training chart manual

SECTION L

TRANSISTOR REGULATORS

Delco Remy

Delco Remy

SECTION L

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introduction

The transistor regulator is a completely static unit containing no moving parts. Consisting primarily of resistors, capacitors, diodes, and transistors mounted on a printed circuit panel board, it performs only one function in the charging circuit — to limit the generator voltage to a safe, preset value.

Although resistors and capacitors are not new in the electrical field, the operating principles of the diode and transistor were first discovered in 1948. Since that time, these devices, commonly referred to as semiconductors, have been developed until now they are in widespread usage in many types of equipment manufactured by Delco-Remy.

The transistor regulator performance is superior in many ways to a regulator having vibrating contact points. For example, with no moving parts to wear out, a maintenance-free service life of long duration can be expected. Also, the transistor regulator voltage control is quite stable, since the voltage setting is relatively unaffected by length of service, mounting position, and changes in generator output and speed. By conducting generator field currents higher than vibrating contacts can withstand, the transistor regulator allows generator designs resulting in improved performance.

As a member of the charging circuit team, the transistor regulator limits the generator voltage to the proper value needed to charge the battery and operate the electrical accessories. The primary purpose of this manual is to explain how the regulator performs this voltage limiting function.

transistor regulators

review of fundamentals...

Since the purpose of this manual is to explain "how a transistor regulator works," a brief review of the operating principles of the components used in transistor regulators will be helpful. As explained in the introductory section, the transistor regulator consists primarily of resistors, capacitors, diodes and transistors.

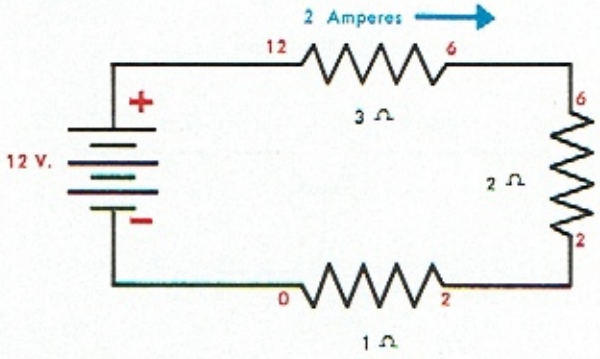
resistor

$$\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

$$\text{or VOLTS} = \text{AMPERES} \times \text{OHMS}$$

$$\text{or OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

A resistor is an electrical device, often of metallic wire or carbon composition, that presents a resistance or opposition to the flow of electric current. The resistance is measured in ohms. When current passes through a resistor, a voltage drop appears across the resistor. This is a statement of Ohm's Law, which can be written as shown. Ohm's Law applies to an entire circuit, or to any part of a circuit.

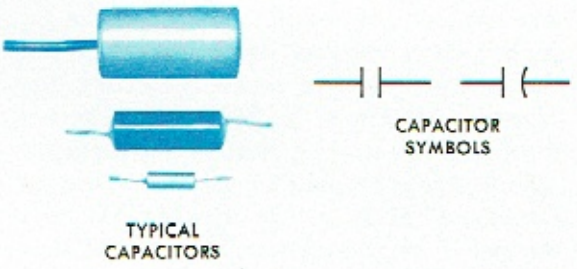


When three resistors are connected to a battery as shown, the total circuit resistance is six ohms. Applying Ohm's Law to the entire circuit, the current flow through each resistor is two amperes. Applying Ohm's Law to the one-ohm resistor, the voltage drop across the resistor is two volts. The voltage potentials across this resistor and the other resistors are shown. Note that the current flows through the external circuit from the battery positive (+) post to the battery negative (−) post. This is the conventional direction of current flow.

For the forthcoming discussion on the internal circuit of a transistor regulator, there are two important things to remember about a resistor:

1. A resistor will limit current flow according to Ohm's Law.
2. A voltage drop occurs across each resistor in a circuit according to Ohm's Law, and the voltage drops establish the voltage potentials on each side of the resistors.

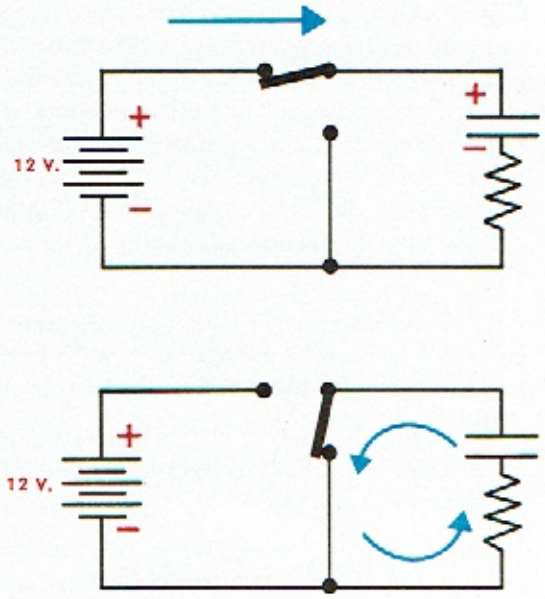
capacitor



A capacitor, sometimes called a condenser, is a device in which electricity is stored. A capacitor consists of two metallic conductors separated by an insulating material. This often takes the form of thin metallic foil separated by thin paper; the foil and paper are then rolled into a cylindrical shape for compactness.

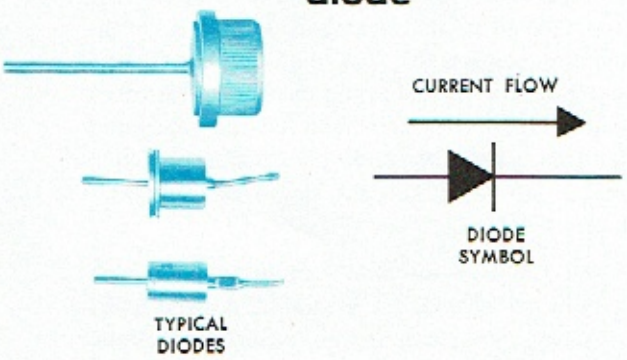
Since the two metallic conductors of a capacitor are electrically insulated, current flows in a capacitive circuit only when the voltage

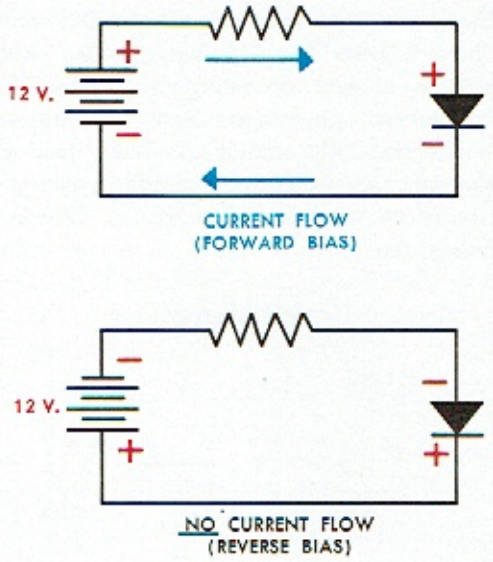
across the capacitor is changing. In the transistor regulator circuit, it will be seen that there are voltages which are changing from one value to another.



To illustrate the operation of a capacitor, consider a circuit consisting of a capacitor, a resistor, and a switch connected to a battery. When the switch is closed to the battery, the voltage across the capacitor will increase from zero to 12, and a current will flow in the circuit causing the capacitor to be charged. The positive and negative charges on the capacitor plates represent stored energy. When the capacitor voltage reaches 12 volts, the current flow will stop. When the switch is thrown to the shorting position, the capacitor will discharge through the resistor. When all the stored energy in the capacitor has been dissipated by the resistor, the current flow will stop.

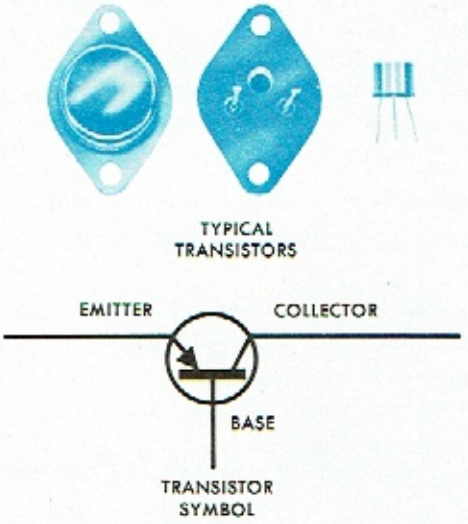
diode



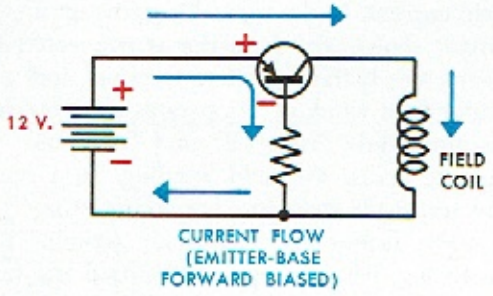


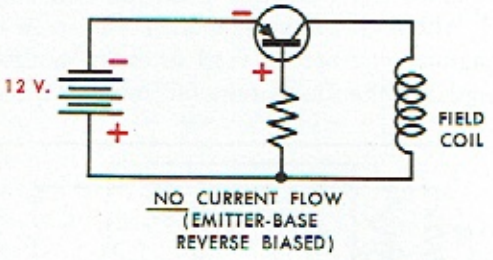
The diode is a semiconductor that will allow current to flow through itself in one direction only. When a battery is connected to a diode with the polarities as shown, called "forward bias," the diode offers only a very small resistance to the flow of current. When the battery polarity is reversed, called "reverse bias," the diode resistance is very high and no appreciable current will flow. (One exception to this is a zener diode, which is a special design of diode that will allow current to flow when reverse biased.)

transistor



The transistor is a semiconductor that consists of two diodes "back to back," or two diodes sharing a common base material. In the symbol shown, the emitter-base junction represents one diode, and the collector-base junction the second diode. Current flows through the emitter in the direction of the arrow; hence the positive side of a battery is connected to the emitter, and the negative side to the base and collector, as shown. The symbol shown represents a PNP transistor.





In the first illustration, the emitter-base is forward biased by the battery, and the entire transistor has very low resistance. Current will flow through the circuit as shown.

If the battery is connected to the emitter-base in the reverse direction, the transistor has a very high resistance, and no current at all will flow through the transistor.

The important thing to observe about the transistor is that the voltage across the field coil, as illustrated, can be "turned on" and "turned off" by reversing the voltage bias across the emitter-base. The transistor thus can be made to behave like a relay, or a closed or open switch.

summary

Although our review has been limited and rather brief, it will serve as a useful background for the discussion on the internal regulator circuit covered in the next section. For more detailed information on components used in transistor regulators, and on the battery and generator, refer to the following Delco-Remy Training Chart Manuals:

DR-5133A — Fundamentals of Electricity and Magnetism

DR-5133B — Storage Batteries

DR-5133J — Fundamentals of Semiconductors

DR-5133K — Fundamentals of Delcotron Generators

transistor regulator operating principles