Practical Exercise for Instruction Pack 5

Contents

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INTRODUCTION

The purpose of this practical exercise is to help you apply your knowledge of motorcycle and ATV electrical systems to some real-life examples. This exercise contains seven suggested activities designed to help you gain a better understanding of the study unit material. Note that these activities are optional and aren't required to complete the program. However, we strongly recommend that you complete as many of the activities as possible.

In the first two activities, you'll learn about wire sizes and the different types of electrical connectors. We'll show you how to use the special tools for measuring wires and connecting wires in a circuit. In the third and fourth activities, you'll make a simple electrical circuit from a wiring diagram and then make voltage and current measurements using a multimeter. The next activity will show you how to use a voltage tester or test light for troubleshooting. Finally, in the last two activities, you'll identify the different types of charging and ignition systems, and practice identifying electrical subsystems and drawing simplified block diagrams.

If you wish to review the text material that covers the topics contained in this practical exercise, you can refer back to the following study units:

- *Electrical Fundamentals* (03301300)
- *Charging and Ignition Systems* (03301400)
- *DC Circuits for Motorcycles and ATVs* (03301500)

When you've finished with the suggested activities, complete the examination at the end of the exercise. The examination is required and must be submitted to the school for grading.

Remember, even though this exercise contains examination questions, we've designed it to be fun! Applying your knowledge will help you to realize just how much you've really learned about motorcycle and ATV electrical systems.

SUGGESTED ACTIVITIES

The following pages contain some activities that relate to the electrical knowledge you've gained from the previous study units. Doing these activities will reinforce the material that you've read by using the electrical tools and test equipment that you'll need to use as a technician. Remember, none of these suggested activities are required to complete the program and none of them will be graded. These activities are simply designed to help you to apply your motorcycle and ATV electrical systems knowledge. When you complete these exercises, proceed to the graded portion of the practical exercise.

Activity 1

In this activity, you'll learn how to determine the size (gauge) of electrical wire. The size of the wire that's installed in a circuit is very important for electrical safety reasons. If a wire is too thin for a particular circuit, it can overheat or melt, causing a short circuit or even a fire. For this reason, the wire that's used in a circuit must be of the proper thickness. If you need to perform electrical repairs on a motorcycle or ATV, you should be knowledgeable of wire sizes.

Insulated wire consists of a conductor, such as copper wire, that's covered with an insulating material such as a plastic coating (Figure 1). In the United States, insulated electrical wires are rated according to the American Wire Gauge (AWG) system. In the AWG system, the diameter or thickness of a wire is identified by a standard gauge number. The smaller the gauge number, the thicker the wire. A few common AWG wire sizes are listed in Table 1. The complete range of wire sizes in the AWG system goes from 0000 gauge (largest) to 36 gauge (smallest). The diameter of 0000 gauge wire is almost ½ inch, while the diameter of 36 gauge wire is only five thousandths (0.005) of an inch. Notice from the table that the larger the wire, the more current it can carry.

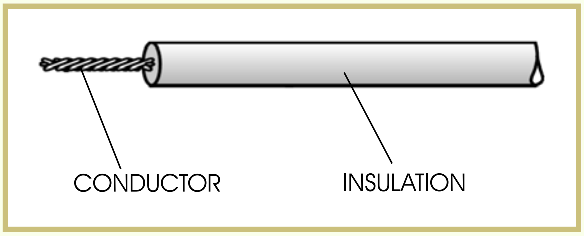


FIGURE 1—An insulated wire contains a conductor surrounded by an insulating jacket of heat- and water-resistant material.

The wire gauge is usually printed on the wire insulation. You can measure the size of a wire using a wire gauge. Wire gauge tools are very inexpensive and are available at hardware stores and electrical supply stores. A wire gauge may be made of metal or plastic.

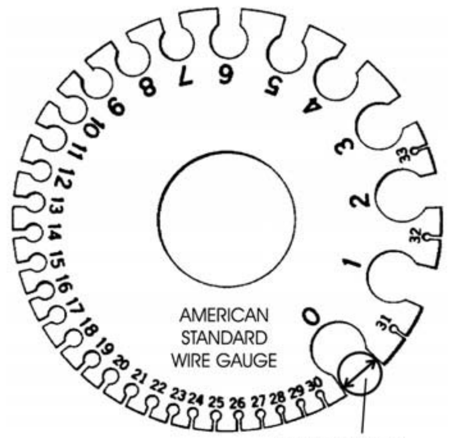
A typical wire gauge is shown in Figure 2. To use the tool, simply insert the wire you want to measure into the slots in the tool until you find the smallest slot that the wire fits into snugly. The number next to the slot is the wire gauge.

Table 1

ELECTRICAL WIRE SIZES

American Wire Gauge	Wire Diameter	Current Capacity
0	0.3249	150 amps
1	0.2893	130 amps
2	0.2576	115 amps
4	0.2043	85 amps
6	0.1620	65 amps
8	0.1285	45 amps
10	0.1019	30 amps
12	0.0808	20 amps
14	0.0640	15 amps
16	0.0508	10 amps

FIGURE 2—Use a wire gauge to measure wire size (diameter). In this illustration, the wire is a 0 gauge which, according to Table 1, has a diameter of approximately ⅓ inch.



Obtain a wire gauge to add to your motorcycle and ATV repair tool supply. Measure several different sizes of wire and compare your result to the wire size printed on the wire insulation.

WARNING

Never use a wire gauge to measure a conductor in a live circuit. Always disconnect the circuit before using the wire gauge.

Activity 2

In order to do simple repairs on a motorcycle or ATV electrical system, you should be able to

- Cut and strip wire
- Splice two wires together
- Attach connectors to the ends of wires

In this activity, we'll look at the methods used to join and repair wires in an electrical system. The tools and parts you'll need to perform these tasks are contained in a wire repair kit. Wire repair kits are inexpensive and can be purchased at most hardware stores, discount stores, or electrical supply stores. The kit should include a wire stripping and crimping tool and several containers of small wire connectors and splices.

You can simply read through the exercise, or, if you wish, purchase a wire repair kit and practice the different techniques described. You'll probably use the kit many times when you begin performing electrical repairs on motorcycles and ATVs.

When you begin to use an electrical repair kit for actual motorcycle repairs, you should purchase one specifically designed for motorcycles. A motorcycle dealer or motorcycle parts supplier will carry electrical high-quality repair kits. An electrical repair kit designed for motorcycles should have double-crimp style connectors that are designed like the original equipment found on a motorcycle.

A close-up view of a wire stripping and crimping tool is shown in Figure 3. This tool has several different features that can be used to repair wire. Let's look at the features shown in the figure from left to right. First, note that the tip of the tool is designed to be used as a pair of pliers. The pliers can be used to pick up or grasp small parts and also to bend wire. Next, moving to the right, you'll see the area of the tool that's used to strip wire and cut wire. The tool has five different stripping holes to fit different wire gauges. The number next to each hole indicates the wire gauge that should be stripped in that hole.

Again, moving to the right, you'll see the bolt-cutting area of the tool. This part of the tool can be used to cut or trim the ends of small fasteners such as screws and bolts. The end of the fastener is inserted into one of the holes in the tool, and the tool handles are then squeezed together to cut off the fastener end.

Finally, between the handles of the tool is the crimping area. The term *crimp* means to pinch or press together in order to form a seal. If you place an object in the crimping area and squeeze the handles of the tool, the object will be pinched tightly. The crimping feature of the tool is used to install connectors on wires.

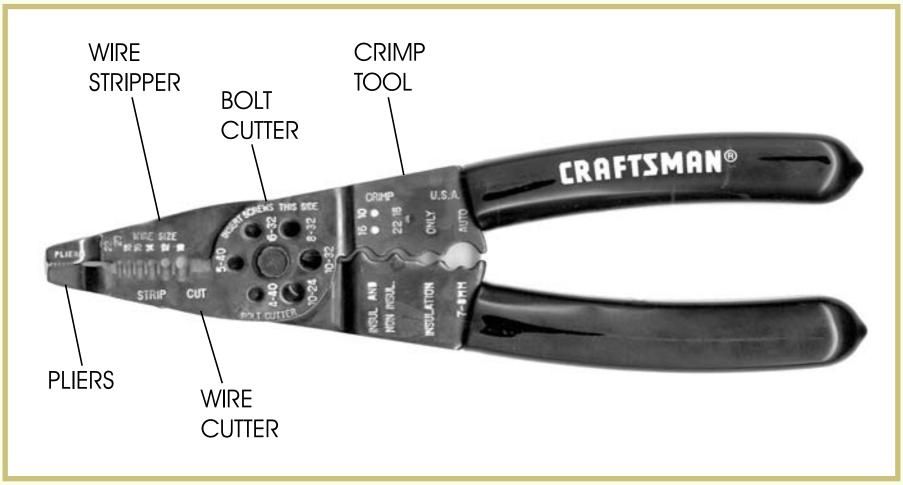


FIGURE 3—This photo shows a typical wire stripping and crimping tool. Note the areas of the tool used for wire stripping, wire cutting, bolt cutting, and terminal crimping. The tip of the tool is designed to be used as a pair of pliers.

Cutting and Stripping Wire

Now that you understand the features of the wire stripping and crimping tool, let's take a closer look at the process used to prepare an insulated wire to be used in a circuit.

The first step is to determine the length of the wire that's needed. You can either measure the length of the wire being replaced, or measure the distance between the components to be connected in the circuit. Be sure to allow a little extra for maneuvering around other components and for the connection at each end of the wire. Then, use the wire cutter portion of the tool to cut the wire to the proper length. Next, you must strip a short length of the plastic insulation off each end of the wire to expose the conductor. To prepare a piece of wire to be connected in a circuit, you would usually strip about ½ inch of insulation from the ends of the wire. To do this, place the wire end between the jaws of the stripping tool in the correct wire-gauge hole. Then, squeeze the tool's handles to clamp the jaws tightly onto the wire. Pull the wire out of the jaws of the tool to remove the insulation from the wire.

Installing Connectors

Next, let's take a look at the connectors that come in the wire repair kit. Figure 4 shows a wire nut, a butt splice, and a terminal end. All of these parts should be included in a typical wire repair kit. The *wire nut* and the *butt splice* are both used to connect the ends of two wires together. The *terminal ends* are attached to wires to provide convenient connectors that can be attached to other electrical devices. Let's take a closer look at each component.

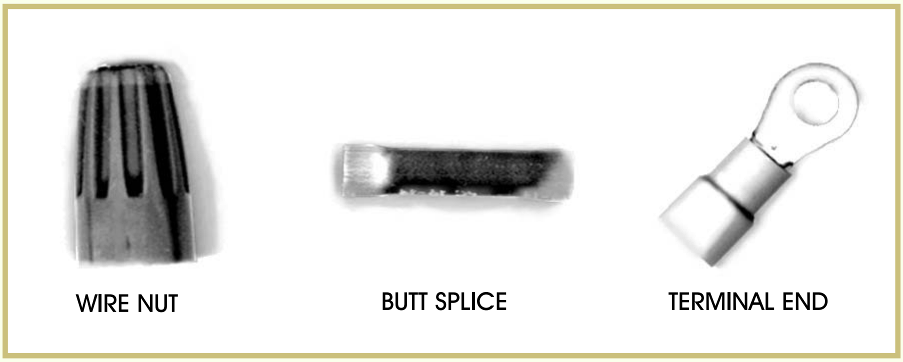


FIGURE 4—Common Types of Wire Connectors

First, let's look at the wire nut. A wire nut is a small device that looks a lot like the cap on a toothpaste tube. On the inside of the wire nut is a threaded metal insert. Wire nuts are used to connect the ends of two wires together and are very simple to install. To connect the ends of two wires with a wire nut, strip the insulation off the two wire ends to expose about ¾ inch of conductor on each wire. Twist the two copper wire ends together about two or three twists. Next, hold the two wire ends in one hand and hold the wire nut in your other hand. Insert the wire ends into the wire nut, and screw the wire nut onto the wires using your fingers until it's tight. Because the inside of the wire nut is threaded, the nut will grasp the wire ends and twist them to form a tight connection.

Wire nuts are generally used to connect wires in situations where little strain will be placed upon the wires (for example, inside the wall of a house). However, in motorcycle and ATV applications, the vibration might cause a wire nut to loosen and fall off. For this reason, a butt splice may be a better connector on a motorcycle or ATV electrical system. A butt splice is a small plastic tube with a metal liner. To use the splice, strip the two wire ends that you want to connect. Insert one wire into one end of the butt splice, then use the crimping tool to pinch the end of the butt splice tightly. Repeat this procedure for the other end of the splice. The crimping will seal the two wires tightly together inside the splice, forming a good electrical connection. After a butt splice is installed, it can only be removed by cutting the wires on both sides of the splice.

The final connector we'll look at is the terminal end. Although stripped wire ends can be attached directly to the terminals on other electrical devices, it's generally preferable to install terminal ends on the wires. The terminal ends are tidy and easier to connect to other devices than bare wire ends.

To install a terminal end on a piece of wire, first strip ½ inch of insulation from the end of the wire. Insert the wire into the terminal end, and crimp the terminal end tightly to seal it onto the wire. The metal ring of the terminal end can then be easily attached to the terminal of an electrical component.

If you have a wire repair kit and a few short lengths of insulated wire available, practice installing these three types of wire repair devices. First, connect two wires together using a wire nut. Next, connect two wires with a butt splice. Finally, practice installing terminal ends. This exercise will also provide you with experience in using the wire stripping and crimping tool.

Activity 3

In this activity, we'll show you how to build a working circuit using a few simple electrical components. The components you'll need are

- Four 1.5-volt "D" sized batteries
- A four-cell battery holder with wire leads
- Two small 6-volt light bulbs
- Three small toggle switches
- A few feet of 20 or 22 gauge wire

These components are inexpensive and can be purchased at any hardware or electronics store.

Set the three toggle switches to the Off position. Make an electrical circuit using the wiring diagram as shown in Figure 5. This circuit is an example of a parallel circuit. When your circuit is complete, check it to be sure it looks similar to the one shown in Figure 6.

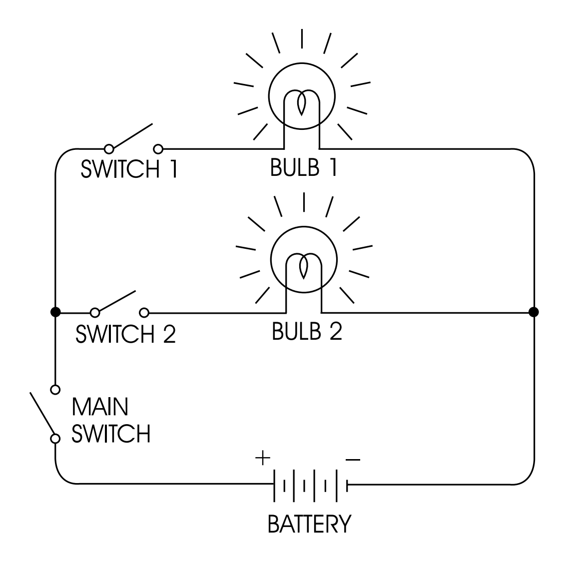


FIGURE 5—This is a schematic of a simple parallel circuit.

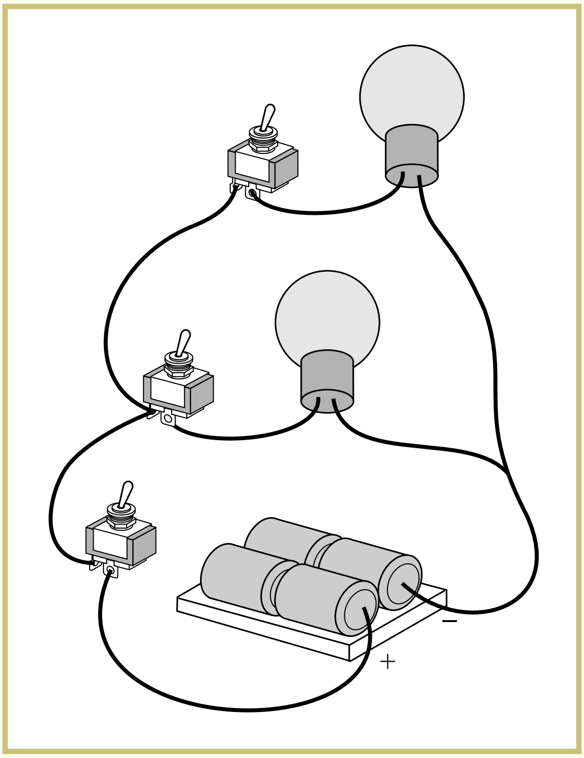


FIGURE 6—This illustration shows what the circuit in Figure 5 should look like when properly wired.

Now, let's check the circuit for proper operation. Remember, all switches should be turned off at this time. Turn on the Main Switch—neither of the two bulbs should light. Next, turn on Switch 1 and check that Bulb 1 lights. Then, turn on Switch 2 and check that Bulb 2 lights. Finally, turn off the Main Switch and check that both lights go out. If your circuit works correctly, proceed to the next activity. If your circuit doesn't work as described, refer to Figures 5 and 6 to rewire your circuit correctly.

Activity 4

Using the circuit that you wired in the previous activity, we'll show you how to make some electrical measurements to verify what you've learned about electrical circuits. This activity will give you some practical experience in using electrical test equipment and teach you more about the relationship of voltage, current, and resistance in an electrical circuit.

Using a multimeter, measure the voltages and currents in your sample circuit and write the values in the following chart. Be sure to connect the multimeter properly in series or in parallel with the component to obtain each reading.

Electrical Measurement	Reading
Voltage across one battery (Connect voltmeter in parallel with one battery.)	
Voltage across all four batteries (Connect voltmeter to battery holder wires.)	
Voltage across Bulb 1 (Connect the voltmeter in parallel with the bulb.)	
Voltage across Bulb 2 (Connect the voltmeter in parallel with the bulb.)	
Current through Bulb 1 (Insert ammeter in place of Switch 1.)	
Current through Bulb 2 (Insert ammeter in place of Switch 2.)	
Total current in circuit (Insert ammeter in place of Main Switch.)	

Voltage Measurements

Let's examine the voltage measurements that you took in your circuit. You should have found the voltage of one "D" cell battery to be 1.5 volts. Because the battery holder has four cells connected in series, the total voltage at the battery holder terminals or wires should have been approximately 6 volts (4 batteries × 1.5 volts per battery).

If you look at the circuit schematic, you'll see that the voltage at the battery holder and the voltage at each of the bulbs is really the same measurement. The leads from the battery holder are directly connected to the bulbs; therefore, the voltage at Bulb 1 and Bulb 2 should also have been 6 volts.

Current Measurements

Now, our sample circuit will show us something that wasn't described in the previous study units. Add the current flowing through Bulb 1 and Bulb 2. You should find that the sum of the current through the two bulbs equals the total current in the circuit. This shows us that the total current in a parallel circuit is equal to the sum of the currents in each of the branches. This is true no matter how many branches are a parallel circuit.

Resistance

Using Ohm's law, you can calculate the resistance of each bulb by dividing the voltage across the bulb by the current flowing through it (R=E/I). However, in our test circuit, if you removed the bulb from the circuit and measured its resistance using an ohmmeter, you wouldn't get the same value as what you calculated. This is because the resistance of the tungsten filament in a bulb increases significantly when electricity passes through it and it heats up. If you wanted to prove Ohm's law using your test circuit, obtain a common electrical resistor and insert it in your circuit in place of the bulb. A resistor isn't as sensitive to heat, and you should be able to prove Ohm's law using your readings.

There's one more important point to make while we're discussing resistance. In a series circuit, the total resistance in a circuit is determined by adding the resistance of each component in the circuit. In a parallel circuit, like your sample circuit, the total resistance is less than the resistance in any branch. In fact, in your parallel circuit that has the same amount of resistance in each branch, the total resistance that the battery sees is one-half of the resistance in one branch. Therefore, if two 10-ohm resistors were connected in parallel, the total resistance would be 5 ohms.

Figure 7 shows a parallel circuit similar to your sample circuit. This figure summarizes the relationship of the voltage, current, and resistance that we've discussed in this activity. Note how Ohm's law applies throughout the circuit.

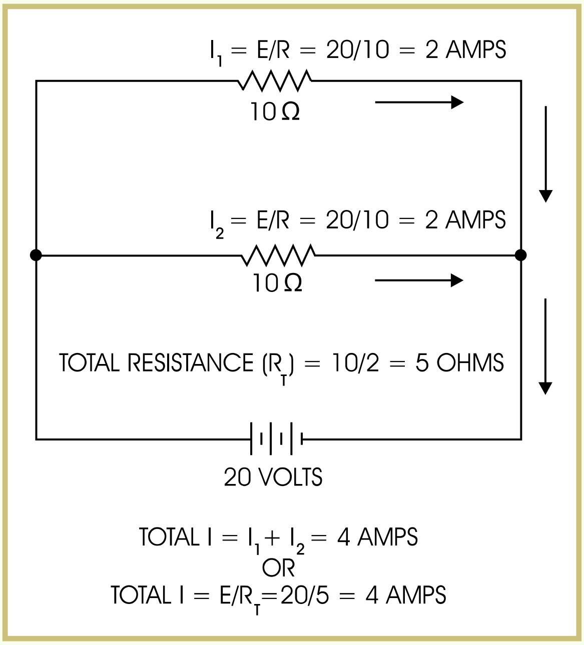


FIGURE 7—This illustration shows how Ohm's law applies to a simple parallel circuit.

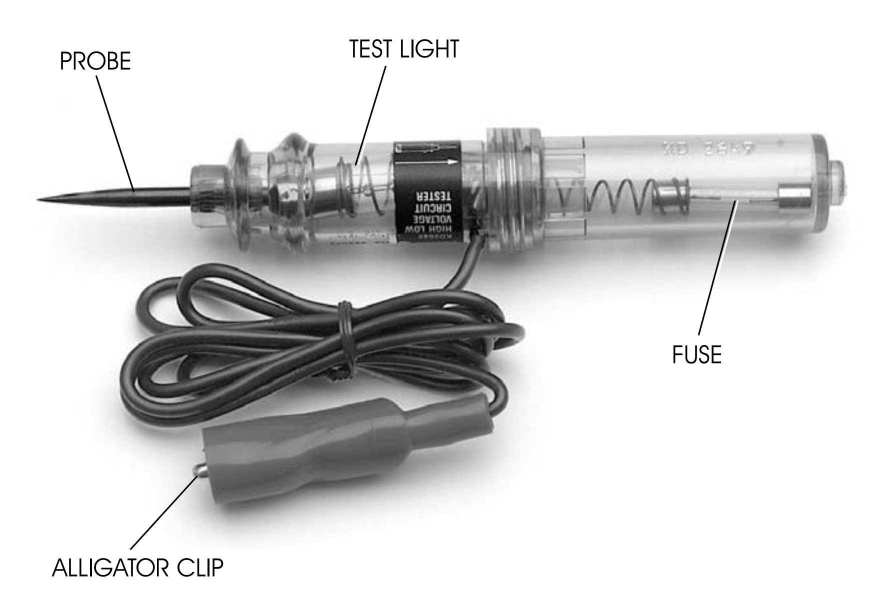
Activity 5

In this activity, we'll show you how to use a simple voltage tester or test light to check an electrical circuit. In an electrical circuit, electricity should flow from the power source, through the wires, through the circuit components (bulbs, switches, etc.), and back to the power source.

A voltage tester checks for the presence of electricity at various points in the circuit. If you find that there's no electricity in a particular area of the circuit, you can test further in that area to find the cause of the fault.

A typical voltage tester is shown in Figure 8. Note that the tester has a pointed metal probe on one end and an alligator clip on the end of its lead wire. The voltage tester is very useful for finding hard-to-see problems such as breaks in wires or loose connections, as well as faulty components. These testers are inexpensive and are available in electrical supply, hardware, and auto parts stores.

FIGURE 8—This photo shows a typical voltage tester which is also known as a test light.



To use the tester, fasten the alligator clip to a grounding point such as the frame of the machine you're testing or to the negative battery terminal. Touch the probe tip to the positive battery terminal to check the condition of both the probe and the battery. Starting at the positive side of the voltage source, move the probe tip to each circuit connection and component in an orderly manner, proceeding toward the negative terminal of the voltage source. The test light illuminates when voltage is present. If the test light fails to light at any point, you've isolated the area of the circuit problem.

If you have a voltage tester, use the tester to check the sample circuit that you made. A 6-volt voltage tester should work with your 6-volt circuit; however, it won't be able to read lower voltages. Turn the circuit on by turning on all of the switches. Attach the clip end of the tester to the negative side of the battery. Then, touch the probe to the positive side of the battery. The test light should light to indicate the presence of voltage. Next touch the probe to each of the switch terminals and to the positive side of the bulbs. The test light should light to indicate that voltage is also present at each test point.

Now, simulate an open circuit by turning off Switch 2 in the circuit. Bulb 1 should be lit, and Bulb 2 should be off. Trace the voltage using the voltage tester. You should find voltage at the battery and at both terminals of the Main Switch. As you move the probe to Switch 2, you should find voltage at one side of the switch, but not at the other side. This tells you that the problem is at Switch 2. The bulb isn't lit because either the switch isn't closed or it's defective.

Activity 6

In this activity, you'll discover the different types of electrical systems that were described in your study units.

Obtain the service manuals for several different motorcycles and ATVs. Try to get a mixture of both newer and older machines. Also try to get different types of machines such as off-road, racing, and street use.

Using the service manuals, determine the source of electrical energy used by the machine. Does the machine use a battery and have a charging system? What type of AC generator is used? What type of rectifier is used—half wave or full wave?

Next, determine the type of ignition system used in each machine. If it's a magneto system, is it a high-tension system, a low-tension system, or an energy-transfer system? Does it use breaker points and a condenser or is it a pointless type of ignition system? If it's a pointless type of system, is it a capacitor discharge system (CDI) or a transistorized system (TPI)?

Lastly, determine the type of voltage regulator that's used. Is it a mechanical regulator or electronic regulator (current limiter). Is the rectifier and regulator integrated into the same unit?

Record your findings in the following chart.

Electrical Systems			
Make and Model	**Power Source**	**Type of Ignition System**	**Regulator**

Activity 7

In this activity, you'll become more familiar with some common electrical circuits found in motorcycles and ATVs. You'll need a pencil and several sheets of paper for this activity.

From the service manuals that you've obtained, select a service manual for a street-type motorcycle or an ATV that contains a complete electrical system having an electric starter and the common electrical accessories. Using the electrical schematic diagram in the service manual, draw a block diagram for each of the following circuits.

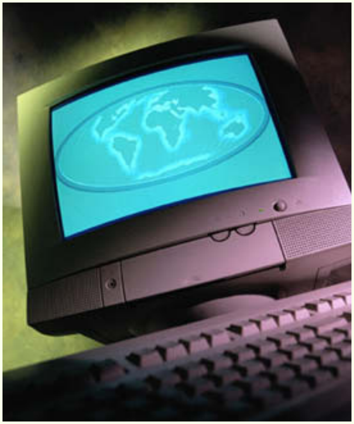
- Electric starter circuit
- Main lighting circuit
- Turn signal circuit
- Horn circuit

Remember that we discussed block diagrams in a previous study unit. A block diagram is a simplified drawing showing the major components of a circuit. In your block diagram, be sure to draw only the items that are directly related to the particular system that you're working on. For each circuit, start at the power source and proceed toward the main object (starter, horn, etc.) of the circuit.

As you can see, once you make a block diagram of the electrical circuit, it becomes much easier to understand and troubleshoot.

Conclusion

We hope you've enjoyed these practical exercises. When you're ready, proceed to the graded portion of the practical exercise. This part of the exercise is completed in the same way as the other examinations for your program. Follow the instructions provided to send your answers in to the school for grading.



ONLINE EXAMINATION

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