MOSFET Testing using a Multimeter

Yes it can be done

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This short article will deal with testing power MOSFETs using an ordinary digital multimeter. Anybody who have ever tried this must have marvelled at strange readings and short circuits found even on surely working devices. Of course, there is no magic involved!

Testing bipolar transistors, whether low or high power, is all plain sailing if you have just an ordinary ohmmeter available and know (1) the connections on the device and (2) the six steps involved. Such a simple test should spot 8 out of 10 defective bipolar transistors, although your editor had to admit defeat with some high-power UHF RF transistors he tried to examine the other day. For example, an MRF646 50-watts 'beast' checked out just fine electrically but its in-circuit power gain was nothing to write home about! Returning to the subject of our article, MOSFET testing is a different (but not necessarily nasty smelling) kettle of fish.

Whither charge and voltage?

It can be argued that MOSFETs are charge controlled devices, because the gate, which is the control electrode, represents a virtually ideal capacitor exhibiting an extremely low leakage current. However, the same charge produces a voltage, which in turn determines the degree of conduction so these wonderful devices may equally be called 'voltage-controlled'.

No matter if voltage or charge-controlled, when a MOSFET is out of its circuit, any charge stored in it will stay there, keeping the device on if it is positive, or keeping it off if it is negative (we are talking of most common N-channel devices, for P-channel MOSFETs you just have to reverse any polarity involved). For an N-channel device, 'negative' also means below the threshold necessary for switching the MOSFET on.

In fact when you handle a MOSFET for testing — pulling it from the circuit or from its protective packaging — your fingers, the soldering iron etc., will typically cause a random charge to be stored in the gate-source equivalent capacitor.

The first thing to be done is give this charge a known value because only then does it become possible to check the drain-source path (junction) for correct on/off operation. Let's see how this is done in practice.

Preparing for testing

First of all you have to switch your digital multimeter to the Diode Check range. This way your multimeter will supply the junction under test with a voltage that's usually of the order of a couple of volts (open-circuit) and a current limited to a few milliamps. This is just what we need — don't try to use an ohm range since the voltage supplied is then much lower (approx. 0.2 volts) and certainly not enough to switch MOSFETs on and off.

Now its time to lay your MOSFET on the table surface. No matter if the surface of the table is conductive or not, the most important point to observe is that the MOSFETs leads do not touch anything. Also be sure not to touch the leads or probe tips with your fingers so as not to lose any stored charge. In the case of power MOSFETs, the Drain tab can be freely touched and laid on the table surface, but a safer method is to pick up and hold the power MOSFET by the tab, then touch the table surface with your other hand, and only then lay the MOSFET on the table.

Let's test again

At his point you are ready for the actual testing, which involves a number of steps described below.

1. In the first test we switch the MOSFET off and test its gate-source (GS) junction.

MOSFET	Gate	Source	Expected reading
Meter	– (black lead)	+ (red lead)	Open circuit

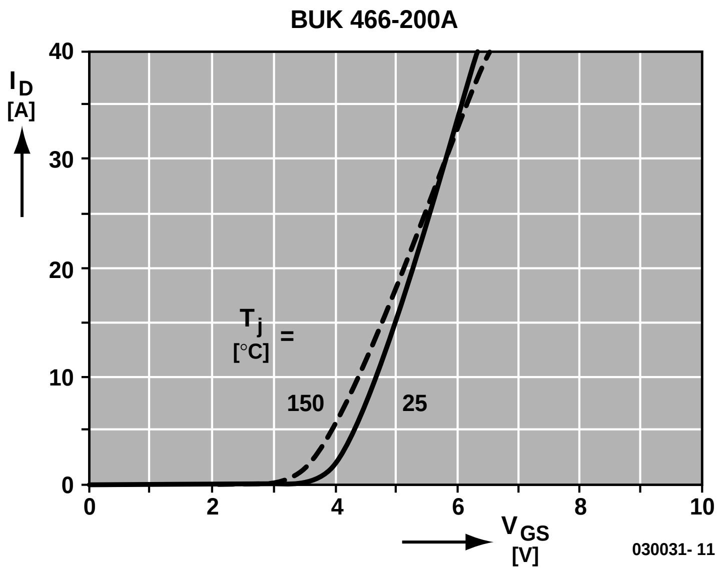

Figure 1. Typical transfer characteristics of an ordinary power MOSFET, in this case, a BUK446-200 from Philips Semiconductors. Graph shows I_D = f(V_{GS}) at V_{DS} = 25 V, with two values of T_j as parameters.

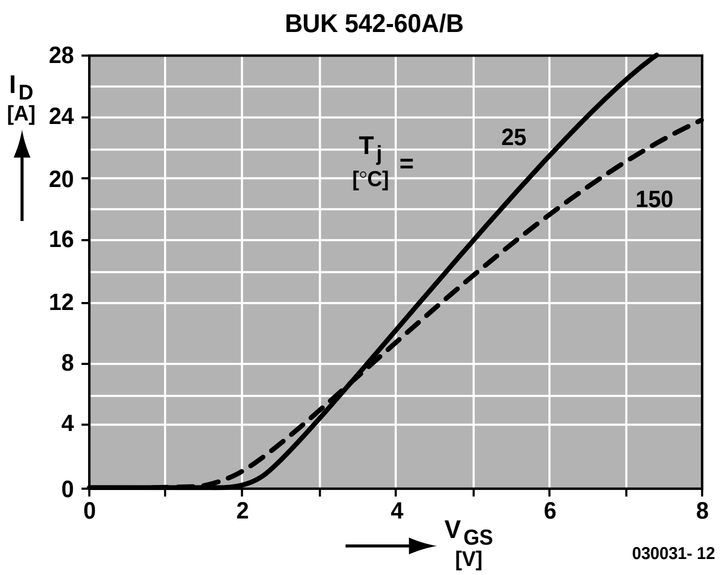

Figure 2. As Figure 1, but for a Logic FET, in this case the BUK542-60A/B.

Any reading other than 'open circuit' means that gate is short-circuited to the source and that the MOSFET may be discarded without the need for any further testing.

2. Now that we have the 'off' charge in the gate we can test if the drain-source (DS) junction is opened. Most MOSFETs have an integral reverse protection diode across the drain and source and this may be tested simply by reversing the test voltage polarity.

MOSFET	Drain	Source	Expected reading
Meter	+ (red lead)	– (black lead)	Open circuit

Any reading other than open-circuit means that MOSFET has a short circuit and should be discarded. Meters usually give readings in mV in this range, so you can expect something between 250 mV and 500 mV for the forward diode drop.

MOSFET	Drain	Source	Expected reading
Meter	– (black lead)	+ (red lead)	Open circuit / Forward diode drop

3. Now it's time to switch our MOSFET on.

MOSFET	Gate	Source	Expected reading
Meter	+ (red lead)	– (black lead)	Open circuit

This way you double check that the gate is not short-circuited. A wrong reading at this point is very rare, but nonetheless you should discard your device if you don't see an open circuit.

4. Now that we have the 'on' charge in the gate, all we have to do is check the drain-source junction for proper conduction. This should be done using both polarities because when a MOSFETs is on, it acts as a small value resistor, irrespective of the direction of the current flow.

MOSFET	Drain	Source	Expected reading
Meter	+ (red lead)	– (black lead)	Short circuit

MOSFET	Drain	Source	Expected reading
Meter	– (black lead)	+ (red lead)	Short circuit

If you don't get these results, the MOSFET has a permanently open-circuit Drain-Source junction and should be discarded.

If the suspect MOSFET has passed steps 1 through 4 successfully it can be relied upon to work properly. As a matter of fact, voltages and currents delivered by multimeters are usually much lower than those required for effective testing of power MOSFETs (IRF, BUZ, etc.) but nonetheless this simple test procedure has given very good results over years of field tests.

If you look at the I_D = f(V_{GS}) graph in **Figure 1**, you'll notice that conduction starts at a gate-source voltage of 3.5 to 4 volts, while at 5 volts (i.e., TTL High level) some 15 A is allowed to flow through the drain-source junction. The graph is for a Philips BUK466-200A which can be describes as a 'typical' example of a power MOSFET.

Other devices called 'logic FETs' start to conduct at slightly lower levels of V_{GS}, for example, at about 2 V already in the case of the BUK542-60 (see **Figure 2**). This makes these devices the perfect choice for direct insertion between a logic output such as a microcontroller port line set up as an output and a (very heavy) load like a power relay or a motor. Again, this is an example only and the graph should not be taken to apply to 'any old logic FET' — see the notes below on finding exact datasheets of the device(s) you're working on.

P-channel devices and the ohmmeter

If you wish to test a P-channel device you should obviously swap the polarity of the test probes in the above tables.

Using an analogue moving coil multimeter is also possible but these instruments usually do not sport a Diode Check range. This requires some investigation about the open circuit voltage and short circuit current supplied by the meter. You should aim at one ohm range to get 2-3 V and 5-20 mA respectively which is ideal for safe testing. You can find out by connecting a second multimeter to the one used for testing MOSFETs. First select a voltage range and the check open circuit voltage on the probes, then switch to current range and note the short circuit current. Usually the OHM×1 or OHM×10 range will do the job. Finally, as we are sure you will note at some point when attempting to use an old fashioned ohmmeter, the – (black) lead is usually positive (+) and vice versa!

Whence the pinout?

At the risk of stating the obvious, you should always know **exactly** where the gate, source and drain pins are on the device you wish to test using the method described in this article. Educated guesses, 'a friend told me' and 'seem to remember' are worthless in this respect and may lead to costly mistakes and hours of fruitless efforts at repairing equipment. The information you want should be obtained from manufacturers' data books or from original datasheets downloaded from the manufacturers' website.

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