

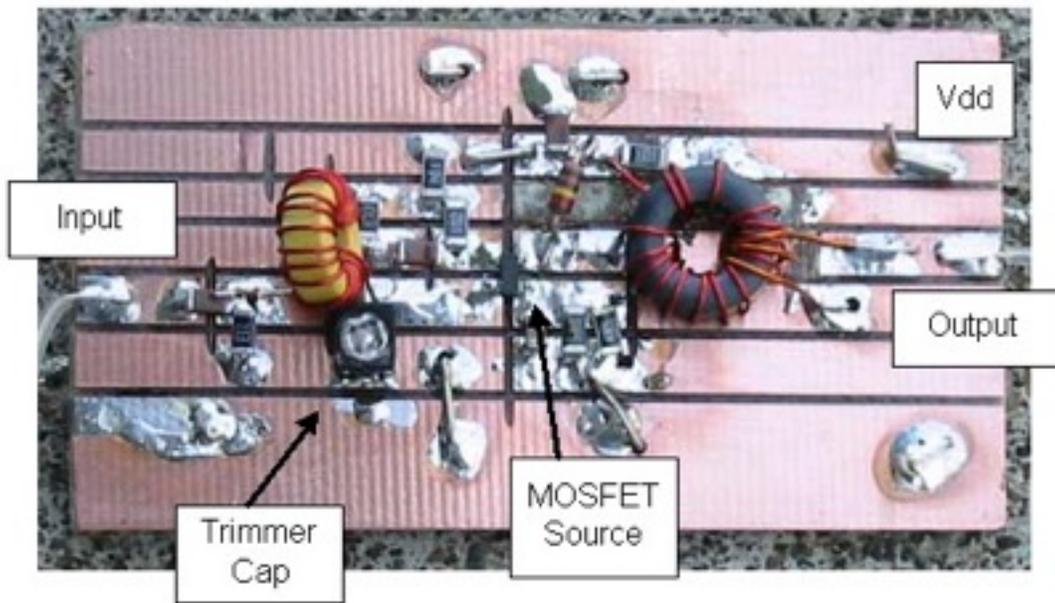
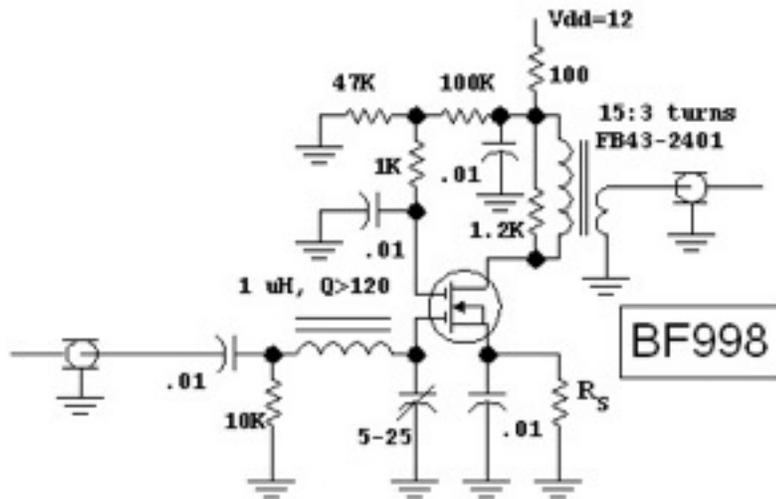
# A SMT Dual Gate MOSFET Preamplifier for 50 MHz.

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## The Circuit

The dual gate MOSFET was an especially popular device for commercial applications in the late 1970 and early 1980 period. Discrete components still dominated, especially when dealing with RF. It was not long after this that monolithic ICs began to take over, causing familiar parts to become scarce or seemingly impossible to obtain. But this is a deception -- the dual gate MOSFET is alive and well. It is **still** manufactured in many types in the US by Infineon and in Europe by Philips. The available parts are generally only found in surface mount form, but that is not a problem for the enterprising experimenter. Indeed, the surface mount parts are easier to tame with regard to spurious oscillation than are the larger leaded parts.

The figure below shows an amplifier built to evaluate a commonly available part, the BF998. These come in a SOT-143 package, much like a SOT-23, but with 4 leads. The larger lead is for the source, while the other leads are drain, G2 and G1, progressively counter clockwise as viewed from the top. The four lead format is actually easier to use in a breadboard than a SOT23. The parts we had on hand were made by Infineon, but the specifications are nearly identical for the two vendors. Our main interest was in gain and noise figure for this experiment.



Note: The 1K lead in G2 was there mainly for layout convenience and could be eliminated. We used a 12 volt supply in our experiment, but the BF998 has a 12 volt drain-source breakdown. Hence, it would be better to use a lower Vdd, perhaps 6 or 8 volts. Gate-2 is biased at about 4 volts in our circuit. Changing the 100 K resistor with a new Vdd would preserve this bias. Experiment.

The input circuit is generally the most critical part of any low noise amplifier, or LNA, and that is the case with this one. We used prior experience with leaded parts to guess at a driving impedance of 2K Ohms for good noise performance. A L network (low pass

form) was designed for 50 MHz. We used a T30-6 toroid for the inductor (16 turns, #28) because this will offer reasonable, if not stellar Q. This is probably not a good place for a SMT part owing to the poor available Q values, especially if optimum noise figure is desired. We did use a SMT trimmer capacitor though. A 10K resistor at the input puts gate 1 at DC ground without compromising the RF input.

The amplifier output uses a ferrite transformer. The bead used is essentially equivalent to the popular FT37-43. We used a 5:1 turns ratio and a 1200 Ohm resistor to back terminate the drain, forcing a good output impedance match. This same transformer should work well at frequencies through the HF range. A transformer on a smaller core might be suitable for 144 MHz use. Alternatively, it may be appropriate to do a tuned output at 144. We are usually interested in loading the drain enough to keep the gain within reasonable limits, so a good choice for a 2M variation of the circuit would be a high pass L network using a SMT inductor.

Our goal was not to build something that was excessively small. Rather, we merely wanted to use available SMT parts with the thought that smaller size could be realized at a later time, if needed. The breadboard circuit is shown in the figure. The circuit board was fabricated with a Dremel tool mounted in a fixture we built. The family of horizontal cuts is especially handy way to make a general purpose HF and VHF breadboard.

## Results

We encountered no problems at all in turning this circuit on. We started with a source resistor of 150 Ohms. With that value, the drain current was only 2.2 mA, but the transducer gain was still 23 dB after the trimmer capacitor was peaked at 50 MHz. There was no sign of any instability.

The source resistor was then dropped to 68 Ohms, increasing current to 3.6 mA. The gain went up to 25 dB and stability was retained.

Moving toward higher current, we dropped the source resistor further to 6.2 Ohms, kicking  $I_d$  up to 7.7 mA. Gain was now 28 dB, and remained stable. Noise figure measurements were performed at this bias using the Y-factor methods outlined in Chapter 7 of Experimental Methods in Radio Frequency Design, producing a result of  $NF=1.5$  dB. This is close to the result graphed in the Infineon data sheet. We did no experiments aimed at determining the optimum driving source impedance. This amplifier is undoubtedly compromised by the modest Q of the input inductor. The SMT trimmer capacitor is also subject. But 1.5 dB will be more than adequate for 50 MHz applications. There should be no difficulty in obtaining similar results at HF and at 144 MHz.

We shorted Gate 2 to ground at one point, producing only a 10 dB decrease in gain.

This was consistent with the data sheets. To really get a reasonable gain control range, one must drop the voltage on G2 below that of the source. A simple way to do this is to bias the source to a positive voltage with a pair of diodes. See section 6.2 in EMRFD.

If higher current is desired in order to obtain either higher gain or improved IMD performance, some forward bias can be applied to gate 1. This should also provide greater gain control range as gate 2 voltage is changed.

A quick search on the web showed a couple of places where the BF998 could be purchased. The Infineon parts are listed in the DigiKey catalog and can be purchased in unit quantities. The Philips parts are listed in the Future Active on line catalog. I suspect that it may be difficult to get small quantities from them, so you may need to investigate this further.

### Getting Parts:

Bob, KE6F, informs me that he has a stock of the BF998s that he is willing to share with experimenters. He said, "*I'd be happy to send them a pinch of 'em for an SASE.*" So drop Bob a note if you would like to try a project. Bob's info can be found in the section of this web site that relates to QST articles. Then look for "free semiconductors." Many thanks for your generosity Bob.