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# ARE FET'S REALLY BIASED?

The field effect transistor, or FET as it is called, has proven to be a very unique device and is now being used quite widely in the electronic industry as well as in amateur radio projects.

The low cost FET is popular with hams because so many things can be done with this electronic marvel. The junction type of FET is extremely rugged, but a few basic facts on these devices should be taken into consideration before your next project with the FET is started. The following points are generally ignored, and as a result many projects do not work out-right, if at all, even though you have followed the schematic and used the same parts. In some cases, the FET has been shunned because it was thought not to be as stable as the transistor. Let s take a look at the important points and how to use them so we can make the FET circuit just as stable, if not more so, as the transistor or the tube.

One of the most important and overlooked parameters of the FET is the $I_{DSS}$ or zero bias drain current of the device. This is always found on the FET spec sheet and is a range of current from 1 mA to as much as 50 mA. Different FET's will have different ranges of current. If one person uses a FET with an $I_{DSS}$ of 2 mA and you use a FET of the same number with an $I_{DSS}$ of 10 mA, you may not be able to get your project to work right, and you will find that the slightest temperature variation will change the circuit conditions. To find out why, let's look at the curve of the drain current of a FET under different temperature conditions to see how they vary. Figure 1 shows this curve with the drain current plotted against

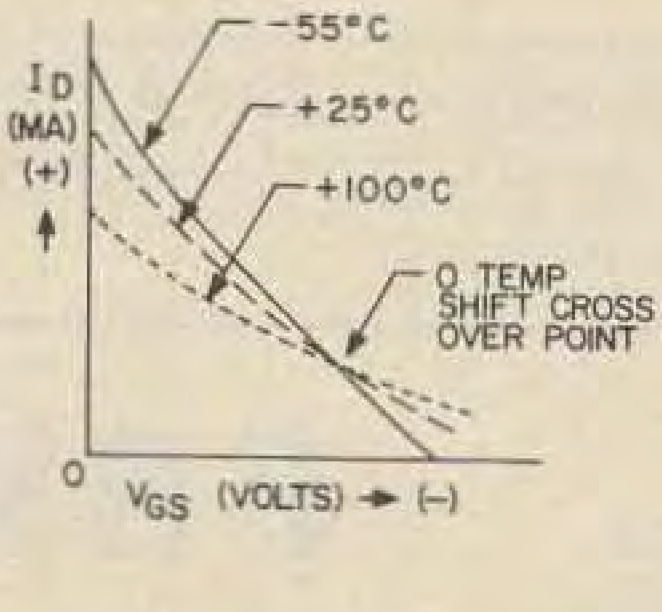


*Fig. 1. Id versus Vgs for 0 temperature shift bias point.*

the gate voltage. As you can see, when the temperature is the coldest, the drain current is the highest at zero bias, and when the temperature goes up, the maximum drain current decreases.

If the FET were biased at zero bias, the maximum amount of gain can be obtained from the circuit, but with the maximum sensitivity to temperature change. The three curves cross at a point with the gate bias negative, causing a low flow of drain current. Beyond that point, the action changes. When designing a circuit for maximum stability, such as an amplifier for mobile operation or an oscillator for a vfo, we would like to bias the FET at the cross-over point or the zero temperature point. This would result in the smallest change in drain current for the maximum temperature variation. To achieve this, you could run a set of curves on the FET's that you are using to find this point, but there is a much simpler method.

Most FET manufacturers have found that the zero temperature point is around .9 to .11 of the $I_{DSS}$ of the FET. We can use this handy information to design our circuits for maximum stability and minimum drift. All we must do is measure the zero bias drain of the FET that we are going to use, and use the average of .10 times the zero bias drain current to find the operating point of the transistor. The $I_{DSS}$ of the FET can be found in two ways: with a commercial FET tester such as the Sencore TF151 that will measure this drain current as well as the Gm or with the circuit of Fig. 2.

The circuit is set up to measure the zero bias drain current for an "N" channel FET. To measure the zero bias drain current of a "P" channel, reverse the meter and battery connections shown. The battery voltage is not critical and any value between six and nine volts can be used with the same figures resulting.

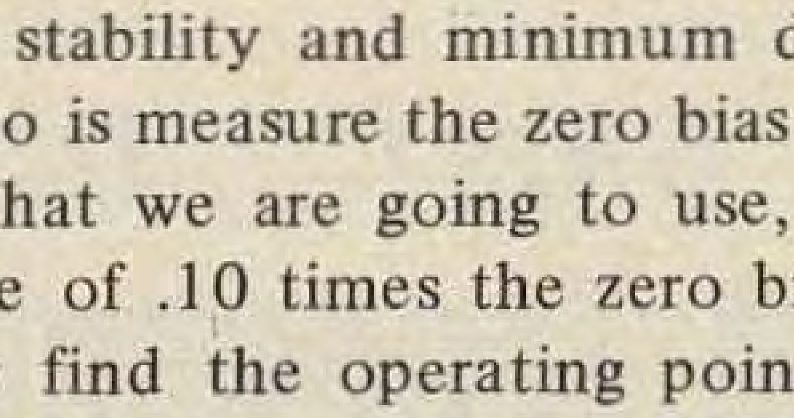


*Fig. 2. Setup for measuring $I_{DSS}$ of a FET reverse meter and battery for "P" channel FET.*

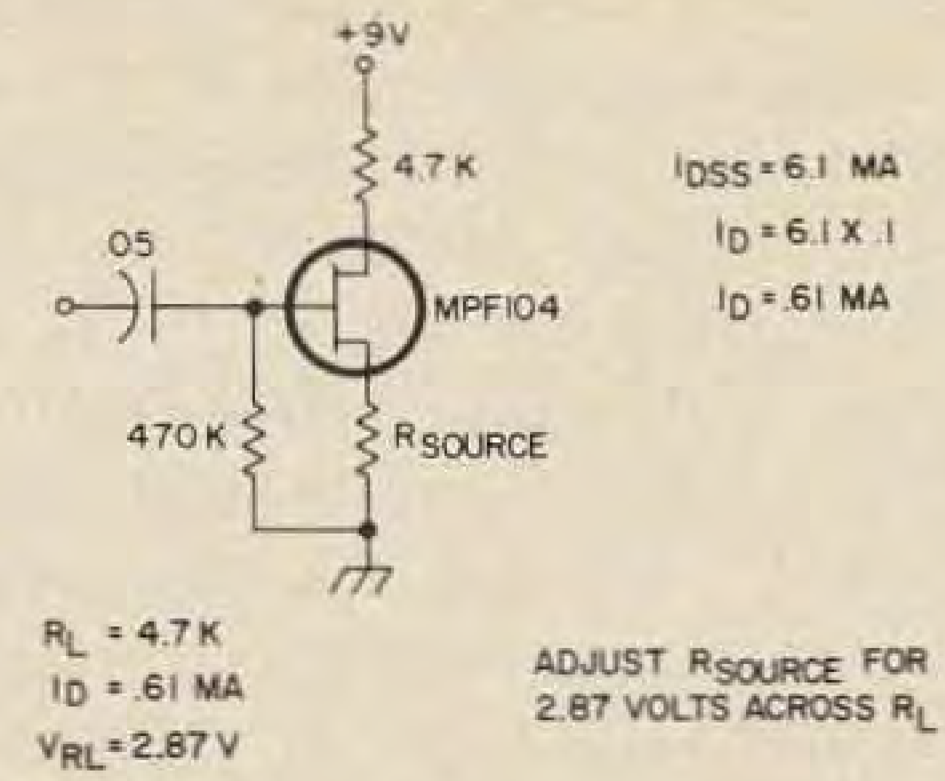


*Fig. 3. Setting up bias point on a FET for 0 temperature shift.*

Here are a few examples of different $I_{DSS}$ currents I measured on several Motorola MPF104 junction FET's. If a pair of FET's were needed, such as in a bridge circuit, numbers 2 and 3 would be the best suited as they are the closest in zero bias drain current measurements.

| FET | $I_{DSS}$ |
|---|---|
| 1 | 4.3 mA |
| 2 | 6.1 mA |
| 3 | 6.9 mA |
| 4 | 7.5 mA |

Numbers 3 and 4 could also be used as a matched pair, but number 1 could not be used with the other three as a matched pair such as in a bridge circuit for a voltmeter. If number 1 was matched with any of the other FET's, the circuit would be unstable and subject to temperature drift. Any of the FET's above could be used as an amplifier for a zero bias stable condition. Let's use the FET with the zero bias drain current of 6.1 mA as an example of how we find the proper operating point of the FET that we are going to use.

The example uses a load resistor of 4.7K and is being used as a low level audio amplifier for a mike stage. If the zero bias drain current is 6.1 mA, then we can use the average of the .08 to .11 figure which is normally .10 as a starting point. Multiply the figure of 6.1 mA times .10 which gives us a figure of .61 mA of drain current for the FET. Using Ohm's Law, this would give us a voltage drop of .61 mA times 4.7K or 2.87V across the load resistor. To achieve this voltage drop, we must now adjust the source resistor in the circuit until the voltage drop across the load resistor is 2.87V. If you have the curves for the FET this can be done simply by finding out how much bias is needed to limit the drain current to around this figure and, again using Ohm's Law, figure out a source resistor with the drain current of .61 mA and the bias voltage. In most cases it is much easier to use a resistor substitution box or a pot in the source and adjust the value until you find the voltage at the drain load resistor to be that which you have calculated.

If a low level signal is to be amplified, a FET with a low $I_{DSS}$ can be used, but if a high level of signal is to be amplified, it is much better to use a FET with a high $I_{DSS}$ so that the resulting drain current will allow a greater swing and still remain in the linear portion of the curve, as you would for a tube circuit. Above all, do not allow the FET to run at a drain current above its normal $I_{DSS}$ or permanent damage to the transistor will result. If you are replacing a FET in an existing circuit, be sure to check to see how much drain current was being drawn by the previous FET. If the circuit draws more drain current than the maximum $I_{DSS}$ of the replacement FET, you will have trouble.

The zero bias drain current or $I_{DSS}$ can be helpful in many ways; for example, to find the best operating point for a vfo, matching a pair of FET's for a bridge circuit, or finding the best operating point for an amplifier for best stability. In rf applications the FET is ideal and in most cases is biased at zero bias to get the maximum gain from the circuit with an agc voltage to control the signal level from the stage. In a cascade amplifier the upper FET must have an $I_{DSS}$ of two to four times that of lower FET.

The FET is the ideal device to be used in rf amplifiers, vfo's, i-f circuits, audio stages, and many others. The high input impeaance that can be achieved with the FET also makes it the ideal device to be used in test equipment around the shack. By using Ohm's Law and the zero bias drain current or $I_{DSS}$ of the FET, these circuits can be made to perform with great satisfiaction and very little trouble.

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