2304 MHz 70 W Rover Amplifier

Bill Koch W2RMA -- W2RMA@ARRL.NET

John Brooks N9ZL – N9ZL@JOHNSWEB.COM

There are papers that discuss something new that really moves Amateur Radio forward in some facet. There are others that take what is already known and blend it with other knowns, reformulating the result to motivate hams into doing something new or better or different to them with their hobby. This latter approach is a type of *Kaizen*.

This paper is of the second ilk – our purpose is to *motivate* 'round-to-it' microwavers to 'Just Do It!' and get on 2304 with some real power. Why? If you're a contester, 2304 rewards you with additional points per Q and more multipliers yielding a higher score. If you aren't really a contester but rather are looking for something operationally new to try, why not work airplane scatter on 2304? W2RMA has done such with a 3' looper and 8W! A W1GHZ 'rover board', a 1 watt amplifier, a $50 parabolic eBay antenna, and this amplifier will make you very competitive on the band!

N9ZL and W2RMA built their amplifiers to make more noise as rovers, to have more fun. The amplifier can be compact to easily fit in or on a 7"x10" box -- passenger car sized. What if such an amplifier could be built with common hand tools not requiring a mill or drill press? Does such sound interesting?

Perhaps a short background might help. N9ZL and W2RMA first met at FM08us, Hogback Overlook in Virginia, during a VHF contest. They had a 1296 QSO and John decided to stop by Bill's rover setup at Hogback. John had some microwave experience, but got further exposed to the microwave virus and rapidly assembled 3cm and 13cm capabilities. His 13cm rig included a $99 Spectrian amplifier board, which worked well. Bill had already purchased the board but was in the 'round to it' mode as he thought that heatsink mounting might be difficult without a drill press. Such is not the case! John sent Bill a picture of how he mounted the board, and the rest is history.

For those who are not familiar with the board, it provides about 70 watts output with about a watt of drive in a linear fashion. The board comes with instructions for power, drive, bias settings and the like. It uses 24-26V but requires up to 17 amps yielding an efficiency of approximately 16%. Ugly, but it was typical of class A and AB amplifiers of the day. EBay has listings of these amplifiers via a seller 'Pyrojoseph' who lists them under a Spectrian name for $99 + shipping. In a conversation with the seller, he said that he had been selling these amplifiers for over 10 years. His feedback rating is 100% and we've found him to be very responsive. He also sells a 25W unit that works with milliwatts of drive power, as well as a unit that puts out 180W.

A number of hams have successfully built this amplifier – we are far from the early adopters. It really is about as close to plug and play as you'll get for a board. As the board is NOS pull, it comes fully assembled, with only two significant challenges:

1. Cooling; and
2. Mounting the SMA connectors onto the board.

The heatsink selection will dictate SMA connector mounting and cooling fan needs. At a dissipation of 350W, the copper clad Spectrian board must use thermal grease to attach to a smooth heatsink with 4-40 screws. Recall, 350W is close to what many electric space heaters put out on low power, so a lot of cooling air is needed. The fins of the heatsink can either be in parallel with the length or the width of the board. In both cases, the heatsink needs to be the same length as the board, about 5 15/16" (150mm) long to facilitate mounting of the SMA jacks. If the fins are parallel with the length of the board, then mounting will require a plate to be drilled and then attached to a heatsink base (figure 3) ¼" (6mm) thick, tapped with 4-40 screws (or metric equivalent). If the fins are parallel with the width of the board, then mounting the SMA connectors is easier as they can be screwed into the edges of the end fin of the heatsink. Measuring and marking are likely simpler.

Unless one has a mill, try to pick a heatsink that is the same length as is the board. Two choices are:

1. W2RMA's mounting with fins running in parallel with the length: Marlin P. Jones and Associates, 32088K, $13.

2. N9ZL's mounting with fins parallel to the width: (eBay: W6 Aluminum Heatsink Cooling Fin 150mmx60mmx25mm for Power Amplifier), $5.

Let's go back to cooling for a minute. If the fins parallel the length of the board, then one fan can blow air through the fins and cool the length of the board as shown in figure 1. On the other hand, with fins running across the width, likely two fans to the transistor hot spots are required as shown in figure 2. In either case, a LOT of air is needed! W2RMA's unit uses a surplus brushless Delta Electronics AFB0612EHE (eBay) fan that sounds a bit like a jet engine winding up. Quiet it is not, though the fan obviates the need for an amplifier 'transmit' LED. It draws 1.7A so it is not the typical 2"x2" computer case fan. The fan is on when transmitting or when the heatsink thermal switches so dictate. Given that the thermal switches have never operated to date, the fan may move more air than is needed.

N9ZL uses two squirrel cage fans that are powered anytime the amplifier has power. These move a lot of air past the heat sink fins directly under the transistors and out the back of the transverter cabinet. A future enhancement will be to use the on board temperature sensor and a comparator circuit to control the fans.

The most perplexing issue is mounting the two SMA jacks to the board. N9ZL's way using aluminum bar stock with screws and JB-Weld is most likely easier. The key advantage to having the fins run across the board (N9ZL) is that the plates that hold the SMA jacks can be attached to the fins.

In W2RMA's case, the end plates have to be attached using drilled and tapped holes into the heatsink' s 'body plate', about ¼"thick (figure 3). The aluminum end plates are bar stock from Ace Hardware. While accurate measuring is very important, he found that the following approach allowed for a good connection to the input and output traces.

1. Measure, drill and tap one end of the plate into the ¼" heatsink base. You may need to make the hole larger in the plate to allow for X and Y movement.
2. Measure and drill a hole for the SMA connector, tightening the screw in step #1.
3. Mark, drill and tap a hole into the plate and ¼" base on the other end of the plate.
4. You may need to drill out the holes on the ends to allow the SMA pin to mate correctly.
5. Nota Bene: DO NOT SOLDER THE SMA CONNECTOR YET!! The traces might otherwise be lifted off the board. If such were to happen, the board is epoxy and a *tiny* bit under the trace may repair the damage.
6. Drill and tap the remaining holes to hold the plate securely to the 1/4" heatsink base.
7. Solder the SMA connector to the trace ONLY after you have attached the sides and are very unlikely to move the end plate. W2RMA used some stock aluminum available from Home Depot or Ace that has an 'L' shape.

The board includes a 10 pin connector (Digi Key 25645-05-ND or 3M1310-ND) that contains pins for bias voltages and transistor currents. Buy several – they are cheap in both senses of the word.

1. Bias. W2RMA brought out bias pins via two feedthroughs so that the currents may be read.

2. Amplifier on-off. What is nice about the board is that a FET switch or relay is not needed. The amplifier is energized by placing +12V @ 50 mA to pin 2 on the 10 pin connector via a feedthrough.
3. Power. There is a pad close to the 10 pin connector that requires 24-26V at 17A. Make sure that the feed though choice handles 20A.

Given the cost of the board and the power dissipated, some sort of temperature control circuitry is prudent. Cooling controls might include the following:

1. Fan energized when +12V power is sent to the amplifier +12V control line.
2. A ‘cool down’ limit switch (Digi Key 480-6552-ND) to keep the fan ‘on’ until the cool down set point of 65C is reached.
3. A ‘high limit’ switch to turn off the amplifier if 90C is reached on the fins.
4. A schematic is shown in figure 6.
5. The switches chosen are AC not DC rated for amperage. However, the current draw (1.7A) is a small percentage of the AC ratings and they only operate to break current flow and should not operate often.

From a cooling perspective, both authors have measured the temperature of the heatsink as well as the tops of the transistors using IR tools. These results were obtained:

W2RMA:

1. Heatsink fins: 60C – warmest spot
2. Tops of MRF286 transistors: 52C and 57C with ambient of 18C and normal on-off activity. When measured after 5 minutes key down time, the temperatures were about 65C.

N9ZL:

1. Heatsink fins: 80C
2. Tops of MRF286 transistors: Driver 54C, Output pair 54C and 68C.Back output transistor is hotter due to the first transistor pre-heating the air.

An IR pic of the N9ZL amplifier is below.

Given that the measurements were made with ambient temperatures of 18-23C, even if one adds 15C to the results for a hot summer’s day, there should be an adequate safety factor for the transistors based on the MRF286 preliminary spec sheet.

Here's a pic of N9ZL in action on 2304….roving at Hogback Overlook, VA, FM08us. His truck is a bit Pavlovian to W2RMA…but someday Santa might leave him a real rover vehicle!

Summary:

This project has been fun for both of us to do and provides a level of power on the band to work anyone who is out there. As there are a number of hams already using the board, it provides a reliable way to generate power on 2304. Combined with a 24 dBi gain dish antenna or a 45 element looper, this amplifier gives an EIRP of 10-18 kW!

Who said that 2 GHz microwave energy needs to be spent on popcorn or hotdogs?

Figure 1: W2RMA's amplifier

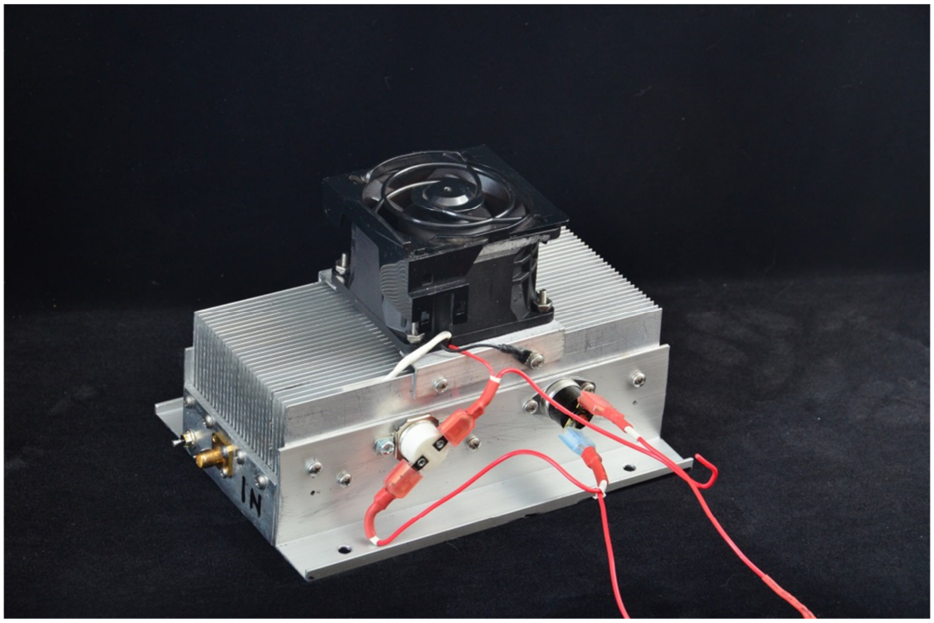

Figure 2: N9ZL's amplifier

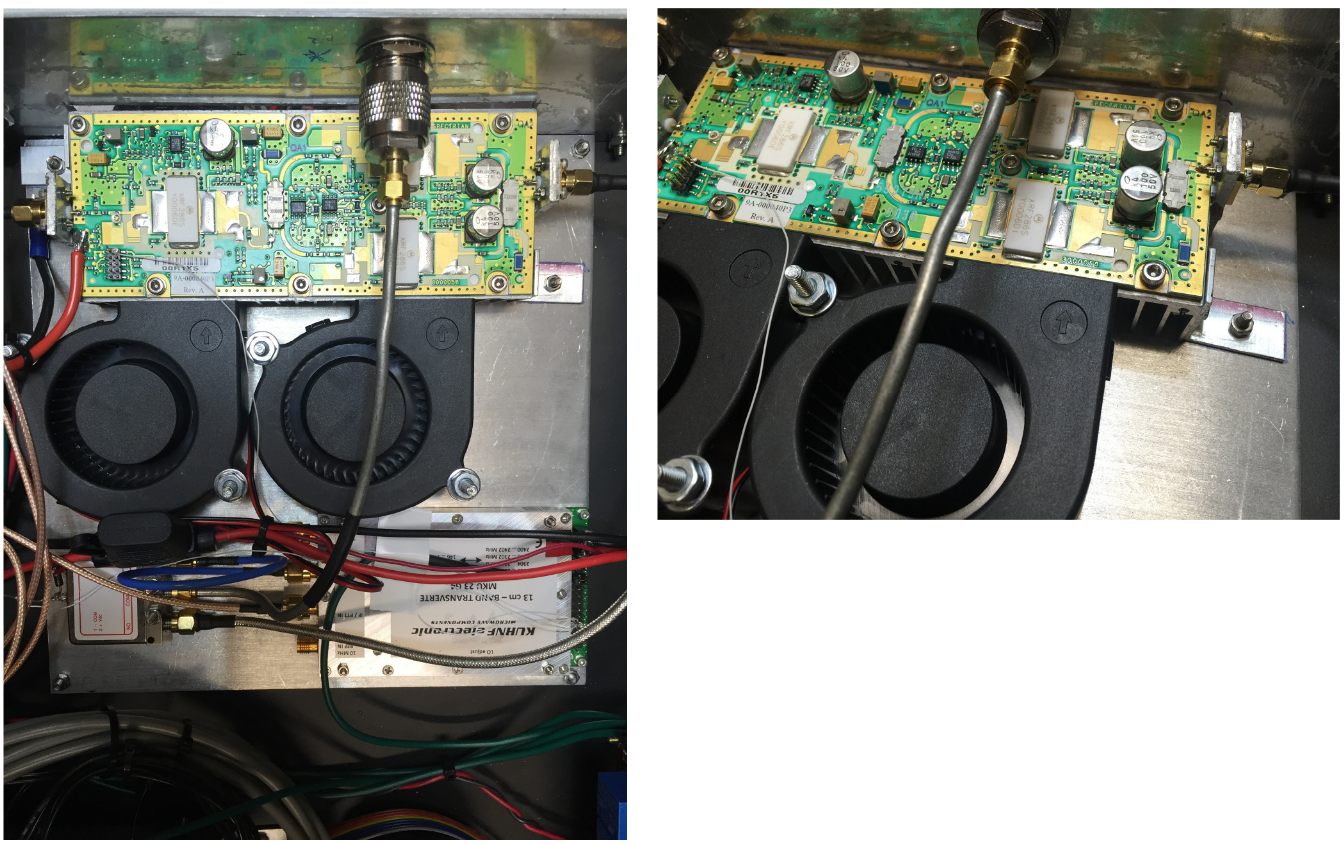

Figure 3: W2RMA Heatsink

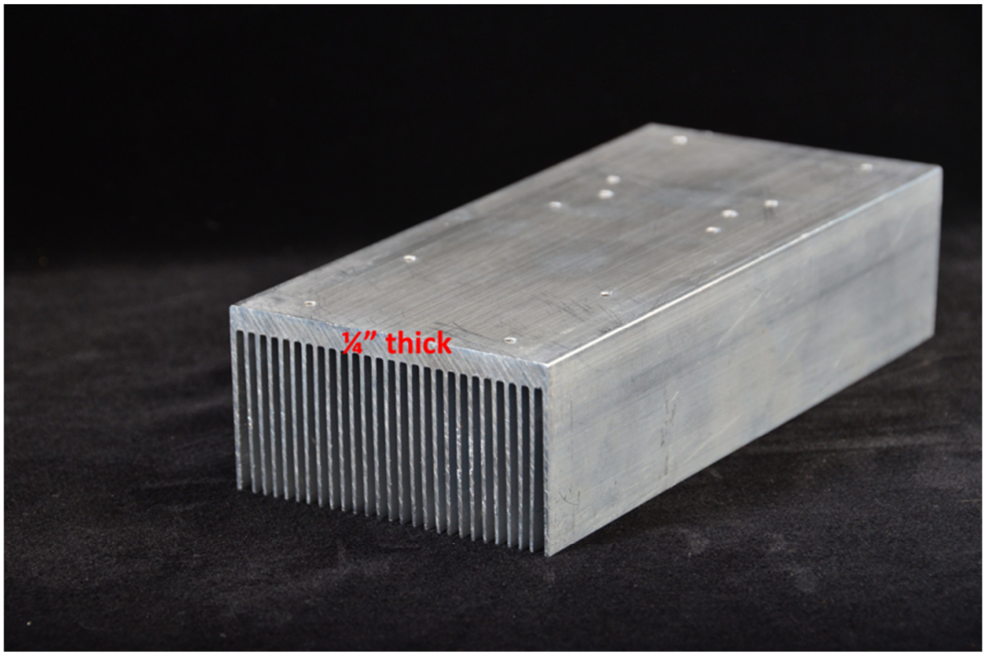

Figure 4: Board view showing placement of thermal switches

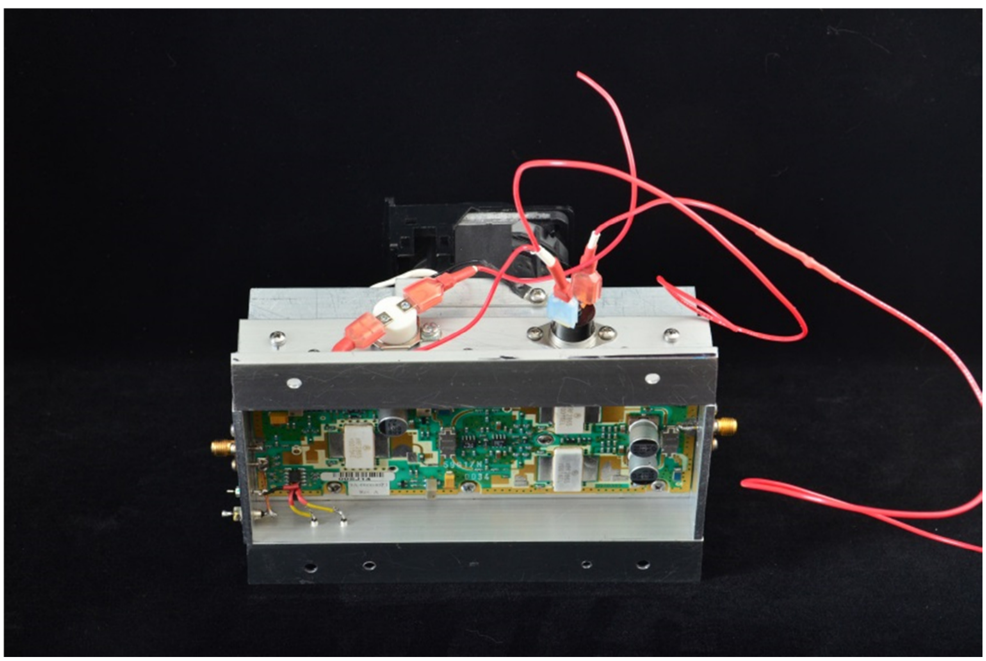

Figure 5: Board view showing +24-26V feed and feedthroughs for current monitoring

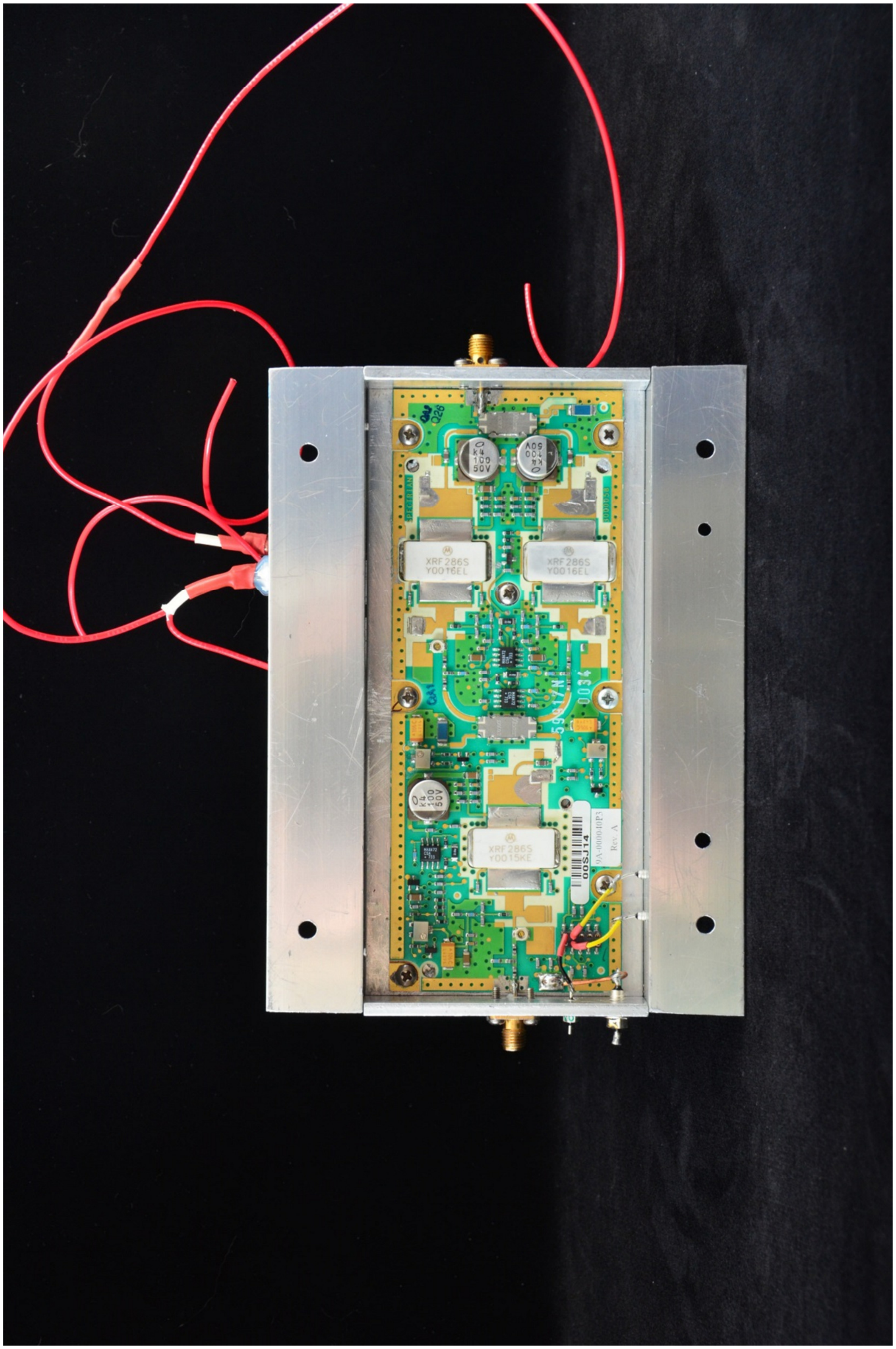

Figure 6: 2304 Heatsink Cooling Control Circuit