Electricity 電力

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Introduction

Possessing a basic knowledge of electricity may not seem essential to doing electrical work, especially if you are using a "how-to" book with simple step-by-step instructions. However, nothing could be farther from the truth. Not every step in a process may be obvious, and very often knowing the basic theory behind a practice may enable you to figure out how to do something you have never done before. The purpose of this chapter is to give you a basic understanding of electricity—what it is, how it is provided, how It works, and how you can work with It safely.

- Knowing a little bit about basic theory may help you figure out what the problem is.

Electricity Defined

Electricity is nothing more than an organized flow of electrons and protons behaving in response to *the* attraction of oppositely charged particles and the repulsion of like-charged particles. If you can get enough electrons to break free of their orbits and start flowing in one direction or another, you have flow of currents. This current, or power. Is defined as electricity. The device that frees the electrons from their orbit is called a power generator. To create vast amounts of electrical power, large generators must be turned on a massive scale. (How Electricity is provided," page 12.)

- *Electricity powers many of our electrical devices and is term for a flow of electrons.*
- *In our homes this flow oscillates back and forth which is properly called alternating current or AC. Think of AC like the waves that moving up and down on the side of the pier.*
- *The other form which is found in our computers, flashlights, and devices that are powered by batteries is known as Direct Current or DC. This current only flows one way unlike AC.*
- *For electricity, the power is in the movement of electrons that turn our electric motors or heats up our coffee.*

Terminology of Electricity

As with most subjects, electricity has its own vocabulary. For this book, however, it is important to know the meaning of only four key terms: ampere (amperage), volt (voltage), watt (wattage), and olms (resistance). By master. these terms. you will better understand electricity

- Depending on how technical we wish to dive into. The basic or common terms used for electricity you may already be familiar with.
- Volts, Amperes, and Watts.   Your flashlight batteries may be marked as 1.5 V or Volts and that is Volts DC. Where as your coffee maker will be marked with 120 V AC. Your hair dryer will also be labeled with 120 V AC but it may also way 1200 W or Watts.   It may or may not indicate Amperes.
- Watts is a measure of power.   It is obtained by multiplying Volts x Amperes. If the hair dryer uses 1200 Watts, on 120 VAC line, then it will require 10 amperes of current.
- The analogy of volts and amperes is often illustrated in terms of water supply, where volts is equivalent to water pressure. Amperes is the amount of water flowing. A large pipe can flow more water than a small pipe. Similarly, a large wire can carry more electrons or amperes than a small wire.
- There is another unit of electricity called olms, which represents resistance. Like the water analogy, a small pipe will offer more resistance to water than a large pipe. Where resistance is commonly used is in producing heat such as coffee maker has a heating element or an electric blanket will have specially made wires embedded that will heat up. A common safety concern is when wires heat up under high current load which can cause fires.

Ampere:

An ampere, or *amp,* measures the rate, or quantity. of electrical flow. A typical contemporary home, for example, might have an electrical system of 150 to 200 amps.

Amperage

Amperage, in contrast, Is the actual measure of current flowing in a circuit to an appliance- Although this can be· measured only when the circuit Is turned on, the rating of an electric appliance. in volts and amperes, or volts and watts, Is required by the National Electrical Code (Section 422.60) to be marked on the identifying name plate of the appliance. Amperes are designated by the letter A.

Ampacity

Ampacity Is the amount of *current* in amperes a wire can safely conduct. Determining the correct ampacity of a wire is important because using on incorrect wire can create a fire hazard. Each wire carries a limited amount of current before it will heat to the point of damaging its insulation. For example, a 14 gauge wire can take a maximum current of 15 amps, a 12 gauge wire 20 amps, and so on, If a wire Is too small for a job, generated heat can destroy its insulation, causing a fire. Amperage rating, are also important when, buy fuses or circuit breakers. Amperage of fuses or breakers, circuits, and appliances must match. Too little fuse or circuit breaker amperage will cause the protection devices to blow or trip. Too much will permit a dangerous amount of over current or flow, which occurs when too many appliances are used on the same circuit or during a power surge. The result is overheating of the circuit, which will create a potential for fire.

Volt

Volt: A volt measures the pressure exerted by electrical power. Voltage is the moving (electromotive) force that causes current to flow in an electrical circuit. A generator creates the pressure that keeps the electrical current flowing through conductors, known as wires.

Voltage

Voltage, designated by the letter V. pushes a current that alternates between positive and negative values. This is known as an *alternating current* (AC). It periodically reverses, or alternates, direction in cycles, called *Hertz*. One cycle takes second to complete. This is usually expressed as a rate of 60 cycles per second. The average voltage on this cycle is measured at 120 volts on the return or neutral wire and 240 volts across both of the hot utility wires entering a home.

Contemporary three wire residential wiring carries both 120. and 240.volt power. Large appliances like air conditioners, electric ranges, and clothes dryers typically use 240-voit wiring. *Electrical devices must* be labeled with their operating voltage level. This means that the product has been designed to operate at the listed voltage only. Do not, for example. hook up an electrical device rate, at 125 volts to a circuit that supplies 220 to 240 volts. You'll bum it out.

Watt,

Wattage: In practical terms, *watts* is the amount of energy used to run a particular appliance. The wattage rating of a circuit is the amount of power the circuit can deliver safely, which is determined by the current carrying capacity of the wires or cables. Wattage also indicates the amount of power a fixture or appliance needs to work properly.

How electricity is provided

- Note… Not sure how important this is to the students.

Generation

- Our electricity is generated from a number of sources. Generally, it is from gas fired electrical generating stations. Typical gas heat generates steam that drives turbines connected to electric generators.

- There is continuing investment in solar power and wind power however these are not consistent nor produce 24 hours a day. Although farther away from Southern California, there is hydroelectric plants near dams like Hoover Dam.

Transmission

- From the generation stations, the electricity is boosted to very high voltages and sent on transmission lines to the cities, then stepped down until it arrives as our homes.
- There are terminologies for the various devices that connect our wall outlet to the power lines.
- High tension lines … tall towers seen around Irvine, where the voltages are in the 400,000 volts go to substations, often well hidden from sight.
- These are series of step down transformers that will feed underground power lines thru our neighborhood.
- Irvine utilities phone, internet, electricity, water, and gas are buried underground.
    - Utility companies have underground step down transformers in our neighborhoods that will step the voltage from higher voltage . 480 vac to 220 vac.
    - 220vac enters our home thru underground line, that is directed to our home thru an electric meter then to our service panel.
    - Service panel contains main circuit breaker and followed by a set of smaller circuit breakers, which protect our house wiring from over load.

Generation

Utility companies generate electricity in a variety of ways. One of the most common methods uses the energy of running water to power a generator. Electrical power created in this way is termed hydroelectricity. To harness the energy of the flowing water on a scale this enormous, a dam may be built across a narrow gorge in a river or at the head of a man-made lake. Water backed up behind this dam, in what is called the fore-bay, is then allowed to flow through a submerged passage or penstock, in a controlled release. The massive force of this elevated water spins the generator's giant turbines as it falls, producing electricity. Electrical power produced in this way is called A C power or alternating current.

Transmission

Once a utility company produces electricity, it must then transmit it through a distribution system for use by its customers. For ease of transmission, the electrical power is raised to many thousands of volts and conducted over high voltage transmission lines to the utility company's regional switching stations. At the regional stations, the utility company steps down the power to a lower voltage for transmission to local substations. The utility company continues this procedure until the power reaches your home. A typical transmission starts at 230,000 volts. Is stepped down to 69,000 volts at a switching station, then is stepped down further at a substation to 13,800 volts. Once at your home, that is reduced to 240 volts.

Point of Use

To be stepped down, the electricity that arrives at your home must first pass through a utility transformer.

It then leaves this transformer via three terminals, mounted on its side, which are connected to three wires. These wires constitute the service drop that leads to your house service entrance. They include two insulated hot wires, or legs, and a grounded neutral. The two hot wires can each provide 120 volts or supply 240 volts of power between the two hot legs. The neutral conductor is usually bare on overhead and insulated in the underground service laterals. A glass-domed meter is connected to the two hot wires leading from the utility transformer. This meter is provided by your utility company to measure the amount of electrical energy in kilowatt hours consumed by your household. This is the rate of energy consumption in kilowatts multiplied by usage in hours.

Service-Entrance Panel

The wires from the electric meter continue on to the service entrance panel. The panel contains circuit breakers or in older homes, fuses and controls the flow of power to individual circuits within your home. These circuits may be 120 volt, 240 volt, or both (120/240 volt). At any given moment, electricity is exiting from one terminal on the utility transformer and returning by the other. Current flows from one terminal, travels through the service drop to the house, and then down the service entrance conduit or cable into the meter base.

From here it flows through the meter into the main panel and is then distributed to each of the circuits within your home. The current returns to the panel via another insulated wire, traveling back to the transformer. The final result is that you never actually "consume" electricity, you just borrow it (although you transform much of its energy, which is what you paid for).

What runs on 220 VAC?

- *Central AC units*
- *Electric ranges*
- *Built in electric ovens*
- *Electric clothes dryers*

If you wish to check your wall outlet for power, a simple Neon circuit tester is handy. It's a neon bulb that glows when power is applied to it. If there is no electricity in the outlet, the bulb will not glow.

Testing Circuits

Neon Circuit Tester

Use the two probes circuit tester to check for live voltage in a circuit. The neon bulb will light if the circuit is live. You can also use the tester to verify that the power to a circuit has been turned off before you work on it.

Receptacle Analyzer

Use a receptacle analyzer to identify faults in receptacle wiring: simply plug the device into the outlet being tested; then read the lighting pattern made by the three bulbs on the analyzer. Different combinations of lighted and unlighted bulbs indicate specific problems with the wiring, such as hot and neutral wires connected in reverse.

Multi-tester

An analog or digital multi-tester or multimeter, is required to measure voltage and current. as well as to make continuity and resistance checks in switches, fixtures, low-voltage transformers and other electrical devices.

Continuity Tester

A continuity tester is powered by its own battery. which is used to generate an electrical current through an attached wire and damp It must only be used when the power to a circuit is turned off. The tester is especially useful for determining whether or not a cartridge fuse has blown. You can test this type of fuse by touching the tester clamp and probe to the opposite end caps of the fuse. A lighted bulb indicates a working fuse. an unlighted bulb means that the fuse has blown and is in need of replacement. The tester can also be used to detect faults and current interruptions in switches and other types of electrical equipment.

Low Voltage Circuit Tester

A low voltage circuit tester looks similar to a neon circuit tester, but it Is strictly limited In testing circuits less than SO volts such as doorbells, transformers, low voltage lamps. and outlets. etc.

Telephone Line Tester.

Use a telephone line tester to resolve problems with standard telephone wiring. A telephone line tester has a phone jack plug end and an LED on the other. Some testers come with a splitter that enables you to strip as well as test telephone wires. Plugging the tester into a modular lack allows you to test whether any of the circuit wires have been reversed or are loose or disconnected. You can also use a telephone line tester used to check the telephone itself for dial-tone and wiring function.

Circuit Breakers

CIRCUIT BREAKERS have replaced fuses as the preferred type of circuit protection. Technically they are called molded-case circuit breakers. or MCCBs. Circuit breakers use a two part system for protecting circuit wiring. When a small overload is on the circuit, a thermal strip will heat up and *open*, or trip, the circuit. When a massive amount of current comes through *very* quickly, as in a ground fault or short circuit, an electro magnet gives the thermal strip a boost. The greater amount of trip current, the faster the breaker will trip.

The most Important advantage circuit breakers have over fuses is that they can be easily reset; you don't have to buy a new one every time an appliance draws excessive current. When a breaker is tripped, it won't work unless <u>you throw it all the way to the off position before you *turn* it back on again</u>. Another characteristic of circuit breakers is that they are air-ambient compensated: the hotter the air around them gets, the sooner they will trip. For example. if all the circuit breakers around *a* specific 20 amp breaker *are* running hot, because of an excessive flow of current, the 20 amp *breaker* may trip at *only* 15 amps.

Residential circuit breakers typically range in size 15 to 60 amps, increasing at intervals of 5 amps. Single pole breakers rated for 15 to 20 amps control most 120 volt general purpose circuits. Double pole breakers rated for 20 to 60 amps control 240 volt circuits.

Standard circuit breakers are universal and have clips on the bottom that snap onto the hot bus tabs in the panel box. Contact the hot bus brings power into the breaker. Be aware. however that some manufacturers make breakers with wire clips that mount on the side. These clips slide over the tab on the hot bus, requiring you to remove one or more of the other breakers to get at the one you want.

Common Breaker Types

In addition to single and double pole breakers, quad breakers, GFCI breakers, and surge-protection devices are also available. Single-pole breakers supply power to 120v loads such as receptacle and light circuits. A hot black or red wire is usually connected to the breaker. Single pole breakers come full size or in a two in one configuration (twin). *The* latter type will fit Into a panel having a split tab hot bus.

Double-pole breakers

Double-pole breakers provide power to 240volt appliance such as electric water heaters and dryers. If a standard NM cable is used as the conductors, both the black and the white wires are connected to the breaker. The white wire must be marked with black tape at both ends. Larger double pole circuits have two black conductors in the circuit.

Specialty Breakers

A quad breaker falls within the half-size breaker family *and* can contain several configurations within one unit. It tray, for example. contain two double-pole circuits, such as a double-pole 30 amp and a double-pole 20-amp circuit. It may have two single-pole breaker and one double pole; or it may provide power to some other combination of circuits. The advantage of a quad breaker is that it takes up half the space of standard breaker. The panel, though, must be specially *designed* to accept quad breakers.

A GFCI circuit breaker fits Into the main panel Just lite a standard circuit breaker. On its face is a test button but no reset. If properly Installed, pressing the test button places a deliberate, preset current imbalance (6 milliamperes) on the line to verify that the breaker will trip when there is an unintended imbalance. When tripped, the breaker arm will go to a halfway off position, cutting power to the circuit.

Arc-fault circuit interrupter (AFCI) breakers are required on branch circuits that supply power to bedrooms. These devices look like CFCI breakers. Their purpose is to detect an arcing situation, such as loose or corroded connections or damaged insulation on a wire, and then shut down the current on the circuit before the heat generated by the arc causes a fire.

At first glance, a surge-protection device can be confusing. You will see a device that looks like a double-pole body. This type of device also has two lights that glow when power is applied to the panel. Never the less, a surge-protection device connects to the buses in the same as any other circuit breaker.

Limits

Circuit breakers are limited in protecting wires, and therefore life and property. Breakers other than CFCI cannot prevent electric shock, for instance. Although breakers trip at 15 amps and above, it only takes about 0.06 amp to electrocute someone. Circuit breakers cannot prevent over heating of a fixture or appliance or other device and they can't prevent low-level faults. For a breaker to trip, a fault must occur when enough current is being demanded to exceed the trip current of the breaker. Breakers cannot trip fast enough to completely block lightning surges from entering the house circuits. They cannot prevent fires within appliances. Circuit breakers are meant to save the wiring to the appliance – not the appliance itself.

Appliance Receptacles

Other types of receptacles have slot configurations that limit their use to specific appliances or groups of appliances. For example, the hot slot on a large 20-amp appliance or tool receptacle is T-shaped, while the hot and neutral slots on an air-conditioner receptacle are horizontal instead of vertical. Appliances that draw high currents, like electric clothes dryers and electric ranges, use a single dedicated receptacle. Each type has a slot configuration designated only for the particular appliance being powered. The amperage and voltage are clearly marked on the receptacle, along with the number assigned by the National Electrical Manufacturers Association (NEMA) and the listing mark of the Underwriters Laboratories (UL). The NEMA code ensures that you are buying the correct receptacle for the appliance, and the UL listing label indicates that the receptacle has passed rigorous testing standards.

Isolated-Ground and GFCI Receptacles

An isolated-ground receptacle is a specialized, orange-colored device. It has an insulated grounding screw and is primarily used to protect sensitive electronic equipment, like computers, from disruptive or damaging electrical power surges. A GFCI (ground-fault circuit-interrupter) receptacle is a special duplex receptacle that protects you from a fatal electrical shock. When incoming and returning current are unequal, the GFCI cuts off the circuit in a fraction of a second, before you can feel a shock. This type of receptacle is required by code in wet locations, such as bathrooms, kitchens, basements, garages, and outdoors.

SWITCHES

Types and Designations

A switch controls the flow of power in an electrical circuit. When a switch is on, electricity flows through the circuit from its source to the point of use. The standard switch used in residential work is the toggle switch, sometimes called a snap switch. Other types include dimmer, pilot-light, timer, and electronic switches. Switches are further categorized by quality and usage. The standard, or construction grade switch is rated for 15 amps and is the grade and type most commonly found in homes.

Toggle Switches

Toggle switches have evolved over time. Now you can perform many functions throughout a home with them.

- **Single Pole:** A standard, single-pole toggle switch turns a light on from only one location. A single-pole switch has two terminal screws. Only this one switch can control the circuit. The hot wire connects to one terminal, and the outgoing wire to the other.
- **Three Way, Four Way:** But switches may also control a circuit from two (three-way switch) or three (four-way switch) locations. A three-way switch has three terminals. One is marked com or “common”; the hot wire connects to this terminal. The other terminals are switch leads. A four-way switch has four terminals.
- **Double Pole:** A similar-looking switch, the double-pole switch, is used to control 240-volt appliances and is differentiated from the four-way switch by the on and off markings on the toggle.

Dimmer Switches

A dimmer switch is used to control the brightness, or intensity, of light emitted from a light fixture by increasing or decreasing the flow of electricity to the fixture. Dimmers may have standard toggle switches, rotary dials, sliders, or automatic electronic sensors that respond to the level of ambient light in a room and adjust accordingly. They can be sing-pole or three-way switches.

Reading A Switch

Switches must be marked with labels that represent different ratings and approvals. These labels convey important information about safety and usage. The designation UND LAB-INC List, for example, means the switch has been listed by the Underwriters laboratories, and independent testing agency.

AC ONLY indicates that the switch can only handle alternating current.

CO/ALR specifies that the switch can be connected to either copper or aluminum wires. A switch marked CU can be used only with copper and not with aluminum wires. The amp and voltage ratings are given by designations like 15A-120V which means the switch is approved for use with circuits that carry 15 amps of current at 120 volts.

Pilot-light Switches

Pilot-light switches are usually found on appliances but are especially useful for controlling remote fixtures, like porch, attic, basement, and garage lights, because they can let you know whether or not a light is on or off. When a fixture or appliance is turned on, the pilot light is illuminated.

Timer Switches

Timer switches come in two varieties: clock and time delay. A clock-timer can be set to turn on a fixture or other device at a preset time of day. An example would be a thermostat set to turn down the heat during the day when no one is home. Another example would be a switch that turns on security lights in your home after dark or when you are away on vacation. This type of switch can also be used to operate a lawn-sprinkler system. In contrast, a time delay switch is designed to allow a fixture or appliance to operate for a set period of time and then shut off. An example would be a heat lamp or exhaust fan in the bathroom.

Electronic Switches

Electronic switches offer automatic control of lights and other devices. As a matter of safety, they can be overridden by using manual switch levers. An automatic switch allows a user to simply wave a hand in front of the switch to turn it on or off. An infrared beam emitted from the switch detects the movement of the user’s hand and activates the switch.