Circuit Protection Devices

An Online Continuing Education Course for Engineers

Course Number: E-2018

Credit: 2 Hours / 2 PDH / 2 CPD

CIRCUIT PROTECTION DEVICES

LEARNING OBJECTIVES

Upon completion of this course you will be able to:

1. State the reasons circuit protection is needed and three conditions requiring circuit protection.

2. Define a direct short, an excessive current condition, and an excessive heat condition.

3. State the way in which circuit protection devices are connected in a circuit.

4. Identify two types of circuit protection devices and label the schematic symbols for each type.

5. Identify a plug-type and a cartridge-type fuse (open and not open) from illustrations.

6. List the three characteristics by which fuses are rated and state the meaning of each rating. Identify a plug-type and a cartridge-type fuse (open and not open) from illustrations.

7. List the three categories of time delay rating for fuses and state a use for each type of time-delay rated fuse.

8. List the three categories of time delay rating for fuses and state a use for each type of time-delay rated fuse. Identify fuses as to voltage, current, and time delay ratings based on markings. List the three categories of time delay rating for fuses and state a use for each type of time-delay rated fuse.

9. Identify a clip-type and a post-type fuse holder from illustrations and identify the connections used on a post-type fuse holder for power source and load connections.

10. List the methods of checking for an open fuse, the items to check when replacing a fuse, the safety precautions to be observed when checking and replacing fuses, and the conditions to be checked for when conducting preventive maintenance on fuses.

11. Select a proper replacement and substitute fuse from a listing of fuses.

12. List the five main components of a circuit breaker and the three types of circuit breaker trip elements.

13. Describe the way in which each type of trip element reacts to excessive current.

14. Define the circuit breaker terms trip-free and nontrip-free and state one example for the use of each of these types of circuit breakers.

15. List the three time delay ratings of circuit breakers.

16. Define selective tripping, state why it is used, and state the way in which the time delay ratings of circuit breakers are used to design a selective tripping system.

17. Identify the factors used in selecting circuit breakers.

18. List the steps to follow before starting work on a circuit breaker and the items to be checked when maintaining circuit breakers.

CIRCUIT PROTECTION DEVICES

Electricity, like fire, can be either helpful or harmful to those who use it. A fire can keep people warm and comfortable when it is confined in a campfire or a furnace. It can be dangerous and destructive if it is on the loose and uncontrolled in the woods or in a building. Electricity can provide people with the light to read by or, in a blinding flash, destroy their eyesight. It can help save people's lives, or it can kill them. While we take advantage of the tremendous benefits electricity can provide, we must be careful to protect the people and systems that use it.

It is necessary then, that the mighty force of electricity be kept under control at all times. If for some reason it should get out of control, there must be a method of protecting people and equipment. Devices have been developed to protect people and electrical circuits from currents and voltages outside their normal operating ranges. Some examples of these devices are discussed in this course.

While you study this course, it should be kept in mind that a circuit protection device is used to keep an undesirably large current, voltage, or power surge out of a given part of an electrical circuit.

INTRODUCTION

An electrical unit is built with great care to ensure that each separate electrical circuit is fully insulated from all the others. This is done so that the current in a circuit will follow its intended path. Once the unit is placed into service, however, many things can happen to alter the original circuitry. Some of the changes can cause serious problems if they are not detected and corrected. While circuit protection devices cannot correct an abnormal current condition, they can indicate that an abnormal condition exists and protect personnel and circuits from that condition. In this course, you will learn what circuit conditions require protection devices and the types of protection devices used.

CIRCUIT CONDITIONS REQUIRING PROTECTION DEVICES

As has been mentioned, many things can happen to electrical and electronic circuits after they are in use. Some of the changes in circuits can cause conditions that are dangerous to the circuit itself or to people living or working near the circuits. These potentially dangerous conditions require circuit protection. The conditions that require circuit protection are direct shorts, excessive current, and excessive heat.

Direct Short

One of the most serious troubles that can occur in a circuit is a DIRECT SHORT. Another term used to describe this condition is a SHORT CIRCUIT. The two terms mean the same thing and, in this course, the term direct short will be used. This term is used to describe a situation in which some point in the circuit, where full system voltage is present, comes in direct contact with the ground or return side of the circuit. This establishes a path for current flow that contains only the very small resistance present in the wires carrying the current.

According to Ohm's law, if the resistance in a circuit is extremely small, the current will be extremely large. Therefore, when a direct short occurs, there will be a very large current through the wires. Suppose, for instance, that the two leads from a battery to a motor came in contact with each other. If the leads were bare at the point of contact, there would be a direct short. The motor would stop running because all the current would be flowing through the short and none through the motor. The battery would become discharged quickly (perhaps ruined) and there could be the danger of fire or explosion.

The battery cables in our example would be large wires capable of carrying heavy currents. Most wires used in electrical circuits are smaller and their current carrying capacity is limited. The size of wire used in any given circuit is determined by space considerations, cost factors, and the amount of current the wire is expected to carry under normal operating conditions. Any current flow greatly in excess of normal, such as there would be in the case of a direct short, would cause a rapid generation of heat in the wire.

If the excessive current flow caused by the direct short is left unchecked, the heat in the wire will continue to increase until some portion of the circuit burns. Perhaps a portion of the wire will melt and open the circuit so that nothing is damaged other than the wire involved. The probability exists, however, that much greater damage will result. The heat in the wire can char and burn the insulation of the wire and that of other wires bundled with it, which can cause more shorts. If a fuel or oil leak is near any of the hot wires, a disastrous fire might be started.

Excessive Current

It is possible for the circuit current to increase without a direct short. If a resistor, capacitor, or inductor changes value, the total circuit impedance will also change in value. If a resistor decreases in ohmic value, the total circuit resistance decreases. If a capacitor has a dielectric leakage, the capacitive reactance decreases. If an inductor has a partial short of its winding, inductive reactance decreases. Any of these conditions will cause an increase in circuit current. Since the circuit wiring and components are designed to withstand normal circuit current, an increase in current would cause overheating (just as in the case of a direct short). Therefore, excessive current without a direct short will cause the same problems as a direct short.

Excessive Heat

As you have read, most of the problems associated with a direct short or excessive current concern the heat generated by the higher current. The damage to circuit components, the possibility of fire, and the possibility of hazardous fumes being given off from electrical components are consequences of excessive heat. It is possible for excessive heat to occur without a direct short or excessive current. If the bearings on a motor or generator were to fail, the motor or generator would overheat. If the temperature around an electrical or electronic circuit were to rise (through failure of a cooling system for example), excessive heat would be a problem. No matter what the cause, if excessive heat is present in a circuit, the possibility of damage, fire, and hazardous fumes exists.

CIRCUIT PROTECTION DEVICES

All of the conditions mentioned are potentially dangerous and require the use of circuit protection devices. Circuit protection devices are used to stop current flow or open the circuit. To do this, a circuit protection device must ALWAYS be connected in series with the circuit it is protecting. If the protection device is connected in parallel, current will simply flow around the protection device and continue in the circuit.

A circuit protection device operates by opening and interrupting current to the circuit. The opening of a protection device shows that something is wrong in the circuit and should be corrected before the current is restored. When a problem exists and the protection device opens, the device should isolate the faulty circuit from the other unaffected circuits, and should respond in time to protect unaffected components in the faulty circuit. The protection device should NOT open during normal circuit operation.

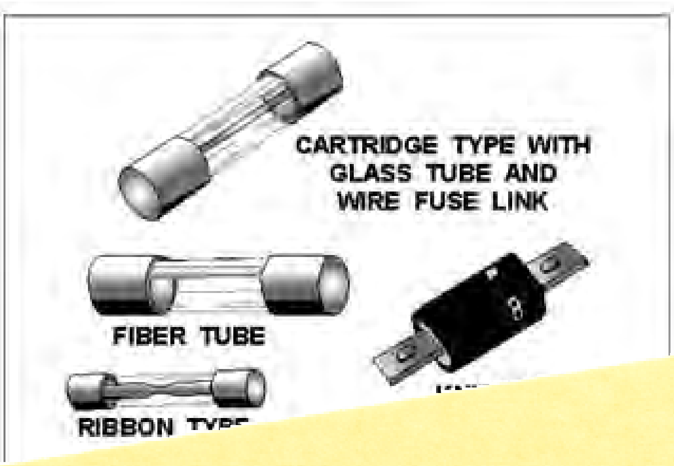
The two types of circuit protection devices discussed in this course are fuses and circuit breakers.

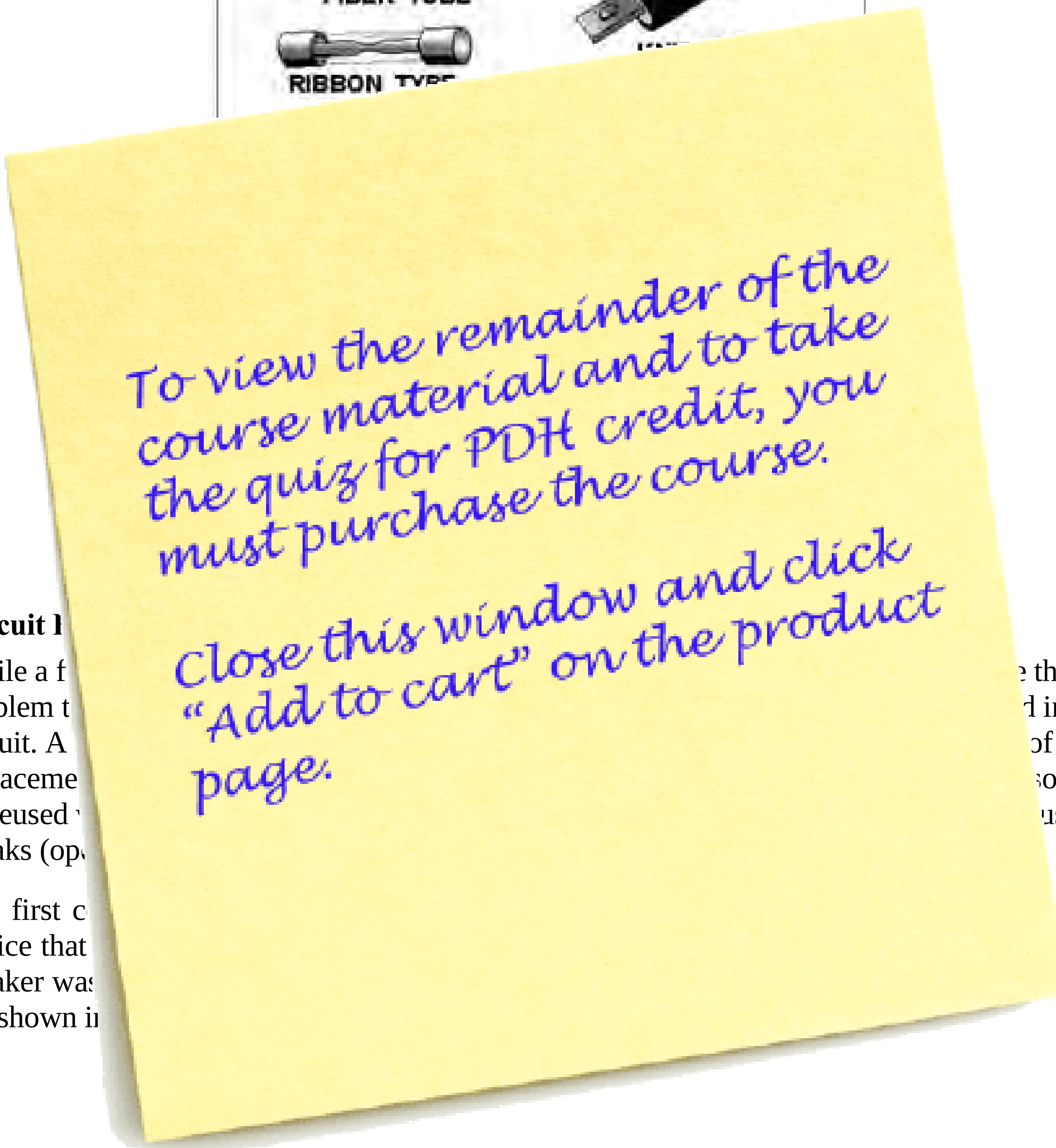
Fuses

A fuse is the simplest circuit protection device. It derives its name from the Latin word "fusus," meaning "to melt." Fuses have been used almost from the beginning of the use of electricity. The earliest type of fuse was simply a bare wire between two connections. The wire was smaller than the conductor it was protecting and, therefore, would melt before the conductor it was protecting was harmed. Some "copper fuse link" types are still in use, but most fuses no longer use copper as the fuse element (the part of the fuse that melts). After changing from copper to other metals, tubes or enclosures were developed to hold the melting metal. The enclosed fuse made possible the addition of filler material, which helps to contain the arc that occurs when the element melts.

For many low power uses, the finer material is not required. A simple glass tube is used. The use of a glass tube gives the added advantage of being able to see when a fuse is open. Fuses of this type are commonly found in automobile lighting circuits.

Figure 1 shows several fuses and the symbols used on schematics.





Circuit

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