Sample / Old Design

Amplifier Circuit

The amplifier was one of the most difficult parts to design since it required both microwave parts and a microstrip circuit layout. The circuit also turned out to be very touchy. Initially, it was hard how the biasing was performed, but after the data sheet was found, the task became much simpler. The amplifier that I used was the ERA-3SM microwave amplifier made by MiniCircuits. As the data sheets specify, the circuit requires several external components besides the amplifier.

DC blocking capacitors are necessary on the input and output of the amplifier to block DC voltages and allow the RF signal to pass. The data sheets specify that the capacitors "should have a low effective series resistance (ESR) and should be free of parasitic (parallel) resonance up to the highest operating frequency." The value of the capacitance is not specified in this case, but 100 pF seems to be a very common value in this type of application. The parts that I found to best match these parameters since I could find a data sheet about them was the micro porcelain capacitor made by Mallory. The ESR is low for these capacitors, and the parallel resonance is at about 3.5 GHz (above the highest operating frequency of 2.6 GHz). The performance charts are shown in the data sheets.

Using a 12 VDC supply, a bias current of 35 mA is desired for proper operation. The DC bias branch must therefore contain a resistor with a value of 243 ohms that can dissipate 300 mW of power. These values are obtained from the MiniCircuits table. The resistor that I used in this case was a 240 ohm resistor with a maximum of 350 mW of power dissipation made by Dale, a subsidiary of Vishay Electronics.

To improve the gain of the amplifier, an inductor was used in the bias branch to reduce the amount of RF power that was lost in the branch. The value of the inductor is chosen to be larger than ten times the load impedance (in this case, the load impedance is the characteristic impedance, $Z_o = 50$ ohms). The inductor must also be "free from parasitic (series) resonance up to the highest operating frequency." The inductor that I chose in this case is an inductor made in Germany by Draloric, also a subsidiary of Vishay Electronics. The value of the inductor was 47 nH. The reason for choosing this inductor was that its self-resonant frequency (SRF) was 2800 MHz. The inductor is a very new part. Self-resonant frequencies of this magnitude are not easy to find.

Another important issue when using RF amplifiers is the issue of grounding. The grounding for the amplifier must be very good. The easiest way to do this is to make large ground pads for the amplifier, drill holes in them that are close to the amplifier pins and all around the pad, and solder ground pins through the holes in the pads to the ground plane. Grounding the circuit effectively will greatly improve the operation of the amplifier.

Spacing for the amplifier and other components must be allotted to allow room for soldering. This is done in the Libra simulation software. A transistor can be used to prepare space for the amplifier and lumped data items with artwork and pads should be used to provide space for the respective components. The case sizes for each of the components can be found on their respective data sheets. Some unit conversions may be necessary depending on the values that are specified. When the circuit design is complete in the Schematic window, the circuit is synchronized and can be viewed in the Layout window where the sizes can be verified and the overall circuit size is noted. The circuit is exported in HPGL format, milled using CircuitCam software, and soldered preferably using the surface mount equipment in the senior design room.

The circuit can be tested in two ways. The first method is to use the HP 8510 Network Analyzer to view the overall performance of the amplifier. The amplifier gain can be seen over the frequency range of interest after calibrating the Network Analyzer. Another method is to test the circuit using the HP ESG-3000A Signal Generator on the input of the amplifier and the HP 8594E Spectrum Analyzer on the output to see the gain at discrete frequencies. The same circuit holder that is used for TRL measurements on the network analyzer is used to connect the microstip circuit to the coaxial lines for the input and the output of the circuit. For amplifiers with a gain higher than 15 dBm, the network analyzer does not display the correct information for the gain, and the signal generator and spectrum analyzer must be used. This is especially true when multiple amplifiers are cascaded to produce higher gain circuits.

The design as previously mentioned is performed in the Libra software. On the next page, the schematic and layout for the circuit is shown.

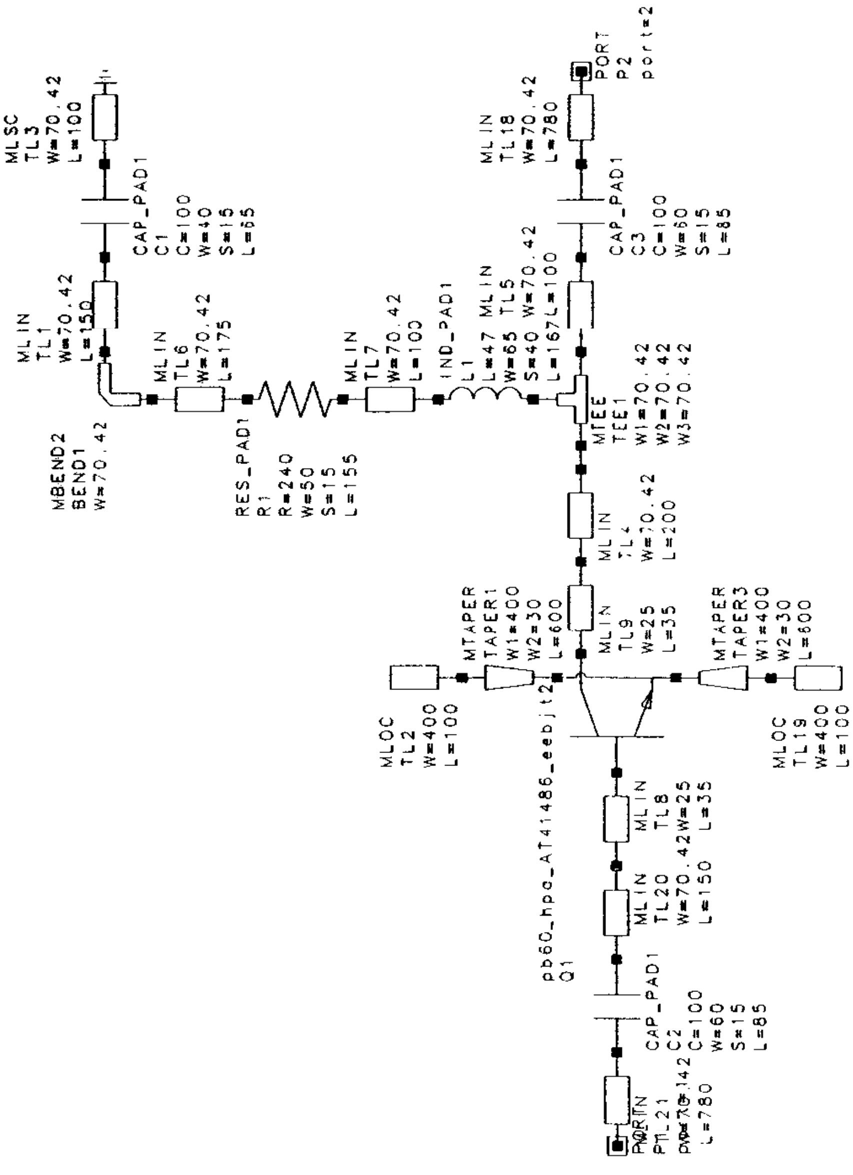

Figure 6 Amplifier Schematic

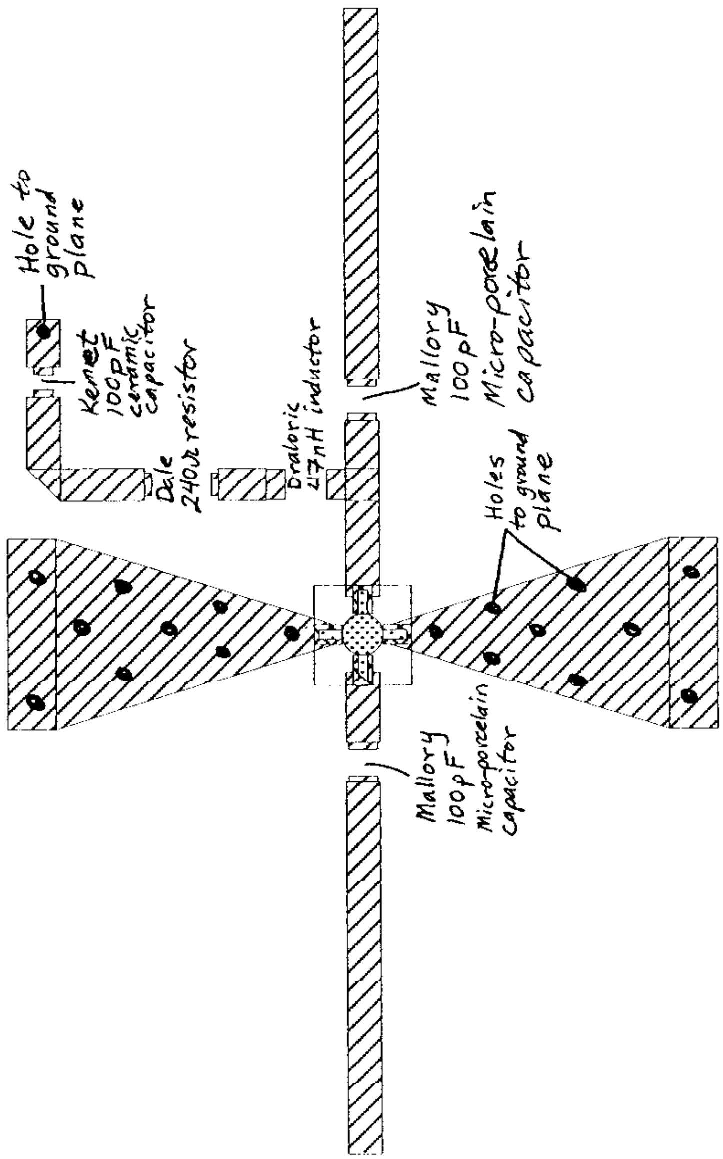

Figure 7 Amplifier Layout