APTA STANDARDS DEVELOPMENT PROGRAM
RECOMMENDED PRACTICE
American Public Transportation Association
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APTA Bus Maintenance Training Working Group

Training Syllabus to Instruct/Prepare for the ASE Transit Bus Electrical/Electronics Test

Abstract: This *Recommended Practice* provides guidelines for establishing a standardized bus maintenance training related to the ASE certification program syllabus for the electrical/electronics systems used in transit buses and coaches.

Keywords: Automotive Service Excellence (ASE) H6, bus, certification, electronics, training, transit

Summary: This *Recommended Practice* provides transit bus maintenance training and transit bus maintenance departments with information to instruct/prepare transit bus technicians and mechanics for the ASE H6 Transit Bus Electrical/Electronic Test and to evaluate, develop or enhance current training programs for the diagnosis, repair and maintenance of transit bus electrical/electronic systems. Individual operating agencies should modify these guidelines to accommodate their specific equipment and mode of operation.

Scope and purpose: This *Recommended Practice* reflects the consensus of the APTA Bus Standards Program members in conjunction with transit labor organizations, including ATU and TWU, on the subject material, manuals and textbooks, test equipment, methods and procedures that have provided the best performance record based on the experiences of those present and participating in meetings of the program task forces and working groups. This document covers basic, intermediate and advanced copper-wired electrical circuits, programmable logic controllers (PLCs) and multiplexing electrical/electronic systems used in transit buses as related to the H6 ASE Certification Test. Although electrical circuits may be referenced for peripheral system electronics used in the control of engines, transmissions, wheelchair lifts, fire suppression systems, etc., the testing for these systems shall be separate and covered by a different test series. APTA recommends the use of this document by organizations that have a training department or conduct training for the maintenance of transit buses, organizations that contract with others for transit bus maintenance training, and organizations that influence how training for transit bus maintenance is conducted.

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Participants

The American Public Transportation Association greatly appreciates the contributions of the **Bus Maintenance Training Working Group**, which provided the primary effort in the drafting of this document.

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Training Syllabus to Instruct/Prepare for the ASE Transit Bus Electrical/Electronics Test

1. Learning environment

For best application of this *Recommended Practice*, a combination of classroom lectures, mentoring, practical training and practice tests should be included in the training program.

2. Computer skills

Basic computer skills are now standard for transit bus technicians. Basic skills and knowledge in the operation of a computer in a Microsoft Windows environment is essential

3. Course learning objectives

The learning objectives listed below have been developed through a labor-management committee of subject matter experts (SMEs). The learning objective levels represent 100 (introductory), 200 (intermediate) and 300 (advanced). Within each level, the learning objectives are organized in the recommended order of instruction. When a transit bus mechanic demonstrates proficiency in the learning objectives, he or she should be capable of attaining ASE Transit Bus Technician Certification.

- **Module A1: General Electrical Safety and Electrical Theory 101:** The objective of these courses is to familiarize the employee with electrical hazards, safety precautions, critical safety procedures and the fundamentals of basic electrical theories and laws, schematic reading and circuit protection.
- **Module A2: Wiring, Connections and Connectors 102:** Participants will receive classroom instruction in which a qualified instructor will review the basics of wiring, connections and connectors as it relates to gauges, warning devices, horns, wipers and HVAC components. Participants will receive instruction on related wiring schematics and how to solder and splice connections. More advanced aspects are covered in the 201 level courses, where emphasis is placed on advanced electrical theories; testing equipment; advanced schematic reading; ladder logic diagrams; multiplexing systems; and circuits, solenoids, diodes, resistors and capacitors (OSHA.gov 29 CFR 1910 Subpart S and NFPA 70F-2012).
- **Module A3: General Electrical Theory and Diagnosis 103:** The objective of these courses is to familiarize the employee with the basics of electrical diagnosis, including pertinent electrical theories and laws, schematic reading, safety issues, applicable tools/equipment and circuit protection. More advanced aspects are covered in the 201 level course, where emphasis is placed on advanced electrical theories; testing equipment; advanced schematic reading; ladder logic diagrams; multiplexing systems; and circuits, solenoids, diodes, resistors and capacitors.
- **Module A4: Vehicle Systems 201:** The objective of these courses is to familiarize the employee with the basics of electrical diagnosis, including pertinent electrical theories and laws, schematic reading, safety issues, applicable tools/equipment and circuit protection.
- **Module B1: Battery 101:** The objective of this course is to familiarize the employee with bus battery basics, including safety, testing, cleaning and inspection, replacement, charging, and jump-starting a bus. Employees will be taught to restore battery and related components to OEM specifications.

- **Module C1, C2: Starting Systems 101, 201:** The objective of these courses is to familiarize the employee with the starting system diagnosis and repair and to improve employee skills with regards to advanced repairs. Emphasis will be placed on inspection, component identification, circuit component replacement, starter circuit wiring, distinguishing between mechanical and electrical causes of starter problems, and restoring starting systems to OEM specifications.
- **Module D1, D2: Charging Systems 101, 201:** The objective of these courses is to familiarize the employee with the basics of charging systems, component identification, diagnosis, inspection, testing, and troubleshooting. Focus will be placed on adjusting, replacing and removing alternators and checking, adjusting and replacing voltage regulators, as well as proper testing and inspection procedures for diagnosis and repair.
- **Module E1: Lighting Systems 101:** The objective of this course is to instruct the employee how to read wiring diagrams, perform visual inspections, and replace various interior and exterior lights and lighting circuits. Emphasis is placed on restoring lighting systems to OEM specifications.
- **Module F1: Fire Suppression 301:** Participants will receive classroom instruction in which a qualified instructor will review the basics of wiring, connections and connectors as they relate to gauges, warning devices, horns, wipers and HVAC components. Participants will receive instruction on related wiring schematics and how to solder and splice connections.
- **Module G1, G2, G3: Multiplexing 101, 201, 301:** The objective of these courses is to familiarize the employee with how to use wiring diagrams to troubleshoot, diagnose, inspect and repair/replace complex electrical circuits, how to properly use test equipment and how to maintain various switches. Emphasis is placed on developing a high understanding of data communications and multiplex systems. The 301 level course is focused on multiplexing system troubleshooting, inspection and maintenance.

4. Exam requirements

The minimum acceptable grade to pass the course and all practical tests is 75 percent. Students must pass written tests with a minimum grade of 80 percent.

5. ASE test content summary

TABLE 1
Specifications for Transit Bus Electrical/Electronics Test

Content Area	Questions in Test	Percent of Test
A. General Electrical Diagnosis	16	32%
B. Battery Diagnosis and Repair	5	10%
C. Starting System Diagnosis and Repair	7	14%
D. Charging System Diagnosis and Repair	7	14%
E. Lighting Systems Diagnosis and Repair 1. Headlights, Daytime Running Lights, Parking, Clearance, Tail, Interior and Dash Lights (4 2. Stoplights, Turn Signals, Hazard Lights and Backup Lights (3)	7	14%
F. Gauges and Warning Devices Diagnosis and Repair	4	8%
G. Related Systems	4	8%
Total	**50**	**100%**

Please see Appendix B for the full list of ASE course tasks that should be covered during the training course.

Related APTA standards

APTA RP-xxx-00x-16, Rev. xx, "Name name name name" [Body Text with Body bold style applied to number, hanging indent of .25 inches]
APTA RP-xxx-00x-16, Rev. xx, "Name name name name"

References

National Institute for Automotive Service Excellence (ASE) website. http://www.ase.com/

Definitions

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Abbreviations and acronyms

A/C air conditioning
APTA American Public Transportation Association
ASE Automotive Service Excellence
ATU Amalgamated Transit Union
CPU central processing unit
DIO digital input/output
DMM digital multimeter
DRL daytime running lights
DSM digital scope meter
GMM graphing multimeter
HCNC high-speed cell net controller
I/O input/output
LED light-emitting diode
MBC main bus controller
mux multiplexer
OEM original equipment manufacturer
PLC programmable logic controller
PM preventative maintenance
PPE personal protective equipment
PTC positive temperature coefficient
SAE SAE International (formerly the Society of Automotive Engineers)
TWU Transit Workers Union

Summary of document changes

- Module listing and associated curriculum in Appendix C updated.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	CEO Approval	Policy & Planning Approval	Publish Date
First published	Mmm. DD, YYYY				
First revision	5/15/13				
Second revision					

Appendix A: Transit bus electrical/electronics learning objectives

101 SAFETY & PROTECTION	
Learning Objectives	**ASE Task Reference**
Follow proper electrical safety procedures and use proper personal protective equipment (PPE)	A17

101 SCHEMATICS	
Learning Objectives	**ASE Task Reference**
Read basic wiring diagrams	A12, E22, E23, E24, F1, F2, G2, G3, G5, G6, G7
Identify symbols used in electrical schematics	A12
Read single-circuit electrical schematics	A12

101 BATTERIES	
Learning Objectives	**ASE Task Reference**
Safely handle batteries and acid	B3
Inspect batteries	B3, C5, D8, D9
Check batteries for water	B1, B2, B3, B4, B5, B6
Clean and check battery and terminal connections	B3, C5
Measure battery voltage/surface charge	B2, D8, D9
Check battery box construction for stress cracks/welds	B4
Replace batteries	B3

101 CIRCUIT PROTECTION	
Learning Objectives	**ASE Task Reference**
Inspect and test circuit breakers	A9
Replace circuit breakers	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Inspect and test fuses	A9
Replace fuses	E23, F3

101 STARTING	
Learning Objectives	**ASE Task Reference**
Inspect starters (motors and solenoids)	A11, C2, C3
Perform voltage drop tests on starter circuits using tester unit	C1
Replace starter circuit relays	A11, C2, C3
Replace starter circuit solenoids	A11, C3
Replace starter circuit switches	C2, C3
Replace starter motor	C4

101 CHARGING	
Learning Objectives	**ASE Task Reference**
Adjust or replace alternator components (belts, gears, fans, etc.)	A17, D12
Remove and replace alternators	D6

101 LIGHTING	
Learning Objectives	**ASE Task Reference**
Visually check wiring for exterior lights	E11, E14, E16
Replace headlights, LED, fluorescent and incandescent lights	E12
Visually check wiring for interior lights	E16

101 ELECTRICAL THEORY	
Learning Objectives	**ASE Task Reference**
Demonstrate knowledge of basic electrical theories and laws	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

102 BATTERIES	
Learning Objectives	**ASE Task Reference**
Measure battery acid specific gravity	B2
Perform battery load and capacity tests on batteries	A8, B1
Charge batteries in vehicles	B5
Jump-start bus using jumper cables	B6
Jump-start bus using auxiliary power supply	B6

102 CIRCUIT PROTECTION	
Learning Objectives	**ASE Task Reference**
Diagnose condition of fuses, circuit breakers and switches	A9

102 SWITCHES, RELAYS & SOLENOIDS	
Learning Objectives	**ASE Task Reference**
Identify symbols used for various switches, relays, and solenoids	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Identify different types and purposes of relays, switches and solenoids	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Inspect and test solenoids, switches and relays	A11
Inspect micro-switches	A16
Replace various switches, relays and solenoids	A16, E14

102 CHARGING	
Learning Objectives	**ASE Task Reference**
Check and adjust voltage regulator set points	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

102 WIRING, CONNECTIONS & CONNECTORS	
Learning Objectives	**ASE Task Reference**
Replace/assemble connectors	C5, D7, E13, E14, E15, E16, E21, E23, E24, F3, F4, G1, G3, G4, G5, G6
Use heat shrinking and crimping equipment	G1, G2, G3, G4, G5, G6, G7

102 LIGHTING	
Learning Objectives	**ASE Task Reference**
Replace interior or exterior lighting circuits	E14
Inspect electrical circuits	F3, F4

103 SCHEMATICS	
Learning Objectives	**ASE Task Reference**
Determine which schematic is related to a specific bus system	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

103 SWITCHES, RELAYS & SOLENOIDS	
Learning Objectives	**ASE Task Reference**
Inspect and test relays	A11
Check, repair or replace electrical relays	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, E23, G1

103 STARTING	
Learning Objectives	**ASE Task Reference**
Inspect various related relay on starting circuits	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

103 CHARGING	
Learning Objectives	**ASE Task Reference**
Replace voltage regulators	D5

103 LIGHTING	
Learning Objectives	**ASE Task Reference**
Replace ballast for interior lights	E16

103 TEST EQUIPMENT	
Learning Objectives	**ASE Task Reference**
Demonstrate proficient use of digital multimeters and other common test equipment	A2, A4
Perform tests for voltage draws and drops using a digital multimeter	A3

103 ELECTRO-PNEUMATIC	
Learning Objectives	**ASE Task Reference**
Inspect electrically operated air equipment	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

104 ELECTRICAL CIRCUITS	
Learning Objectives	**ASE Task Reference**
Repair or replace any electrical circuit components	A17, E14, E15, E22, E23, E24, F5, G1, G5, G6, G7

104 WIRING, CONNECTIONS & CONNECTORS	
Learning Objectives	**ASE Task Reference**
Solder connections	G1, G2, G3, G4, G5, G6, G7
Splice connections	G1, G2, G3, G4, G5, G6, G7

104 ELECTRO-PNEUMATIC	
Learning Objectives	**ASE Task Reference**
Replace electrically operated air equipment	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

201 SCHEMATICS	
Learning Objectives	**ASE Task Reference**
Draw basic wiring diagrams	A12
Use wiring diagrams to troubleshoot electrical problems	A12
Use wiring diagrams to troubleshoot problems with gauges and warning devices	F1, F2, F3, F4, F5

201 MULTIPLEXING	
Learning Objectives	**ASE Task Reference**
Demonstrate the ability to read and interpret ladder logic diagrams	A13, A14
Use LEDs to troubleshoot system	A14
Explain the functions of the multiplex controller and its related components	A14
Use ladder logic diagrams to troubleshoot a multiplex system	A14
Read PLC addressing	F1, F2, F3, F4, F5
Use logic diagrams to troubleshoot a PLC system	F1, F2, F3, F4, F5
Identify symbols used for multiplexing inputs and outputs	F1, F2, F3, F4, F5
Replace multiplexing input and output cards	F1, F2, F3, F4, F5
Replace HCNC and DIO modules	F1, F2, F3, F4, F5
Use multiplex software	F1, F2, F3, F4, F5
Replace control rack	F1, F2, F3, F4, F5

201 STARTING	
Learning Objectives	**ASE Task Reference**
Distinguish between mechanical and electrical causes of starter problems	C4, C6
Replace starter circuit wiring	C1, C2, C3, C4, C5, C6
Inspect and diagnose starting systems	C1, C2, C3, C4, C5, C6

201 CHARGING	
Learning Objectives	**ASE Task Reference**
Diagnose cause of various charging conditions and determine proper repair procedure	D1
Inspect overall charging system operation	D3
Inspect and repair connectors and wires in charging circuits	D7, D8
Perform alternator output tests (amp draw tests) using tester unit	D1, D3
Diagnose charging systems using fault tree chart	D1, D2, D3, D4, D5, D6, D7, D8, D9
Perform alternator voltage drop tests using tester unit	D4
Inspect and troubleshoot power supply	F1, F2, F3, F4, F5

201 ELECTRICAL CIRCUITS	
Learning Objectives	**ASE Task Reference**
Diagnose circuit malfunctions (short circuits, grounded circuits and open circuits)	A1, A2, A7, E22, E23, E24, F1, F2, G2, G3, G5, G6, G7
Diagnose, inspect and troubleshoot complex traditional electrical circuits (non-electronic)	F1, F2, F3, F4, F5
Replace/rewire electrical power circuits	G1, G2, G3, G4, G5, G6, G7

201 WIRING, CONNECTIONS & CONNECTORS	
Learning Objectives	**ASE Task Reference**
Inspect wiring on engines	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Remove and replace electrical connectors and terminals	G1, G2, G3, G4, G5, G6, G7

201 LIGHTING	
Learning Objectives	**ASE Task Reference**
Diagnose lighting systems and circuits	E13, E14, E15, E21, E22, E23, E24, F4

201 DOORS	
Learning Objectives	**ASE Task Reference**
Remove, replace or adjust sensitive door edge wiring	G1, G2, G3, G4, G5, G6, G7
Inspect door circuits	G1, G2, G3, G4, G5, G6, G7
Inspect door edge wiring	G1, G2, G3, G4, G5, G6, G7
Replace door system wiring	G1, G2, G3, G4, G5, G6, G7
Distinguish between pneumatic, mechanical and electrical causes of door problems	G1, G2, G3, G4, G5, G6, G7
Replace or repair/rewire door circuits	G1, G2, G3, G4, G5, G6, G7

201 TEST EQUIPMENT	
Learning Objectives	**ASE Task Reference**
Use diagnostic software to troubleshoot equipment	A1
Use ammeter to inspect motor	A4
Use digital multimeters to check circuit voltage amperage and resistance	A6, E22, E23, E24, F1, F2, G2, G3, G5, G6, G7
Operate Windows-based computer for diagnostic purposes	A15
Demonstrate basic PC knowledge	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

201 ELECTRONICS & DATA COMMUNICATIONS	
Learning Objectives	**ASE Task Reference**
Inspect and test resistors	A6, A10
Inspect and test diodes	A10
Inspect and test capacitors	A10
Replace electronic modules	F1, F2, F3, F4, F5

201 ELECTRONIC THEORY	
Learning Objectives	**ASE Task Reference**
Explain the operation of a suppression diode, and test a suppression diode	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Describe the difference between digital and analog signals	F1, F2, F3, F4, F5
Describe purpose of network protocol CAN/J1939 and J1708	F1, F2, F3, F4, F5

201 SOLENOIDS	
Learning Objectives	**ASE Task Reference**
Replace solenoids	A11
Describe function of power equalizer	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Replace gateway module (SAE network to mux)	F1, F2, F3, F4, F5

202 SCHEMATICS	
Learning Objectives	**ASE Task Reference**
Use drawings to assemble bus electrical equipment for new circuits (retrofits)	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

202 MULTIPLEXING	
Learning Objectives	**ASE Task Reference**
Troubleshoot multiplex controller for communication problems	A1
Diagnose, inspect and troubleshoot input and output circuits in multiplex systems	A13, A14
Repair faults through reading ladder logic diagrams	A14
Troubleshoot electrical faults by analyzing combinations of inputs and outputs	A14
Inspect and troubleshoot remote I/O blocks	F1, F2, F3, F4, F5
Replace remote I/O blocks	F1, F2, F3, F4, F5
Cross-reference ladder diagrams and schematics to locate ladder rungs related to particular systems	F1, F2, F3, F4, F5
Check multiplex control modules	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Replace multiplex control modules	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Describe the functions of the multiplex controller and its related components	F1, F2, F3, F4, F5
Describe function of EM70 microprocessor-based controls	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Replace central processing unit (CPU) card	F1, F2, F3, F4, F5

202 ELECTRICAL CIRCUITS	
Learning Objectives	**ASE Task Reference**
Repair interlock systems	G1, G2, G3, G4, G5, G6, G7
Replace current limiters/PTC	F1, F2, F3, F4, F5

202 ELECTRONICS & DATA COMMUNICATIONS	
Learning Objectives	**ASE Task Reference**
Replace diodes	A10
Replace resistors	A10
Replace capacitors	A10
Diagnose and replace faulty circuit boards	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

202 SENSORS, SENDERS & PROBES	
Learning Objectives	**ASE Task Reference**
Identify sensors, senders and probes	A16, F5
Determine expected sensor output	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Determine sensor air gap	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

202 SWITCHES	
Learning Objectives	**ASE Task Reference**
Identify proper settings and calibrate address/dip switches	F1, F2, F3, F4, F5
Repair or replace magnetic, optical and/or half-effect proximity switches	F1, F2, F3, F4, F5

202 TEST EQUIPMENT	
Learning Objectives	**ASE Task Reference**
Use service tools to diagnose communication link problems	F1, F2, F3, F4, F5
Use fault codes to diagnose and repair systems	F1, F2, F3, F4, F5

202 WIPERS	
Learning Objectives	**ASE Task Reference**
Maintain wiper motors	G3, G4

203 SCHEMATICS	
Learning Objectives	**ASE Task Reference**
Reference bus maintenance manuals to locate and use specific electrical schematics	G1, G2, G3, G4, G5, G6, G7

203 WIRING, CONNECTIONS & CONNECTORS	
Learning Objectives	**ASE Task Reference**
Repair or create wiring harnesses	G1, G2, G3, G4, G5, G6, G7

203 MULTIPLEXING	
Learning Objectives	**ASE Task Reference**
Inspect/troubleshoot input and output cards	F1, F2, F3, F4, F5

203 TEST EQUIPMENT	
Learning Objectives	**ASE Task Reference**
Demonstrate use of lab scope/oscilloscope/graphing multimeter	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

203 ELECTRONIC THEORY	
Learning Objectives	**ASE Task Reference**
Describe magnetic inductance	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Describe basic electronics theory of components	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17
Describe waveforms (pulse width, frequency/hertz, duty cycle)	A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17

203 ELECTRONICS & DATA COMMUNICATIONS	
Learning Objectives	**ASE Task Reference**
Inspect and troubleshoot CPU card	F1, F2, F3, F4, F5
Inspect and troubleshoot gateway module	F1, F2, F3, F4, F5
Inspect, troubleshoot and repair data communications network	F1, F2, F3, F4, F5
Check, repair or replace data communications cable	F1, F2, F3, F4, F5
Inspect and troubleshoot HCNC and DIO modules	F1, F2, F3, F4, F5
Use code scanner and adapter card to troubleshoot system	F1, F2, F3, F4, F5

301 MULTIPLEXING	
Learning Objectives	**ASE Task Reference**
Troubleshoot and maintain multiplexing systems	F1, F2, F3, F4, F5
Inspect/troubleshoot main bus controller (MBC) and PMS modules	F1, F2, F3, F4, F5
Check/repair/replace control rack	F1, F2, F3, F4, F5

301 FIRE SUPPRESSION	
Learning Objectives	**ASE Task Reference**
Maintain fire suppression electrical systems	G1, G2, G3, G4, G5, G6, G7
Diagnose and repair or replace VMU unit	G1, G2, G3, G4, G5, G6, G7

Appendix B: ASE course task list

A. General electrical diagnosis

1. Verify operator complaint, reproduce the condition (including intermittent problems) and/or road test vehicle; determine necessary action.
2. Check continuity in electrical/electronic circuits using appropriate test equipment.
3. Check applied voltages, circuit voltages and voltage drops in electrical/ electronic circuits using a digital multimeter (DMM) or a graphing multimeter (GMM).
4. Check current flow in electrical/electronic circuits and components using an ammeter, DMM, clamp-on ammeter or GMM.
5. Check electronic circuit waveforms using an oscilloscope; interpret readings and determine needed repairs.
6. Check resistance in electrical/electronic circuits and components using an ohmmeter, DMM or GMM.
7. Locate shorts, grounds and opens in electrical/electronic circuits.
8. Diagnose battery drain problems with the master/key switch off.
9. Inspect and test fusible links, circuit breakers, solid-state current limiters and fuses; replace as required.
10. Inspect and test spike suppression diodes/resistors and capacitors; replace as required.
11. Inspect and test relays and solenoids; replace as required.
12. Read and interpret electrical schematic diagrams and symbols.
13. Read and interpret ladder logic diagrams.
14. Diagnose and repair computer communication multiplex systems; determine needed repairs.
15. Using a laptop computer, establish communication with a multiplex control system. Verify that the needed ladder logic inputs are active to control an individual/specific ladder logic output.
16. Remove, replace and adjust electrical/electronic switches, sensors and other electrical/electronic components.
17. Ensure proper care and handling of electrical/electronic components.

B. Battery diagnosis and repair

1. Perform battery tests (load, capacitance and specific gravity); determine needed repairs.
2. Determine battery state of charge by measuring terminal post voltage using a DMM.
3. Inspect, clean and service battery, cables, terminal connections and disconnects; replace as required.
4. Inspect, clean and repair battery boxes, mounts and hold-downs; replace as required.
5. Charge battery(s), using slow or fast charge method as appropriate.
6. Jump-start a transit bus using jumper cables and a booster battery or auxiliary power supply.

C. Starting system diagnosis and repair

1. Perform starter circuit voltage drop tests; determine needed repairs.
2. Inspect and test components of the starter control circuit (key switch, push button and/or magnetic switch and wires); replace as required.
3. Inspect and test starter relays and solenoids/switches; replace as required.
4. Remove and replace starter; inspect flywheel ring gear or flex plate.
5. Inspect, clean, repair or replace cranking circuit battery cables and connectors.
6. Differentiate among electrical, multiplex or mechanical problems that cause slow cranking, no cranking, extended cranking or cranking noise conditions.

D. Charging system diagnosis and repair

1. Diagnose the cause of a no-charge, low-charge or overcharge condition; determine needed repairs.
2. Inspect and adjust alternator drive belts/gears, pulleys, fans, mounting brackets and tensioners; replace as required.
3. Perform charging system output tests (12 V and 24 V); determine needed repairs.
4. Perform charging circuit voltage drop tests; determine needed repairs.
5. Test, adjust or replace voltage regulator.
6. Maintain, remove and replace alternator.
7. Inspect, repair or replace charging circuit connectors and wires.
8. Check battery equalizer output, check wiring and mounting; determine needed repairs.
9. Verify operation of charging system circuit monitor; determine needed repairs.

E. Lighting systems diagnosis and repair

1. Headlights, daytime running lights, parking, clearance, tail, interior and dash lights

1. Diagnose the cause of brighter-than-normal, intermittent, dim or no headlight and daytime running light (DRL) operation.
2. Test, aim and replace headlights.
3. Test headlight and dimmer switches, wires, connectors, terminals, sockets, relays and control components; repair or replace as required.
4. Inspect, test and repair parking, clearance and taillight circuit switches, bulbs, sockets, connectors, terminals, relays, wires and light-emitting diodes (LEDs); replace as required.
5. Inspect, test and repair dash light circuit switches, bulbs, sockets, connectors, terminals, wires and printed circuits; replace as required.
6. Inspect, test and repair interior and exterior light circuit switches, bulbs, sockets, connectors, terminals, ballasts and wires; replace as required.

2. Stoplights, turn signals, hazard lights and backup lights

1. Inspect and test stoplight circuit switches, bulbs, sockets, connectors, terminals, relays, control components and wires; repair or replace as required.
2. Diagnose the cause of turn signal and hazard flasher light system malfunctions; determine needed repairs.
3. Inspect and test turn signal and hazard circuit flashers, switches, bulbs, sockets, connectors, terminals, relays, wires and LEDs; repair or replace as required.
4. Inspect, test and adjust backup light and warning devices, circuit switches, bulbs, sockets, connectors, terminals and wires; repair or replace as required.

F. Gauges and warning devices diagnosis and repair

1. Diagnose the cause of intermittent, high, low or no gauge readings; determine needed repairs.
2. Diagnose the cause of control area network (CAN) driven gauge malfunctions; determine needed repairs.
3. Inspect, test and adjust gauge circuit sending units, sensors, gauges, connectors, terminals and wires; repair or replace as required.
4. Inspect and test warning device (lights and audible) circuit sending units, sensors, bulbs, audible component, sockets, connectors, terminals, wires and printed circuits/control modules; repair or replace as required.
5. Inspect and test electronic speedometer and odometer systems; replace as required; verify proper calibration for vehicle application.

G. Related systems

1. Inspect and test horns, horn circuit relays, switches, connectors, terminals and wires; repair or replace as required.
2. Diagnose the cause of constant, intermittent or no wiper operation; diagnose the cause of wiper speed control and/or park problems.
3. Inspect and test wiper motor, resistors, park switch, relays, switches, connectors, terminals and wires; repair or replace as required.
4. Inspect and test windshield washer motor or pump/relay assembly, switches, connectors, terminals and wires; repair or replace as required.
5. Inspect and test side view mirror motors, heater circuit grids, relays, switches, connectors, terminals and wires; repair or replace as required.
6. Inspect and test HVAC electrical components, including A/C clutches, motors, resistors, relays, switches, controls, connectors, terminals and wires; repair or replace as required.
7. Inspect and test engine cooling fan electrical control components; replace as required.

Appendix C: Sample curriculum

Electrical/Electronics—Module A1
General Electrical Safety & Theory 101

Goal: Participants should understand electrical hazards, safety precautions and critical safety procedures and the fundamentals of basic electrical theories and laws, schematic reading and circuit protection.

Objectives:
Upon completion of this course, participants should be able to:

- demonstrate knowledge of electrical hazards, safety precautions and critical safety procedures (including personal protection equipment [PPE]);
- explain and demonstrate local emergency and first responder procedures;
- identify whether voltage is present;
- identify and use insulated tools;
- demonstrate knowledge of basic electrical theories and laws (including Ohm's law);
- read basic wiring diagrams, identify schematics symbols and read single-circuit electrical schematics;
- determine which schematic is related to a specific bus system;
- inspect, test and replace circuit breakers and fuses;
- demonstrate ability to use digital multimeters and other test equipment; and
- perform tests for voltage draws and drops using a digital multimeter.

Job tasks/learning objectives/OJT checklist:

1. 101 Safety & PPE
2. 101 Electrical Theory
3. 101 Schematics
4. 101 Circuit Protection
5. 102 Circuit Protection
6. 103 Test Equipment
7. 103 Test Equipment

Course description: Participants will receive classroom instruction in which a qualified instructor will review the importance of safety practices and how to comply with them, the basics of electrical theories and laws, schematic reading, applicable tools/equipment and circuit protection. Participants should leave the course with a thorough understanding of electrical safety, and a basic understanding of electrical theories and laws and how they apply to general diagnosis.

Electrical/Electronics—Module A2
Wiring, Connections &Connectors 101

Goal: Participants should be able to demonstrate basic knowledge of wiring, connections and terminals as it relates to gauges, warning devices and related systems such as horns, wipers and HVAC components.

Objectives:
Upon completion of this course, participants should be able to:

- read interconnect wire diagrams related to specific components and systems;
- demonstrate knowledge of commonly used connectors and terminals;
- assemble/install/replace various types of connectors and terminals; and
- solder/splice various types of connections and terminals.

Job tasks/learning objectives/OJT checklist:

1. 101 Schematics
2. 102 Wiring, Connections & Connectors

3. 102 Wiring, Connections & Connectors
4. 104 Wiring, Connections & Connectors

Course description:
Participants will receive classroom instruction in which a qualified instructor will review the basics of wiring, connections, connectors and terminals as it relates to gauges, warning devices, horns, wipers and HVAC components. Participants will receive instruction on related wiring schematics and how to solder and splice connections.

Electrical/Electronics—Module A3

General Electrical Theory & Diagnosis 102

Goal: Participants should understand more advanced electrical theory; know how to use testing equipment, have a basic knowledge of switches, relays, contactors, solenoids, sensors, senders and probes; and demonstrate an advanced knowledge of schematics.

Objectives:
Upon completion of this course, participants should be able to:

- use common and specialized test equipment, including digital multimeters (DMMs), ammeters, oscilloscopes/lap scopes/graphing multimeters and computerized diagnostic software;
- explain electrical theory of components, magnetic inductance, waveforms and the operation of a suppression diode;
- draw and use wiring diagrams for troubleshooting and equipment assembly
- inspect, test and replace resistors, diodes and capacitors;
- replace relays and solenoids, and identify sensors, senders and probes; and
- diagnose circuit malfunctions and inspect wiring on engines.

Job tasks/learning objectives/OJT checklist:

1. 101 Electrical Theory
2. 201 Schematics
3. 103 Test Equipment
4. 201 Electronics & Data Communications
5. 102 Switches, Relays & Solenoids; 201 Solenoids
6. 201 Electrical Circuits; 201 Wiring, Connections & Connectors

Course description: Participants will receive classroom instruction in which a qualified instructor will review more advanced aspects of electrical diagnosis, including advanced electrical theories, testing equipment, advanced schematic reading, solenoids, diodes, resistors and capacitors.

Electrical/Electronics—Module A4

Vehicle Systems 103

Goal: Participants should be able to use proper test equipment, schematics and wiring diagrams to troubleshoot, diagnose, inspect and repair/replace various vehicle systems.

Objectives:

Upon completion of this course, participants should be able to:

- diagnose, inspect, and troubleshoot complex electrical circuits;
- replace/rewire electrical power circuits;
- remove and replace multipin, electrical connectors and terminals;
- repair or create wiring harnesses;
- repair electrical interlock systems;
- repair or replace magnetic, optical and/or Hall effect proximity switches; and
- inspect, troubleshoot and repair/replace doors, door wiring and related components.

Job tasks/learning objectives/OJT checklist:

1. 201 Electrical Circuits
2. 201 Electrical Circuits
3. 201 Wiring, Connections & Connectors
4. 202 Electrical Circuits
5. 202 Electrical Circuits
6. 202 Switches
7. 202 Test Equipment
8. 203 Wiring, Connections & Connectors
9. 203 Electronics & Data Communication
10. 203 Electronics & Data Communication
11. 201 Doors

Course description: Participants will receive classroom instruction in which a qualified instructor will review how to use proper test equipment and wiring diagrams to troubleshoot, diagnose, inspect and repair/replace various vehicle systems.

Electrical/Electronics—Module B1

Battery 101

Goal: Participants should be able to safely and properly handle, inspect, test, clean and charge batteries.

Objectives:

Upon completion of this course, participants should be able to:

- safely handle batteries and acid;
- inspect and replace batteries;
- clean and check battery terminal connections;
- measure battery voltage/surface charge;
- check battery box construction for stress cracks/welds;
- measure battery acid specific gravity;
- perform battery load and capacity tests;
- charge batteries; and
- jump-start bus using jumper cables and auxiliary power supply.

Job tasks/learning objectives/OJT checklist:

1. 101 Batteries
2.
3. 102 Batteries

Course description: Participants will receive classroom instruction in which a qualified instructor will review bus battery basics, including safety, testing, cleaning and inspection, replacement, charging, and jump-starting a bus.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands on, online, lab): Hands-on and classroom

Course duration: 34 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or white board (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, flow charts, PowerPoint, homework assignments

Instructor:

Course developer: Educational Data Systems Inc.

Subject matter experts: Contact APTA.

Revision dates: 8/31/2010

Follow-up: Most recent revision should be sent to committee for feedback

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Electrical/Electronics—Module C1

Starting Systems 101

Goal: Participants should be able to identify starting system components, perform inspection, perform voltage drop tests and replace starter circuit components.

Objectives:
Upon completion of this course, participants should be able to:

- inspect starters (motors and solenoids);
- perform voltage drop tests on starter circuits using tester unit;
- replace starter circuit relays, solenoids and switches; and
- replace starter motor.

Job tasks/learning objectives/OJT checklist:

1. 101 Starting
2. 103 Starting

Course description: Participants will receive classroom instruction where a qualified instructor will review the basics of starting system diagnosis and repair. Emphasis will be placed on inspection, component identification and circuit component replacement.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands on, online, lab): Hands-on and classroom

Course duration: 4 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or white board (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, flow charts, PowerPoint, homework assignments, vehicle to perform voltage drop

Instructor:

Course developer: Educational Data Systems Inc.

Subject matter experts: Contact APTA.

Revision dates: 8/31/2010

Follow-up: Most recent revision should be sent to committee for feedback

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Electrical/Electronics—Module C2

Starting Systems 201

Goal: Participants should be able to perform more advanced starting system diagnosis and repair, including replacement of circuit wiring, distinguishing between mechanical and electrical causes and complete starting system repair/replacement.

Objectives:
Upon completion of this course, participants should be able to:

- replace starter circuit wiring;
- distinguish between mechanical and electrical causes of starter problems; and
- complete starting system inspection and diagnosis.

Job tasks/learning objectives/OJT checklist:

1. 201 Starting

Course description: Participants will receive classroom instruction in which a qualified instructor will assist the participants in improving their skills with starting system diagnosis and repair. Advanced repairs such as replacement of starter circuit wiring will be emphasized, and participants will be taught to distinguish between mechanical and electrical causes of starter problems.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands on, online, lab): Hands-on and classroom

Course duration: 4 to 8 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or white board (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, flow charts, PowerPoint, homework assignments

Instructor:

Course developer: Educational Data Systems Inc.

Subject matter experts: Contact APTA.

Revision dates: 8/31/2010

Follow-up: Most recent revision should be sent to committee for feedback

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Electrical/Electronics—Module D1

Charging Systems 101

Goal: Participants should understand the basics of charging systems and all related components.

Objectives:
Upon completion of this course, participants should be able to:

- explain the purpose of charging systems and identify all related components;
- adjust or replace alternator components (belts, gears, fans, etc.);
- remove and replace alternators;
- check and adjust voltage regulator set points; and
- replace voltage regulators.

Job tasks/learning objectives/OJT checklist:

1. 101 Charging
2. 102 Charging
3. 103 Charging
4. 201 Charging

Course description: Participants will receive classroom instruction in which a qualified instructor will review the basics of charging systems, including component identification. Focus will be placed on adjusting, replacing and removing alternators and checking, adjusting and replacing voltage regulators.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands on, online, lab): Hands-on and classroom

Course duration: 4 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or white board (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, flow charts, PowerPoint, homework assignments

Instructor:

Course developer: Educational Data Systems Inc.

Subject matter experts: Contact APTA.

Revision dates: 8/31/2010

Follow-up: Most recent revision should be sent to committee for feedback

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Electrical/Electronics—Module D2

Charging Systems 201

Goal: Participants should be able to perform inspection, testing, diagnosis, and repair of charging systems.

Objectives:
Upon completion of this course, participants should be able to:

- diagnose the cause of various charging conditions and determine proper repair procedure;
- inspect overall charging system operation;
- inspect and repair connectors and wires in charging circuits;
- perform alternator output tests using tester unit;
- diagnose charging systems using fault tree chart;
- perform alternator voltage drop tests using tester unit; and
- inspect and troubleshoot power supply.

Job tasks/learning objectives/OJT checklist:

1. 201 Charging

Course description: Participants will receive classroom instruction in which a qualified instructor will review diagnosis, inspecting, testing and troubleshooting charging systems. Emphasis is placed on diagnosis and repair of the charging system, as well as proper testing and inspection procedures.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands on, online, lab): Hands-on and classroom

Course duration: 4 to 8 hours (troubleshooting portion with three students per instructor)

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or white board (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, flow charts, PowerPoint, homework assignments

Instructor:

Course developer: Educational Data Systems Inc.

Subject matter experts: Contact APTA.

Revision dates: 8/31/2010

Follow-up: Most recent revision should be sent to committee for feedback

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Electrical/Electronics—Module E1

Lighting Systems 101

Goal: Participants should be able to perform visual inspections of lighting system components to determine necessary replacements.

Objectives:
Upon completion of this course, participants should be able to:

- read basic wiring diagrams;
- replace fuses;
- visually check wiring for interior and exterior lights;
- replace headlights, as well as LED, florescent and incandescent lights;
- replace interior or exterior lighting circuits;
- inspect electrical circuits;
- replace ballast for interior lights; and
- diagnose lighting systems and circuits.

Job tasks/learning objectives/OJT checklist:

1. 101 Schematics
2. 101 Circuit Protection
3. 101 Lighting
4. 102 Lighting
5. 103 Lighting
6. 201 Lighting

Course description: Participants will receive classroom instruction in which a qualified instructor will review reading wiring diagrams, performing visual inspections, and replacing various interior and exterior lights and lighting circuits.

Recommended class size: 8:1

Prerequisites (previous module and/or demonstrated experience):

Delivery method (e.g., lecture, hands on, online, lab): Hands-on and classroom

Course duration: 4 hours

Target audience: All new and existing mechanics

Classroom equipment and supplies: Notepads, pens/pencils, flip chart or white board (and markers), classroom, laptop, projector, highlighters, note cards and name cards

Course materials, training aids and references: Student workbook, manuals, handouts, flow charts, PowerPoint, homework assignments

Instructor:

Course developer: Educational Data Systems Inc.

Subject matter experts: Contact APTA.

Revision dates: 8/31/2010

Follow-up: Most recent revision should be sent to committee for feedback

Instructor and course evaluation: Local course evaluation sheets should be used if present.

Electrical/Electronics—Module F1

Fire Suppression 301

Goal: Participants should be able to maintain, diagnose, and repair fire suppression systems.

Objectives:
Upon completion of this course, participants should be able to:

- maintain fire suppression electrical systems (standards).

Job tasks/learning objectives/OJT checklist:

1. 301 Fire Suppression

Course description: Participants will receive classroom instruction in which a qualified instructor will review fire suppression system maintenance, diagnosis and repair.

Electrical/Electronics—Module G1

Multiplexing 102

Goal: Participants should understand more advanced electrical theory, a basic knowledge of computerized multiplexing systems and ladder logic diagrams.

Objectives:

Upon completion of this course, participants should be able to:

- explain the function of the multiplex controller;
- troubleshoot multiplex controllers and diagnose, inspect, and troubleshoot input and output circuits in multiplex systems;
- read, interpret and use ladder logic diagrams;
- diagnose faults through reading ladder logic diagrams; and
- check, reprogram and replace multiplex control modules.

Job tasks/learning objectives/OJT checklist:

1. 101 Electrical Theory
2. 201 Schematics
3. 103 Test Equipment
4. 201 Electronics & Data Communications
5. 102 Switches, Relays & Solenoids; 201 Solenoids
6. 201 Electrical Circuits; 201 Wiring, Connections & Connectors
7. 201 Multiplexing
8. 201 Multiplexing
9. 202 Multiplexing
10. 203 Multiplexing

Course description: Participants will receive classroom instruction in which a qualified instructor will review computerized multiplexing systems, including advanced electrical theories, ladder logic diagrams, multiplexing modules and circuits.

Electrical/Electronics—Module G2

Multiplexing 201

Goal: Participants should be able to use wiring diagrams to troubleshoot, diagnose, inspect and repair/replace complex electrical circuits; use proper test equipment; and maintain various switches. Participants should develop a better understanding of multiplex systems as well as data communication.

Objectives:

Upon completion of this course, participants should be able to:

- diagnose, inspect and troubleshoot complex electrical circuits;
- replace/rewire electrical power circuits;
- remove and replace multipin electrical connectors and terminals;
- repair or create wiring harnesses;
- repair interlock systems and replace current limiters/PTCs;
- identify proper settings and calibrate address/dip switches;

- repair or replace magnetic, optical and/or Hall effect proximity switches;
- use service tools and fault codes to diagnose communication link problems or repair systems;
- inspect, troubleshoot and repair/replace CPU card, gateway module, data communications network, data communications cable, and HCNC and DIO modules;
- use code scanner and adapter card to troubleshoot system;
- demonstrate an increased understanding of multiplex systems, including PLCs, logic diagrams, input and output cards, HCNC and DIO modules, multiplex software, I/O blocks, CPU cards, and multiplex controllers

Job tasks/learning objectives/OJT checklist:

1. 201 Electrical Circuits
2. 201 Electrical Circuits
3. 201 Wiring, Connections & Connectors
4. 202 Electrical Circuits
5. 202 Electrical Circuits
6. 202 Switches
7. 202 Test Equipment
8. 203 Wiring, Connections & Connectors
9. 203 Electronics & Data Communication
10. 203 Electronics & Data Communication
11. 201 and 202 Multiplexing

Course description: Participants will receive classroom instruction in which a qualified instructor will review how to use wiring diagrams to troubleshoot, diagnose, inspect and repair/replace complex electrical circuits; proper use of test equipment; and how to maintain various switches. Emphasis is placed on developing a high level of understanding of data communications and multiplex systems.

Electrical/Electronics—Module G3

Multiplexing 301

Goal: Participants should be able to apply advanced multiplexing knowledge to troubleshoot, inspect and maintain multiplexing systems.

Objectives:

Upon completion of this course, participants should be able to:

- diagnose, repair and replace VMU units;
- troubleshoot and maintain multiplexing systems;
- inspect/troubleshoot main bus controller and PMS modules; and
- check/repair/replace control racks.

Job tasks/learning objectives/OJT checklist:

1. 301 Multiplexing

Course description: Participants will receive classroom instruction in which a qualified instructor will review multiplexing system troubleshooting, inspection and maintenance.

