

**USER MANUAL FOR THE MOSFET IRF 530 POWER AMPLIFIER**  
**FUNCTIONAL MODULE**

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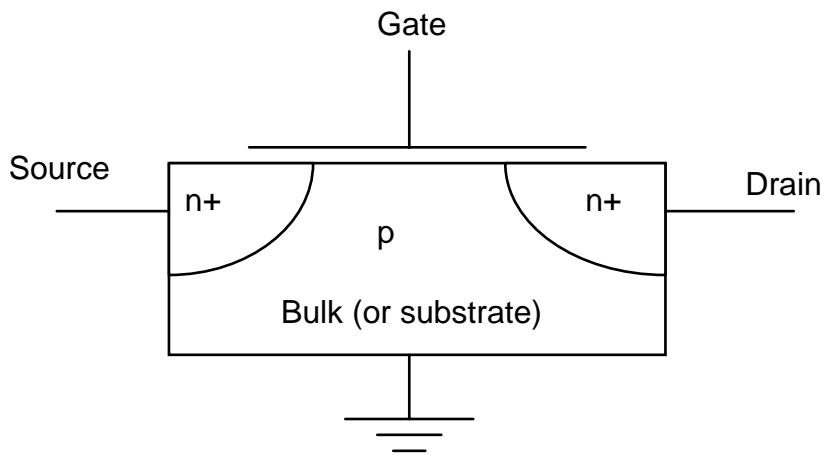
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## 1. INTRODUCTION

Unlike the bipolar junction transistor (BJT), the metal-oxide-semiconductor field effect transistor (MOSFET) is composed of a bulk substrate of metal oxide ions, which form  $n$ - and  $p$ -charged regions in order to amplify analog voltages across a circuit. Figure 1 shows the basic of a MOSFET. Note the charged  $n$ -regions in the substrate and the four terminals (3 active, 1 grounded). Furthermore, unlike the BJT, the operation of the MOSFET is determined by a voltage rather than a current. Figure 2 shows the amplifier circuit with the MOSFET IRF-530 transistor.



**Figure 1** Diagram of the composition of a MOSFET, including the three current-carrying terminals (Rizzoni, 2000).

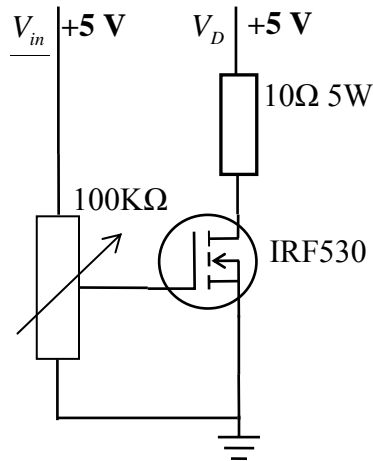


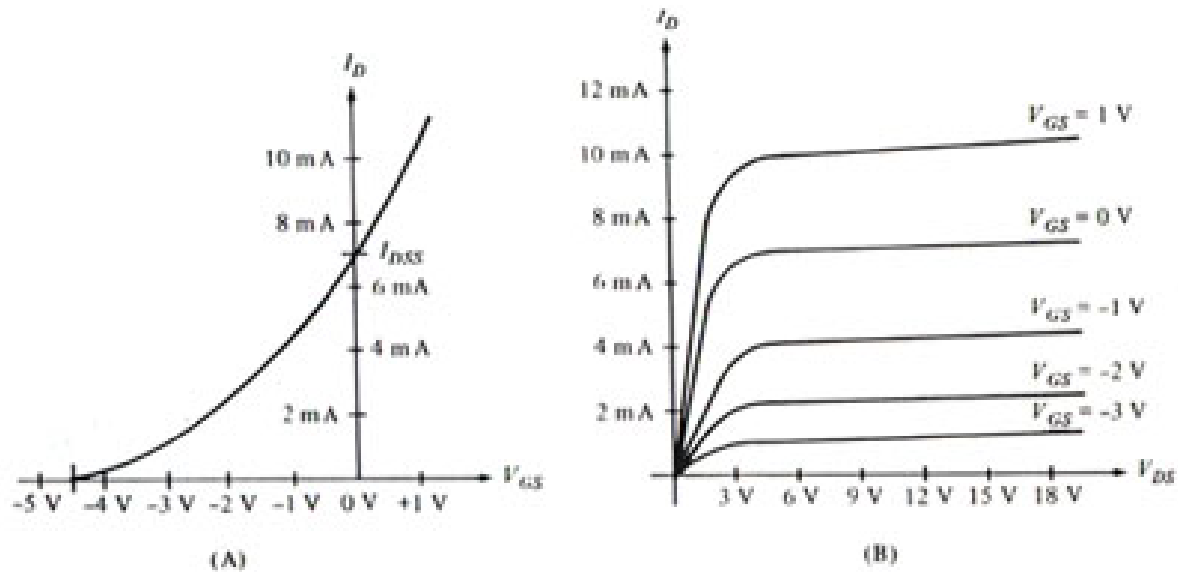
Figure 2 Circuit diagram for the IRF530 MOSFET power amplifier.

In this manual, we will explain the use of this voltage-determined transistor as an amplifier. Additionally, we will determine the relationship between the gate voltage and the current across the source. We will also investigate the physical limits of the IRF530, the MOSFET being used in this laboratory.

## 2. THEORY AND PREDICTIONS

Like the bipolar junction transistors, the MOSFETs are composed of two different semiconductor regions,  $n$  and  $p$ . Instead of creating a current through the device by filling of “holes” in the  $p$  region, the MOSFET forms a “channel” of the positively charged  $n$  layer between the two  $n$  sections, as shown in Figure 1. This “channel” forms when a voltage is applied across the gate, attracting the electrons in the  $n$  region nearer to the gate charge. The strength of the gate voltage determines the geometry of the channel and the current that passes through it. Figure 3 shows the *drain characteristic* of the MOSFET, the relationship between the drain-source voltage and the drain current. Like

the collector characteristic of the BJT, the MOSFET drain characteristic uses two voltages and the gate voltage to construct a series of characteristic curves for the device.



**Figure 3** Drain characteristic for a MOSFET (American Microsemiconductor, 2000).

The figure on the left shows a single characteristic curve of the gate-source voltage versus the drain current, while the figure on the right shows the drain-source voltage versus the drain current at several values of the gate-source voltage.

Two voltages are keys to the operation of the MOSFET, the threshold voltage and the gate voltage. The *threshold voltage*,  $V_T$ , is the voltage at which the MOSFET begins to conduct the electrons from the drain to the source. The difference between it and the gate voltage,  $V_G$ , determines the flow of the electrons through the “channel.” If the difference between the threshold and the gate is negative, no current flows. If this difference is greater than zero, current flows between the two terminals.

At a certain point within the *saturation region*, a “pinch-off” occurs. The “pinch-off” means that the channel thins, not allowing electron flow between the two terminals..

Generally, if the difference between the gate voltage and the threshold voltage is greater than or equal to the threshold voltage, this “pinch-off” occurs..

$$V_G - V_T \geq V_T \quad (1)$$

Equation 1 shows this condition. It also means that when the gate voltage is twice as great as the threshold voltage, then the “pinch-off” occurs. See Equation 2.

$$V_G \geq 2V_T \quad (2)$$

Between the cutoff and saturation regions is the ohmic region. (The ohmic region is analogous to the active region in the TIP120 BJT.) In this region, the channel’s geometry is proportional to the difference between the gate voltage and the threshold voltage. A certain gate voltage is required to create a channel and overcome the drain voltage, and the difference between these voltages becomes the output of the device—the source voltage from the MOSFET.

$$V_G - V_T = V_S \quad (3)$$

According to Ohm’s law, voltage is directly proportional to current. We state that the source current is related to the difference of gate and drain voltages. In experimentation, we measure the current across a static resistor in series with the transistor and find the current at its source terminal,

$$I_S = \frac{V_G - V_D}{R_D} \quad (4)$$

where  $I_S$  is the source current and  $R_D$  is the drain load resistance.

If the difference in voltages is zero, then the current is zero. If the difference in potentials is less than zero, then the current passes back across the MOSFET, preventing amplification. Obviously, Equation 4 represents the region within which the transistor

operates. Figure 4 shows the theoretical behavior of the MOSFET in the operating region. In this case, we measure the drain current when the gate voltage varies. The input voltage and the drain voltage are 5 volts, and the drain load resistance is 10 ohms.

### **3. FUNCTIONAL MODULE DESCRIPTION**

Figure 4 is a picture of the MOSFET transistor functional module. In the picture the major electronic components present are the resistors, the MOSFET transistor, the potentiometer, the voltage output terminal, the ground terminal and the input voltage terminal. The input voltage terminal will receive a signal of +5V. The functional module consists of one circuit that contains the MOSFET transistor which is used in this application as a power amplifier. MOSFET transistors also can be used as a switch in an electronic circuit. Below is the picture of the MOSFET transistor functional module.

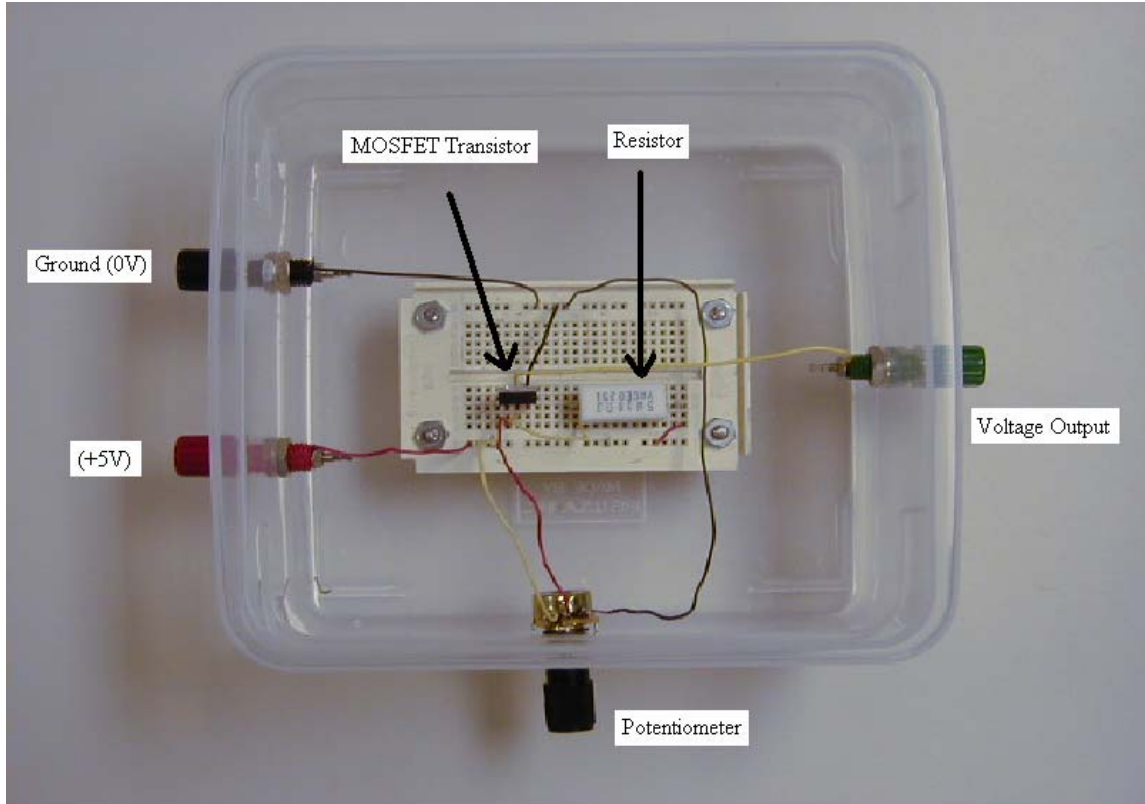


Figure 4 Labeled Picture of MOSFET Transistor functional module.

#### 4. WIRING INSTRUCTIONS

Table 1 Wiring of a MOSFET amplifier circuit.

Red	Input voltage, 5V
	Input voltage to static resistor
	Static Resistor to drain terminal
Green	Input voltage, 5V
	Input voltage to first terminal, potentiometer

	Second terminal, potentiometer, out
	Second terminal, potentiometer, to gate terminal
Black	Ground voltage, 0V
	Third terminal, potentiometer, to ground
	Source terminal to ground
Yellow	Signal wire
	Source terminal out

## 5. APPARATUS

Table 2 Apparatus Needed for Testing

Digital multimeter, or equivalent ohmmeter, ammeter, and voltmeter
Power source
Voltage box, with ground (0 volts), -15, +15, and +5 volt outlets
5/32" flathead screwdriver

## 6. TESTING SEQUENCE

Adjust the gate potentiometer with the screwdriver. Once the power source is giving voltage to the circuit, read the voltage across the drain resistance with the multimeter, which should yield an approximate result. Then read the resulting gate source with the multimeter. Table 3 describes the expected results when the gate voltage is varied, while  $V_{in}=4.96V$ . Figure 4 shows the graph of the test data, illustrating (1) the linear relationship in the active region, and (2) the physical limitations of the saturated and cutoff regions of the IRF530, as the asymptotes the curve approaches.

Table 3 Testing Sequence for MOSFET amplifier, for gate voltage,  $V_G$ , and drain current,  $I_D$ , when  $V_{in}=5V$  and  $V_D=5V$ .

Gate Voltage $V_G$ (V)	Drain Current $I_D$ (A)
0.5	0
1.5	0
2.75	0
2.93	0.001
3	0.002
3.1	0.004
3.15	0.007
3.23	0.015
3.3	0.025
3.37	0.041
3.42	0.058
3.47	0.08
3.52	0.109
3.59	0.151
3.65	0.185
3.69	0.208
3.71	0.233
3.76	0.258
3.83	0.297
3.87	0.346
3.92	0.364
3.95	0.391
3.99	0.405
4.03	0.435
4.17	0.485
4.25	0.491
4.3	0.495
4.4	0.498
4.5	0.501
4.7	0.503
4.94	0.505

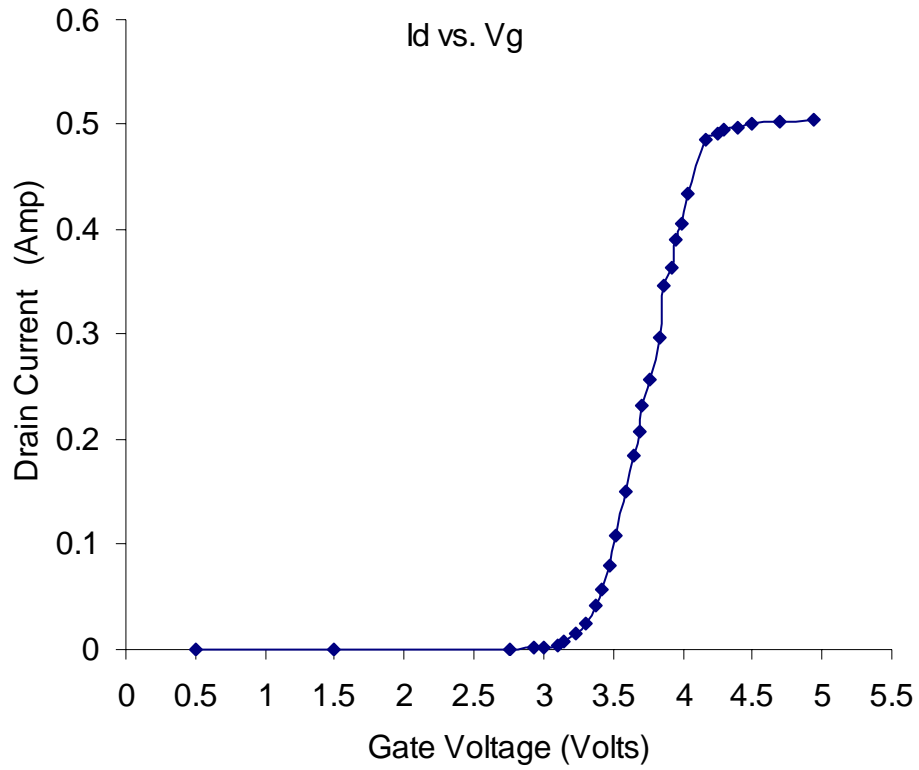


Figure 5 Variation of drain current,  $I_D$ , as the gate voltage,  $V_G$ , is varied, when  $V_{in}=5V$  and  $V_D=5V$ .

**7. LIST OF PARTS**

Table 4 List of Required Components

Part	Value	Unit
Potentiometer	100	k $\Omega$
Static Resistor	10, 5	$\Omega$ , W
MOSFET (IRF530)	Not applicable	Not applicable
Red wire	Not applicable	Not applicable
Green wire	Not applicable	Not applicable
Black wire	Not applicable	Not applicable
Yellow wire	Not applicable	Not applicable
Breadboard	Not applicable	Not applicable

**8. REFERENCES**

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