

Building Enclosures for Microwave Circuits

By Rus Healy, NJ2L

Many microwave projects are offered as etched circuit boards and board-level kits. Microstrip filters and amplifier circuits, etched on PC-board material, give home builders access to microwave technology that was previously available to only those who were willing to reproduce complex discrete circuits and spend a lot of time tuning them. So now, for reasonable prices, we can build microwave transverters, oscillators, filters, preamplifiers and power amplifiers that work well with few or no tuning adjustments. But one issue remains critical to success with these projects: proper packaging techniques.

The packaging problem is really several individual issues. For one thing, if a board is part of a project that contains many gain stages, the packaging of each board must isolate the stages well enough so that they don't oscillate. It must also provide for low-loss, low-inductance RF input and output connections, and appropriate decoupling of power and bias voltages coming from outside the circuit. These aren't difficult matters to address, but require some thought and preparation. You just can't mount a microwave circuit into any convenient enclosure, run long leads to it, and expect it to work right.

An effective approach that's much less expensive than commercial boxes is to *build* an enclosure to fit the board you're working with. After all, you're building the rest of the circuit, so you may as well build the box!

Unetched fiberglass-epoxy PC-board material and hobby brass make great enclosures. Although PC-board material is widely available, it's a bit less convenient to work with than hobby brass. Brass stock is also widely available (many hobby shops stock K&S brand brass and aluminum stock). It comes in a wide range of widths and thicknesses. A useful size, 0.5 inch wide and 0.025 inch (25 mils) thick, comes in 1-foot lengths that list for \$0.50. Using this material, you can box three or four microwave preamplifiers for a dollar. Now *that's* economical packaging!

Building a Box from Brass

For boxing preamplifiers and other small circuits, half-inch-wide, 25-mil brass strip stock is nearly ideal (other common thicknesses are 20 and 31 mils). Half-inch-wide stock is most convenient because it's the same width as industry standard, four-hole-flange SMA connectors. SMA connectors are best for microwave circuits, because they work well and are widely available in male and female forms for every size of coax commonly used at these frequencies.

Before beginning the brass preparation, clean the brass with a ScotchBrite pad or emery paper. This makes it much easier to solder. Also, drill any necessary holes in the PC board for bias components, transistors, through-hole grounds, and so forth. This is much more difficult after the board is in its case. Look over the circuit and the part-placement diagram carefully so you don't miss anything.

Preparing the sides of the box requires some attention to detail and some common tools. Before you start, collect some brass stock, a drill, the necessary RF and dc connectors, a steel rule, square, file, center punch, scribe, utility knife, pencil, and a flat work surface (a piece of plywood is fine). A drill press and small vise come in handy, but aren't necessary. (You may want to drill and tap the connector holes for #2-56 or #3-48 screws, but that's not necessary; gold-plated connectors can be soldered directly to the brass walls.) The following procedure assumes you're packaging a typical, small microwave project, such as a preamplifier.

Step-by-Step Procedure

1) Start with an end of the circuit board that requires an RF connector. Lay a piece of brass along that edge of the board, with one end of the brass flush with one end of the board. Lay the steel rule along the edge of the board so that it lies flush with the board and crosses the brass. See Figure 1. Mark the brass where the ruler, PC board and brass strip meet. You're marking the brass piece so that it's *exactly* as long as the RF-connector end of the board. Using a square along a long edge of the brass, mark a cut line across the brass with a pencil or scribe.

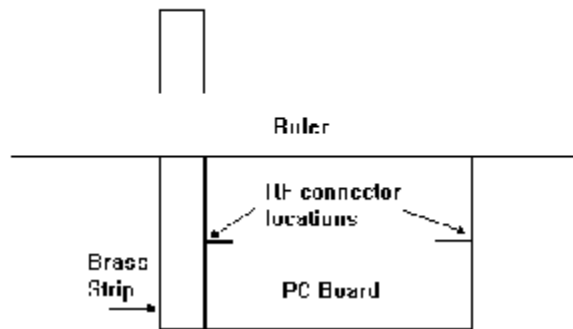


Figure 1 Measuring the first end piece.

- 2) Using a straight edge or square, mark the center position of the RF connector.
- 3) Measure along the line you just marked, to the center of the brass strip. This is the center point of the connector. Using a center punch, dimple that point for drilling.

4) Repeat steps 2 and 3 for any remaining RF connectors. It's good practice to mount dc connectors on the same sides as RF connectors for ease of mounting the finished assembly inside another case. You may want to standardize on mounting dc connections on the RF-input side, to minimize the possibility of connecting the assembly backwards later. (Stranger things happen every day!) Mark the dc connector hole positions, keeping in mind that the PC board will sit in the center of the finished brass case. Don't locate any feed-through capacitors in places where they'll interfere with the PC board.

5) Lay the steel rule along the cut line you scribed or marked for the edge of the board. Using a utility knife, cut along that line, at first using light to moderate pressure. Make sure to follow the scribed line. It's a good idea to cut slightly outside the line, to allow for filing the brass to its final size. Increase the pressure after the first few cuts, once the cut line has been well established. When you've cut about halfway through the strip, grasp the brass between your thumbs and forefingers just on either side of the cut. Flex the brass until it snaps at the cut line, being careful to keep the brass from bending anywhere except the cut line. File the cut edge just enough to clean up the rough edge. Lay the cut piece along the edge of the board to make sure it's the right length and the connector hole centers line up with the appropriate PC-board traces. If the piece is too long, file it to length, keeping in mind that how much material you remove from each end will affect connector position.

6) Drill or punch the connector-mounting center holes. The holes should be several times the diameter of the connector center pin, and at least slightly wider than the microstrip trace to which the connector's center pin will be soldered. If you're drilling the hole, start with a small drill (#43 or smaller) and open the hole to its finished size with a larger one. Deburr the hole *by hand* using a drill bit about twice the size of the finished hole. Spin the drill bit between your fingers while applying enough pressure to remove the drilling burrs. This is also a useful technique for clearing the foil away from ground-plane side of a PC board hole where a wire will pass through the board.

7) If you want to drill and tap the connector mounting holes (necessary for stainless steel connectors, but optional for gold-plated ones), do the following; otherwise, skip to the next step. Place the connector in the hole and visually center the center pin. While holding the connector in place, mark the flange hole locations on the brass with a pencil or scribe. Remove the connector. Center-punch, drill and tap each hole, then mount the connector using short screws (0.25 inch or less).

8) Wear a heavy cloth or leather work glove for this step. Place the connector in its hole and visually center the center pin. Using a stout soldering implement, heat and solder the connector in place. (Inexpensive soldering pencils sold for stained glass work deliver just the right amount of heat for this job.)

9) Repeat steps 1 through 8 for the opposite end of the board.

10) Measure the sides of the PC board that won't hold any connectors. Add 0.25 inch to the measurement and mark two pieces of brass to this length. Cut them as described in

step 5, then file the edges clean and round the corners slightly so that you won't gouge yourself on them later.

11) With the RF connectors mounted to the brass end plates, align their center pins with their respective microstrip traces. Solder the center pins flat to the appropriate traces while holding the board in its final position with respect to the brass. Reheat the center pin and make any small adjustments. *Do not* attempt to adjust the position by twisting the brass or the board without reheating the solder; this can lift the trace from the board, ruining it.

12) Using a stout soldering implement, solder the board to the brass stock along the bottom (ground-plane side) of the board.

13) Repeat steps 11 and 12 for the other connector end of the board.

14) Align the side pieces with the brass end plates that are soldered to the board. This is most easily done by laying the side piece flat on a wooden work surface, then holding the assembly in place above it. Solder the seams formed where the side piece meets the ground-plane side of the board and the brass end plates.

15) Repeat step 14 for the other side plate. Be careful to keep the side plates aligned during this process; the whole assembly should sit flat when you're done.

Tips

Rather than using separate side and end plates, some builders elect to use only two L-shaped pieces of brass, as shown in Figure 2, bending them at 90-degree angles. Each L-shaped piece forms one end and one side of the box. This results in only two seams in the brass enclosure, at opposite corners of the board. This approach makes it easier to make boxes that sit flat, and requires making fewer cuts. But it takes extra care to get the bends in exactly the right places so that the connector holes are properly centered.

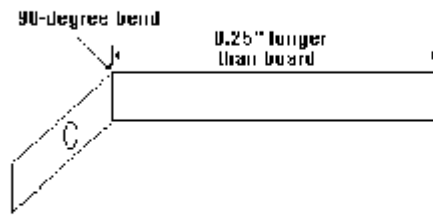


Figure 2 Using a single brass piece to form one end and one side of a box.

You should now have an assembly that's relatively inflexible. You can now solder on the board-mounted parts. Although it requires good dexterity and physically small parts, it's possible to build active bias circuits for amplifiers and preamplifiers onto the back side of the board once its enclosure is completed. This isn't recommended for first-time builders, and is unnecessary for boards that use only MMICs, but is worth the effort in compactness, simplicity and idiot-proofing for complicated projects with lots of separate modules, such as 10-GHz transverters.

Thanks to Zack Lau, KH6CP, whose work has provided me, over the past several years, with a lot of the visual cues I use to make and package microwave circuits.