



COURSE: Battery Electric Bus Familiarization

Name _____

Date _____

Experience repairing/maintain with hybrids? YES / NO _____

If YES, how much/where? _____

Pre-Course Assessment

1. **Circle** the correct answer. Which of the following are components that are *similar* in both traditional and battery electric buses?
 - a) Air system and power steering
 - b) Axles
 - c) Low voltage 12V and 24 V systems
 - d) Grounding process
 - e) Multiplexing and I/O systems
 - f) Cooling systems
 - g) CAN systems and principles
 - h) Doors and ADA equipment
 - i) All are similar between bus types

2. **Circle** the correct answer. Which of the following are components that are *different* between both traditional and battery electric buses?
 - a) Powertrain
 - b) HV batteries and HV battery management systems
 - c) Charging methods and equipment
 - d) All of these are different between bus types
 - e) None of these are different between bus types

3. Use the phrases from the word bank to fill in the blanks to describe the process of power flow on a BEB:
 - a) *ESS, AC waveform, never a positive and negative of the same phase at the same time, alternate, magnetic attraction, contactors, high voltage junction box [HVJB], traction motor*

BEBs however, will use the energy stored in the _____ to power a traction motor, which is connected to the drive axle.

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In any instance where a subsystem was driven by an accessory belt on a diesel bus, an appropriately-sized electric motor is used to drive that accessory. The 3-phase inverters switch high voltage DC energy on and off to create an _____.

Essentially, you are switching on—whether it be two positive phases, or two negative phases—but _____.

In order to turn the rotor inside the traction motor, power is supplied to the coils to generate a magnetic field in each. To continue the rotation of the rotor, the pattern needs to _____.


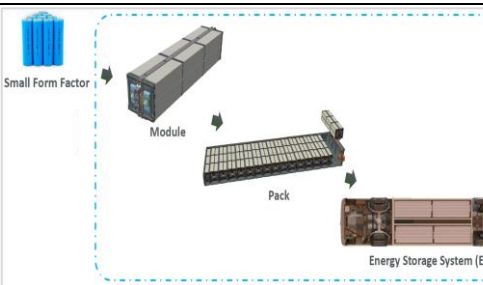
An AC motor works by applying alternating current to stator windings, which produce a rotating magnetic field in the rotor. The rotor will then start to follow the rotating field and stator windings due to the _____.

Starting off, after initial safety checks are performed by the controllers, the _____ inside the high voltage batteries are commanded closed to supply power to the high voltage system




High voltage power from the ESS is sent first to the _____ for distribution amongst the high voltage subsystems

From the HVJB, high voltage power is supplied to the _____ and inverted to provide acceleration to move the bus bottom.

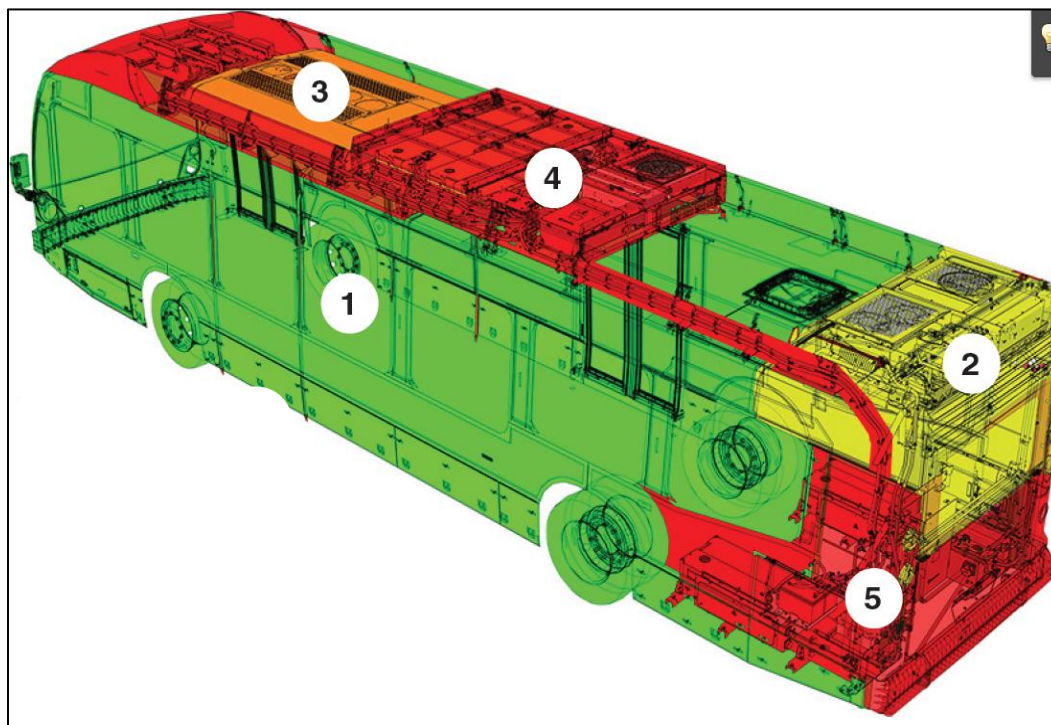
4. Use the table below to fill in the missing section of detail for the components:

Component	Function	Image
	This port is used to connect the depot's installed charging equipment to the bus. This allows for controller area network [CAN] communication between the vehicle charge controller and the charging equipment.	
Energy Storage System (ESS)		

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High Voltage Junction Box [HVJB]		
	A liquid cooled component that used to change high voltage DC to low voltage DC ("step down" HV). These converters charge the low voltage batteries and supply low voltage power when the high voltage system is enabled.	
	Used throughout the bus to monitor and control the high voltage and low voltage power. They help ensure the safe operation of all subsystems on the bus.	

5. Using the image below to answer the question: Which components in areas 4 and 5 have high voltage?



6. **Circle** the correct answer. Which of the following is not a component of a BEB that utilizes a coolant loop/cooling management?
- DC/DC Converter
 - Battery Coolant loop
 - Power Electronics coolant loop
 - Coolant temperature sensors
 - Coolant loop filters
 - All of them utilize coolant loops/cooling management
7. **True or false.** CAN systems are a type of serial communications protocol that allows electronic units to communicate and share essential vehicle control data and allows data to be packaged together, reducing the number of transmissions necessary.
8. Use the phrases from the word bank to fill in the blanks to describe the multiplexing system theoretically operates:
- Input, signal, other modules, act, output, other modules*
- An _____ is received by a module (from a switch, sensor, etc.).
The input acts as a _____ (of voltage or ground from a switch, sensor, etc.).

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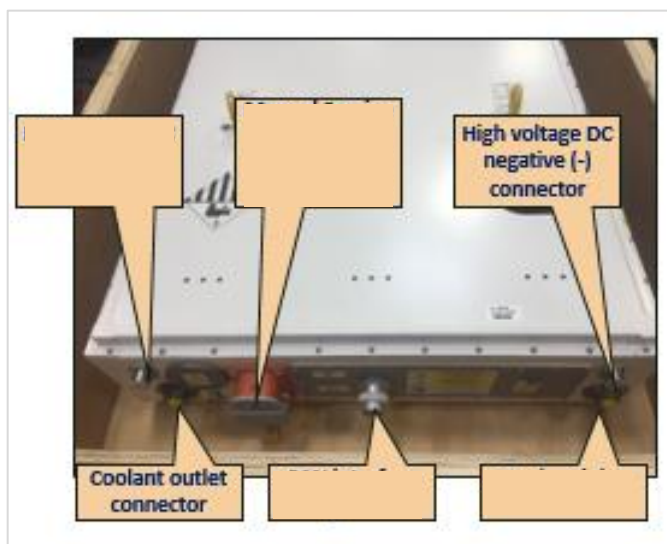
That module will then send a signal over the communication network to the _____.

The other modules are programmed to _____ when they receive a particular command.

An _____ is sent as a signal (voltage or ground) from a module to a load or another device.

The process continues constantly; every module is constantly in communication with the _____.

9. Using the word bank provided, fill in the areas of an ESS battery module in the image below:
- a) High voltage positive (+) connector, Manual Service Disconnect location with battery LOTO, MSD, CAN interface port, Coolant inlet connector

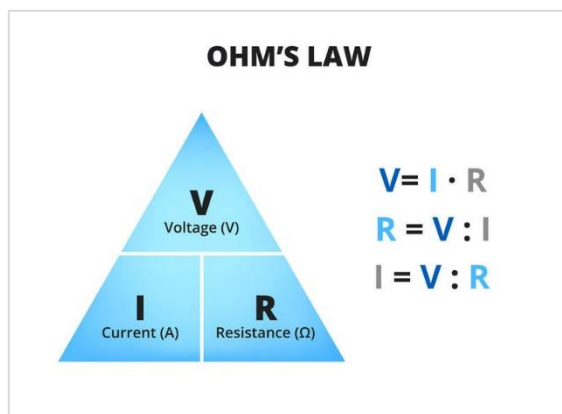


10. **Circle** the correct answer. Which of the following is the purpose of a battery thermal management system [BTMS]?
- a. A low voltage control safety feature
 - b. A device to prevent us from getting exposed to high voltage in the event of leakage in the batteries
 - c. Maintain the internal temperatures of the battery packs to prolong lifespan
 - d. A serial communication network that allows electronic units to share essential vehicle data
11. **True or false.** Preventive maintenance is the act of performing a series of maintenance tasks/activities within a regularly scheduled period to prevent possible outcomes or vehicle failures.

12. **Circle** the correct answer. Which of the following is not a type of diagnostic equipment?

- a. Powertrain dongle
- b. NEXIQ interface tool
- c. Laptop
- d. All of these are diagnostic equipment

13. **Circle** the correct answer. Based on the image in below, which of the following is the common formula for calculating **voltage through Ohm's Law**?



- a. $I \times R$
- b. V^2/P
- c. P/I
- d. V/R

14. **True or false.** High voltage risk can occur with anything over **50 volts**.

15. **True or false.** Always assume the system is safely *de-energized*.

16. **True or false.** You should work on an HV system by yourself because there is no need for a qualified second person to act as an observer and safety backup.

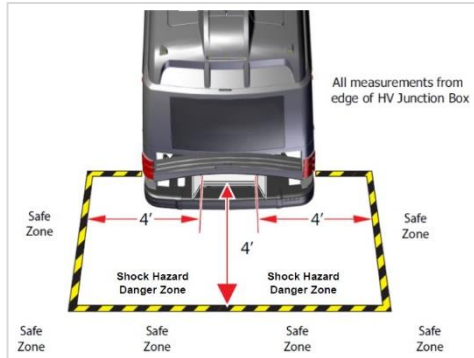

17. What are some risks and considerations that can be associated with arc flashes?

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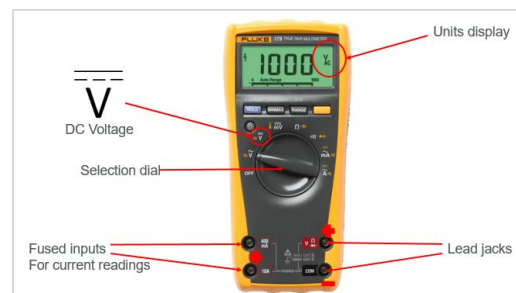
18. **Circle** the correct answer(s). What is a thermal runaway event?
- a) A sudden release of energy or undesired electric discharge the generated intense light and heat, radiating at supersonic speeds
 - b) The electrical disconnect verification procedure(s) for a BEB
 - c) The chance (high or low) that any hazard will actually cause someone harm
 - d) A condition that typically occurs due to increased heat and temperature conditions within the battery packs, that is created when the heat generated within a battery exceeds the amount of heat dissipated to its surroundings.
19. **True or false.** It is critical that the safety observer (monitor/checker) wear the same PPE while in the same approach boundary as the person testing for the absence of voltage.
20. **True or false.** BEB battery packs will be well-encased and include locked/non-conductive covers, venting and are moisture proofed.
21. **Circle** the correct answer. Which of the following is *not* true of the High Voltage Interlock Loop [HVIL]?
- a. When a failure is detected in this circuit **and** the parking brake is set, the vehicle controller will respond with an emergency high voltage shutdown to remove any potential high voltage exposure as quickly as possible
 - b. You can disconnect this without switching off the battery disconnect switch first
 - c. Troubleshooting this system will require that the vehicle be in a low voltage on mode of operation
 - d. The HVIL is a system designed to prevent unexpected exposure to High Voltage – it is not intended as a way to isolate the High Voltage system. High Voltage isolation should always be accomplished via the LOTO process
 - e. All are considerations of the HVIL safety features
22. Describe the options for testing and inspection rubber insulated gloves.

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23. Use the table below to fill in the missing sections of detail for BEB components:

Component	Function	Image
Safety Barricade		 <p>All measurements from edge of HV Junction Box</p> <p>4' 4' 4' 4'</p> <p>Shock Hazard Danger Zone</p> <p>Safe Zone</p>
	<p>A utility tool that acts as an extension pole for you or another person to safely move or remove someone who may have been injured or incapacitated by a source of HV or electrical hazards. The extended length of the hook allows using it to maneuver the incapacitated person without exposing themselves to the same electrical hazard.</p>	

Meters & Digital
Multimeter
[1000v Category
III/600 Cat
IV/10 Mega
Ohm Impedance
(or greater)]



24. Match the correct charging options to their definitions below:

- i. Plug-In or Depot Charging [AC Charger]
- ii. DC Charger
- iii. Overhead
- iv. Inductive/wireless charging

1. _____

- v. A means of charging with a unit at the depot (agency). Initially depot charging was typically an AC charger that was used to replace the diesel fuel nozzle

2. _____

- vi. Has the inverter in the converter [DC], so it will have a bigger cabinet and be more expensive (but that is fine with BEBs). The trade-off is that it can charge faster and requires less time to charge.

3. _____

- vii. Done via overhead using a roof-mounted pantograph charging system. Overhead pantograph typically will incorporate power distribution box and a means of charging

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- viii. Includes pantograph down or pantograph down styles, where the pantograph comes down and charges the bus. The on top of the bus will have rails to accept the power. Overhead chargers are typically pantograph up or down style. This charging method usually requires less battery capacity as charging more frequently on the route
4. _____
- ix. Done via electromagnetic induction, and is a relatively new emerging technology that has been gaining popularity
- i. technology consists of a wireless charging station in the ground (a pad) and with pads on the bus as well
25. **Circle** the correct answer. Given a bus with a battery capacity of 360kWh and an effective charging power of 120 kW, what is the anticipated charge time?
- a. 4.6 hours
b. 3 hours
c. 4 hours
d. 3.6 hours
26. **True or false.** The purpose of a switchgear is to transfer electrical energy from one electrical (AC) circuit to another circuit (even multiple) while either increasing or decreasing voltage.
27. **True or false.** Standard J1772 describes the electrical and physical interfaces between the vehicle and supply equipment in a plug-in configuration to facilitate conductive charging.
28. **True or false.** Standard J2954-2 describes the method of depot charging utilizing smart charging capabilities.
29. List three (3) safety precautions for charger maintenance.