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FOURTH EDITION

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ELECTRONICS



FOURTH EDITION

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Resistors marked with the color code are available in hundreds of size and wattage rating combinations. Wattage rating refers to the wattage or power consumed by the resistor.

Ohm's Law

A German physicist by the name of Georg Ohm discovered the relationship between voltage, current, and resistance in 1827. He found that in any circuit where the only opposition to the flow of electrons is resistance, there is a relationship between the values of voltage, current, and resistance. The strength or intensity of the current is directly proportional to the voltage and inversely proportional to the resistance.

It is easier to work with Ohm's law when it is expressed in a formula. In the formula, E represents emf, or voltage; I is the current, or the intensity of electron flow; R stands for resistance. The formula is $E = I \times R$. It is used to find the emf (voltage) when the current and the resistance are known.

To find the current, when the voltage and resistance are known, use

$$I = \frac{E}{R}$$

To find the resistance, when the voltage and current are known, use

$$R = \frac{E}{I}$$

Using Ohm's Law

Ohm's law is very useful in electrical and electronics work. You will need it often to determine the missing value. In order to make it easy to remember the formula take a look at Figure 2-7. Here the formulas are arrived at by placing your finger on the unknown and the other two will have their relationship displayed.

The best way to become accustomed to solving problems is to start with something simple, such as:

1. If the voltage is given as 100 V and the resistance is 25 Ω , it is a simple problem and a practical application of Ohm's law to find the current in the circuit. Use

$$I = \frac{E}{R}$$

Substituting the values in the formula,

$$I = \frac{100}{25}$$

means 100 is divided by 25 to produce 4 A for the current.

2. If the current is given as 2 A (you may read it on an ammeter in the circuit), and the voltage (read from the voltmeter) is 100 V, it is easy to find the resistance. Use

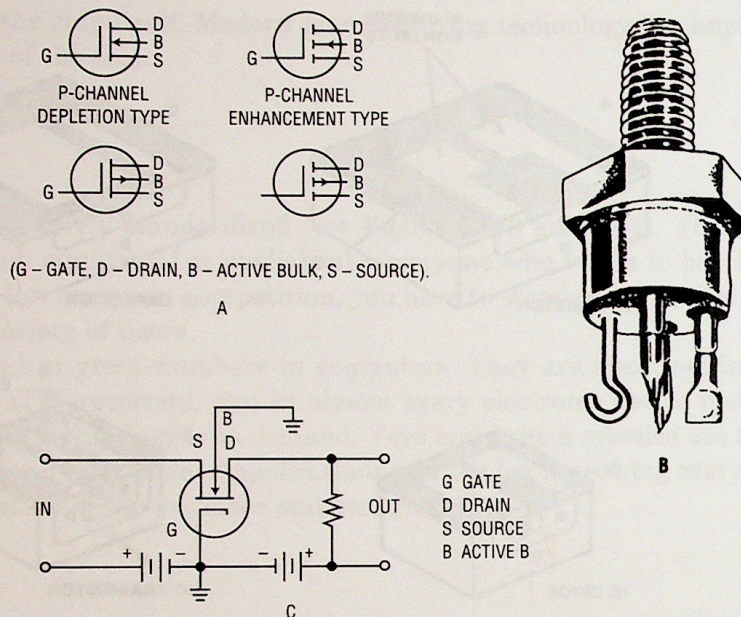


Figure 6-30. A. Symbols for FET transistors. B. MOS (metal-oxide semiconductor) transistor. C. An FET transistor in a circuit configuration.

Integrated Circuits

The integrated circuit (IC) is a single, monolithic chip made of semiconductor material. It was first designed and developed in 1958 a short time after the transistor was introduced and made available for experimentation. J. S. Kilby was responsible for the fabrication of the first IC, or integrated circuit. He was able to make both active and passive circuit elements become part of the chip by using diffusion and deposition techniques. Shortly after his success, Robert Noyce made a complete circuit on a single chip. This led the way to the modern, inexpensive IC.

Transistors, diodes, resistors, and capacitors can now be deposited on a chip. Diodes can be made in many groups to do different things. Photolithography, a combination of photographic and printing techniques, has been used to make the complete circuit. This type of printing has made it possible to produce some very sophisticated ICs with very high reliability.

Figure 6-31 shows how an IC has the resistor, capacitor, diode, and transistor etched on its surface and turned into a complete circuit on a flat surface which can be easily packaged and protected. Figure 6-31A shows how a resistor is placed on the chip. The resistor is made in the form of a thin filament of conductive material. Contacts are made. It is insulated by a reverse-biased junction. It is possible to create a few ohms (Ω) or up to 20,000 Ω on ICs.

Figure 6-31B shows how a low-loss capacitor is formed. This is done by depositing a thin insulating layer of silicon dioxide on a conducting region. It is then given a metallized layer to form the second plate. It is possible to reverse-bias a diode to form a capacitor with up to 50 picofarads (pF) of capacitance. Note how capacitors require more space on the chip than resistors. The transistors and diodes require less space. They are connected

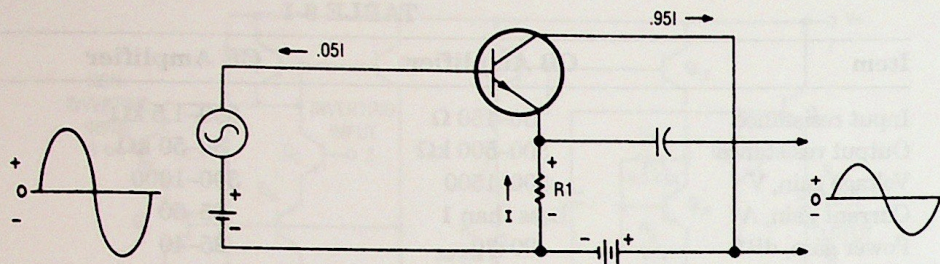


Figure 8-13. Common-collector transistor amplifier with current flow and voltage waveforms.

Common Base

Note the connections made to the base, emitter, and collector of the transistor in Figure 8-11. Current flow through the NPN transistor is indicated by the arrows. About 95 percent of the emitter current reaches the collector. In practical circuits the flow is 92 to 98 percent. Here we use 95 as a compromise; the remainder (5 percent) flows through the base.

Input and output waveforms represent the voltage of the signal. Input signal from the generator is applied in series with the bias (battery) between the base and emitter. The output signal appears across the collector load resistor R_1 . The output signal has the same shape and phase as the input except that it is amplified.

Common Emitter

The common-emitter circuit is shown in Figure 8-12. Again, the arrows indicate the current flow and its direction. The input signal of the common-emitter amplifier is 180° out of phase with the output signal that appears across R_1 .

Common Collector

The common-collector circuit is shown in Figure 8-13. This is a particularly useful type of circuit when it comes to impedance matching. It does not amplify, but acts as an impedance-matching device. Note that the signal is not reversed but is the same phase as the input. This can be visualized easily if you note that the output signal is taken from the emitter resistor R_1 .

Table 8-1 will aid you in summarizing the characteristics of the various types of transistor amplifier circuits.

Integrated Circuits

Chips, ICs, integrated circuits all mean the same thing. The integrated circuit is just what its name says: It is a circuit. This circuit can contain the resistances, capacitances, and inductances as well as the transistors and diodes. All this can be contained in a small chip which is so tiny that it is difficult to see with the unaided eye (see Figure 8-14).

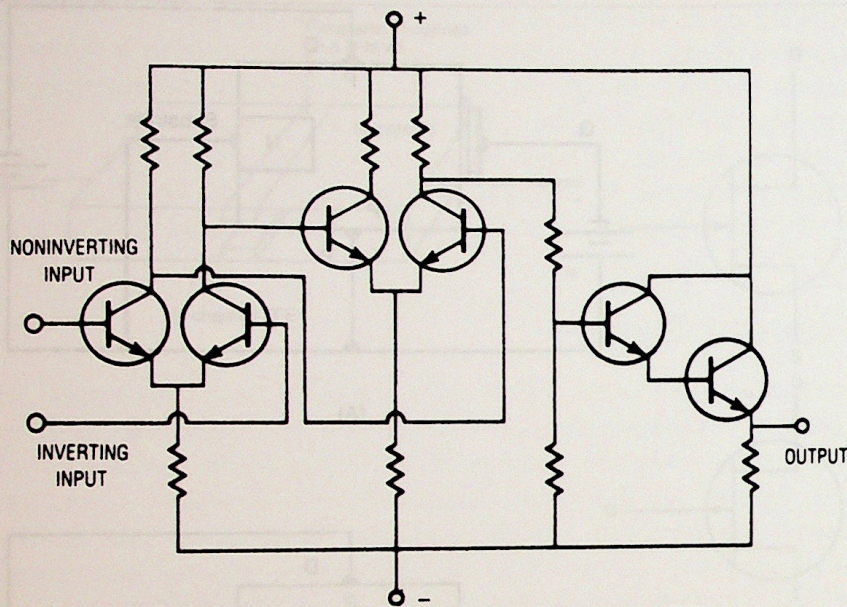


Figure 9-15. Three differential amplifiers connected in cascade.

Field Effect Transistors

The field effect transistor (FET) has high input impedance compared with the low input impedance of the bipolar transistor. The FET operates on low dc supply voltages. This type of transistor is used in many consumer devices inasmuch as it is lightweight, rugged, and very small in size.

The FET has three terminals with slightly different names from those encountered with transistors. It has a gate (G), drain (D), and source (S). The drain could be called the anode and the source called the cathode, with the gate being the current controlling connection (see Figure 9-16).

FETs can be classified as to two major types: junction FET (JFET) and metal oxide semiconductor (MOSFET). Sometimes the MOSFET is also referred to as the insulated gate FET (IGFET). The JFET is further classified according to the type of material that makes up its *channel*. The channel is either P-type or N-type material. However, the MOSFET is classified according to its *mode* of operation — that could be either depletion mode or the enhancement mode. Figure 9-17 shows the schematic for MOSFETs.

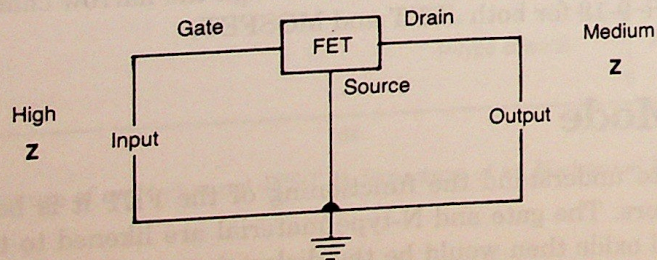


Figure 9-16. Single gate FET circuit configuration.

Chapter 14

RECEIVERS

The other half of the radio frequency (RF) communications consists of a receiver. The transmitted wave is of very little use unless it is received and decoded to present the information, music, or speech as intended. This is where the receiver does its half of the job in a communications system.

Antennas

Antennas have already been mentioned and discussed in transmitters. The reciprocity principle can be applied here since the transmitting antenna can also be used as a receiving antenna. When a transmitted wave passes a receiving antenna, it induces a current in the antenna as a result of electromagnetic induction. This current varies with the frequency of the wave. This weak current can then be amplified and processed to produce the intelligence it contains.

A number of different stages are designed for various purposes in a receiver. It is the intent of this chapter to cover the stages and how they operate to produce the output in the form of speech, music, or other intelligence.

Requirements for receiving antennas are much less severe than those for a transmitter. If you are not using the same antenna that the transmitter used, you can use some rather simple ones for receivers since they use very low signal strengths. Antennas for receivers may include a straight piece of wire, coils of wire, or basic dipoles. They can also be a little more complicated when it comes to bringing in very weak signals from long distances. The parabolic reflector in the form of a receiving dish is used in satellite communications and in home reception of satellite television.

A stacked array, or dish, can become more directional and enable the operation of a receiver on very weak signals (see Figure 14-1). Figure 14-2 is a loop antenna used for simple amplitude modulation (AM) reception on the broadcast band, i.e., 535 to 1605 kilohertz (kHz). A dipole for frequency modulation (FM) enhances reception if the signal is weak or if stereo is to be picked up. A stereo signal requires a stronger signal fed into the amplifier than the mono FM signal. Figure 14-3 shows an FM dipole antenna that aids in bringing in weaker stations. In most instances, point-to-point communications on FM need a stacked array.

Transmission Lines

Getting the signal from the antenna is no problem in most small portable AM receivers or in FM sets that operate on local stations, but the signal from the antenna to the receiver,

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