Recognizing DC Drive Hardware and Functions
Lesson Objectives

After completing this lesson, you will be able to recognize DC drive hardware and functions by performing the following tasks:

- Recognize DC drive hardware
- Recognize DC drive functions
- Recognize the DC power conversion process using a drive wiring diagram
A DC drive controls the speed, torque, horsepower, and direction of a DC motor. One example of a DC drive is shown below:
A DC drive is composed of two major sections:

- **Power Section**: Converts incoming AC power into DC output to energize a DC motor's armature and field windings.
- **Control Section**: Analyzes voltage and speed feedback signals to regulate the voltage produced by the power section.
DC Drive Hardware

The following graphic presents a more detailed breakdown of these sections:

**Control Section**
- External Single-Phase AC Power Supply

**Power Section**
- Three-Phase AC Input
- Line Reactor or Isolation Transformer
  - L1
  - L2
  - L3
- AC Input Fuses
  - F1
  - F2
  - F3
- Drive Regulator Board
- I/O Board
- Power Stage Interface Board
- Driver Board
- TB2
- 3ø AC Input
- Three-Phase Armature Bridge
- DC Output
- Single-Phase Field Bridge
- DC Output

(Continued)
DC Drive Hardware

The following graphic presents a more detailed breakdown of these sections:
The control section of a DC drive is a series of circuit boards that are configured to perform the drive's control functions:
DC drives typically contain the following circuit boards:

- **Drive Regulator Board**: Gathers inputs from adapter boards, current transformers, current transducers, and external feedback devices and send inputs to the driver board.
- **Driver Board**: Controls the firing of silicon-controlled rectifiers (SCRs) in the armature bridge and the field bridge.
- **I/O Board**: Provides an interface with external control devices, including programmable controllers and discrete inputs/outputs.
Circuit boards contain the following devices:

- **Sensing Devices:** Detect or measure current and send back an electrical signal to an input circuit.
- **Microprocessors:** Mini-computers that control various functions of the drive.
- **Firmware:** Electrically programmable read-only memory (EPROM) chips that store software programs used by microprocessors to perform all of the software functions of the drive.
- **EEPROM (Electronically Erasable Programmable Read-Only Memory):** A chip that stores data so that information is not lost when power is removed.
- **RAM (Random Access Memory):** A chip that stores the data required by the microprocessor to execute the software functions of the drive. RAM information is lost when power is removed.
The **power section** produces DC output for the motor's armature and field windings. It includes the following components:

- Armature bridge
- DC contactor
- Field bridge
The **armature bridge** converts three-phase AC input to DC output for the motor's armature power supply. The armature bridge includes the following components:

- **Armature Current Transformers (ACT-1 and ACT-2):** Measure the AC current being supplied to the three-phase armature bridge:
The **armature bridge** converts three-phase AC input to DC output for the motor's armature power supply. The armature bridge includes the following components:

- **Silicon Controlled Rectifiers (SCRs):** Control the amount of current and voltage sent to the DC motor armature windings:
The **armature bridge** converts three-phase AC input to DC output for the motor's armature power supply. The armature bridge includes the following components:

- **DC Transducer (TD-1):** Senses the DC current at the output of the armature bridge:

  ![DC Transducer](image)
The **DC contactor** connects or disconnects the DC output from the armature bridge to the DC motor armature:

**Not included in the PowerFlex DC**
AC to DC Power Conversion in the Armature Bridge

The armature bridge converts **AC power** to **DC power** using the following process:

1. Protection and filtering devices (i.e., line reactors, fuses, MOVs) smooth incoming AC power and prevent excess voltage from reaching the armature bridge.

2. Silicon controlled rectifiers (**SCRs**) convert the AC input into DC output.

3. Additional **protection devices** prevent voltage spikes from damaging the SCRs.

4. The **DC contactor** provides a connection between the armature bridge and the motor's armature windings.
The **field bridge** converts AC input to DC output for the motor's DC field supply. The bridge includes a **field current transformer (FCT)**, which measures the AC current being supplied to the bridge:

DC drives will use diodes to create a fixed field voltage or SCRs to regulate variable field voltages.
**Terminal Blocks**

Terminal blocks are hardware components that provide functions for both the power and control sections of a DC drive. Terminal blocks are a series of screws, solders, or electrical connection points for wires. Each terminal provides access for wire connection:
Terminal blocks are typically referred to as TB1 and TB2 based on the wires connected to each block:

- **TB1**: Houses incoming power wiring and outgoing motor wiring.
- **TB2**: Houses control signal wiring for devices such as pushbuttons and analog potentiometers.

Some DC drives contain more than two terminal blocks.
The **DC drive** controls the speed, torque, horsepower, and direction of a DC motor by performing the following operations:

- Converting three-phase fixed AC voltage into adjustable DC voltage.
- Regulating the applied armature voltage and current.

Voltage goes through a three-phase, full-wave rectification in the drive:
During full-wave rectification, there are two half-cycles:

- **Positive Half-Cycle:**
  - Anode is positive relative to the cathode.
  - SCRs are forward biased.
  - SCRs conduct.

- **Negative Half-Cycle:**
  - Anode is negative relative to the cathode.
  - SCRs are reverse biased.
  - SCRs do not conduct.
Unlike other rectifiers, an SCR needs to meet all of the following conditions before conduction occurs:

- Firing current pulses applied
- Sufficient current
- Forward bias
Power Conversion

Power conversion begins when three-phase fixed AC voltage enters the drive and is filtered by protection devices:

![Power Conversion Diagram](image)
Power conversion begins when three-phase fixed AC voltage enters the drive and is filtered by protection devices:
As the power conversion process continues, **hardware components** monitor and filter current. Some hardware is internal to the drive and some hardware is external to the drive:

- **Driver:**
  - Fires the SCRs at the proper time and sequence
  - Produces required voltage and current
- **Summing Junction:**
  - Adds a reference signal with a feedback signal
  - Creates an error signal
- **Current Regulator:**
  - Automatically adjusts the output current according to the error signal
  - Feeds the driver the proper sequencing signals
- **Speed Regulator:**
  - Automatically adjusts the speed according to the error signal
  - Provides up to 0.2% speed regulation at a particular set speed
As the power conversion process continues, **hardware components** monitor and filter current. Some hardware is internal to the drive and some hardware is external to the drive:

- **Tachometer:**
  - Is external to the drive
  - Improves speed regulation by providing a voltage signal that is proportional to output speed
  - Provides up to 0.1% speed regulation at a particular set speed

- **Encoder:**
  - Is external to the drive
  - Improves speed and current regulation by employing digital circuits that are not subject to the same noise as analog circuits
  - Provides up to 0.01% speed and current regulation at a particular set speed

Tachometers and encoders are not found on every DC motor. If no tachometer or encoder is present, the drive receives armature voltage feedback that provides 1% speed regulation.
As the power conversion process continues, **hardware components** monitor and filter current. Some hardware is internal to the drive and some hardware is external to the drive:

- **Resolver:**
  - Is internal to a servo motor
  - Translates the angular position of a rotating shaft into a series of digital pulses
  - Provides absolute position over one shaft revolution