Modern DC motors use permanent magnets. These magnets are always oriented in the same North/South arrangement. These motors have two leads that come from the armature through brushes. If the armature leads are reversed, motor direction reverses. It is the difference between attracting magnetism between the magnets and the armature, or repelling magnetism. This holds true with little slot car motors or modern car starter motors with permanent magnets.

So, switching either the field magnetism or armature magnetism reverses motor shaft direction.

Before we had strong permanent magnets we made electro-magnetic FIELD COILS: "Positive" Current always produces north-to-south magnetism in the same direction, depending on which direction the coils are wound. High current produces very strong magnetism, in the same way. We can run high current through thick wires or wrap fine wires around iron hundreds of times which 'adds' each small current to produce strong magnetism.

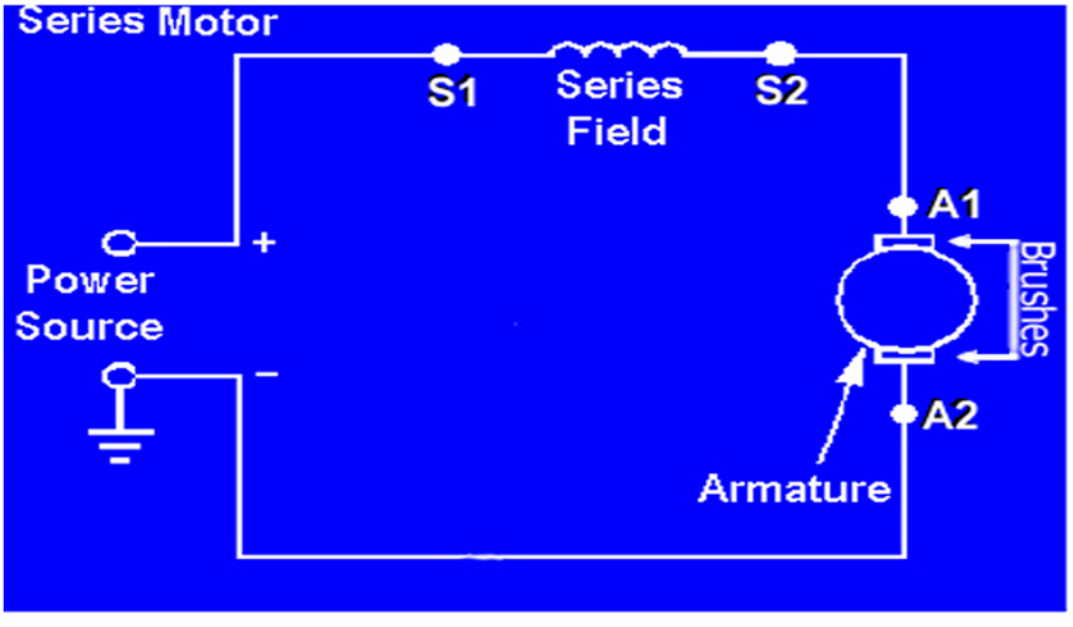
So, switching field wires OR switching armature wires, will reverse a DC motor shaft. Of course, if we switch both, the shaft direction will not change.

Electromagnetic field windings have their own pair of wires, and armatures have their pair. That's four wires. How those wires are connected make a huge difference in motor performance. What's the difference? Torque vs. speed regulation.

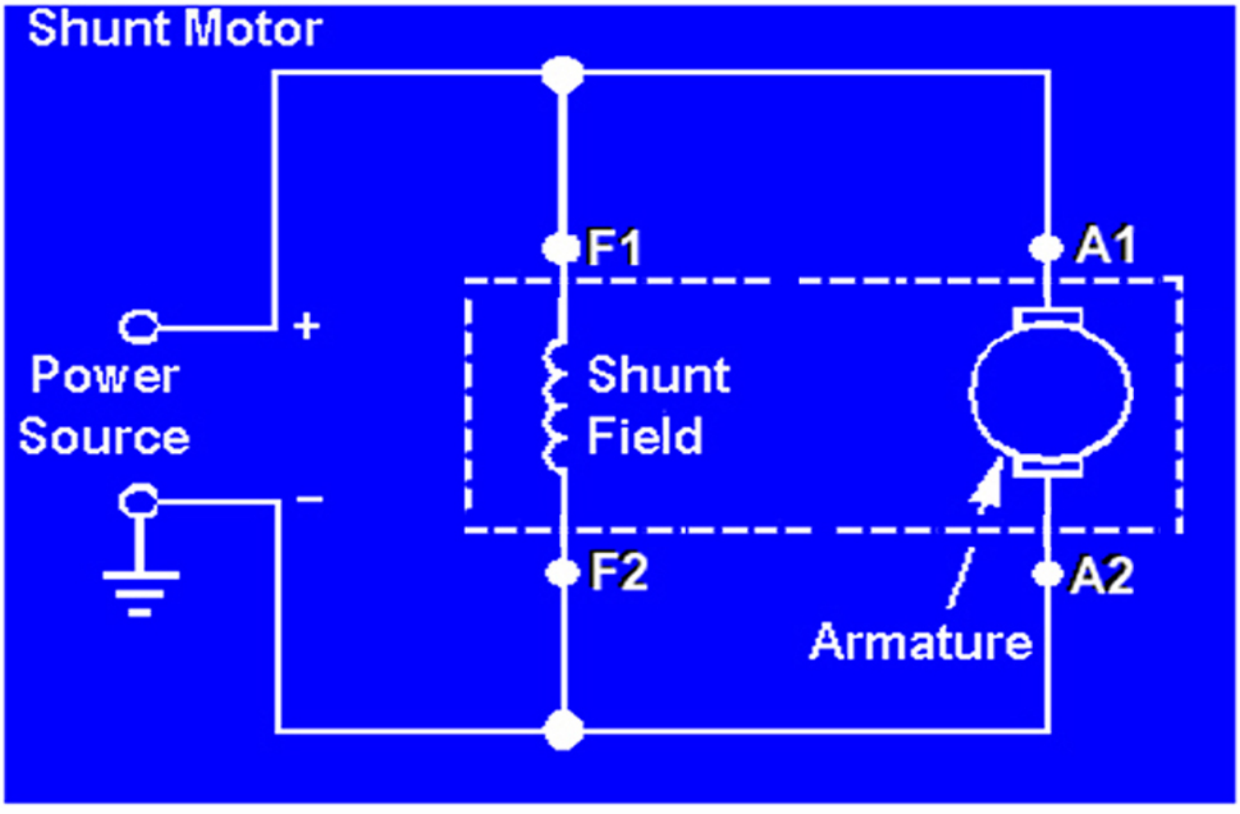
Aside from permanent magnet motors, there are only two types of DC motors, and many combinations of those.

Series
Shunt
Compound (a combination of Series and Shunt motors, to be discussed later, if needed.)

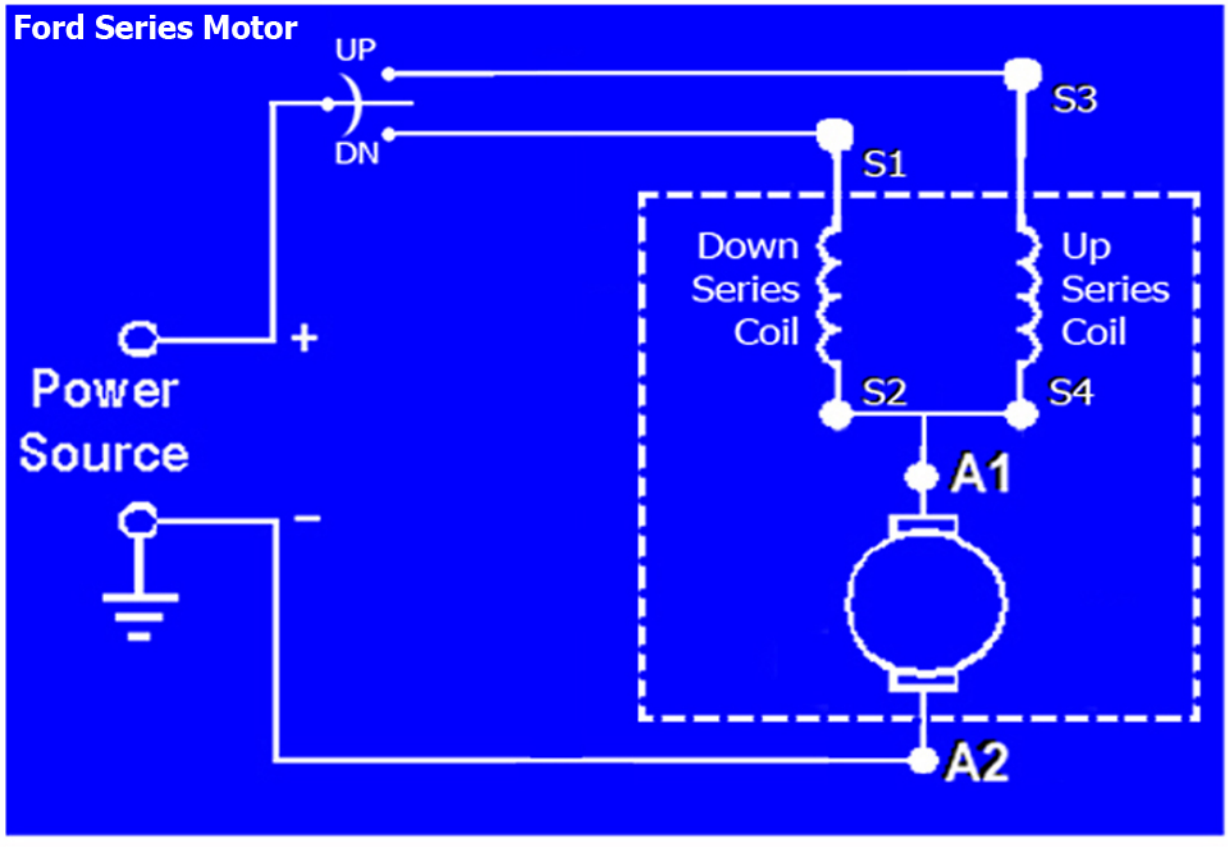
The most basic DC motor (and the strongest) is a 'Series-Motor'. The field wires can be as thick as coat hangers and they are connected in series with the armature through brushes. That means all current must flow through the field and the armature. Any break in the series causes current (and motion) to stop. Starter motors are series-motors. They have great torque but poor speed control. Applications where the motor is always connected to the load and slow speed is unimportant, usually employs a series motor.



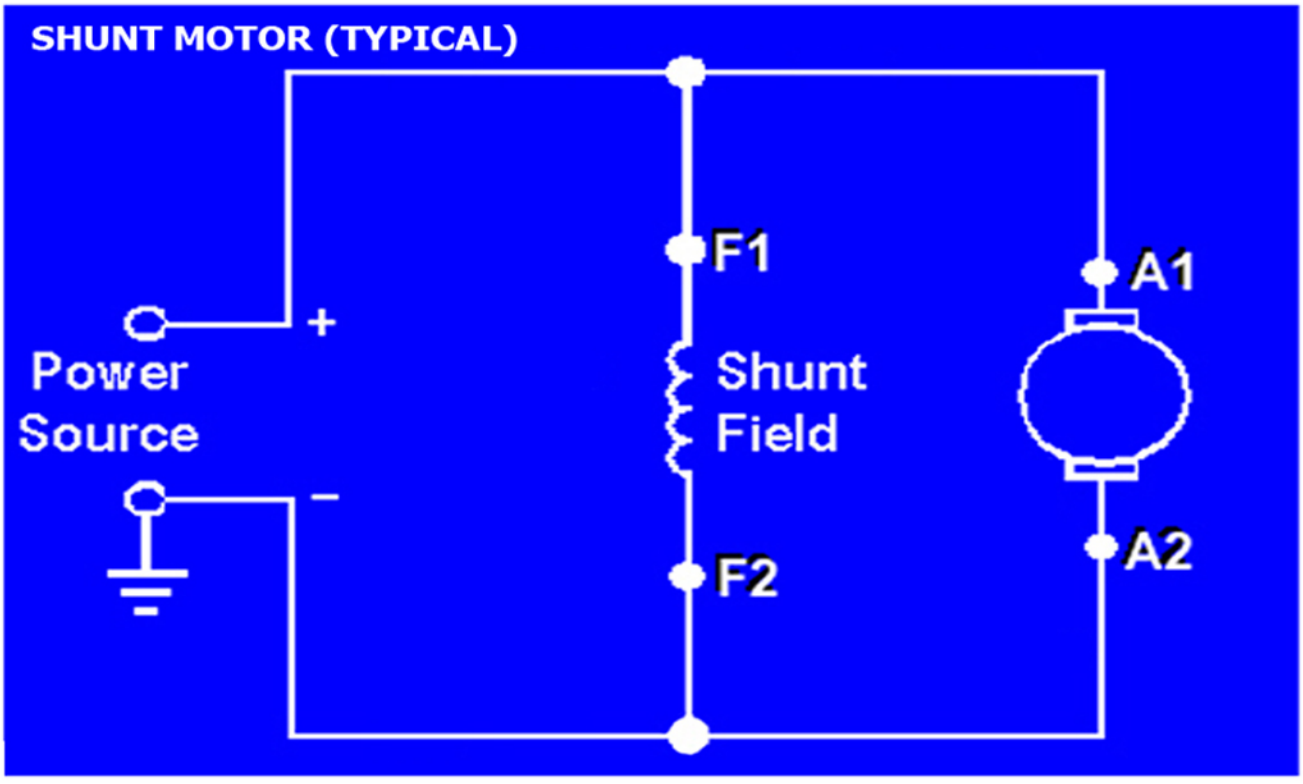
Shunt motors energize their field separately from the armature. This gives excellent speed control but poorer torque. The field strength can be varied, which allows the armature to go slower without wasting any power.



1963-on Thunderbird Power Window motor. Notice the field coils are wound opposite from each other and in series with the armature. If both fields were energized, the magnetisms would cancel each other and the armature would not move. Wires (S2, S4, & A1) are connected to each other internally, so only three wires come out.



Let's revisit the Shunt Motor to see the difference in Ford Squarebird power window Motors.



Below is a typical Squarebird Power Window motor having four wires:
F1, F3, A1, and A2 (GND). Ford motors reverse direction by using two separate fields.