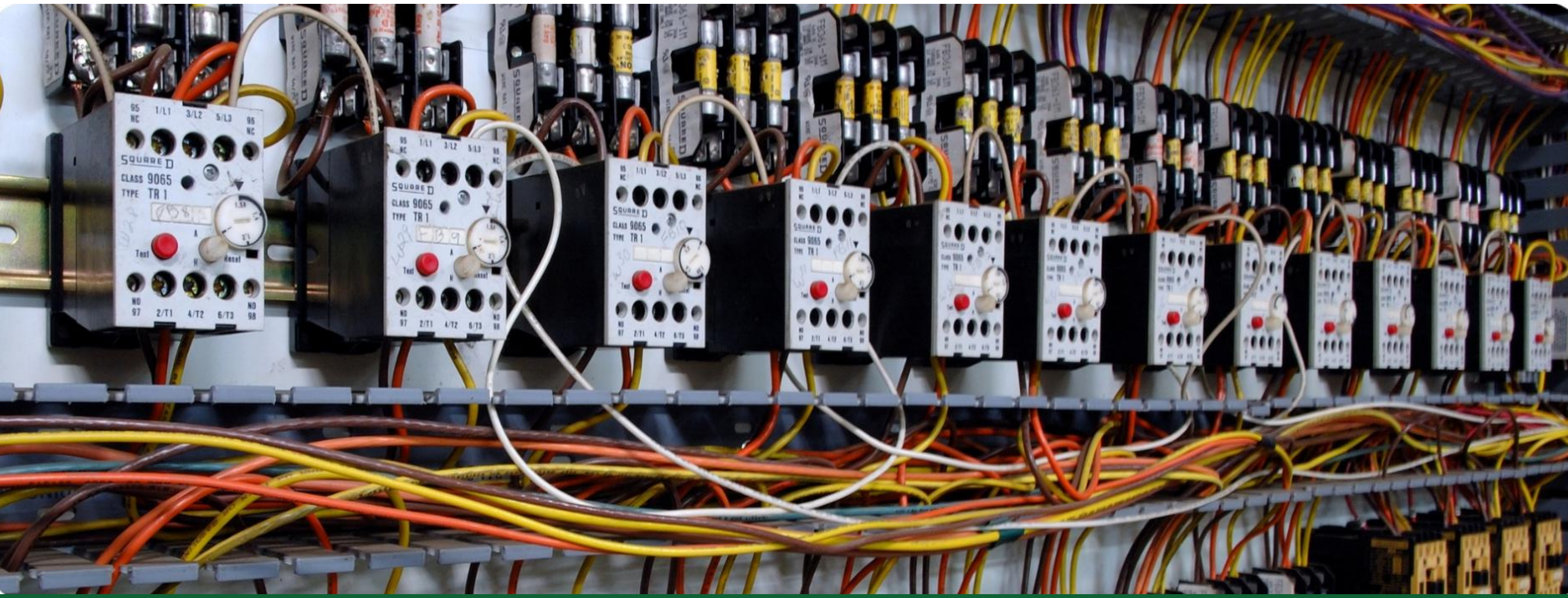
Transit Core Competencies Curriculum

Participant Resource Guide

Electrical Foundations

May 2026



Course Outline

- Module 1: Introduction to Electricity
- Module 2: Basic Electrical Principles
- **Module 3: AC and DC Electricity**
- Module 4: Circuit Components & Architecture
- Module 5: Magnetism and Electromagnetism
- Module 6: Electrical Tools
- Module 7: Safety and PPE

TWC Transit Workforce Center

U.S. Department of Transportation
Federal Transit Administration

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Course: Electrical Foundations
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Module 3 – AC and DC Electricity

Objectives

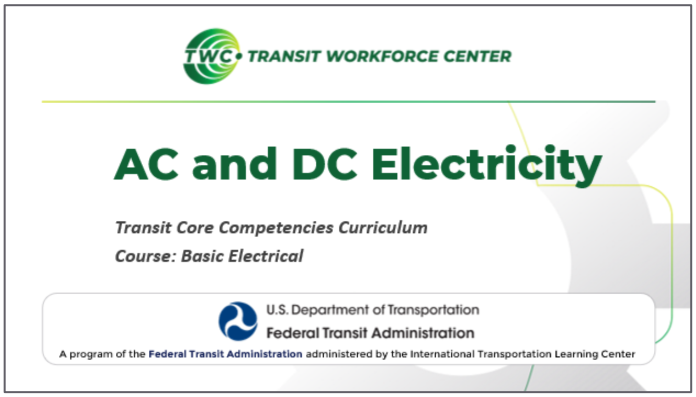
- Explain the difference between AC and DC electricity.
- Identify common uses of AC and DC in transit systems.
- Explain the basic advantages and disadvantages of AC and DC.
- Describe frequency and phase and why they matter for equipment.
- Explain how power is converted between AC and DC.

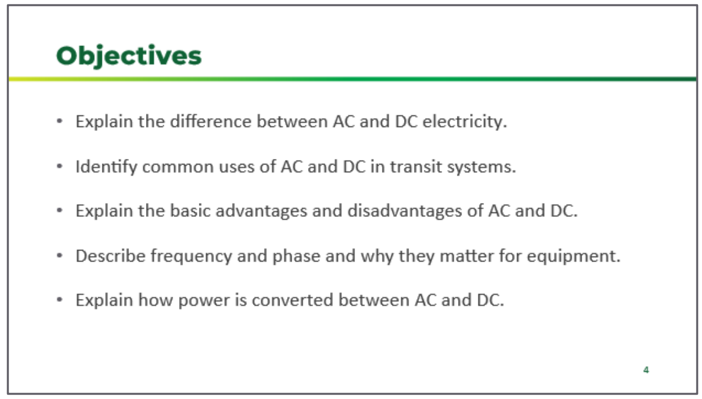
Key Terms

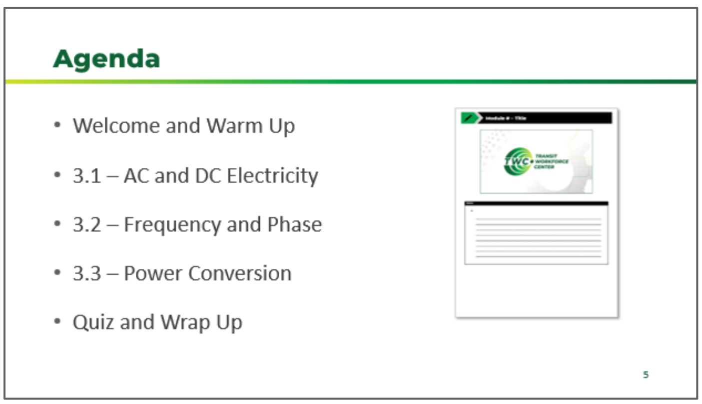
- Alternating Current (AC)
- Converter
- Direct Current (DC)
- Equipment Nameplates
- Frequency
- Inverter
- Phase
- Power Conversion
- Rectifier
- Single-Phase Power
- Three-Phase Power
- Transformer

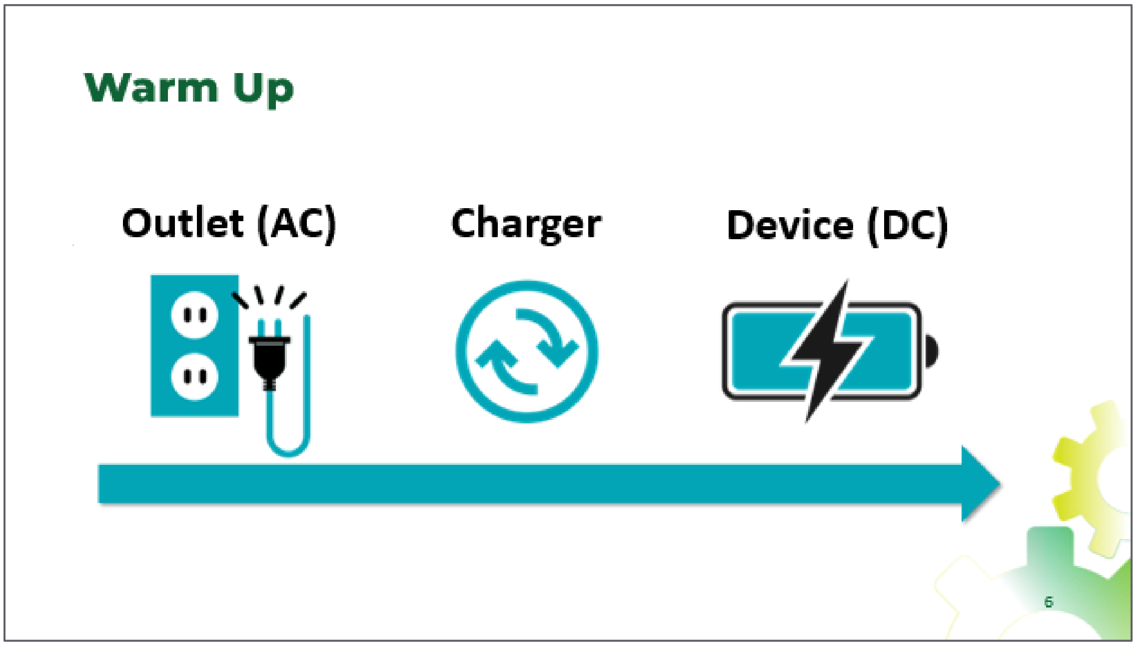
Participant Resource Guide

AC and DC Electricity



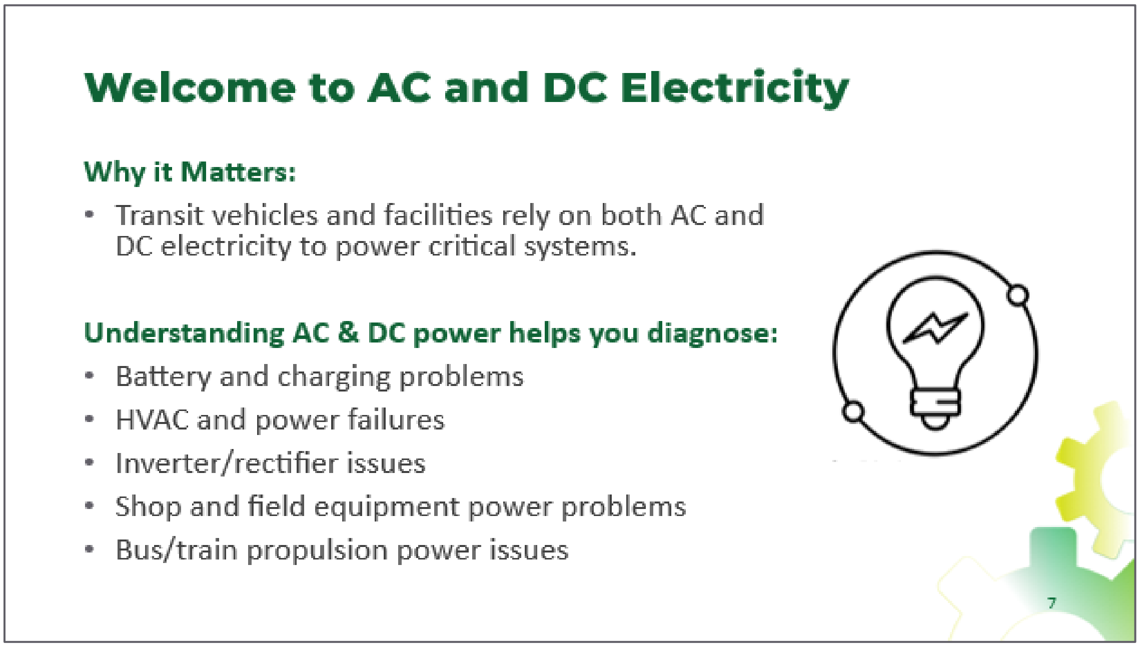






Notes:

- When you plug a charger into a wall outlet, the electricity coming from the outlet is alternating current, or **AC power**.
- However, most electronic devices like phones and laptops operate using direct current, or **DC power**.
- Because the outlet provides AC and the device needs DC to charge, the charger must **convert** the incoming AC electricity into DC electricity that the device can safely use.
- Inside the charger are electronic components that perform this conversion. During this process, the system is not perfectly efficient. Some of the electrical energy is lost as it passes through the internal components.
- That lost energy is released as heat, which is why the charger may feel warm when it is operating.
- This is normal and happens because electrical systems rarely operate at one hundred percent efficiency.



Notes:

- Many electrical problems technicians encounter involve systems that rely on either AC power, DC power, or both working together.
- For example, troubleshooting might involve:
  - battery charging problems
  - HVAC power failures
  - inverter or rectifier issues
  - shop equipment that won't power on
  - or propulsion power issues on vehicles.
- Understanding the difference between AC and DC electricity helps you better understand how these systems are designed and where problems may occur.

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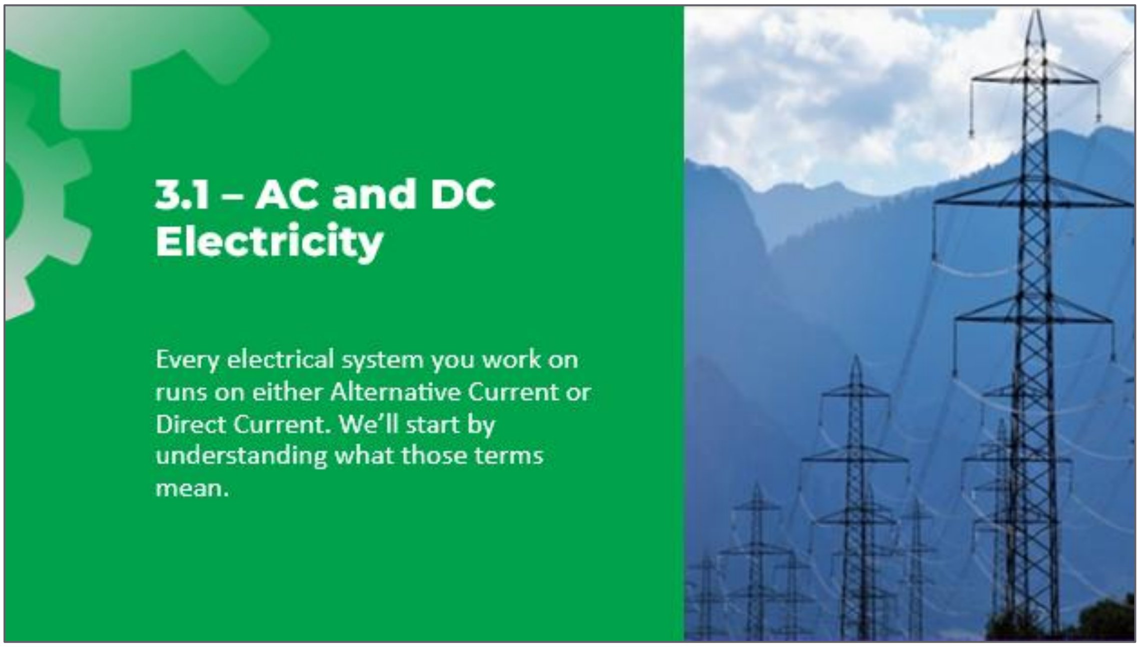

Notes:

- Every electrical system you work on runs on either Alternative Current or Direct Current. We'll start by understanding what those terms mean.

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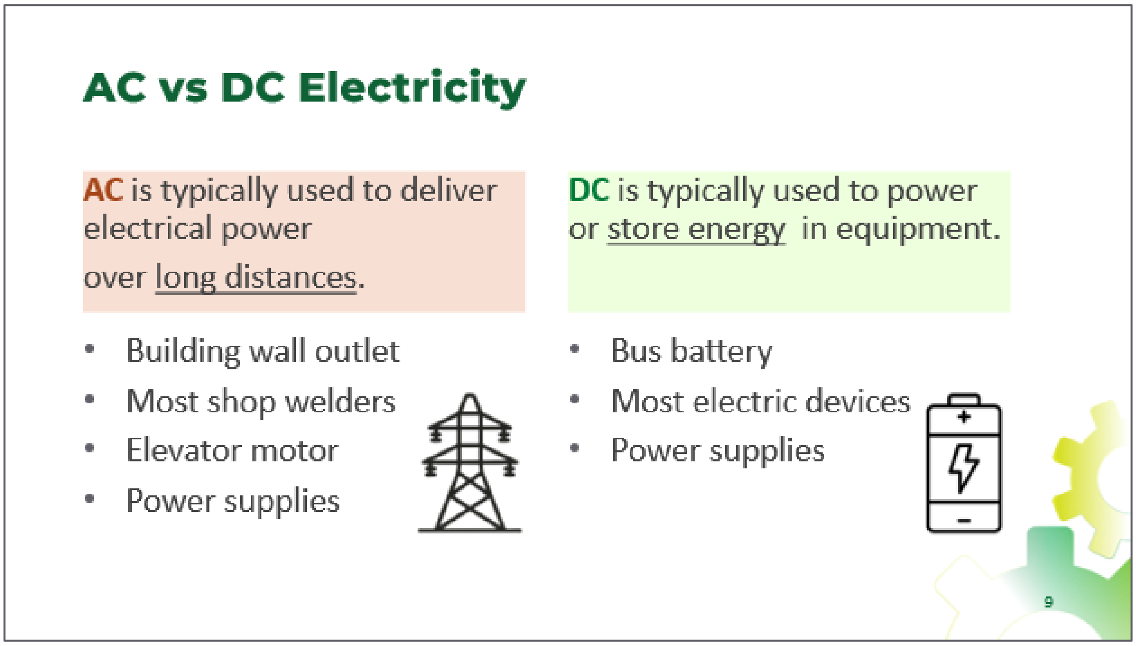
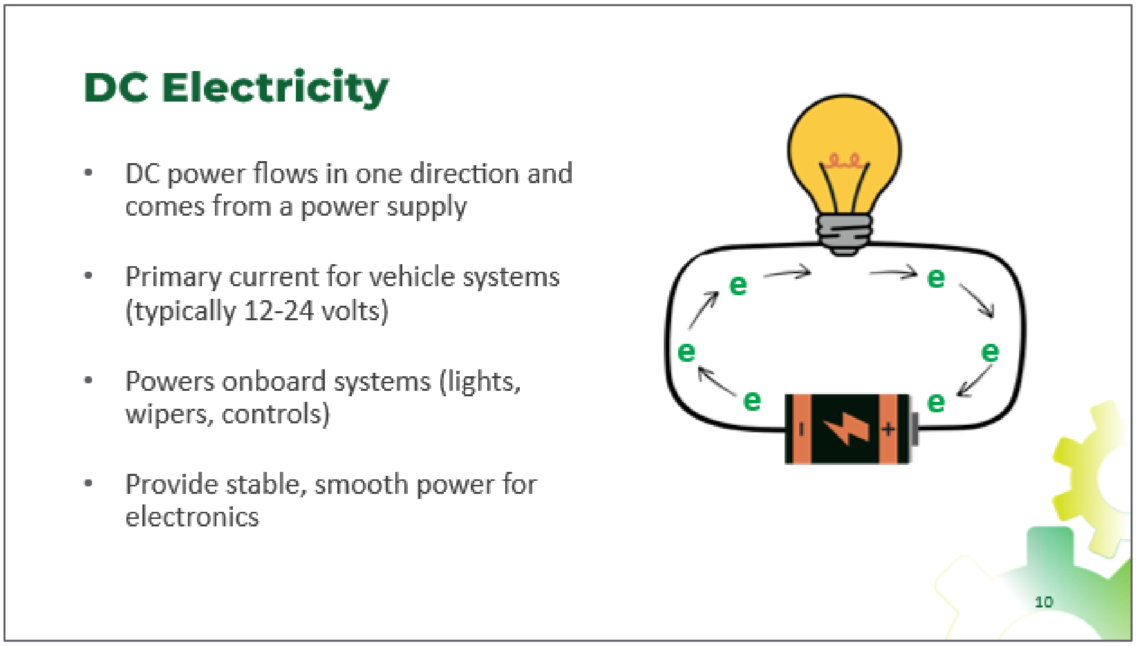


Notes:

- For our purposes, electricity is categorized as AC or DC electricity.
  - **AC power** is typically how electricity is delivered over long distances. Power plants generate electricity and it is transmitted through the grid to buildings and facilities as AC power.
  - **DC power** is typically what equipment uses or stores, especially batteries & many electronic systems.
- Many electrical systems use *both* AC and DC power together. For example, power may enter a building as AC and then be converted to DC to operate electronics or charge batteries.
- That is why understanding the difference between AC and DC electricity is important for troubleshooting and maintenance.
- As maintainers, one of the first things you often need to identify is whether a system is using AC power, DC power, or both.
- The chart shows some common examples you may encounter in transit systems and facilities.



Notes:

- When the electricity is said to be **Direct Current** (DC), the electrons flow in one direction, like a river. They move from the positive to the negative terminal.
    - Think of DC as the “steady” type of power.
    - Batteries, lights, horns, fareboxes, GPS, radios are all DC.
- Primary current for vehicle systems (typically 12-24 volts).
- If DC isn’t stable, you’ll see flickering screens, slow cranking, or modules resetting.
- Most electrical complaints on vehicles start as DC problems.
- Most of what you’ll touch day-to-day on a vehicle is DC, usually 12 or 24 volts.

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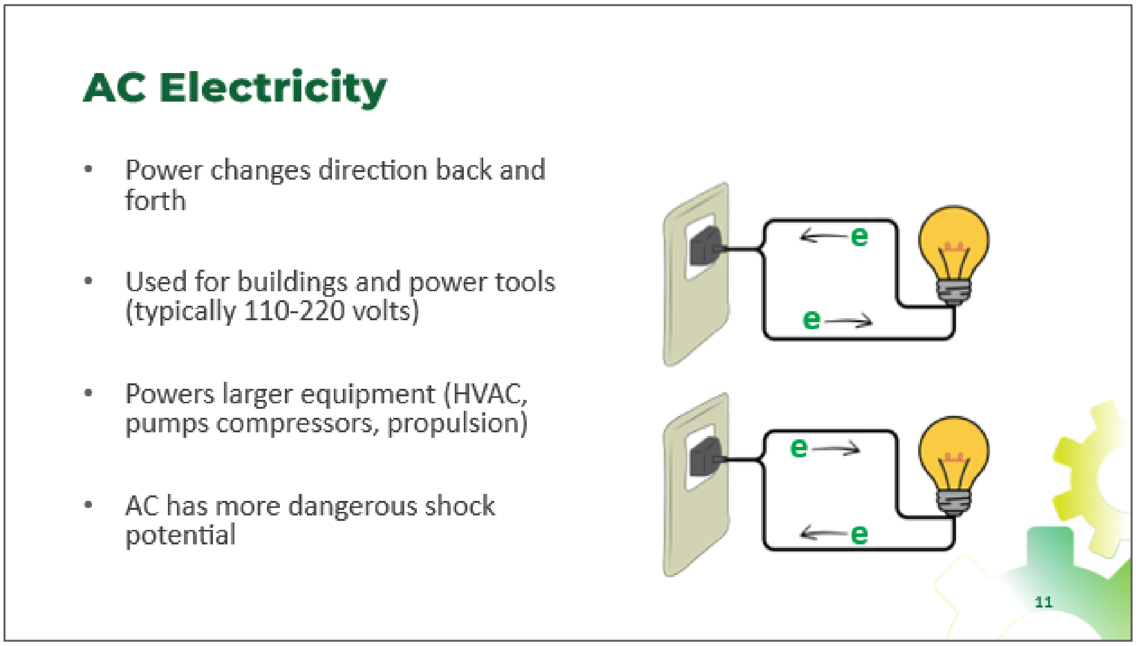
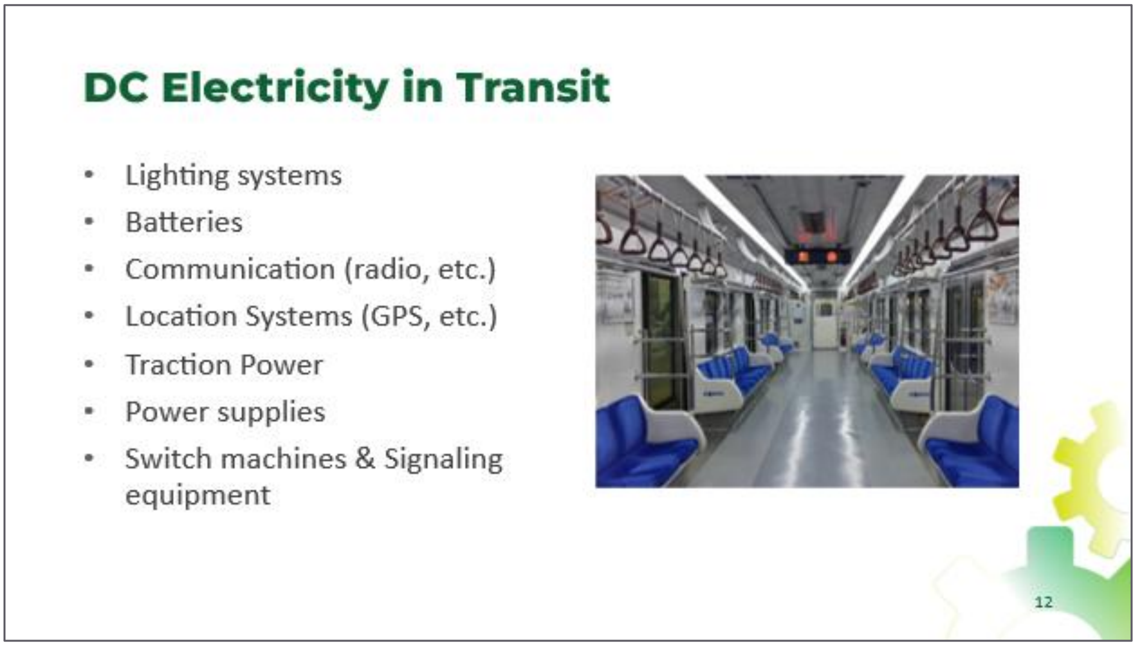


Notes:

- **Alternating Current** (AC) is when electrical power that flows back and forth in cycles. The current alternates direction, changing from positive to negative and back again.
- AC is what comes out of shop wall outlets. It's strong and travels well.
- Transit vehicles turn AC into DC or DC into AC depending on the system.
    - Propulsion motors, HVAC compressors, and power steering pumps often use AC.



Notes:

- DC power is very common in transit systems because it provides steady and stable electrical energy.
- Many systems that rely on electronics or stored energy operate on DC power.
    - **Batteries** store energy as DC electricity. That stored energy is used to start vehicles, power onboard systems, and support electrical equipment.
    - **Lighting systems** and many electronic components also rely on DC power because it provides consistent voltage.
    - **Communication** and **location systems**, such as radios and GPS units, also use DC power because electronic devices require stable power to operate correctly.
    - In rail systems, DC is also used for **traction power** in many systems to drive trains.
- You will also see DC used in **switch machines** and **signaling equipment** because these systems require reliable, consistent electrical control.
- Understanding where DC power is used helps technicians quickly identify the type of electrical system they are working with during maintenance and troubleshooting.

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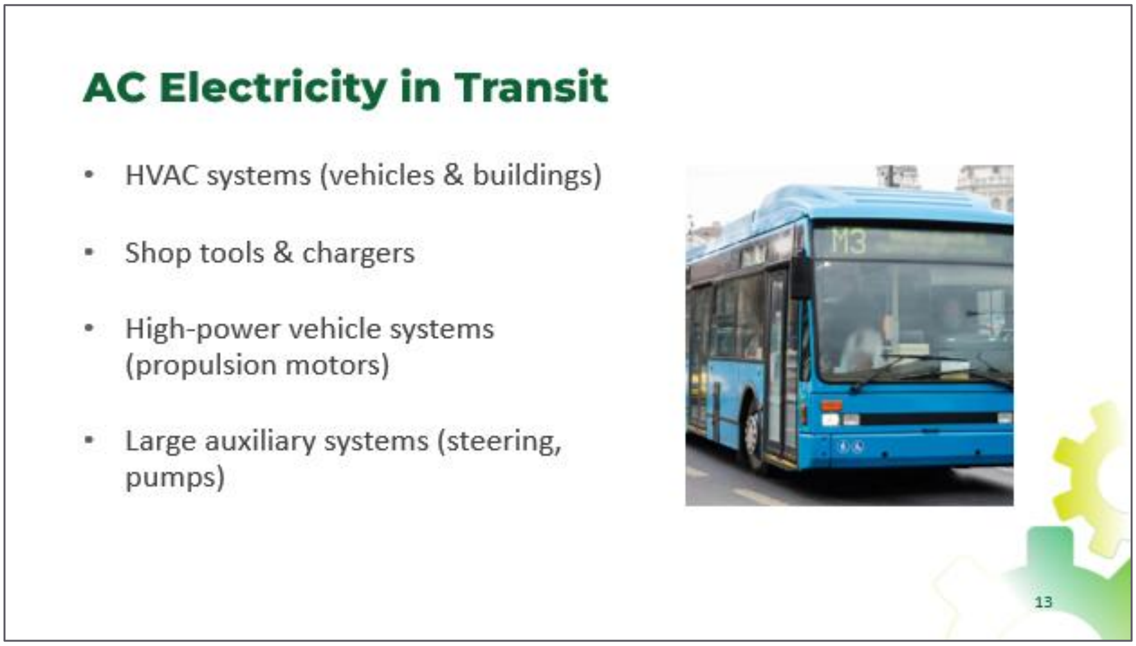

Notes:

- AC power is commonly used in transit systems when higher power levels or electric motors are required.
- One common example is **HVAC systems** in both vehicles and buildings. Heating, ventilation, and air conditioning equipment often use AC motors to drive compressors and fans.
- AC power is also commonly used for **shop tools** and **chargers**.
- Most maintenance equipment in facilities is designed to operate on standard AC power from building electrical systems.
- **High-power vehicle systems** may also use AC motors, especially propulsion motors in many modern transit vehicles.
- Even when the main power source is DC, an inverter may convert that power into AC so that motors can operate efficiently.
- **Large auxiliary** systems such as steering systems or pumps may also rely on AC motors because they provide strong and reliable mechanical power.
- Understanding where AC power is used helps technicians recognize how power flows through transit equipment and why certain systems require AC instead of DC.

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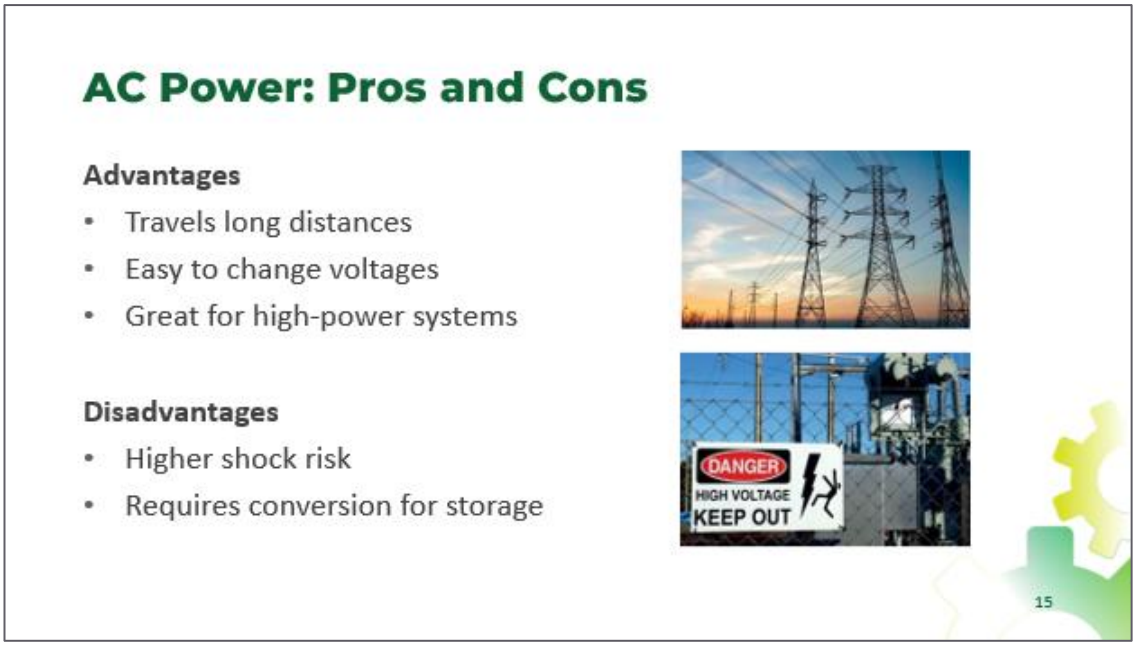
Notes:

Advantages

- DC power is easier to store and ideal when a steady, one-way flow of electricity is needed—like in batteries or electronic circuits.
- It's easier to control the speed of DC motors, which makes them useful in transit and industrial systems.
- While DC doesn't travel far on its own, High-Voltage DC (HVDC) can extend its range and even support things like large-scale air conditioning systems.

Disadvantages

- The downsides include more complex and costly voltage conversion to AC, and the need for more infrastructure, like additional transmission lines, to distribute DC effectively.
- Cannot use a simple transformer to change voltage levels.
- DC is reliable but doesn't travel well. If DC voltage drops even slightly, electronics can become faulty.



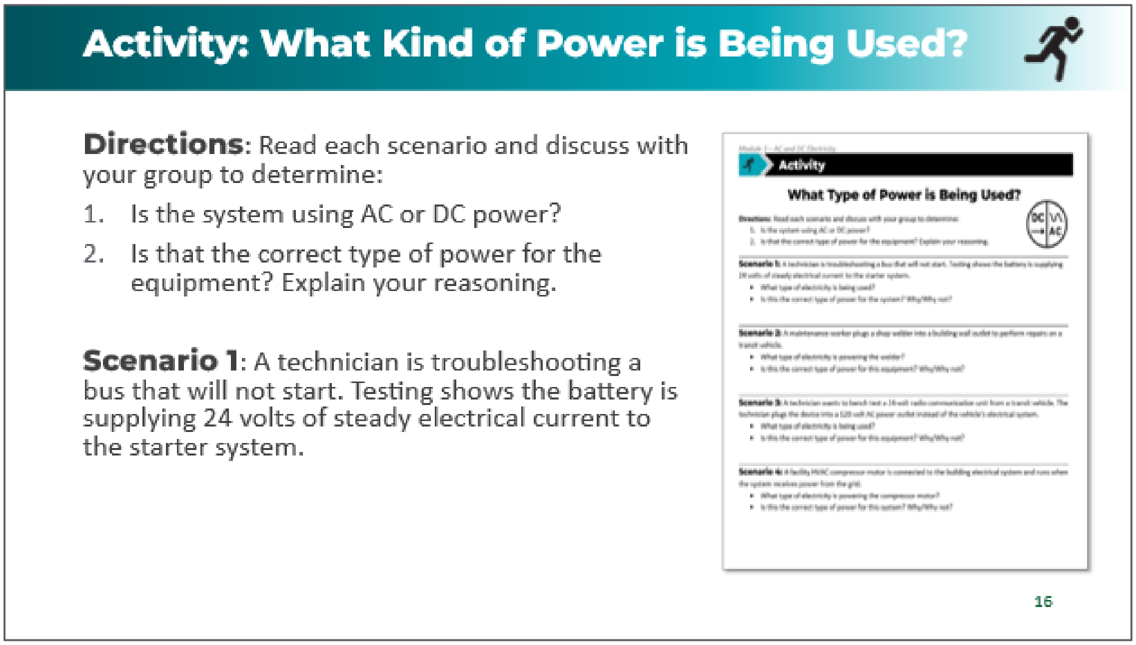
Notes:

Advantages

- AC is more efficient for power distribution because it can travel long distances with less energy loss, which is why it's used in the power grid.
- It's also easier to manage and convert than DC, especially when changing voltage levels.

Disadvantages

- The downside is that AC can be more dangerous, especially at high voltages, which increases the risk of serious electrical shock.



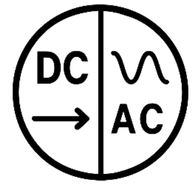
Notes:

- When troubleshooting electrical systems, one of the first things technicians must identify is whether the system is operating on AC or DC power.
- Using the correct type of electricity is important because different equipment is designed to operate with specific types of power.
- In some cases, using the wrong type of electricity could prevent the system from working properly or even damage the equipment.

1. Discuss each scenario with your group and decide what type of electricity is being used and whether it is appropriate for that system.
2. **Be ready to explain your reasoning.**

Activity

What Type of Power is Being Used?



Directions: Read each scenario and discuss with your group to determine:

1. Is the system using AC or DC power?
2. Is that the correct type of power for the equipment? Explain your reasoning.

Scenario 1: A technician is troubleshooting a bus that will not start. Testing shows the battery is supplying 24 volts of steady electrical current to the starter system.

- What type of electricity is being used?
- Is this the correct type of power for the system? Why/Why not?

Scenario 2: A maintenance worker plugs a shop welder into a building wall outlet to perform repairs on a transit vehicle.

- What type of electricity is powering the welder?
- Is this the correct type of power for this equipment? Why/Why not?

Scenario 3: A technician wants to bench test a 24-volt radio communication unit from a transit vehicle. The technician plugs the device into a 120-volt AC power outlet instead of the vehicle's electrical system.

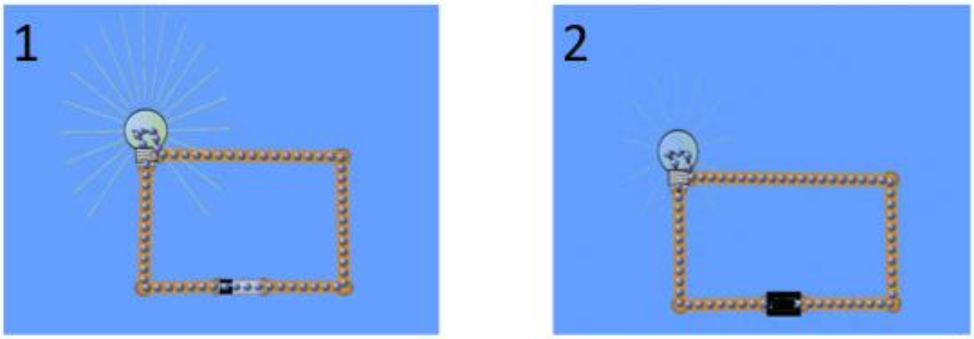
- What type of electricity is being used?
- Is this the correct type of power for this equipment? Why/Why not?

Scenario 4: A facility HVAC compressor motor is connected to the building electrical system and runs when the system receives power from the grid.

- What type of electricity is powering the compressor motor?
- Is this the correct type of power for this system? Why/Why not?

Knowledge Check

Determine which GIF shows AC and DC current. Explain your choice.



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Knowledge Check

Why is AC commonly used for buildings and long-distance power transmission?

(A). It is easier to store.

(B). It travels well over distances.

(C). It is always safer.

(D). It never needs conversion.

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Summary and What's Next

- DC flows in one direction and powers batteries and electronics.
- AC changes direction and is used for power delivery and high-power systems.
- Transit systems use both AC and DC depending on the application.
- Equipment labels tell technicians what values to expect.
- Knowing AC vs DC helps troubleshoot common electrical problems.

Next, we'll look at frequency and phase and how AC behaves and why it matters for equipment performance.

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Notes:

- In this module, we introduced the basic differences between AC and DC electricity.
  - **DC electricity** flows in one direction and is commonly used in batteries and many electronic systems.
  - **AC electricity** changes direction many times per second and is commonly used to deliver power over long distances and operate high-power equipment.
- In **transit systems**, both AC and DC electricity are used depending on the type of equipment and the job the system needs to perform.
- Technicians often rely on **equipment labels** and **system information** to identify the type of electricity and the electrical values they should expect to see.
- Understanding whether a system uses AC or DC power is an important first step when **troubleshooting** electrical problems.
- Next, you will look more closely at how AC electricity behaves by examining frequency and phase and why those characteristics matter for equipment performance.

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Notes:

- DC flows in one direction while AC moves in waveforms.
- Those waves have characteristics that are important to understand.

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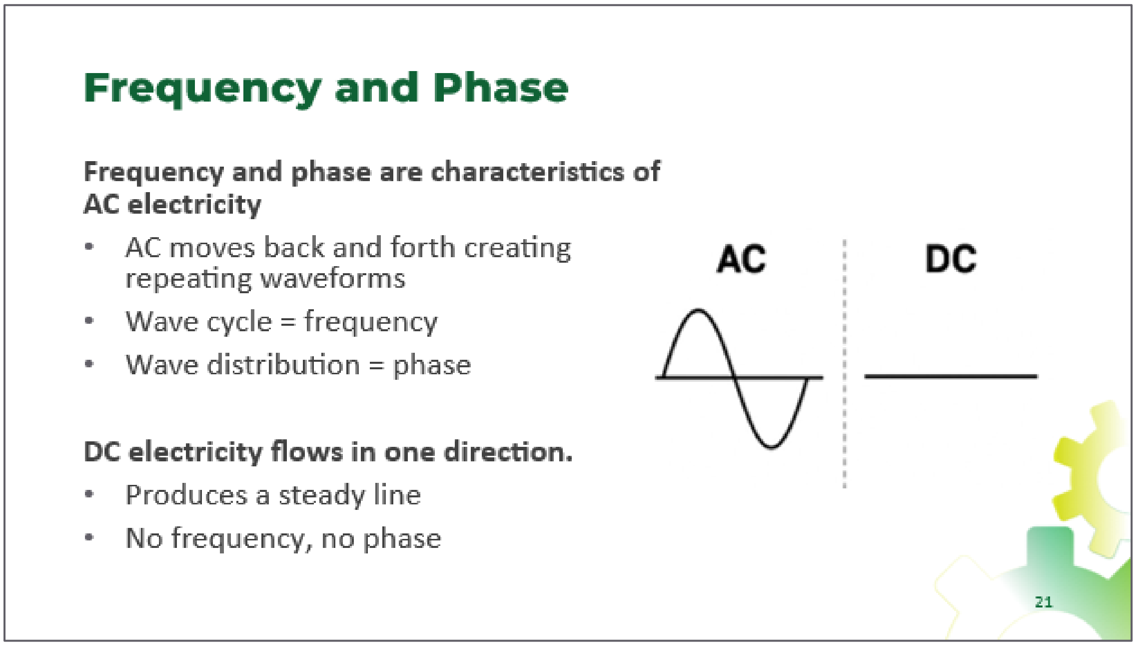

Notes:

- Frequency and phase are characteristics that apply **only to alternating current**.
- AC electricity moves back and forth, which creates a repeating wave pattern called a waveform.
- Each time that wave completes **one full cycle**, it represents a unit of **frequency**.
  - Frequency tells us how many times the current changes direction each second.
- **Phase** describes how waves are **positioned** relative to one another.
  - In many electrical systems, multiple AC waves may be present, and their timing relationship is called phase.
- Direct current behaves differently. DC flows in only one direction and maintains a **steady voltage** level.
- Because DC does not alternate back and forth, it does not form a waveform like AC.
- Without a repeating wave pattern, **DC does not have frequency or phase**.
- Understanding this difference helps technicians interpret electrical measurements and understand how AC systems behave in real equipment.

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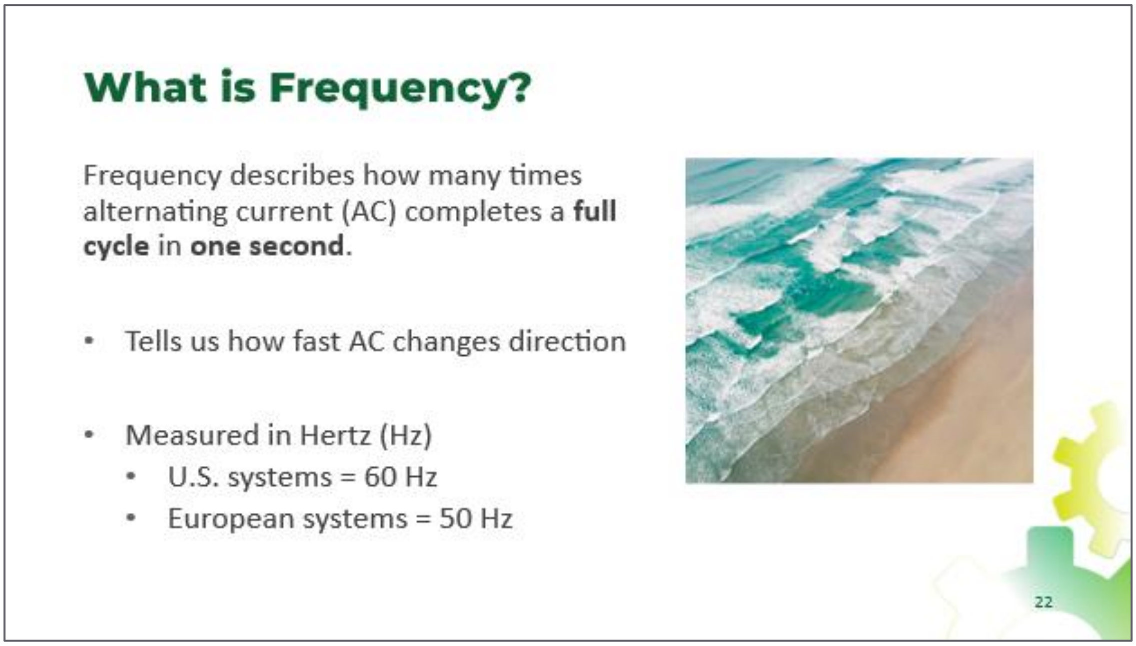

Notes:

- **Frequency** describes how many times an AC waveform completes a full cycle in one second. A full cycle means the current flows in one direction, reverses, and then returns to its starting point.
    - Frequency also tells us how fast the current changes direction.
- In the **United States**, the standard electrical frequency is 60 Hertz, or 60 cycles per second.
    - That means the current completes 60 full-wave cycles every second.
- In many **European countries**, the standard is slightly different at 50 Hertz, meaning the current completes 50 cycles per second.
- We often visualize frequency using a waveform, also called a sine wave. The more waves that occur in one second, the higher the frequency.
    - A simple way to think about this is to imagine waves hitting the shore at a beach.
    - If 60 waves reached the shore in one second, that would represent 60 Hertz.
- This analogy helps show that frequency is simply measuring how often the wave repeats each second.
- Frequency matters because many electrical devices are designed to operate at a specific frequency.
    - Motors, transformers, and other electrical equipment rely on that consistent frequency to operate properly.

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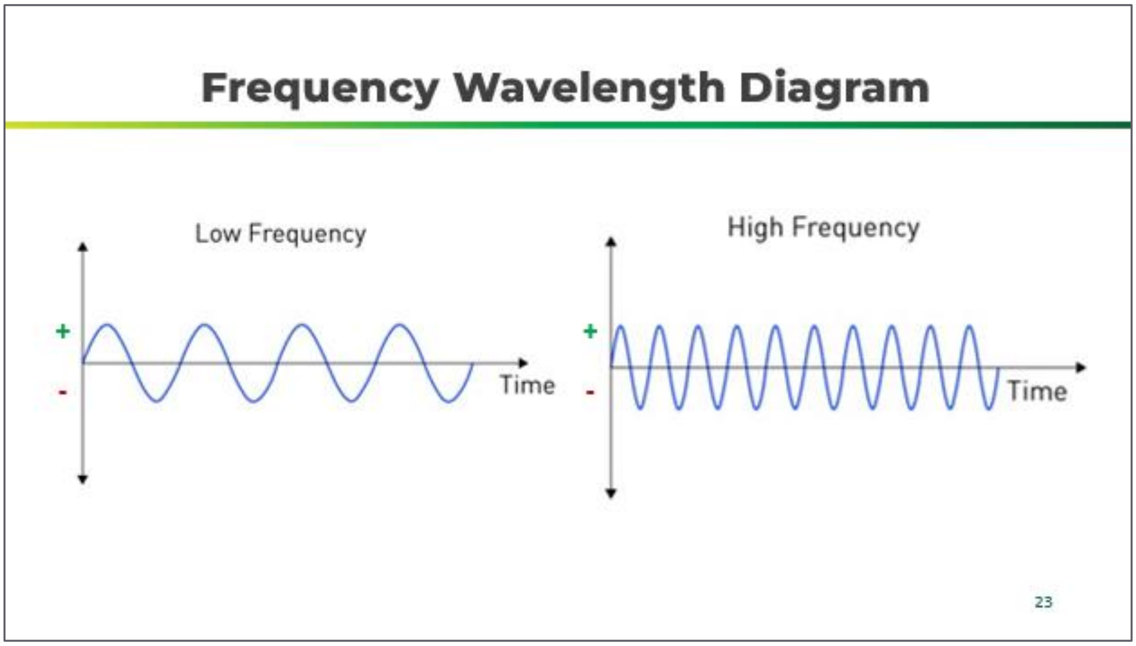
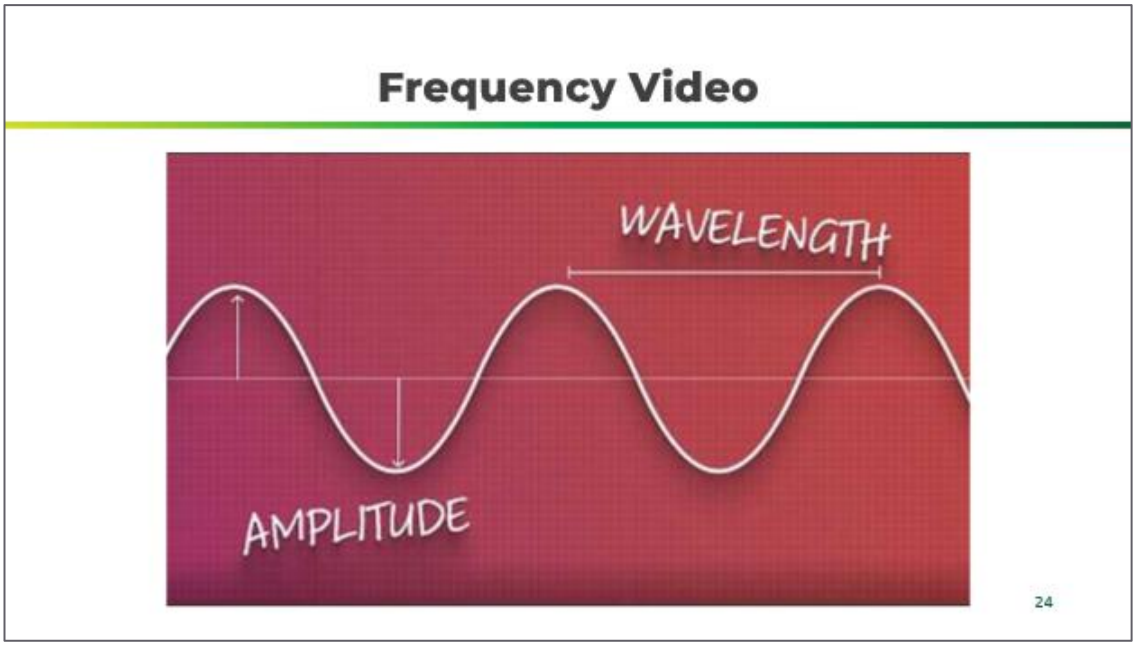


Notes:

- In AC, the power will **oscillate (move back and forth)** between positive and negative voltage. On this diagram, the positive alteration of current appears above the midway line.
- The negative alteration is shown below the midway line.
- **In the low frequency diagram…**
  a) There are four cycles depicted during a 1-second interval of time. Therefore, the frequency is 4 Hertz.
  b) Each positive alternation is marked with a sign that says period.
  c) There are four complete periods during this 1-second interval.
- **In the high frequency diagram…**
  a) There are ten cycles depicted during a 1-second interval of time. Therefore, the frequency is 10 Hertz.
  b) There are ten complete periods during this 1-second interval.
  c) Frequency is measured using a multimeter device, which you'll learn about later in this course.


Frequency Video
WAVELENGTH
AMPLITUDE
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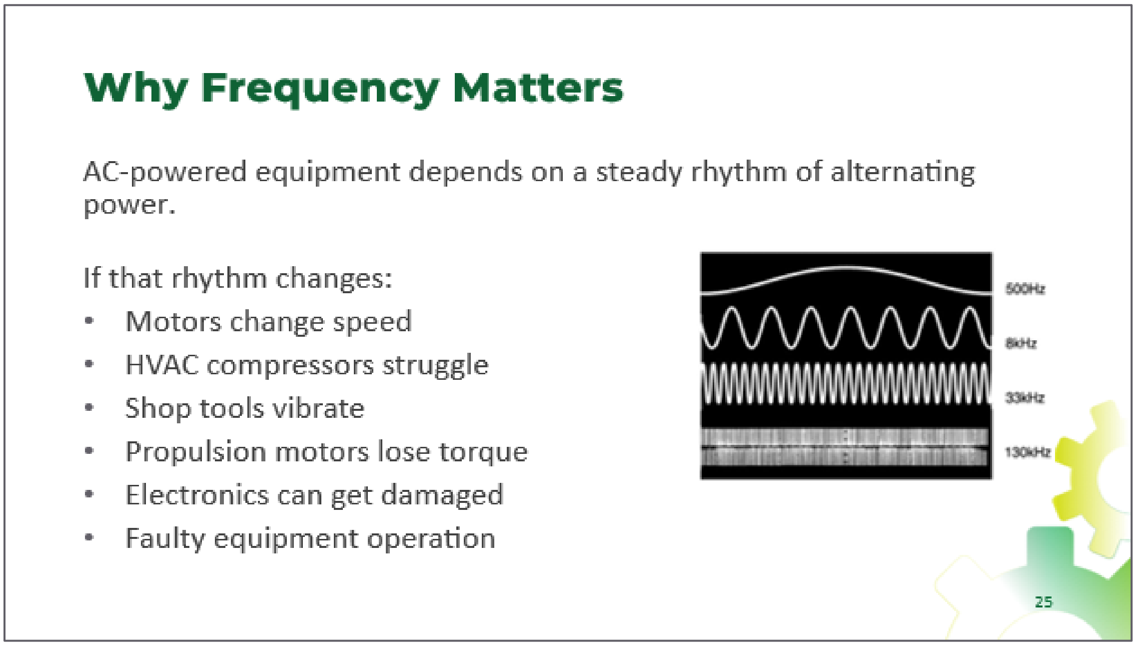

Notes:

- AC-powered equipment depends on a steady rhythm of electrical cycles. That rhythm is the frequency.
- When electrical systems operate at the correct frequency, equipment behaves the way it was designed to operate. Many electrical devices rely on that consistent timing.
  - For example, electric motors depend on frequency to determine how fast they rotate. If the frequency changes, the motor speed can change as well.
- HVAC compressors and other mechanical equipment may struggle to start, operate inefficiently, or shut down if the frequency is outside the expected range.
- Shop tools may begin to vibrate or behave irregularly because the electrical input is not stable.
- In transit systems, propulsion motors can also be affected.
- If the frequency is incorrect, the motor may lose torque or fail to perform as expected.
- Sensitive electronics can also be damaged if electrical conditions are unstable.
- The key idea is that equipment is designed to operate at a specific frequency.
  - When the frequency is correct, the equipment works properly.
  - When the frequency is incorrect, the equipment may behave unpredictably or fail.

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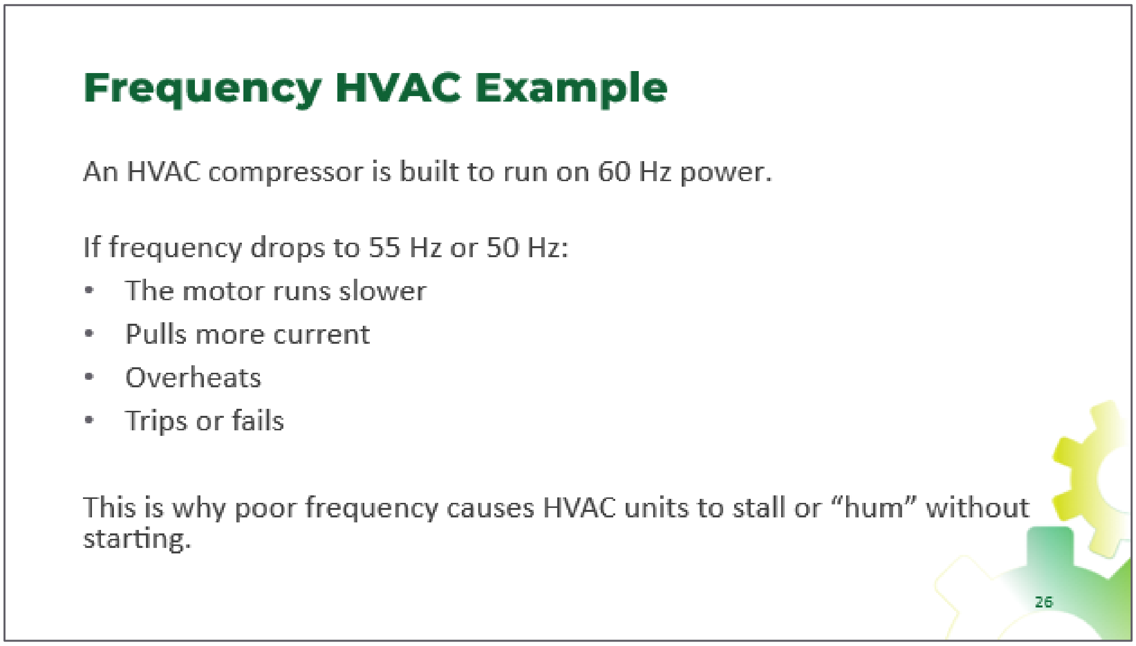
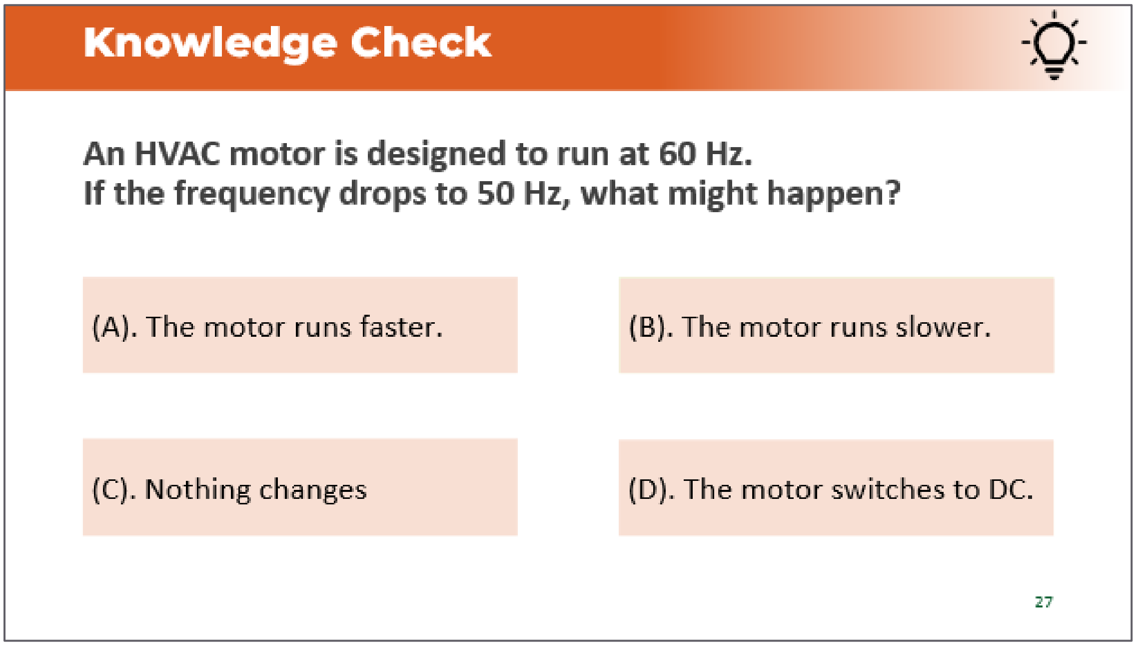


Notes:

- Many HVAC compressors are designed to operate on 60 Hertz power, which is the standard electrical frequency in the United States.
- When the electrical system is operating at that correct frequency, the compressor motor runs at the proper speed, and the system functions normally.
- If the frequency drops below the expected level, such as to 55 Hertz or even 50 Hertz, the motor may not operate as designed.
- The motor can begin to run more slowly because its **speed** is closely related to the **electrical frequency**.
- As the motor struggles to maintain operation, it may start drawing more electrical current. This extra current can cause the motor to **overheat**.
- If the problem continues, protective devices may trip, or the motor may fail.
- Sometimes you may hear the motor “hum” but not start. That sound often indicates the motor is receiving power but cannot start properly due to electrical conditions or load issues.
- This example shows why maintaining the correct electrical frequency is important for reliable equipment operation.


Knowledge Check
An HVAC motor is designed to run at 60 Hz.
If the frequency drops to 50 Hz, what might happen?
(A). The motor runs faster.
(B). The motor runs slower.
(C). Nothing changes
(D). The motor switches to DC.
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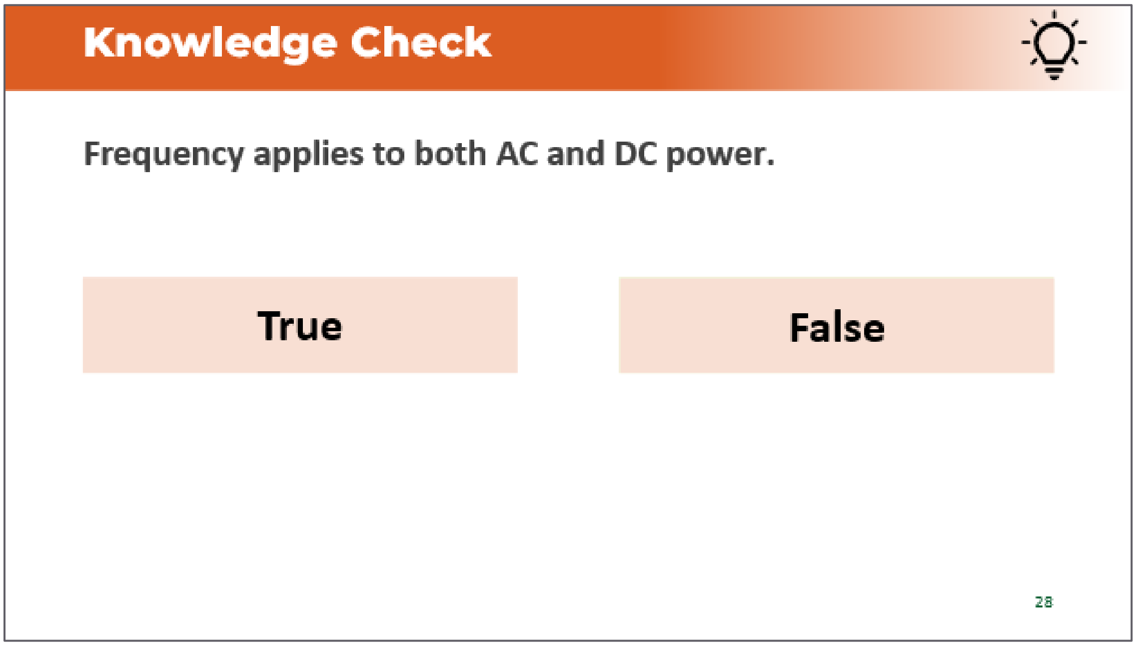
Knowledge Check
Frequency applies to both AC and DC power.
True
False
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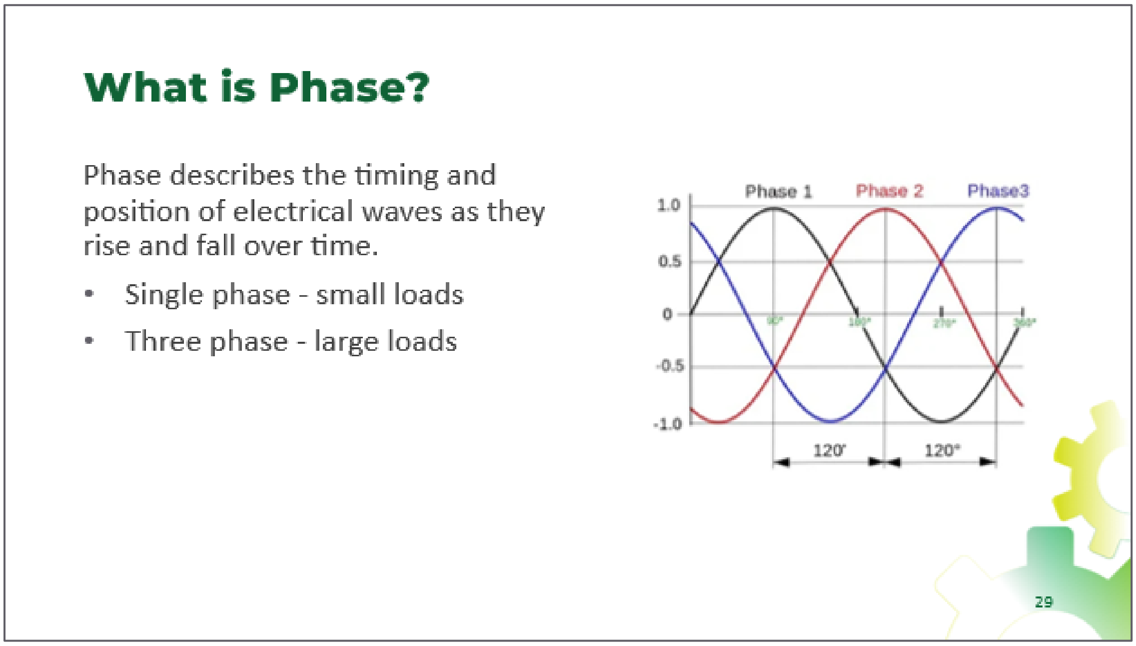

Notes:

- Now let’s introduce another important AC concept called phase.
- When we talk about **phase** in electricity, we are referring to the timing and position of electrical waves as they rise and fall over time.
- In AC systems, electricity moves in a repeating waveform. When multiple waves are present, phase describes how those waves are spaced or timed relative to one another.
- Managing phase correctly helps keep electrical power balanced across circuits.
- This becomes especially important in systems that use multiple phases, such as three-phase power systems commonly found in industrial and transit environments.
  - **Single-phase power** is typically used for smaller electrical loads, such as lighting or basic equipment.
  - **Three-phase power** is used for larger loads, especially electric motors and heavy-duty equipment, because it delivers power more smoothly and efficiently.
- If phase becomes unbalanced or out of sync, several problems can occur. Circuits can become overloaded, equipment can operate inefficiently, and electrical components may be damaged.
- A helpful way to think about phase is to imagine it as the rhythm of the electrical current—if it’s out of sync, everything else can fall apart.

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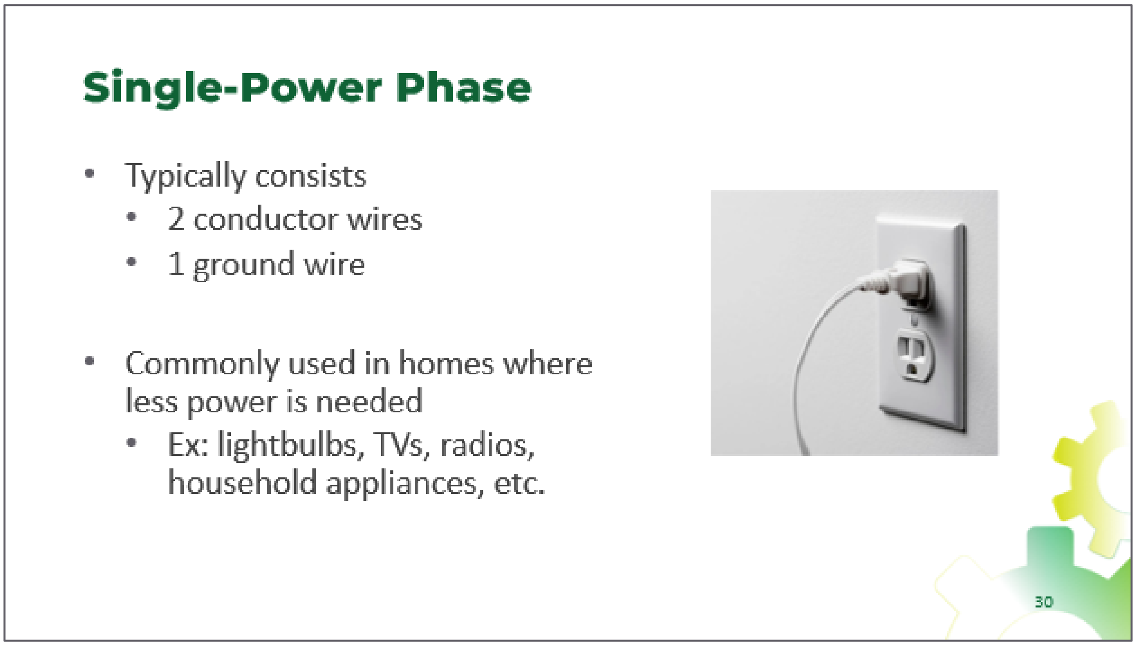
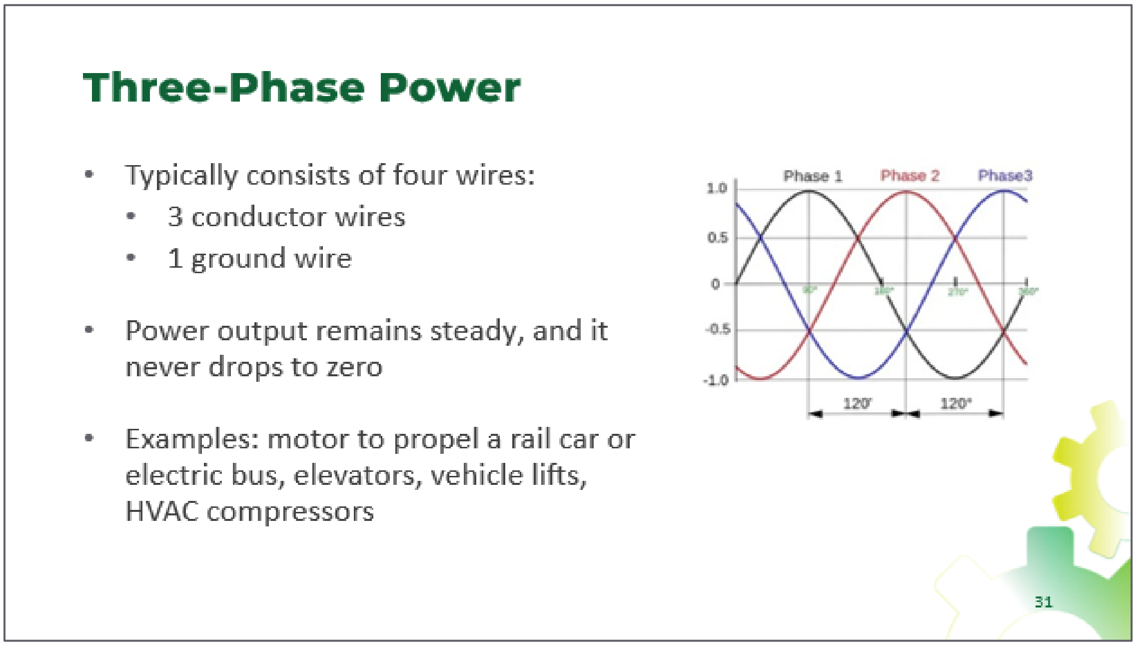


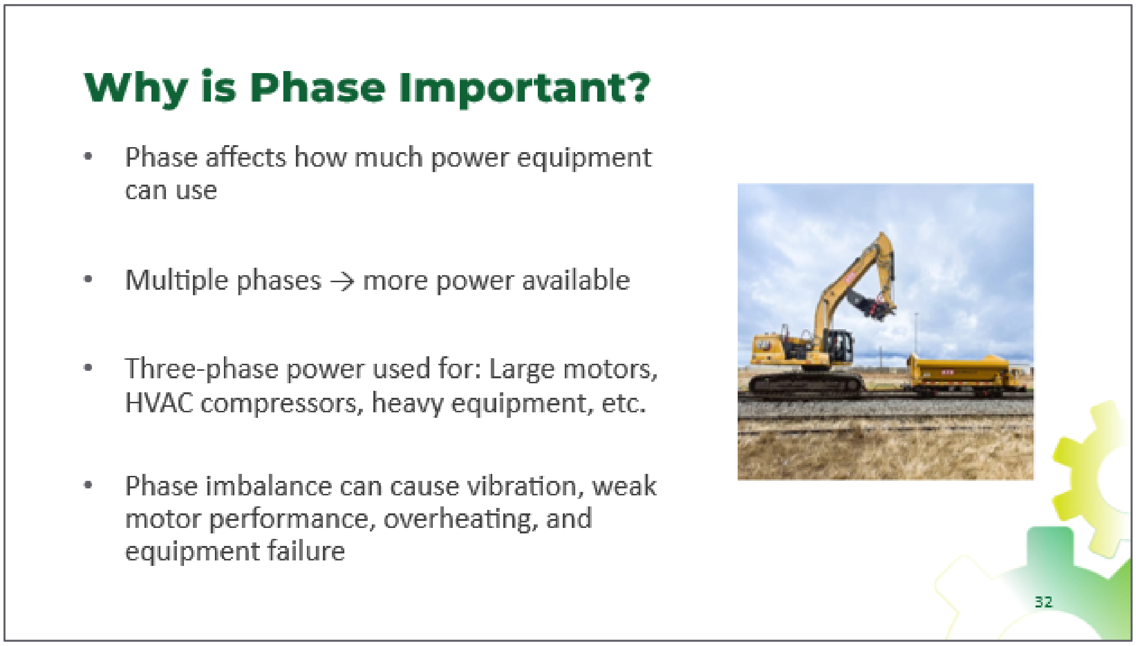
Notes:

- Single-phase power is the most common type of electrical power used in homes and small buildings.
- Because it is widely used in residential settings, it is sometimes referred to as "residential voltage."
- **Single-phase systems** typically include two current-carrying conductors along with a ground wire for safety.
- This type of power is used where smaller amounts of electricity are needed.
- Common examples include lighting, televisions, radios, phone chargers, and many household appliances.
- You will also find single-phase power used in many shop outlets and light-duty equipment.
- Even though the current is constantly alternating direction, the change happens extremely fast.
- Single-phase power works well for everyday electrical loads, but larger equipment and motors often require a different system called three-phase power.



Notes:

- **Three-Phase Power** typically consists of four wires: **1 neutral wire** and **3 conductor wires**.
- In this type of system, the power output remains steady, and it never drops to zero.
- During one cycle, three-phase systems can transmit 3x as much power as a single-phase system.
- It is worth mentioning that there is a second phase, but we will not be discussing it in this module.
- With 3-phase power, it's multiple phases that overlap one another. Always a positive and negative happening at the same time.
- Examples of three-phase power include heavy-duty motors, such as motors that propel RC or drive an escalator/elevator.



Notes:

- Phase is important - it affects **how much** electrical power equipment can safely and efficiently use.
- When electrical systems use multiple phases, such as three-phase power, they can deliver more power to equipment.
- More electrical power means the equipment can perform more work. This is why large motors and heavy-duty equipment often rely on three-phase power.
- In industrial environments and transit systems, three-phase power is commonly used for equipment like large HVAC compressors, pumps, and high-horsepower motors.
- Three-phase systems also provide smoother and more consistent power to motors, which helps them run more efficiently.
- However, problems can occur if the phases become unbalanced or if one phase drops out.
- When that happens, motors and other equipment may begin to vibrate, lose power, overheat, or eventually fail.

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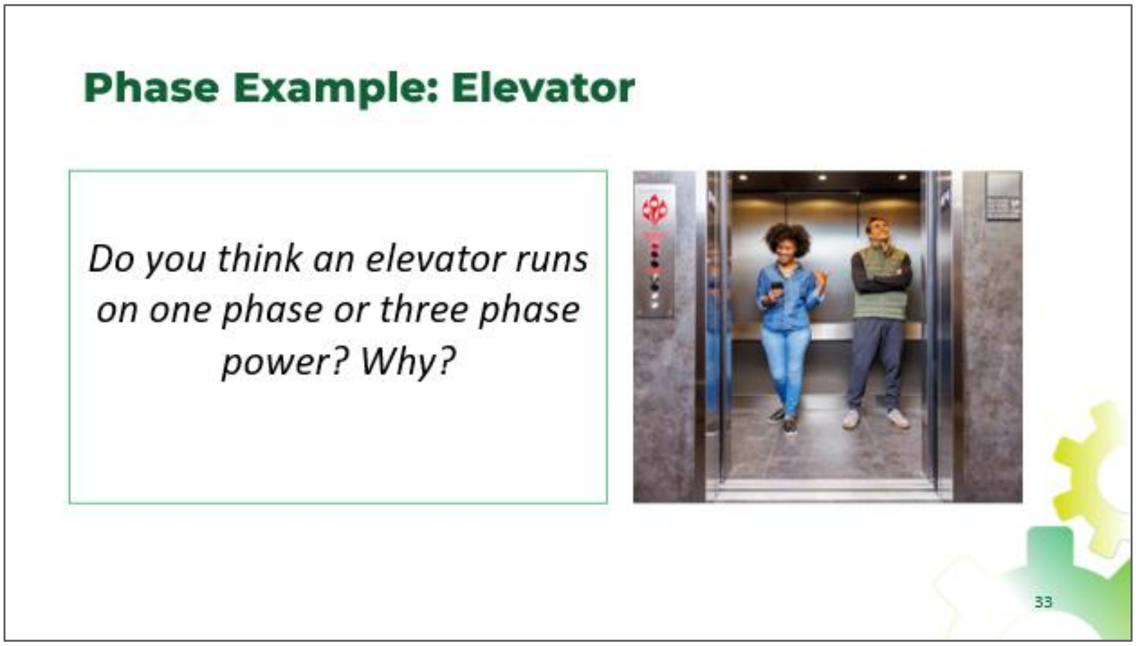

Notes:

- Elevators use large electric motors to lift and lower heavy loads. Because of the power required, these motors typically operate on three-phase electrical systems.
- Three-phase power provides a steady and efficient flow of energy that allows large motors to run smoothly and produce enough torque to move the elevator.
- If one of the phases is missing or drops out, the motor no longer receives balanced power.
    - When that happens, the elevator motor may begin to vibrate or run unevenly.
- The motor may also run slower or weaker because it is not receiving the full amount of power it was designed to use. In some cases, the elevator may not lift at all.
- If the problem continues, the motor can overheat or fail due to the imbalance in electrical power.
- This example shows why *maintaining proper phase balance* is important for large equipment that relies on three-phase power.

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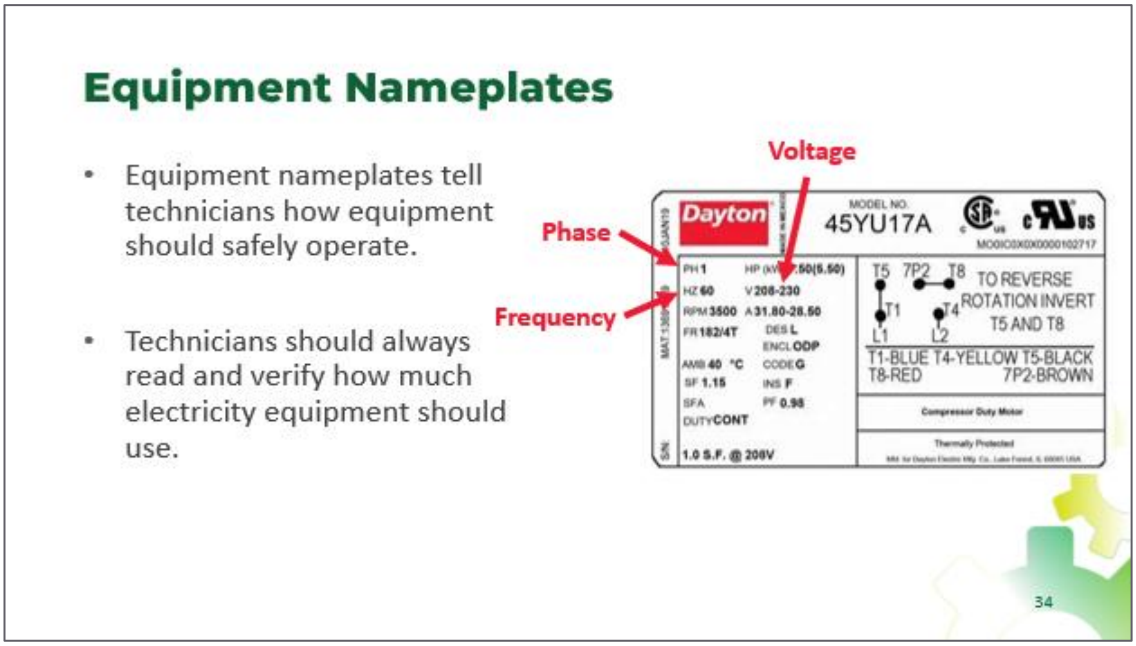
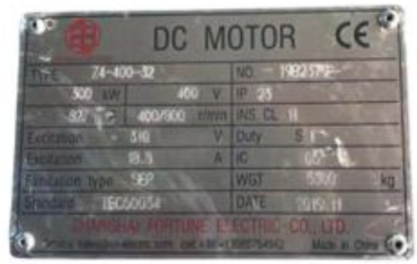


Notes:

- Equipment nameplates, sometimes called rating plates or labels, provide important information about how equipment is designed to operate.
- These labels help technicians quickly identify what they are working on and what electrical values the equipment should normally use.
- A nameplate typically lists important details such as voltage, current, frequency, and sometimes phase requirements.
- When troubleshooting equipment, technicians often compare the expected values listed on the label with what they measure in the system.
- Meters show what is actually happening in the circuit at that moment.
    - If the meter readings are close to the values listed on the equipment label, the system is likely operating normally.
    - If there is a large difference between the label values and the meter readings, it usually means something in the circuit has changed, or a problem may be present.

AC vs. DC Nameplates

Feature	AC Nameplate	DC Nameplate
Voltage	Listed as AC voltage	Listed as DC voltage
Frequency	Includes frequency (ex: 60 Hz or 50 Hz)	No frequency listed
Phase	May list or three-phase	Phase not listed
Current	May show amps at a specific voltage and phase	Shows current draw at DC voltage



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Notes:

- Use the chart to review the differences between DC and AC nameplates.

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What to Look For on Equipment Nameplates

- **Voltage**
  - Required voltage?
  - AC or DC?
- **Current**
  - How much current does it draw?
- **Phase & Frequency (AC only)**
  - Single-phase or three-phase?

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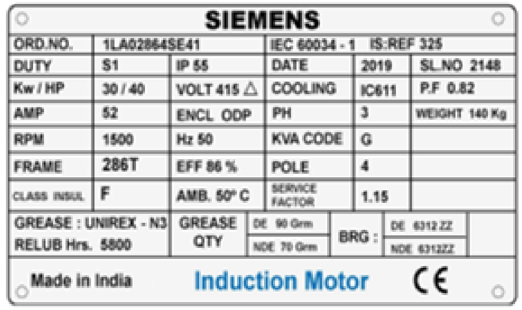
Activity: Reading Nameplates

Review the nameplate to determine the following:

- Does this equipment run on **AC or DC**?
- What is the **voltage**?
- What is the **current**?
- What is the **frequency**? (if applicable)
- What is the phase? (if applicable)



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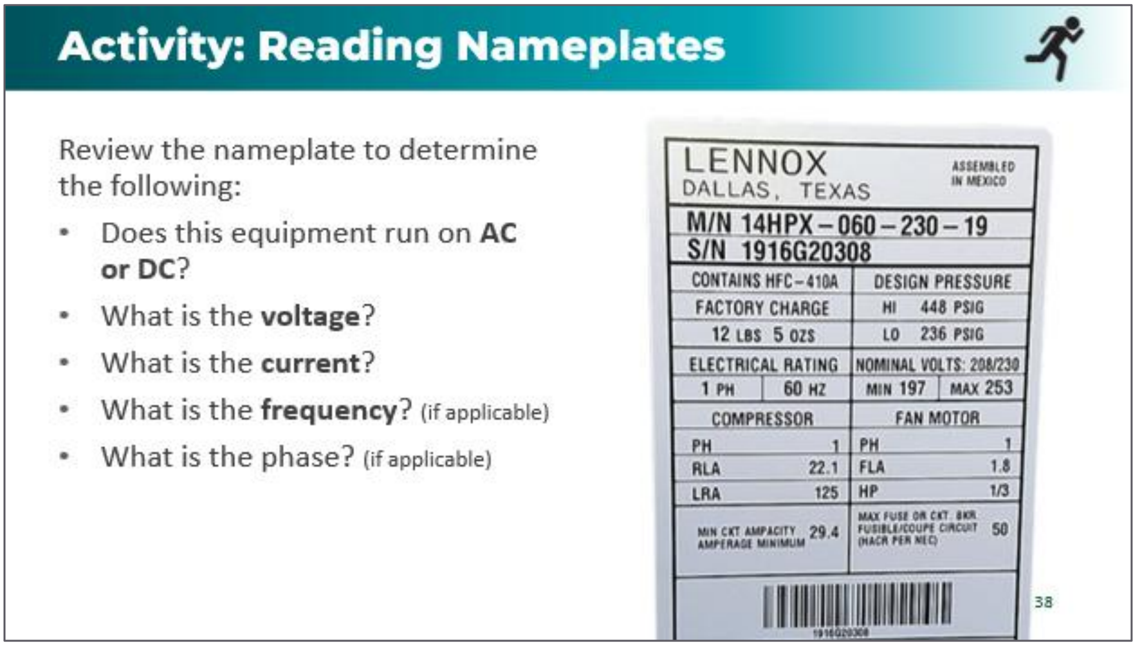
Activity: Reading Nameplates
Review the nameplate to determine the following:
• Does this equipment run on AC or DC?
• What is the voltage?
• What is the current?
• What is the frequency? (if applicable)
• What is the phase? (if applicable)
LENNOX
DALLAS, TEXAS
ASSEMBLED IN MEXICO
M/N 14HPX – 060 – 230 – 19
S/N 1916G20308
CONTAINS HFC – 410A
DESIGN PRESSURE
FACTORY CHARGE
HI 448 PSIG
12 LBS 5 OZS
LO 236 PSIG
ELECTRICAL RATING
NOMINAL VOLTS: 208/230
1 PH
60 HZ
MIN 197
MAX 253
COMPRESSOR
FAN MOTOR
PH 1
RLA 22.1
LRA 125
PH 1
FLA 1.8
HP 1/3
MIN CKT AMPACITY AMPERAGE MINIMUM 29.4
MAX FUSE OR CKT. BKR. FUSIBLE/COUPE CIRCUIT (HACR PER NEC) 50
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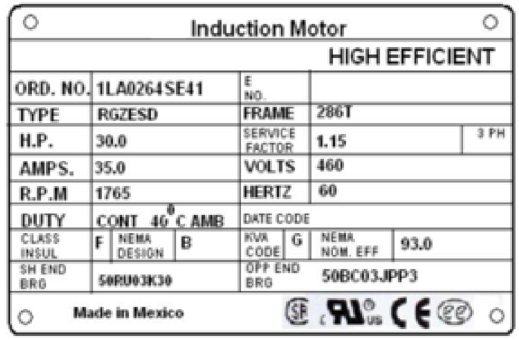
Activity: Reading Nameplates

Review the nameplate to determine the following:

- Does this equipment run on **AC or DC**?
- What is the **voltage**?
- What is the **current**?
- What is the **frequency**? (if applicable)
- What is the phase? (if applicable)



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Knowledge Check

Which type of power is typically used for large motors?

(A). Zero Phase

(B). Single Phase

(C). Double Phase

(D). Three Phase

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Knowledge Check

If one phase drops out of a three-phase system, what might you observe?

(A). Equipment runs smoother

(B). Equipment shuts off permanently

(C). There would be faulty equipment operation

(D). It switches to DC automatically

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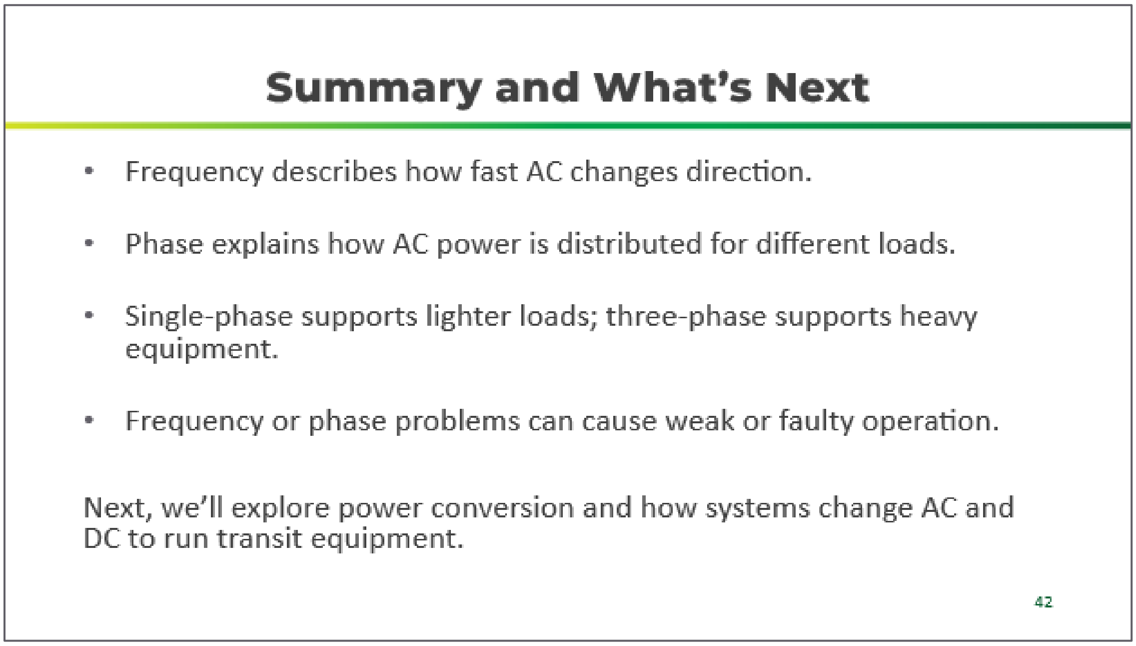

Notes:

- **Frequency** describes how fast alternating current changes direction. In the United States, most electrical systems operate at a frequency of 60 Hertz.
- **Phase** explains how AC power is distributed across electrical circuits, especially in systems that use multiple phases.
- **Single-phase power** is typically used for lighter electrical loads, such as household equipment and smaller devices.
- **Three-phase power** is used for larger equipment, especially motors and heavy-duty systems that require more power.
- When frequency or phase conditions are incorrect, **equipment may run weak**, operate inefficiently, or fail.
- Understanding these concepts helps technicians recognize electrical problems and understand how power systems support transit equipment.
- Next, you will look at power conversion and explore how electrical systems change AC power to DC power and DC power to AC power to operate different types of equipment.

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Notes:

- Most systems don't run on just AC or just DC, they need both. That's where power conversion comes in.

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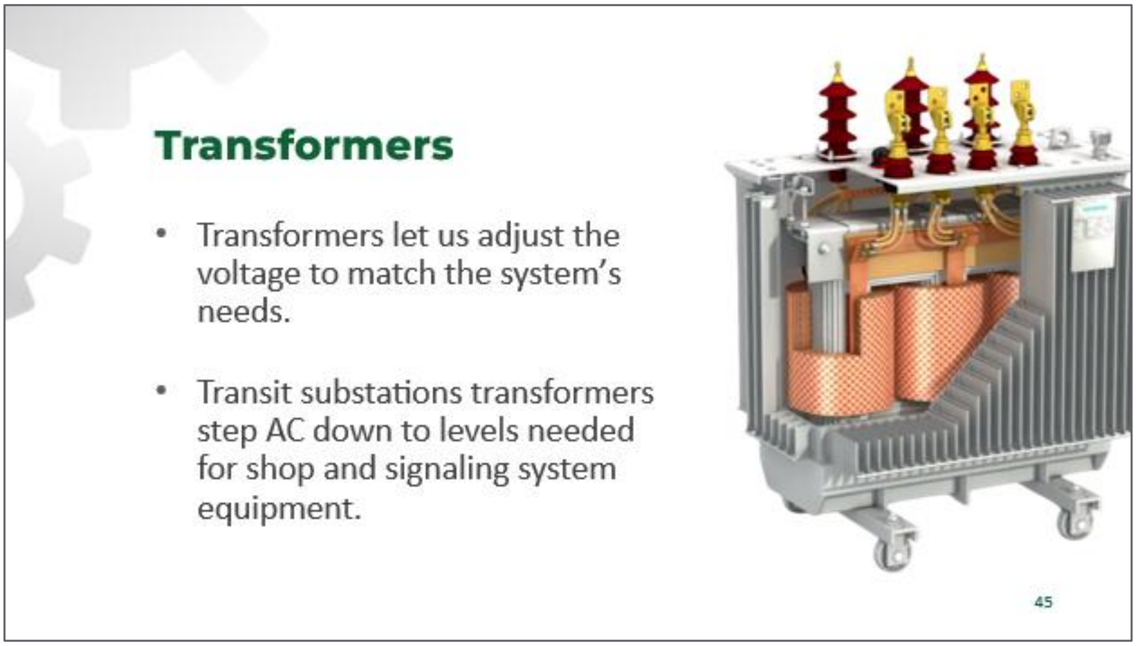
Notes:

- Electrical power conversion is all about adapting electricity to fit a specific purpose, whether that's powering a small device, running a motor, or charging a battery.
- We often **convert** AC to DC when charging things like phones or powering electric buses.
- Sometimes we need to **raise or lower voltage** levels, and that's where **transformers** come in.
- Each of the devices listed, transformers, inverters, rectifiers, and converters, plays a unique role in making sure power is delivered in the right form, at the right level, and to the right place.
- You'll see conversion happening everywhere: chargers, substations, inverters, DC-DC converters, propulsion systems. If a converter fails, whole systems shut down.
- If conversion fails, equipment operation and systems like HVAC, propulsion, or charging may stop working.



Notes:

- Transformers let us adjust the voltage to match the system's needs.
- You've probably seen them in your neighborhood—those gray cans on utility poles or large green boxes on the ground are transformers.
- They step down the high-voltage electricity from power lines to a safer level for homes and businesses.
- In transit systems, transformers are used at substations, where power from the utility company is delivered in bulk.
- The substation steps it down to levels that are safe and usable for rail vehicles, station systems, and onboard equipment.
- Transformers can be on poles and other locations and are not limited to substations.

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Rectifier

Rectifiers convert AC into DC

Common in these systems:

- Battery charges
- Onboard electronics
- Rail power systems
- Power supplies
- Switch machine power circuits

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Notes:

- A **rectifier** does the opposite of what an inverter does—it converts **AC** power into **DC** power.
- This is important because many systems, especially those involving batteries or sensitive electronics, require DC power to function properly.
- In transit applications, rectifiers are used in substations to take AC power from the grid and convert it to DC for use by trains, buses, or control systems.
- You'll also see rectifiers in battery chargers—like the ones used in electric vehicles—or inside power supplies that run electronics like radios or fare machines.
- The goal is to deliver smooth, unidirectional current that can be stored in batteries or used directly by DC-based equipment.

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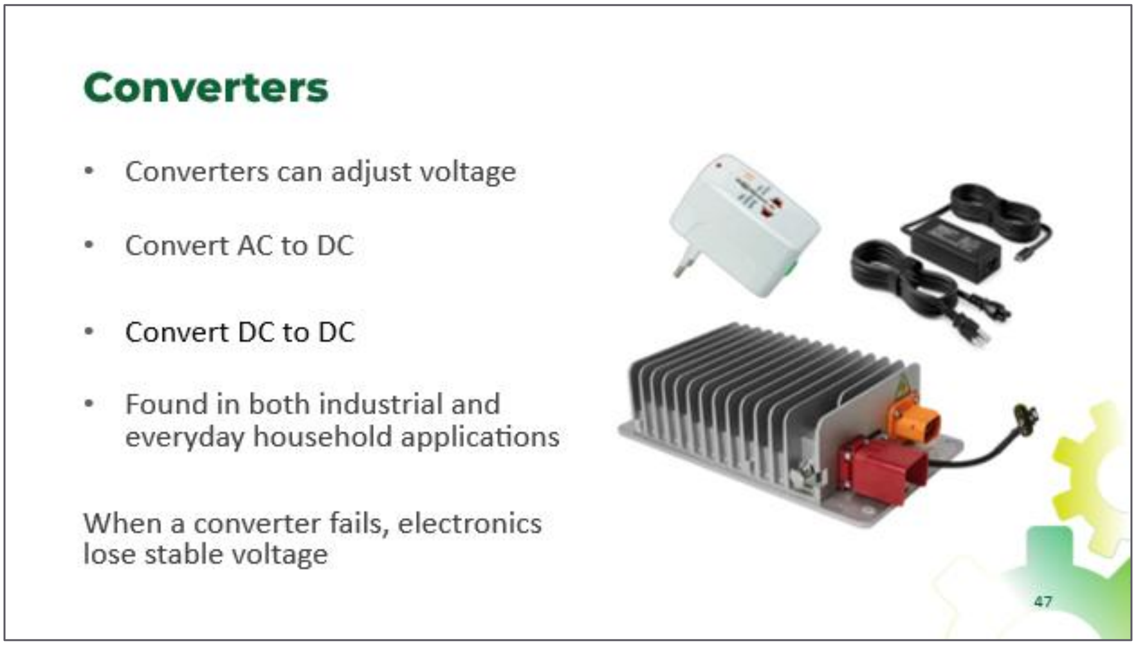
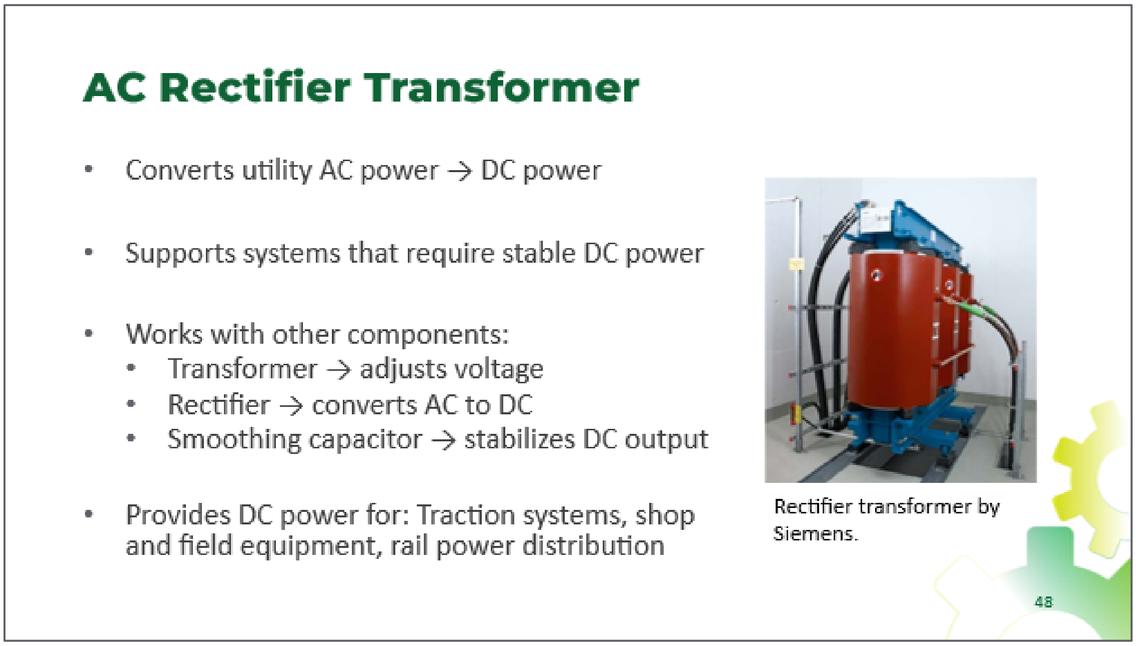


Notes:

- **Converters** are versatile tools in electrical systems. They allow us to adjust how electricity behaves so it can safely and efficiently power different types of equipment.
- You'll find converters in everything from electric buses and rail vehicles to solar power systems and charging stations.
- Converters aren't just found in big machines or transit systems—they're all around us at home, too.
- That power brick on your laptop charger - It's a converter. It takes in high-voltage AC from the wall and changes it into safe, low-voltage DC for your device.
- So even though converters can seem like high-tech tools, they're actually working behind the scenes in your home every day to make sure electricity is safe, stable, and usable.



Notes:

- Many transit systems receive electricity from the utility grid as alternating current, or AC power. However, some rail systems and equipment require direct current, or DC power, to operate properly.
- To make this possible, the electrical system must convert AC power into DC power.
- This conversion often happens at a **traction power substation** using equipment that includes a **transformer**, a **rectifier**, and other supporting components.
  Here's how it works:
  1. The transformer first adjusts the voltage level coming from the electrical grid, so it matches what the rail system requires.
  2. Next, a rectifier converts the AC electricity into DC electricity. After that, smoothing capacitors help stabilize the DC output by reducing electrical ripple and fluctuations in the current.
- Together, these components provide stable and reliable DC power for systems that require it.

Inverters

- Inverters convert DC to AC
- Used for: HVAC, AC loads on hybrid/electric vehicles, rail car propulsion systems
- *Example*: DC traction power is changed to AC by the inverter on the rail car

Inverter Installed on a Train Courtesy of MBTA.

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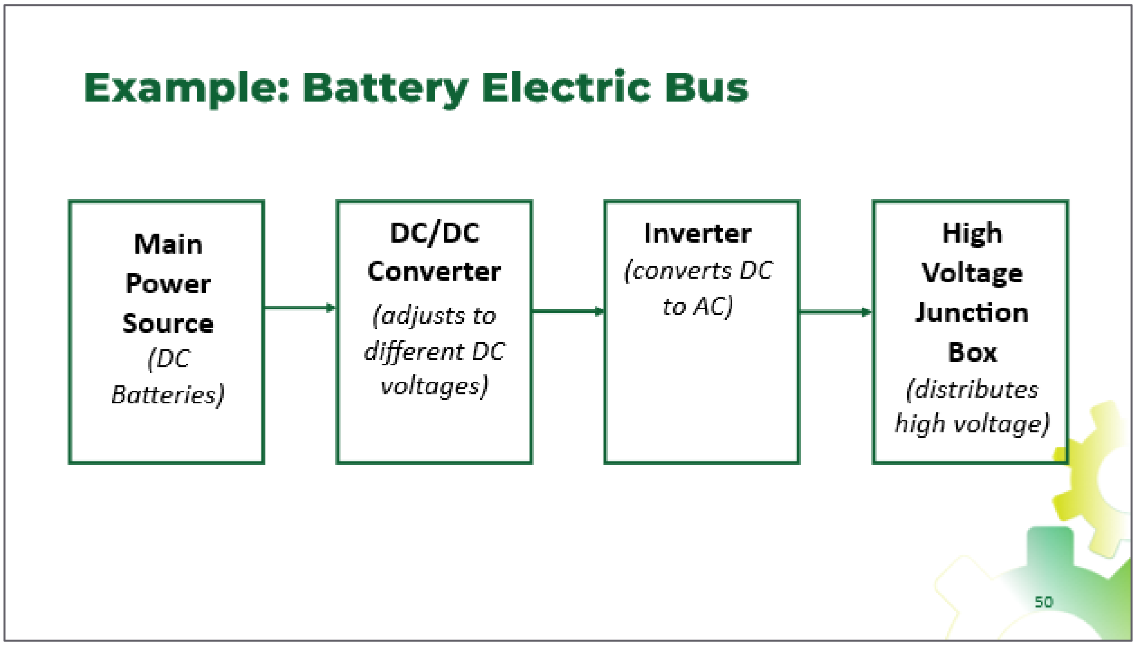
Notes:

- As we have learned, DC and AC are different types of power. Technology exists to change power from one form to another for our needs.
- **Inverters** are devices used to convert DC input voltage to AC voltage for output.
- In electric transit vehicles, the battery stores power as DC, but the traction motor, air compressor, and HVAC system often need AC.
- The inverter acts like a bridge, converting the battery's power into something those systems can use.
- This photograph, courtesy of MBTA, depicts a propulsion inverter installed on a train. It is used to convert incoming DC high-voltage power to AC power, which is used to drive the traction motors.



Notes:

- This diagram illustrates a bus power system in which energy undergoes conversion.
- The charger/discharger power converter assists in regulating the DC bus voltage and interfaces with the battery.

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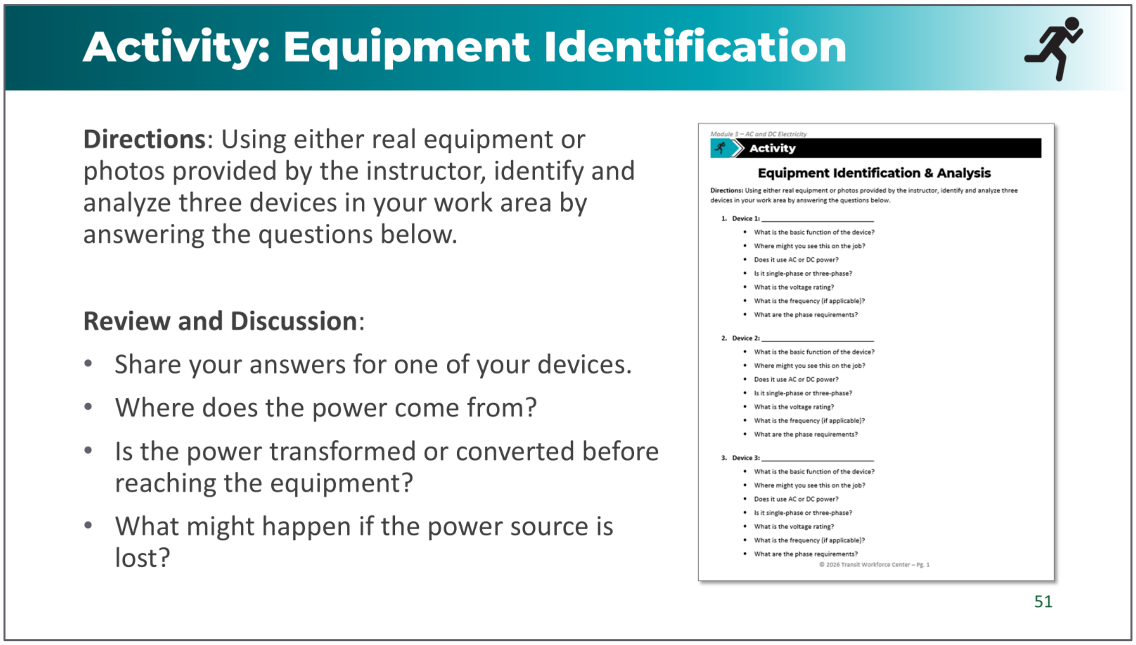

Notes:

- Take a field trip to your work environment to visit different pieces of equipment (rectifier, transformer, inverter, capacitor, etc.).
- Work in pairs or small groups to answer the questions on their handout for each device.
- Rreference equipment nameplates or labels if available.
- Regroup back in the classroom or in a place suitable for discussion. Be ready to share your answers.
- This activity helps connect the electrical concepts we've discussed to real equipment you may encounter on the job.
- We are going to take a brief fieldtrip to the shop floor to analyze a few pieces of equipment.
- Work with a partner or small group to answer the questions on your handout for three different devices.
- Use the nameplate on the devices to help you answer the questions.
- After you have had some time to work, we'll regroup to review and discuss.

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Activity

Equipment Identification & Analysis

Directions: Using either real equipment or photos provided by the instructor, work in groups or pairs to identify and analyze three devices in your work area by answering the questions below.

1. **Device 1: ________________________________**
    - What is the basic function of the device?
    - Where might you see this on the job?
    - Does it use AC or DC power?
    - Is it single-phase or three-phase?
    - What is the voltage rating?
    - What is the frequency (if applicable)?
    - What are the phase requirements?

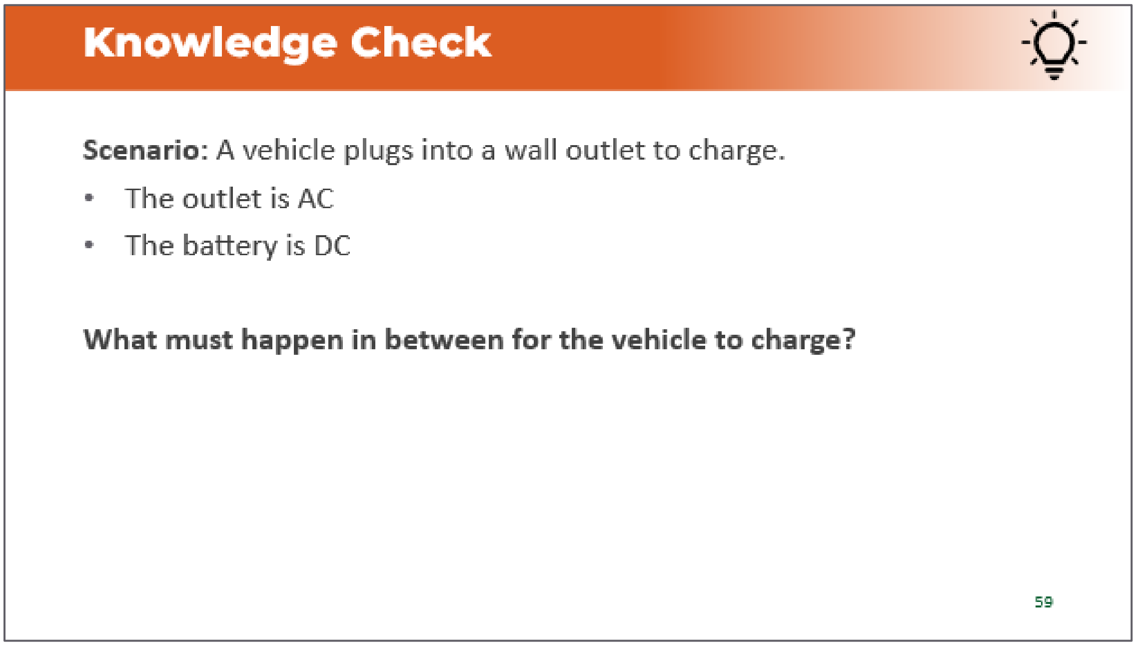
2. **Device 2: ________________________________**
    - What is the basic function of the device?
    - Where might you see this on the job?
    - Does it use AC or DC power?
    - Is it single-phase or three-phase?
    - What is the voltage rating?
    - What is the frequency (if applicable)?
    - What are the phase requirements?

3. **Device 3: ________________________________**
    - What is the basic function of the device?
    - Where might you see this on the job?
    - Does it use AC or DC power?
    - Is it single-phase or three-phase?
    - What is the voltage rating?
    - What is the frequency (if applicable)?
    - What are the phase requirements?

Discussion Questions:

- Where does the power come from?
- Is the power transformed or converted before reaching the equipment?
- What might happen if the power source is lost?

Notes:


Knowledge Check
Scenario: A vehicle plugs into a wall outlet to charge.
• The outlet is AC
• The battery is DC
What must happen in between for the vehicle to charge?
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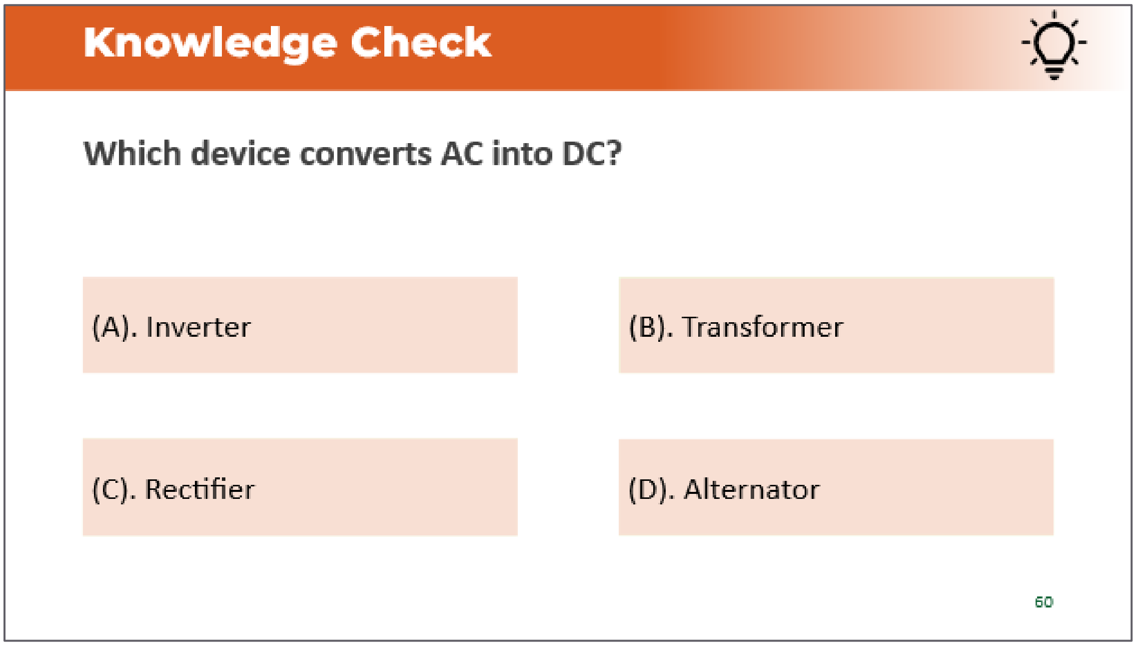
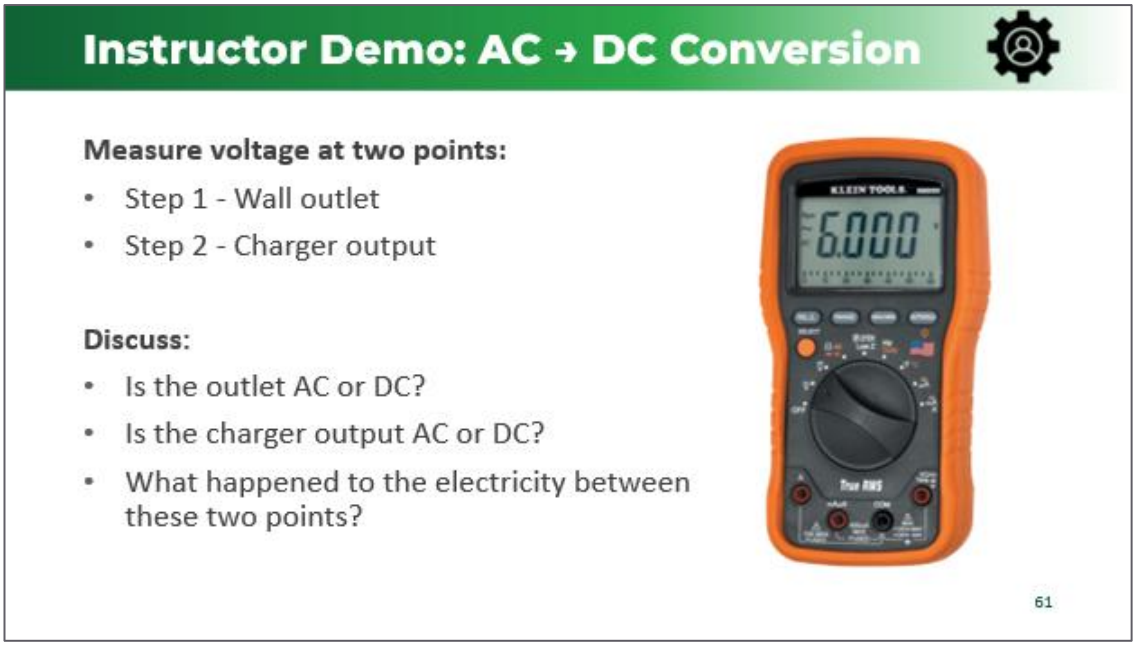
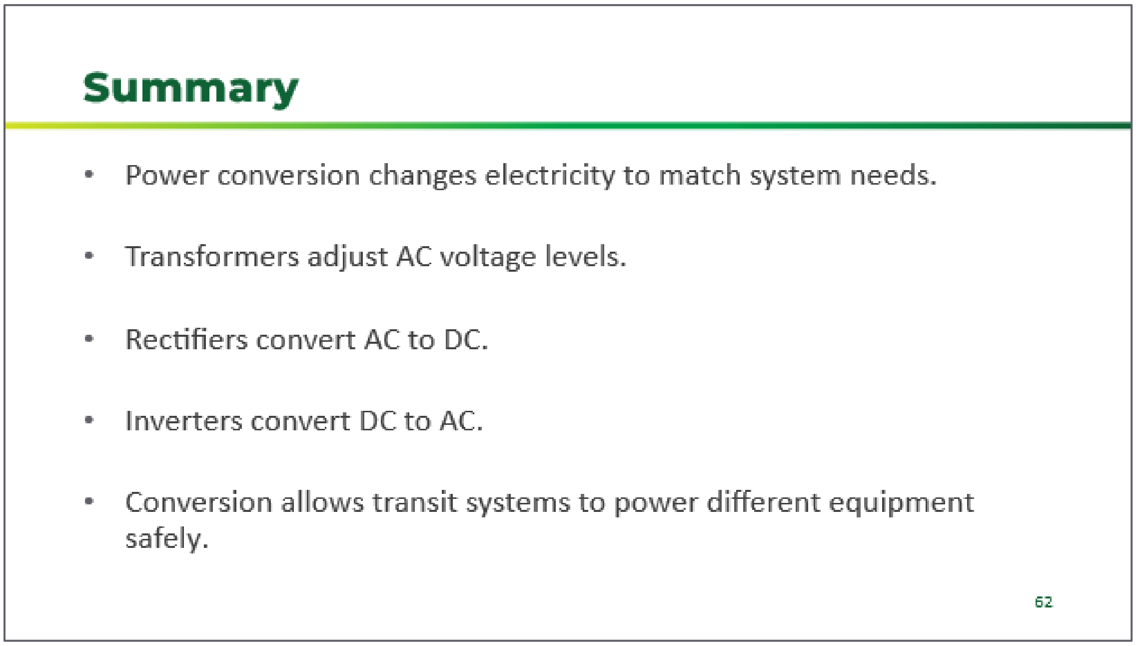

Knowledge Check
Which device converts AC into DC?
(A). Inverter
(B). Transformer
(C). Rectifier
(D). Alternator
60



Notes:

- A **multimeter** is a handheld instrument used to measure key electrical properties in a circuit, including voltage, current, and resistance.
- **First**, we measure the voltage at the wall outlet. In most buildings, the electrical outlet provides alternating current, or AC power.
- **Next**, we measure the voltage at the charger output.
    - You should see that the charger output is direct current, or DC power.
- The charger contains electronic components that convert the incoming AC power into DC power.
- This type of conversion is very common in electrical systems.
- Many devices, including electronics, battery chargers, and vehicle systems, require DC power even though electricity is delivered from the grid as AC power.



Notes:

- **Power conversion** allows electrical systems to change electricity, so it matches the needs of different equipment.
- In many cases, the electricity coming from the grid must be adjusted or converted before it can be used by a device.
- **Transformers** are used to adjust AC voltage levels so that the power delivered matches what equipment requires.
- **Rectifiers** convert alternating current into direct current.
- **Inverters** do the opposite by converting direct current into alternating current.
- These different types of **conversion** allow transit systems to safely power a wide range of equipment, including electronics, motors, batteries, and traction systems.
- Understanding how electricity is converted helps technicians understand how power moves through electrical systems and where problems may occur.

Notes:

- Time for a quiz! Let's see what you have retained from today's lesson.

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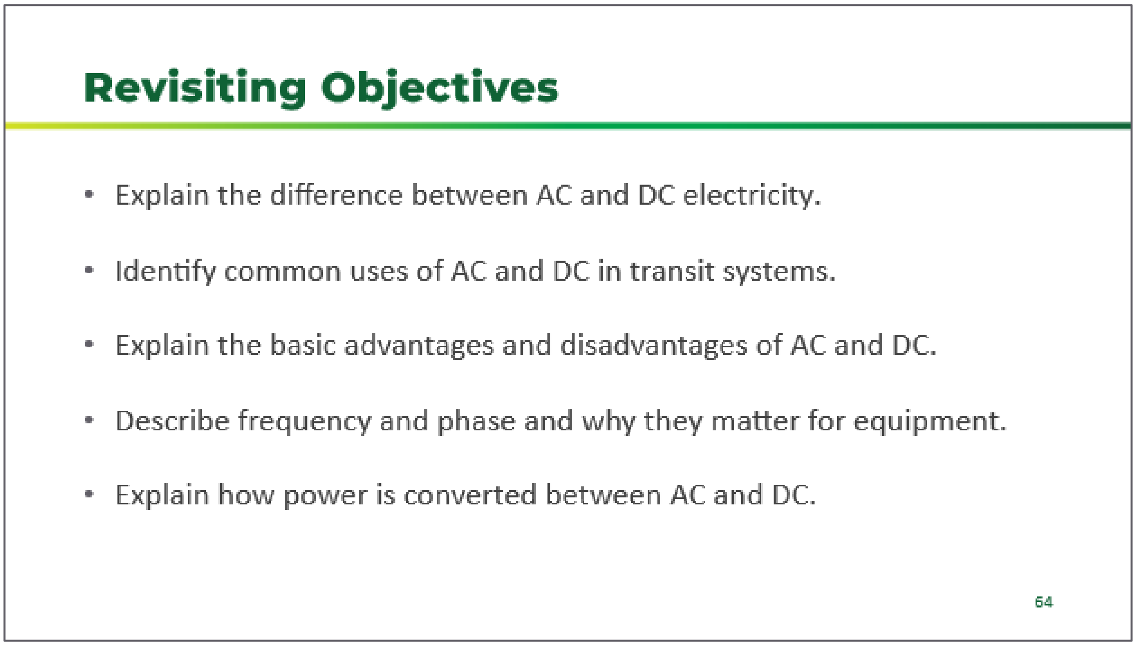

Notes:

- If you were explaining today's objectives to someone else, how would you summarize what they mean and why they matter?
- Which of today's objectives do you feel most confident about? Which were most challenging? Explain your reasoning.
- Can you give an example of how you could apply one of today's objectives in a real-world situation?