

Medium Power VHF & UHF Amplifiers using small Misubishi MOSFET Modules

Paul Wade, W1GHZ ©2023

w1ghz@arrl.net

For my transverters for 144, 222, and 432 MHz, I usually use a small Mitsubishi MOSFET module as a power amplifier. These modules can provide at least 7 or 8 watts output, adequate to drive modern LDMOS amplifiers, with a few milliwatts input from a basic transverter board. For simplicity and flexibility, I use a separate PC board for the amplifier module, usable at all three bands, similar to the one that G4DDK¹ used with his Anglian two-meter transverter. A major advantage of the separate PC board is that the module can be tested and adjusted standalone.

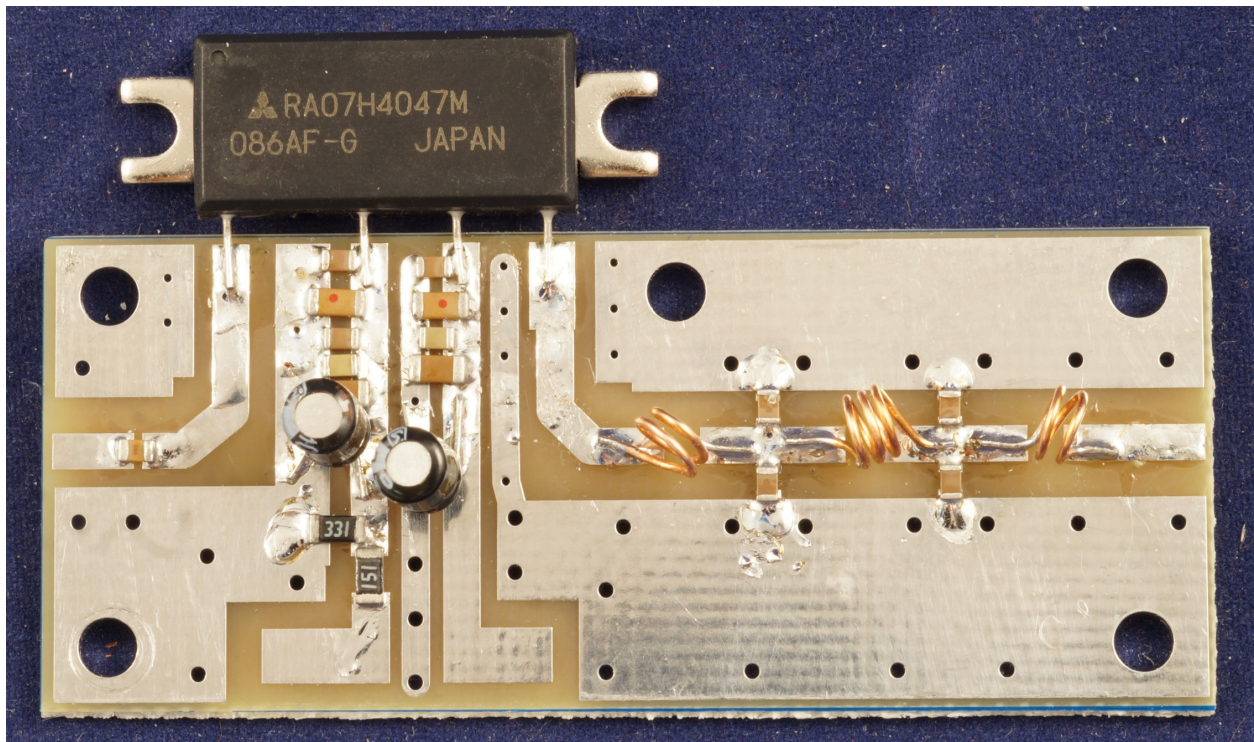


Figure 1 – 432 MHz MOSFET Module and PC board with Low-Pass Filter

An amplifier board for 432 MHz is shown in Figure 1, including a low-pass filter on the output and adequate bypassing of the DC supply and bias leads. What is not shown in the picture is the metal plate underneath. The module has no ground return lead, so it relies on the flange for both ground connection and for heat sinking. The PC board has a ground plane on the bottom and many plated-thru holes to provide short connections to the metal plate or heat sink to which the module is bolted. At these power levels, bolting them to a die-cast aluminum box with a light smear of thermal grease is often adequate. If the amplifier feels too warm after running overnight, a small heat sink on the outside of the box might be needed.

The DC lines are bypassed by an assortment capacitors, as recommended by the manufacturer, covering a wide frequency range to ensure stable operation, as shown in the schematic, Figure 2. I start with a value suitable for the operating frequency placed closest to the module, then space the others further away, with small electrolytic capacitors for low frequencies furthest from the module.

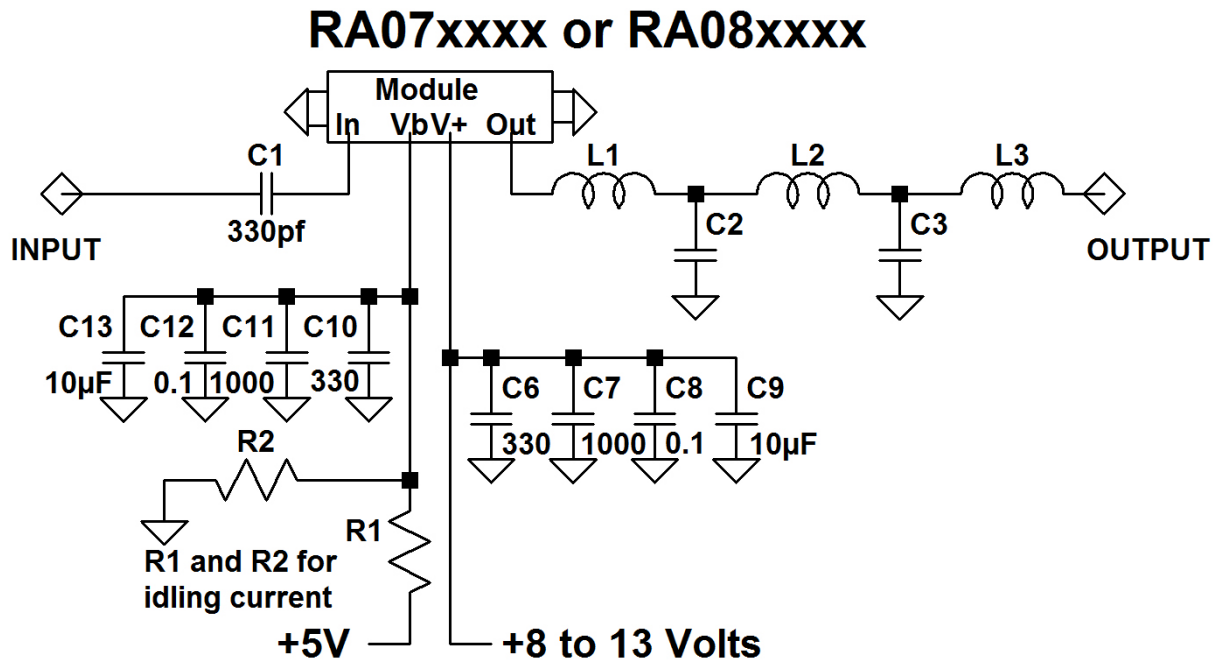


Figure 2 – Schematic diagram of MOSFET module amplifier

The maximum power output of a module is limited by the supply voltage – some versions are specified for 7.2 volt operation while others are for 12.5 volts typical. All can provide at least 8 watts maximum output at specified voltage. I sometimes reduce the supply voltage to limit the maximum output power from the module to avoid the possibility of blowing up an expensive LDMOS transistor if something goes wrong.

The bias voltage enables an idling current for reasonable linearity, and also controls the gain, typically 26 to 34 dB, depending on current and frequency. Typical bias voltage is around 3 volts, but the current changes fairly quickly with bias voltage, so a regulated voltage source is recommended – I take it from a 5-volt regulator with the voltage divider shown in the schematic with R1 chosen for the desired idling current. In various transverters, I have set idling current anywhere from 0.35 to 0.8 amps. In normal operation, the V+ voltage is on all the time and the Vb, the bias voltage is switched on during transmit. With no bias voltage, the module draws no current.

The output power curve seems to be fairly independent of the bias voltage and idling current, and seems pretty linear up to about half of saturated output power. If the module is driving a high

power SSPA, bias might be adjusted in a two-tone test for best IMD. Rover stations running barefoot might prefer a lower current.

At high gain, the module may be sensitive to input impedance of the preceding stage – I saw one instance where changing the input cable length changed the output power. If enough drive is available, a small attenuator at the input might be a good idea – a chip resistor on the PC board in place of C1 with shunt resistors on each side to form a π -attenuator will work fine (the input capacitor isn't necessary).

All broadband amplifiers will generate harmonics when driven near maximum output power, so a low-pass filter on the output is recommended and included on the PC board. It is much easier to filter at these low power levels. Table 1 shows the nominal low-pass filter values. The capacitors, C2 and C3, may be made up of two capacitors, one on each side of the transmission line, like Figure 1, to reduce loss and to make non-standard values. For instance, 28 pf = 18 pf + 10pf.

Low-Pass Filter Components

<u>Frequency</u>	<u>L1</u>	<u>C2</u>	<u>L2</u>	<u>C3</u>	<u>L</u>
144 MHz	60 <u>nh</u>	28 pf	100 <u>nh</u>	28 pf	60
222 MHz	25 <u>nh</u>	20 pf	50 <u>nh</u>	20 pf	25
432 MHz	15 <u>nh</u>	10 pf	27 <u>nh</u>	10 pf	15

Table 1

The inductance of a coil is measured by putting the coil in parallel with a chip capacitor and measuring the resonant frequency with an antenna analyzer¹, impedance analyzer, or VNA, as shown in Figure 3 – maximum impedance of a parallel-resonant circuit occurs at resonance.

The resonant frequency calculation is $f = \frac{1}{2\pi\sqrt{LC}}$

Turning this around, inductance is $L = \frac{1}{C \cdot (2\pi f)^2}$

C is the value of the chip capacitor, plus 1 or 2 pf for the PC board capacitance.



Squeeze and stretch the coils until the desired resonant frequency is reached. Adding turns to the coil or increasing the diameter increases inductance, if the first try misses.

The filter is tuned on the PC board with a 50-ohm load at the output, shown in Figure 4, before installing the amplifier module, using the same instrument or a VNA. SMA edge mount connectors are slipped on PC traces at the ends of the filter – most connectors fit tightly enough so that solder is not needed for the temporary connection. Squeeze and stretch the coils to tweak for best response at the operating frequency, with good VSWR below the operating frequency and high VSWR above the operating frequency. If you are using a VNA, you can also measure the transmission response, like Figure 5.

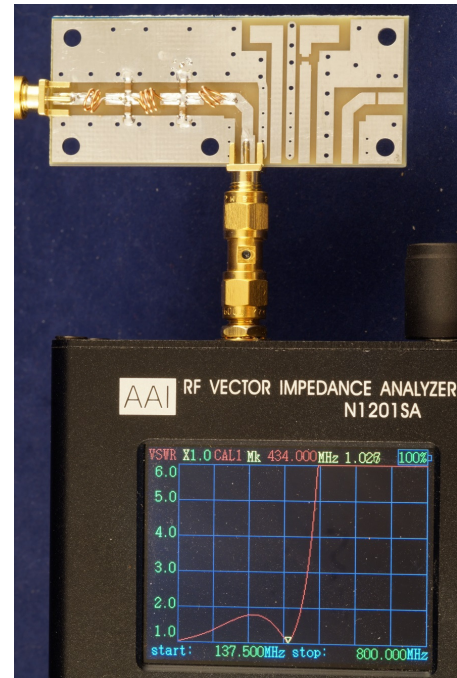


Figure 4

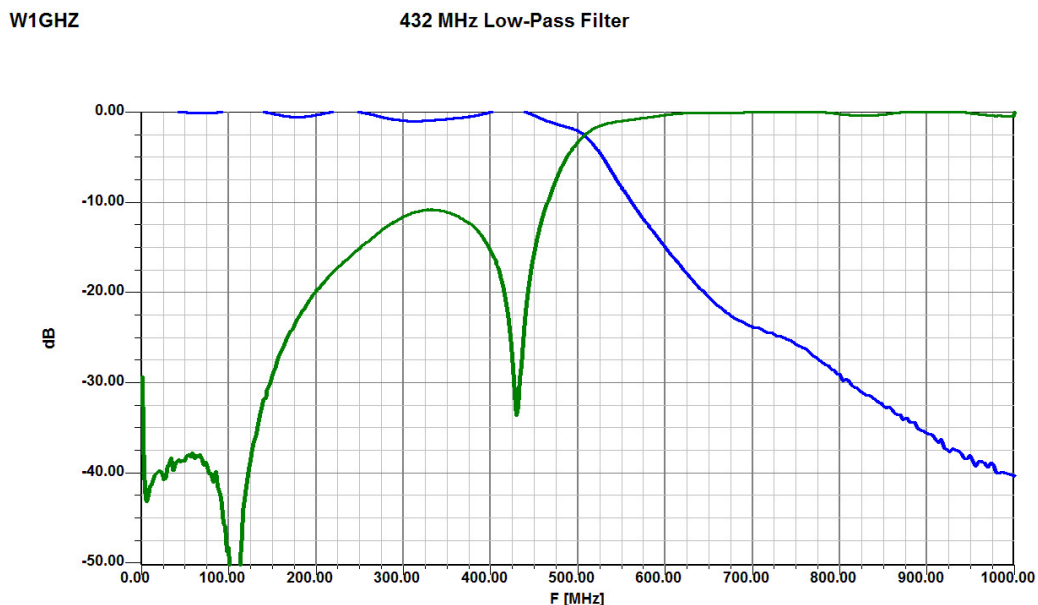


Figure 5 – 432 MHz Low-Pass Filter response after tweaking

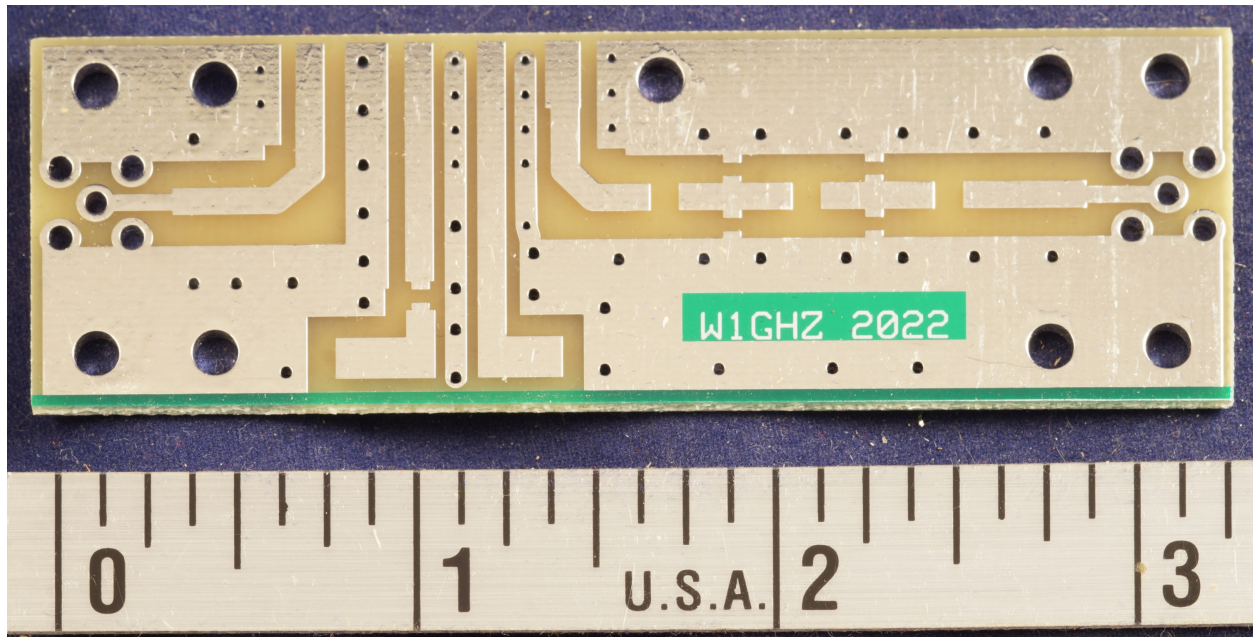


Figure 6 – PC board for module amplifier with provision for SMA connectors

My latest revision of the PC board, shown in Figure 6, includes board-mounted SMA connector footprints, making a standalone amplifier easier. These can be cut off to allow for a pigtail coax connection, shown at the input of the module in Figure 7, or attached at a right-angle to make an SMA connection like the one on the output. This amplifier is part of a 2-meter transverter driven by an SDR as an alternative to an FT-817 as a microwave IF. The transverter is identical to my 222 MHz transverter⁴ with different filter components for 144 MHz.

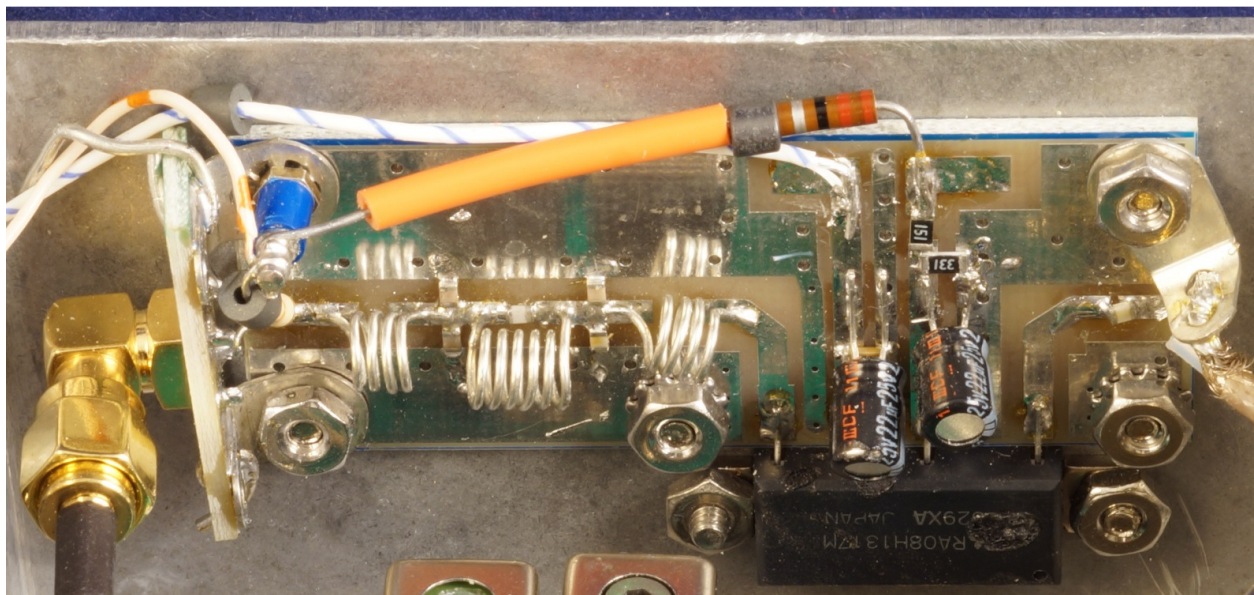


Figure 7 – Amplifier for 144 MHz showing alternative coax connections

Some of the 144 and 432 MHz version of the modules are available from RFParts.com, while the 222 MHz modules and some other versions seem only to be available from ebay sellers. The usual cautions apply, but some prices are attractive. I test them in a standalone amplifier – the module leads are easily soldered and unsoldered – and all so far have been functional.

Notes

1. Sam Jewell, G4DDK, “144MHz 8W low power linear amplifier,” <http://www.g4ddk.com/144MHz8WPA.pdf>
2. Paul Wade, W1GHZ, “Antenna Analyzer Pet Tricks,” *QEX*, January/February 2019, pp. 22-26. Also http://www.w1ghz.org/QEX/Antenna_Analyzer_Pet_Tricks.pdf
3. www.nanovna.com
4. Paul Wade, W1GHZ, “222 MHz Transverter, Mark 3,” *Proceedings of the 54th Conference of the Central States VHF Society*, ARRL, 2022, pp 146-165. Also http://www.w1ghz.org/xvtr/222_MHz_Transverter_Mark3.pdf