V
R2 100
R3 100
D1 1N4007
C1 5.6pF
C2 18pF
L1 186nH 150MHz
L2 139nH 100MHz
C3 56pF
C4 100pF
C5 47pF
1T:26T
30 AWG
15 inch
T1 F37-43
J2
IN
JP1 TEST
R8 1K
TX
D3
C6 1nF
C7 .1uF
C8 0.68 uF
L3 VK200 3A
L4
R4 0 ohms
D2 1N5711
C12 0.68uF
Q2 2N3906
R5 10K
C9 1nF
C10 .01
C11 680 uF
R6 402
VR1 200
C13 .01
Q3 2N5089
R7 10K
U1 78L05
VIN VOUT GND
C14 .01
C15 .01
PWR+
J3
PWR-
J4
STDBY
OPER
SW1 SW SPST
HF PROJECTS 2009
Title
6M PACKER AMP
Size B
Document Number 6MAV1
Rev 0
Date: Thursday, August 13, 2009
Sheet 1 of 1

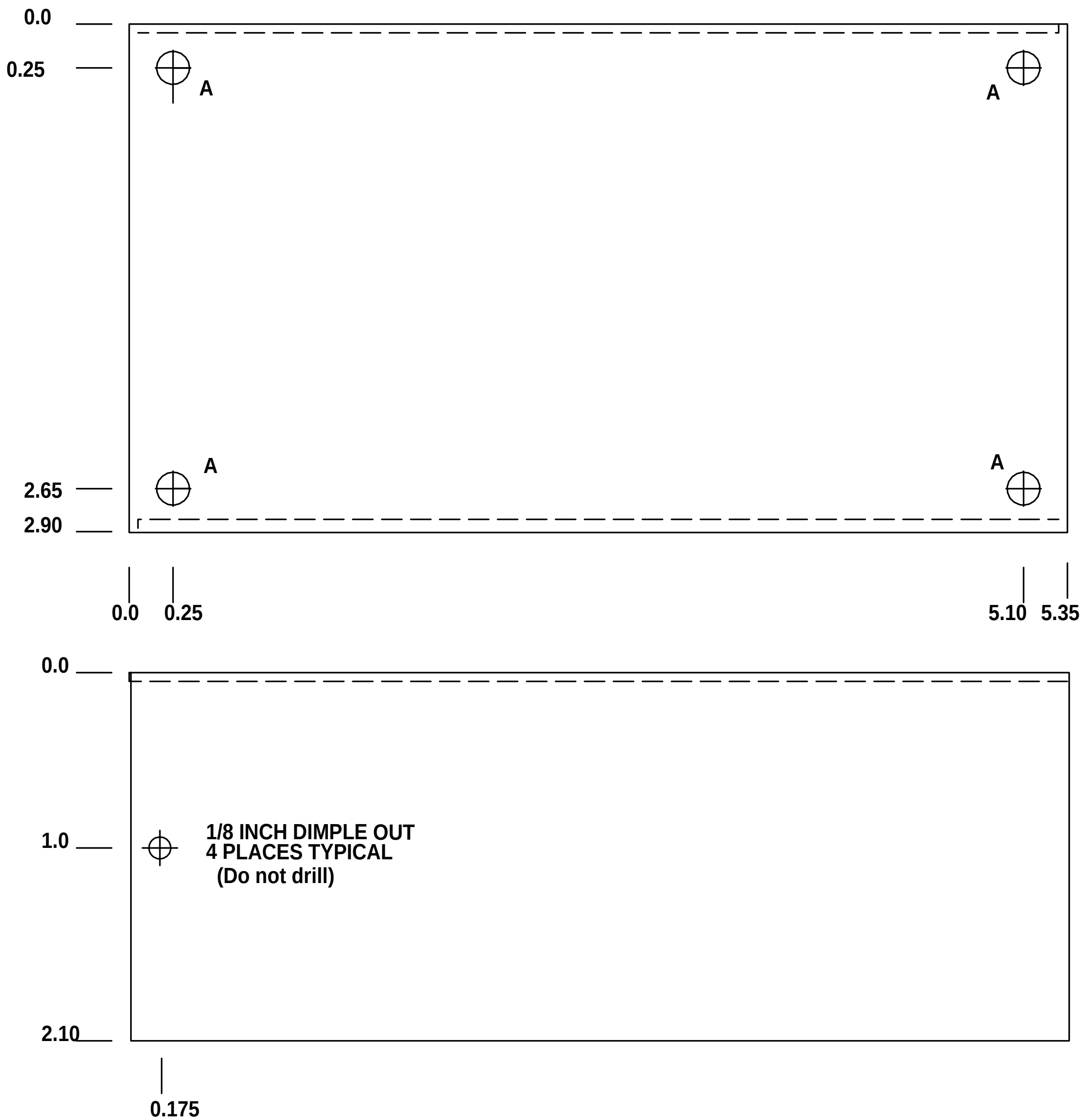






A=3/8 inch DIA. B=5/8 inch DIA.
D=5/32 inch DIA
E=1/8 inch DIA
J = 0.68 x 0.36 inch rectangle 0.06 Radius
K = .76 x 0.51 inch rectangle 0.03 Radius
L = 0. 539 x 0.362 rectangle 0.06 Radius
M = 3/16 inch DIA, 4 places

VHF PACKER 6M AMP VER 2009



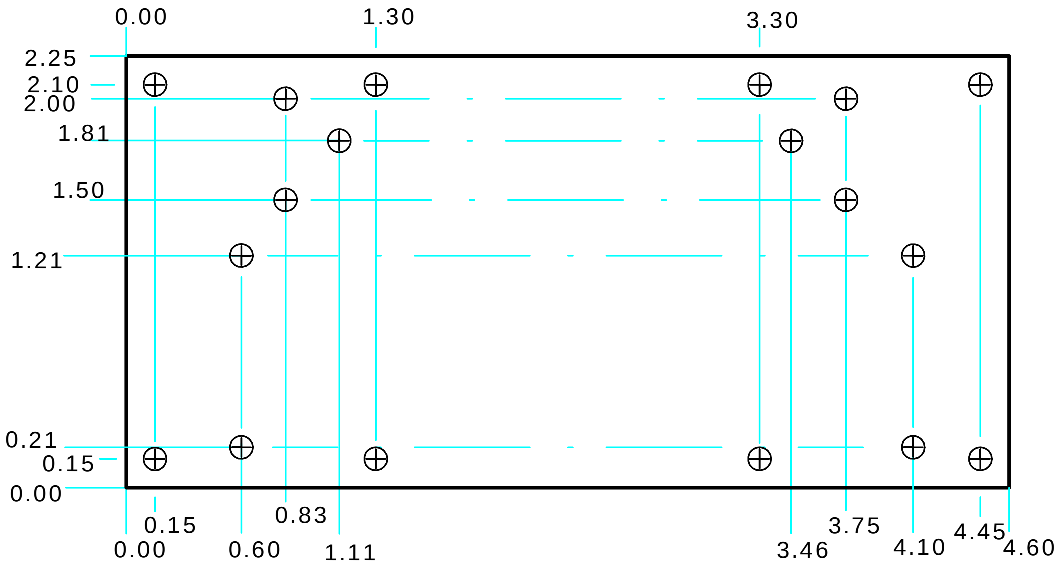
FAB PER LMB JIFFY BOX J880

MATERIAL: ALUM. 0.04 - 0.05 THICK
PAINT: GLOSS BLACK POWDER COAT

A = 7/32 inch DIA. (rubber feet)

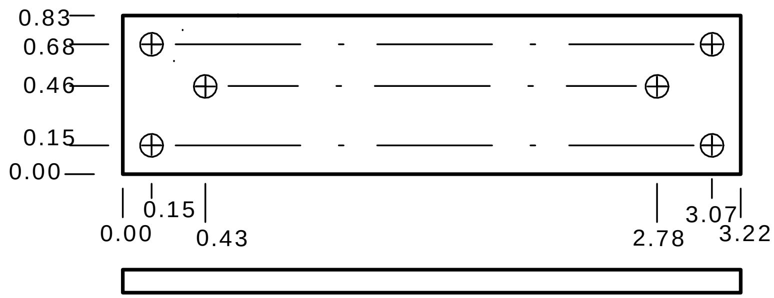
VHF PACKER 6M AMP 2009

HF PROJECTS



Material: Heat Sink, AAVID 4.6 x 2.25 inch
Drill and Tap 4-40 holes through 18 places

HF PROJECTS
Heat Sink Modification
7/26/2009



Material: 1/8 inch aluminum, no finish

6 holes: 9/64 inch dia. through

HF PROJECTS
Heat Sink Plate
7/26/2009

ELECTROSTATIC SENSITIVE DEVICE
OBSERVE HANDLING PRECAUTIONS

MITSUBISHI RF MOSFET MODULE

RA30H0608M

RoHS Compliance , 66-88MHz 30W 12.5V, 2 stage Amp. for MOBILE RADIO

DESCRIPTION

The RA30H0608M is a 30-watt RF MOSFET Amplifier Module for 12.5-volt mobile radios that operate in the 66- to 88-MHz range.

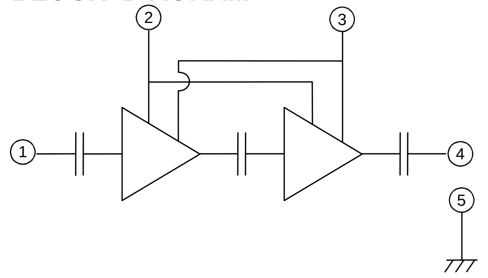
The battery can be connected directly to the drain of the enhancement-mode MOSFET transistors. Without the gate voltage (V_{GG}=0V), only a small leakage current flows into the drain and the RF input signal attenuates up to 60 dB. The output power and drain current increase as the gate voltage increases. With a gate voltage around 3V (minimum), output power and drain current increases substantially. The nominal output power becomes available at 4V (typical) and 5V (maximum). At V_{GG}=5V, the typical gate current is 1 mA.

This module is designed for non-linear FM modulation, but may also be used for linear modulation by setting the drain quiescent current with the gate voltage and controlling the output power with the input power.

FEATURES

- Enhancement-Mode MOSFET Transistors (I_{DD}≅0 @ V_{DD}=12.5V, V_{GG}=0V)
- P_{out}>30W, η_T>40% @ V_{DD}=12.5V, V_{GG}=5V, P_{in}=50mW
- Broadband Frequency Range: 66-88MHz
- Low-Power Control Current I_{GG}=1mA (typ) at V_{GG}=5V
- Module Size: 66 x 21 x 9.88 mm
- Linear operation is possible by setting the quiescent drain current with the gate voltage and controlling the output power with the input power

BLOCK DIAGRAM



1. RF Input (P_{in})
2. Gate Voltage (V_{GG}), Power Control
3. Drain Voltage (V_{DD}), Battery
4. RF Output (P_{out})
5. RF Ground (Case)

PACKAGE CODE: H2S

RoHS COMPLIANCE

- RA30H0608M-101 is a RoHS compliant products.
- RoHS compliance is indicate by the letter “G” after the Lot Marking.
- This product include the lead in the Glass of electronic parts and the lead in electronic Ceramic parts.

How ever ,it applicable to the following exceptions of RoHS Directions.

1.Lead in the Glass of a cathode-ray tube, electronic parts, and fluorescent tubes.

2.Lead in electronic Ceramic parts.

ORDERING INFORMATION:

ORDER NUMBER	SUPPLY FORM
RA30H0608M-101	Antistatic tray, 10 modules/tray

MAXIMUM RATINGS (T_{case}=+25°C, unless otherwise specified)

SYMBOL	PARAMETER	CONDITIONS	RATING	UNIT
V_{DD}	Drain Voltage	V_{GG}<5V, Z_G=Z_L=50Ω	17	V
V_{GG}	Gate Voltage	V_{DD}<12.5V, P_{in}=50mW, Z_G=Z_L=50Ω	6	V
P_{in}	Input Power	f=66-88MHz, V_{GG}<5V	100	mW
P_{out}	Output Power	f=66-88MHz, V_{GG}<5V (Note 2)	45	W
$T_{case(OP)}$	Operation Case Temperature Range	f=66-88MHz, V_{GG}<5V	-30 to +110	°C
T_{stg}	Storage Temperature Range		-40 to +110	°C

Note 1: The above parameters are independently guaranteed.
Note 2: This device may destroyed in a few minutes when output power from module is more than 45W. Therefore, please keep the output power of device less than 45W even operating under the high load VSWR conditions.

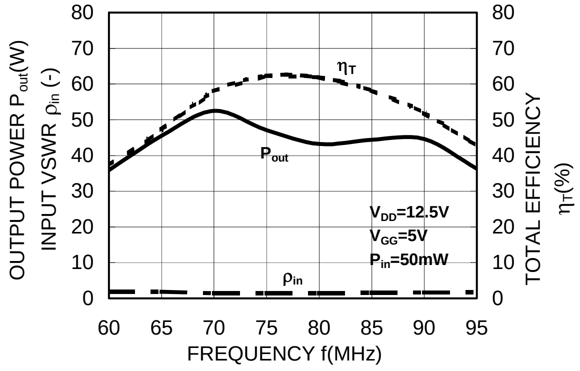
ELECTRICAL CHARACTERISTICS (T_{case}=+25°C, Z_G=Z_L=50Ω, unless otherwise specified)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
f	Frequency Range		66		88	MHz
P_{out}	Output Power	V_{DD}=12.5V V_{GG}=5V P_{in}=50mW	30			W
η_T	Total Efficiency		40			%
$2f_o$	2^{nd} Harmonic				-25	dBc
ρ_{in}	Input VSWR				3:1	—
I_{GG}	Gate Current			1		mA
—	Stability	V_{DD}=10.0-15.2V, P_{in}=25-70mW, P_{out}<30W (V_{GG} control), Load VSWR=3:1	No parasitic oscillation			—
—	Load VSWR Tolerance	V_{DD}=15.2V, P_{in}=50mW, P_{out}=30W (V_{GG} control), Load VSWR=20:1(all phase)	No degradation or destroy			—

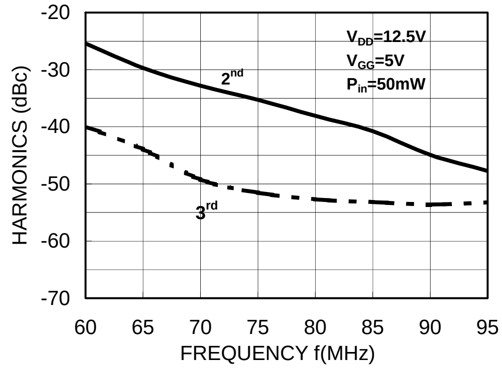
All parameters, conditions, ratings, and limits are subject to change without notice.

TYPICAL PERFORMANCE (T$_{case}$=+25°C, Z$_G$=Z$_L$=50Ω, unless otherwise specified)

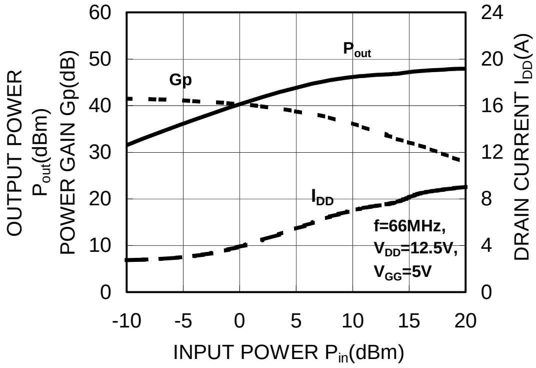
OUTPUT POWER, TOTAL EFFICIENCY, and INPUT VSWR versus FREQUENCY



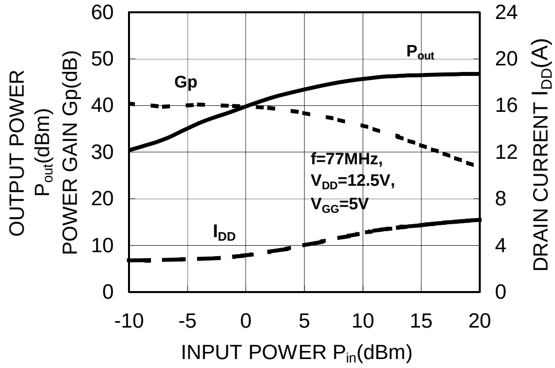
2nd, 3rd HARMONICS versus FREQUENCY



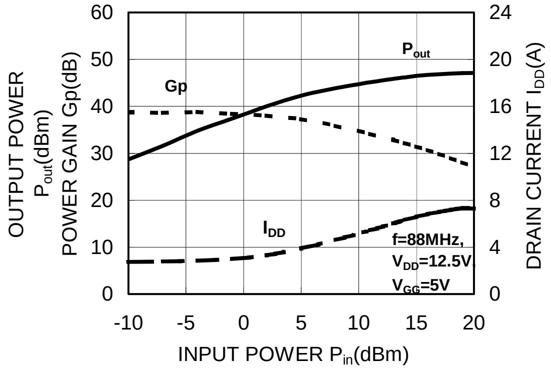
OUTPUT POWER, POWER GAIN and DRAIN CURRENT versus INPUT POWER



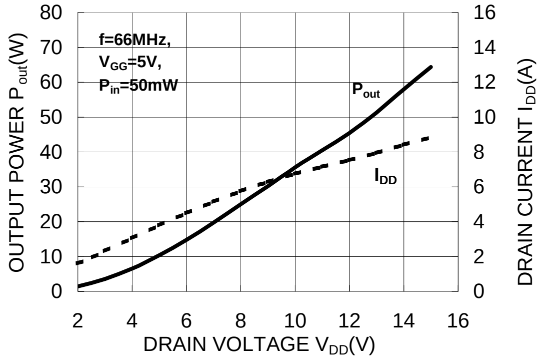
OUTPUT POWER, POWER GAIN and DRAIN CURRENT versus INPUT POWER



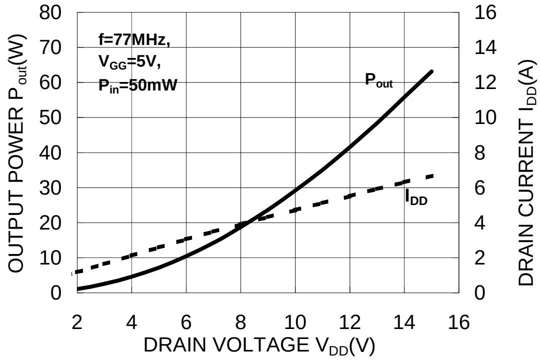
OUTPUT POWER, POWER GAIN and DRAIN CURRENT versus INPUT POWER



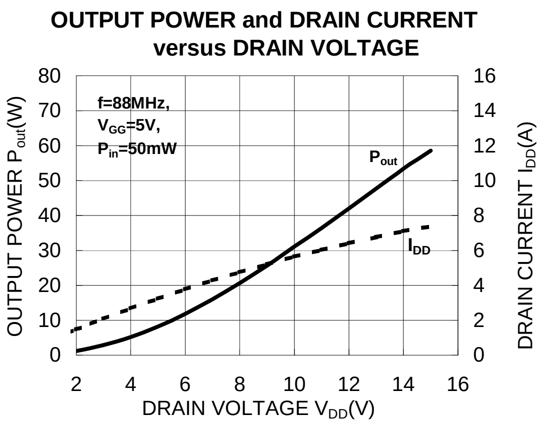
OUTPUT POWER and DRAIN CURRENT versus DRAIN VOLTAGE

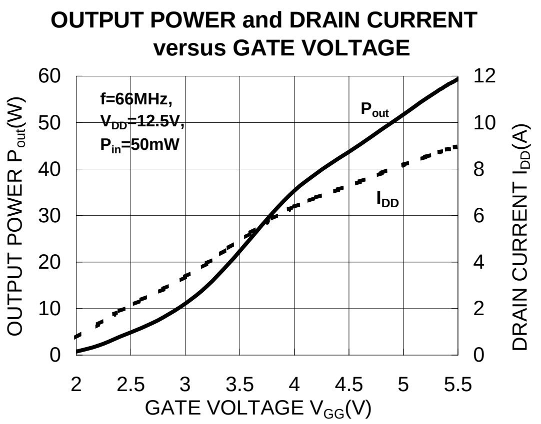


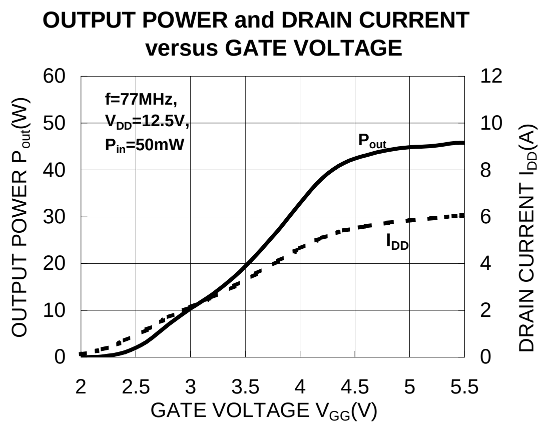
OUTPUT POWER and DRAIN CURRENT versus DRAIN VOLTAGE

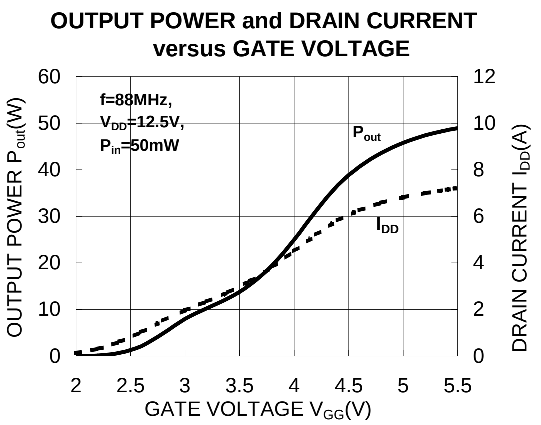


TYPICAL PERFORMANCE (T_{case}=+25°C, Z_G=Z_L=50Ω, unless otherwise specified)

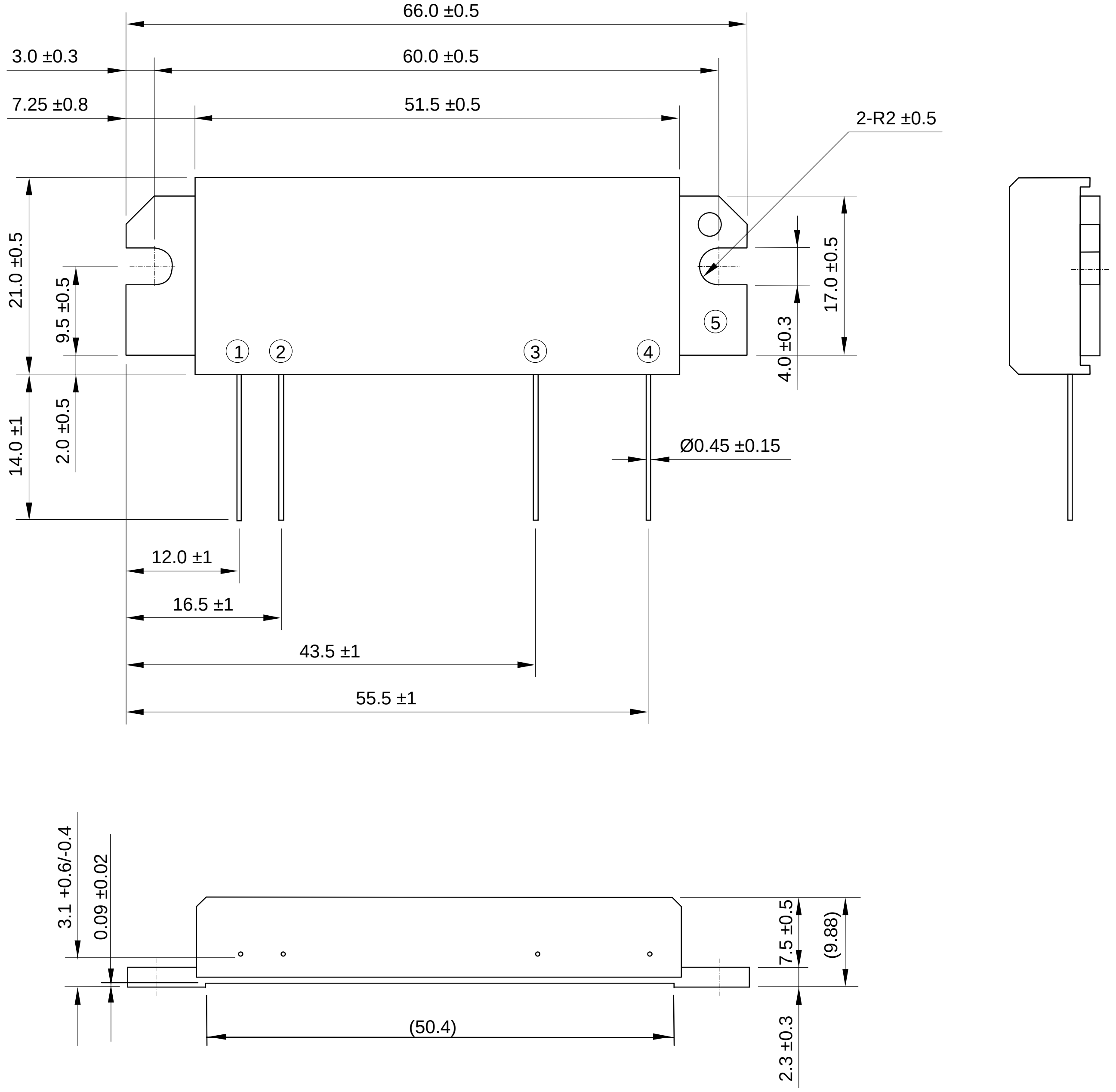






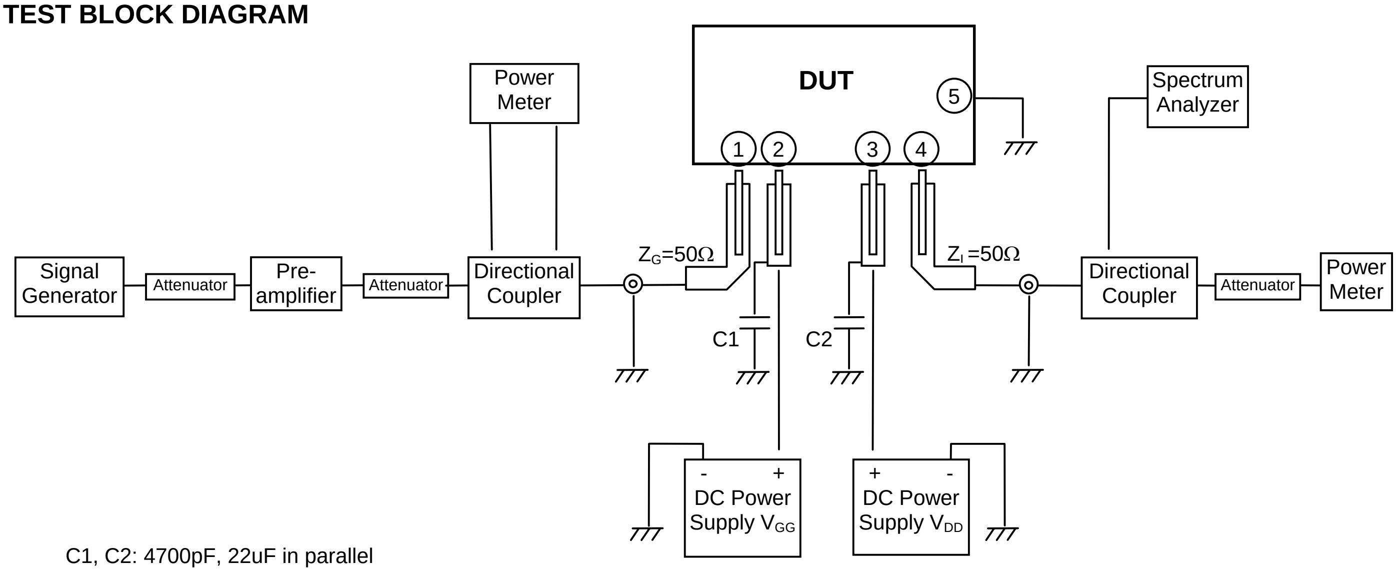


OUTLINE DRAWING (mm)



① RF Input (P_{in})
② Gate Voltage (V_{GG})
③ Drain Voltage (V_{DD})
④ RF Output (P_{out})
⑤ RF Ground (Case)

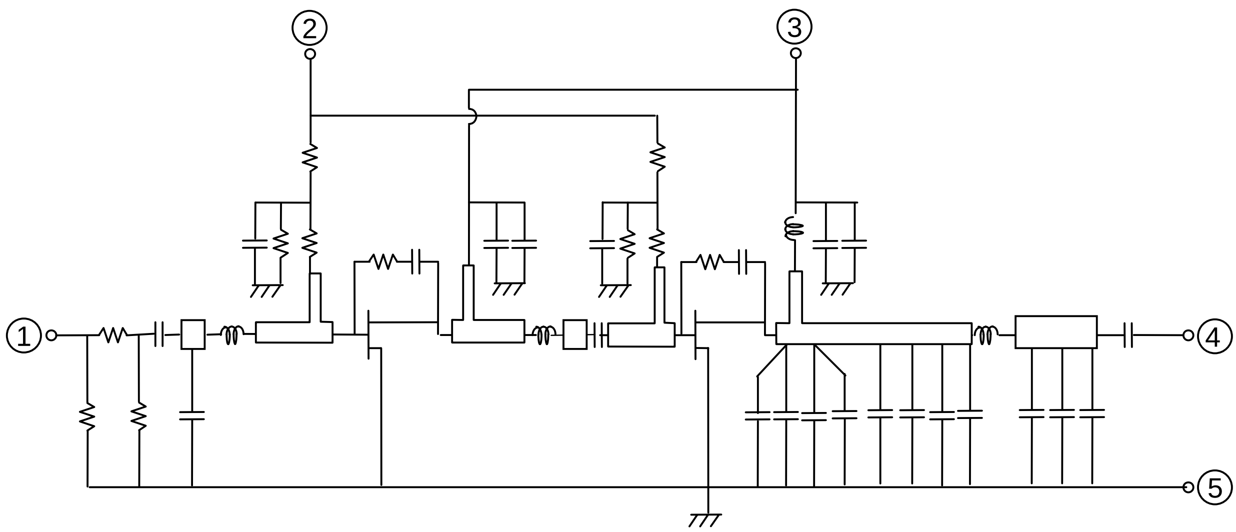
TEST BLOCK DIAGRAM



C1, C2: 4700pF, 22uF in parallel

1. RF Input (P_{in})
2. Gate Voltage (V_{GG})
3. Drain Voltage (V_{DD})
4. RF Output (P_{out})
5. RF Ground (Case)

EQUIVALENT CIRCUIT



PRECAUTIONS, RECOMMENDATIONS, and APPLICATION INFORMATION:

Construction:

This module consists of an alumina substrate soldered onto a copper flange. For mechanical protection, a plastic cap is attached with silicone. The MOSFET transistor chips are die bonded onto metal, wire bonded to the substrate, and coated with resin. Lines on the substrate (eventually inductors), chip capacitors, and resistors form the bias and matching circuits. Wire leads soldered onto the alumina substrate provide the DC and RF connection.

Following conditions must be avoided:

a) Bending forces on the alumina substrate (for example, by driving screws or from fast thermal changes)
b) Mechanical stress on the wire leads (for example, by first soldering then driving screws or by thermal expansion)
c) Defluxing solvents reacting with the resin coating on the MOSFET chips (for example, Trichloroethylene)
d) Frequent on/off switching that causes thermal expansion of the resin
e) ESD, surge, overvoltage in combination with load VSWR, and oscillation

ESD:

This MOSFET module is sensitive to ESD voltages down to 1000V. Appropriate ESD precautions are required.

Mounting:

Heat sink flatness must be less than 50 µm (a heat sink that is not flat or particles between module and heat sink may cause the ceramic substrate in the module to crack by bending forces, either immediately when driving screws or later when thermal expansion forces are added).

A thermal compound between module and heat sink is recommended for low thermal contact resistance and to reduce the bending stress on the ceramic substrate caused by the temperature difference to the heat sink.

The module must first be screwed to the heat sink, then the leads can be soldered to the printed circuit board.

M3 screws are recommended with a tightening torque of 0.4 to 0.6 Nm.

Soldering and Defluxing:

This module is designed for manual soldering.

The leads must be soldered after the module is screwed onto the heat sink.

The temperature of the lead (terminal) soldering should be lower than 350°C and shorter than 3 second.

Ethyl Alcohol is recommend for removing flux. Trichloroethylene solvents must not be used (they may cause bubbles in the coating of the transistor chips which can lift off the bond wires).

Thermal Design of the Heat Sink:

At P_{out}=30W, V_{DD}=12.5V and P_{in}=50mW each stage transistor operating conditions are:

Stage	P_{in} (W)	P_{out} (W)	$R_{th(ch-case)}$ (°C/W)	I_{DD} @ η_T=40% (A)	V_{DD} (V)
1st	0.05	3.0	23.0	0.36	12.5
2nd	3.0	30.0	1.2	5.6	

The channel temperatures of each stage transistor $T_{ch} = T_{case} + (V_{DD} \times I_{DD} - P_{out} + P_{in}) \times R_{th(ch-case)}$ are:

$T_{ch1} = T_{case} + (12.5V \times 0.36A - 3.0W + 0.05W) \times 23.0°C/W = T_{case} + 35.7 °C$

$T_{ch2} = T_{case} + (12.5V \times 5.6A - 30.0W + 3.0W) \times 1.2°C/W = T_{case} + 51.6 °C$

For long-term reliability, it is best to keep the module case temperature (T_{case}) below 90°C. For an ambient temperature T_{air}=60°C and P_{out}=30W, the required thermal resistance $R_{th\ (case-air)} = (T_{case} - T_{air}) / ((P_{out} / \eta_T) - P_{out} + P_{in})$ of the heat sink, including the contact resistance, is:

$R_{th(case-air)}$ = (90°C - 60°C) / (30W/40% – 30W + 0.05W) = 0.67 °C/W

When mounting the module with the thermal resistance of 0.67 °C/W, the channel temperature of each stage transistor is:

$T_{ch1} = T_{air} + 65.7 °C$

$T_{ch2} = T_{air} + 81.6 °C$

The 175°C maximum rating for the channel temperature ensures application under derated conditions.

Output Power Control:

Depending on linearity, the following two methods are recommended to control the output power:

a) Non-linear FM modulation:

By the gate voltage (V_{GG}).

When the gate voltage is close to zero, the RF input signal is attenuated up to 60 dB and only a small leakage current flows from the battery into the drain.

Around V_{GG}=3V, the output power and drain current increases substantially.

Around V_{GG}=4V (typical) to V_{GG}=5V (maximum), the nominal output power becomes available.

b) Linear AM modulation:

By RF input power P_{in}.

The gate voltage is used to set the drain's quiescent current for the required linearity.

Oscillation:

To test RF characteristics, this module is put on a fixture with two bias decoupling capacitors each on gate and drain, a 4.700 pF chip capacitor, located close to the module, and a 22 µF (or more) electrolytic capacitor.

When an amplifier circuit around this module shows oscillation, the following may be checked:

a) Do the bias decoupling capacitors have a low inductance pass to the case of the module?

b) Is the load impedance Z_L=50Ω?

c) Is the source impedance Z_G=50Ω?

Frequent on/off switching:

In base stations, frequent on/off switching can cause thermal expansion of the resin that coats the transistor chips and can result in reduced or no output power. The bond wires in the resin will break after long-term thermally induced mechanical stress.

Quality:

Mitsubishi Electric is not liable for failures resulting from base station operation time or operating conditions exceeding those of mobile radios.

This module technology results from more than 20 years of experience, field proven in tens of millions of mobile radios. Currently, most returned modules show failures such as ESD, substrate crack, and transistor burnout, which are caused by improper handling or exceeding recommended operating conditions. Few degradation failures are found.

Keep safety first in your circuit designs!

Mitsubishi Electric Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur. Trouble with semiconductors may lead to personal injury, fire or property damage. Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of non-flammable material, or (iii) prevention against any malfunction or mishap.