DC Shunt Motors

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Electrical Diagram of a Shunt Motor

The shunt motor is different from the series motor in that the field winding is connected in parallel with the armature instead of in series. You should remember from basic electrical theory that a parallel circuit is often referred to as a shunt. Since the field winding is placed in parallel with the armature, it is called a shunt winding and the motor is called a shunt motor. Figure 12-13 shows a diagram of a shunt motor. Notice that the field terminals are marked Fl and F2, and the armature terminals are marked Al andA2. You should notice in this diagram that the shunt field is represented with multiple turns using a thin line.

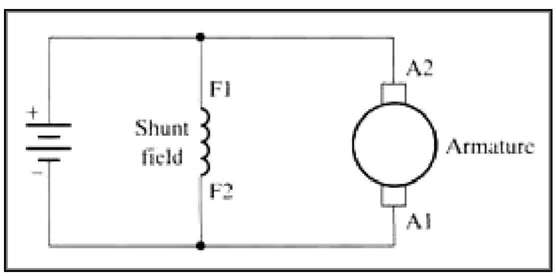

FIGURE 12-13 Diagram of DC shunt motor. Notice the shunt coil is identified as a coil of fine wire with many turns that is connected in parallel (shunt) with the armature.

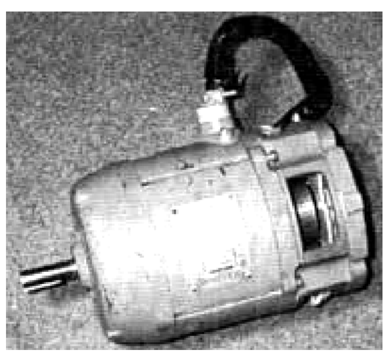

FIGURE 12-14 Typical DC shunt motor. These motors are available in a variety of sizes. This motor is a 1 hp (approximately 8 in. tall).

The shunt winding is made of small-gauge wire with many turns on the coil. Since the wire is so small, the coil can have thousands of turns and still fit in the slots. The small-gauge wire cannot handle as much current as the heavy-gauge wire in the series field, but since this coil has many more turns of wire, it can still produce a very strong magnetic field. Figure 12-14 shows a picture of a DC shunt motor.

Shunt Motor Operation

A shunt motor has slightly different operating characteristics than a series motor. Since the shunt field coil is made of fine wire, it cannot produce the large current for starting like the series field. This means that the shunt motor has very low starting torque, which requires that the shaft load be rather small.

When voltage is applied to the motor, the high resistance of the shunt coil keeps the overall current flow low. The armature for the shunt motor is similar to the series motor and it will draw current to produce a magnetic field strong enough to cause the armature shaft and load to start turning. Like the series motor, when the armature begins to turn, it will produce back EMF. The back EMF will cause the current in the armature to begin to diminish to a very small level. The amount of current the armature will draw is directly related to the size of the load when the motor reaches full speed. Since the load is generally small, the armature current will be small. When the motor reaches full rpm, its speed will remain fairly constant.

Controlling the Speed

When the shunt motor reaches full rpm, its speed will remain fairly constant. The reason the speed remains constant is due to the load characteristics of the armature and shunt coil. You should remember that the speed of a series motor could not be controlled since it was totally dependent on the size of the load in comparison to the size of the motor. If the load was very large for the motor size, the speed of the armature would be very slow. If the load was light compared to the motor, the armature shaft speed would be much faster, and if no load was present on the shaft, the motor could run away.

The shunt motor's speed can be controlled. The ability of the motor to maintain a set rpm at high speed when the load changes is due to the characteristic of the shunt field and armature. Since the armature begins to produce back EMF as soon as it starts to rotate, it will use the back EMF to maintain its rpm at high speed. If the load increases slightly and causes the armature shaft to slow down, less back EMF will be produced. This will allow the difference between the back EMF and applied voltage to become larger, which will cause more current to flow. The extra current provides the motor with the extra torque required to regain its rpm when this load is increased slightly.

The shunt motor's speed can be varied in two different ways. These include varying the amount of current supplied to the shunt field and controlling the amount of current supplied to the armature. Controlling the current to the shunt field allows the rpm to be changed 10-20% when the motor is at full rpm.

This type of speed control regulation is accomplished by slightly increasing or decreasing the voltage applied to the field. The armature continues to have full voltage applied to it while the current to the shunt field is regulated by a rheostat that is connected in series with the shunt field. When the shunt field's current is decreased, the motor's rpm will increase slightly. When the shunt field's current is reduced, the armature must rotate faster to produce the same amount of back EMF to keep the load turning. If the shunt field current is increased slightly, the armature can rotate at a slower rpm and maintain the amount of back EMF to produce the armature current to drive the load. The field current can be adjusted with a field rheostat or an SCR current control.

The shunt motor's rpm can also be controlled by regulating the voltage that is applied to the motor armature. This means that if the motor is operated on less voltage than is shown on its data plate rating, it will run at less than full rpm. You must remember that the shunt motor's efficiency will drop off drastically when it is operated below its rated voltage. The motor will tend to overheat when it is operated below full voltage, so motor ventilation must be provided. You should also be aware that the motor's torque is reduced when it is operated below the full voltage level.

Since the armature draws more current than the shunt field, the control resistors were much larger than those used for the field rheostat. During the 1950s and 1960s SCRs were used for this type of current control. The SCR was able to control the armature current since it was capable of controlling several hundred amperes. In Chapter 11 we provided an in-depth explanation of the DC motor drive.

Torque Characteristics

The armature's torque increases as the motor gains speed due to the fact that the shunt motor's torque is directly proportional to the armature current. When the motor is starting and speed is very low, the motor has very little torque. After the motor reaches full rpm, its torque is at its fullest potential. In fact, if the shunt field current is reduced slightly when the motor is at full rpm, the rpm will increase slightly and the motor's torque will also in-crease slightly. This type of automatic control makes the shunt motor a good choice for applications where constant speed is required, even though the torque will vary slightly due to changes in the load. Figure 12-15 shows the torque/speed curve for the shunt motor. From this diagram you can see that the speed of the shunt motor stays fairly constant throughout its load range and drops slightly when it is drawing the largest current.

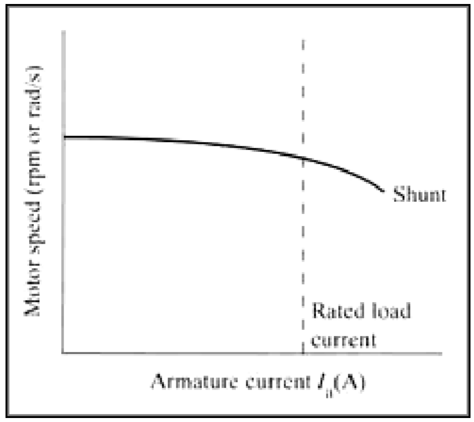

FIGURE 12-15 A curve that shows the armature current versus the armature speed for a shunt motor. Notice that the speed of a shunt motor is nearly constant.

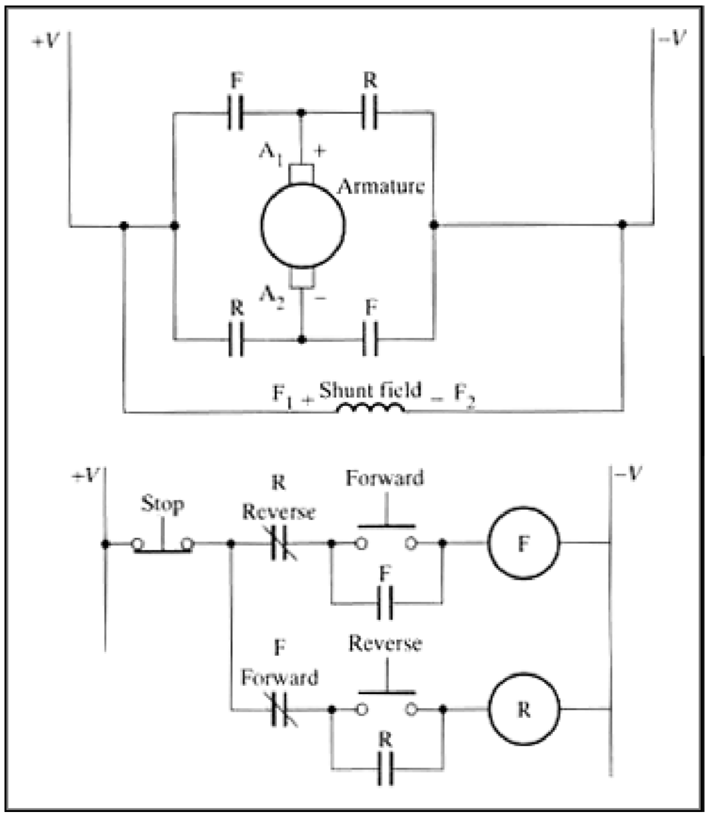

FIGURE 12-16 Diagram of a shunt motor connected to a reversing motor starter. Notice that the shunt field is connected across the armature and it is not reversed when the armature is reversed.

Reversing the Rotation

The direction of rotation of a DC shunt motor can be reversed by changing the polarity of either the armature coil or the field coil. In this application the armature coil is usually changed, as was the case with the series motor. Figure 12-16 shows the electrical diagram of a DC shunt motor connected to a forward and reversing motor starter. You should notice that the Fl and F2 terminals of the shunt field are connected directly to the power supply, and the Al and A2 terminals of the armature winding are connected to the reversing starter.

When the FMS is energized, its contacts connect the Al lead to the positive power supply terminal and the A2 lead to the negative power supply terminal. The Fl motor lead is connected directly to the positive terminal of the power supply and the F2 lead is connected to the negative terminal. When the motor is wired in this configuration, it will begin to run in the forward direction.

When the RMS is energized, its contacts reverse the armature wires so that the Al lead is connected to the negative power supply terminal and the A2 lead is connected to the positive power supply terminal. The field leads are connected directly to the power supply, so their polarity is not changed. Since the field's polarity has remained the same and the armature's polarity has reversed, the motor will begin to rotate in the reverse direction. The control part of the diagram shows that when the FMS coil is energized, the RMS coil is locked out.

Installing a Shunt Motor

A shunt motor can be installed easily. The motor is generally used in belt-drive applications. This means that the installation procedure should be broken into two sections, which include the mechanical installation of the motor and its load, and the installation of electrical wiring and controls.

When the mechanical part of the installation is completed, the alignment of the motor shaft and the load shaft should be checked. If the alignment is not true, the load will cause an undue stress on the armature bearing and there is the possibility of the load vibrating and causing damage to it and the motor. After the alignment is checked, the tension on the belt should also be tested. As a rule of thumb, you should have about *V2* to 1/4 inch of play in the belt when it is properly tensioned.

Several tension measurement devices are available to determine when a belt is tensioned properly. The belt tension can also be compared to the amount of current the motor draws. The motor must have its electrical installation completed to use this method.

The motor should be started, and if it is drawing too much current, the belt should be loosened slightly but not enough to allow the load to slip. If the belt is slipping, it can be tightened to the point where the motor is able to start successfully and not draw current over its rating.

The electrical installation can be completed before, after, or during the mechanical installation. The first step in this procedure is to locate the field and armature leads in the motor and prepare them for field connections. If the motor is connected to magnetic or manual across the line starter, the Fl field coil wire can be connected to the Al armature lead and an interconnecting wire, which will be used to connect these leads to the Tl terminal on the motor starter. The F2 lead can be connected to the A2 lead and a second wire, which will connect these leads to the T2 motor starter terminal.

When these connections are completed, field and armature leads should be replaced back into the motor and the field wiring cover or motor access plate should be replaced. Next the DC power supply's positive and negative leads should be connected to the motor starter's LI and L2 terminals, respectively.

After all of the load wires are connected, any pilot devices or control circuitry should be installed and connected. The control circuit should be tested with the load voltage disconnected from the motor. If the control circuit uses the same power source as the motor, the load circuit can be isolated so the motor will not try to start by disconnecting the wire at terminal L2 on the motor starter. Operate the control circuit several times to ensure that it is wired correctly and operating properly. After you have tested the control circuit, the lead can be replaced to the L2 terminal of the motor starter and the motor can be started and tested for proper operation. Be sure to check the motor's voltage and current while it is under load to ensure that it is operating correctly. It is also important to check the motor's temperature periodically until you are satisfied the motor is operating correctly.

If the motor is connected to a reversing starter or reduced-voltage starting circuit, their operation should also be tested. You may need to read the material in Section 15.3.6 to fully understand the operation of these methods of starting the motor using reduced-voltage methods. If the motor is not operating correctly or develops a fault, a troubleshooting procedure should be used to test the motor and locate the problem.

Troubleshooting

When a DC shunt motor develops a fault, you must be able to locate the problem quickly and return the motor to service or have it replaced. The most likely problems to occur with the shunt motor include loss of supply voltage or an open in either the shunt winding or the armature winding. Other problems may arise that cause the motor to run abnormally hot even though it continues to drive the load. The motor will show different symptoms for each of these problems, which will make the troubleshooting procedure easier.

When you are called to troubleshoot the shunt motor, it is important to determine if the problem occurs while the motor is running or when it is trying to start. If the motor will not start, you should listen to see if the motor is humming and trying to start. When the supply voltage has been interrupted due to a blown fuse or a de-energized control circuit, the motor will not be able to draw any current and it will be silent when you try to start it. You can also determine that the supply voltage has been lost by measuring it with a voltmeter at the starter's LI and L2 terminals. If no voltage is present at the load terminals, you should check for voltage at the starter's Tl and T2 terminals. If voltage is present here but not at the load terminals, it indicates that the motor starter is de-energized or defective. If no voltage is present at the Tl and T2 terminals, it indicates that supply voltage has been lost prior to the motor starter. You will need to check the supply fuses and the rest of the supply circuit to locate the fault.

If the motor tries to start and hums loudly, it indicates that the supply voltage is present. The problem in this case is probably due to an open field winding or armature winding. It could also be caused by the supply voltage being too low.

The most likely problem will be an open in the field winding since it is made from small-gauge wire. The open can occur if the field winding draws too much current or develops a short circuit between the insulation in the coils. The best way to test the field is to remove supply voltage to the motor by opening the disconnect or de-energizing the motor starter. Be sure to use a *lockout* when you are working on the motor after the disconnect has been opened. The lockout is a device that is placed on the handle of the disconnect after the handle is placed in the off position, and it allows a padlock to be placed around it so it cannot be removed until the technician has completed the work on the circuit. If lockout has extra holes, additional padlocks can be placed on it by other technicians who are also working on this system. This ensures that the power cannot be returned to the system until all technicians have removed their padlocks. The lockout will be explained in detail in the chapter on motor controls later in this text.

After power has been removed, the field terminals should be isolated from the armature coil. This can be accomplished by disconnecting one set of leads where the field and armature are connected together. Remember that the field and armature are connected in parallel and if they are not isolated, your continuity test will show a completed circuit even if one of the two windings has an open.

When you have the field coil isolated from the armature coil, you can proceed with the continuity test. Be sure to use the R X 1k or R X 10k setting on the ohmmeter because the resistance in the field coil will be very high since the field coil may be wound from several thousand feet of wire. If the field winding test indicates the field winding is good, you should continue the procedure and test the armature winding for continuity.

The armature winding test may show that an open has developed from the coil burning open or from a problem with the brushes. Since the brushes may be part of the fault, they should be visually inspected and replaced if they are worn or not seating properly. If the commutator is also damaged, the armature should be removed, so the commutator can be turned down on a lathe.

If either the field winding or the armature winding has developed an open circuit, the motor will have to be removed and replaced. In some larger motors it will be possible to change the armature by itself rather than remove and replace the entire motor. If the motor operates but draws excessive current or heats up, the motor should be tested for loose or shorting coils. Field coils may tend to come loose and cause the motor to vibrate and overheat, or the armature coils may come loose from their slots and cause problems. If the motor continues to overheat or operate roughly, the motor should be removed and sent to a motor rebuilding shop so that a more in-depth test may be performed to find the problem before the motor is permanently damaged by the heat.

Related Links:
Compound Motors
DC Motor Components
DC Motor Operation
DC Motor Theory
DC Series Motors

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