Title

Southern California Transit Training Consortium Online Training in Electrical Systems and Battery Electric Safety Training

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Publication Date

2023-12-01

DOI

10.7922/G2862DTB

Southern California Transit Training Consortium Online Training in Electrical Systems and Battery Electric Safety Training

December 2023

A Summary Report from the National Center for Sustainable Transportation

Thomas J. O'Brien, California State University, Long Beach

National Center for Sustainable Transportation
A USDOT University Transportation Center

CALIFORNIA STATE UNIVERSITY LONG BEACH

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. NCST-CSULB-RR-23-32	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle Southern California Transit Training Consortium Online Training in Electrical Systems and Battery Electric Safety Training		**5. Report Date** December 2023 **6. Performing Organization Code** N/A
7. Author(s) Thomas J. O'Brien, PhD, https://orcid.org/0000-0002-6518-0263		**8. Performing Organization Report No.** N/A
9. Performing Organization Name and Address California State University, Long Beach Center for International Trade and Transportation 6300 State University Dr. Suite #225 Long Beach, CA 90815-4670		**10. Work Unit No.** N/A **11. Contract or Grant No.** USDOT Grant 69A3551747114
12. Sponsoring Agency Name and Address U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology 1200 New Jersey Avenue, SE, Washington, DC 20590		**13. Type of Report and Period Covered** Summary Report (July 2017 – March 2019) **14. Sponsoring Agency Code** USDOT OST-R

15. Supplementary Notes
DOI: https://doi.org/10.7922/G2862DTB

16. Abstract
In partnership with the Southern California Regional Transit Training Consortium (SCRTTC), the California State University at Long Beach (CSULB) expanded potential audiences and offered program support for the Electric Vehicle Transit Bus High Voltage Safety Awareness class, which was previously developed under the National Center for Sustainable Transportation (NCST). CSULB expanded both the number of online offerings and the geographic reach by opening the class to transit agencies and campus fleet operators within the NCST network. The course was designed to enhance a technician's basic electrical skills and 2-circuit diagnosis, while teaching students how to work with a Digital Volt-Ohm Meter (DVOM). The effort supports the broader goal of building the workforce needed to support the transition to alternative energy and zero emission bus fleets.

17. Key Words Transit, Online training, Workforce Development, Zero emission	**18. Distribution Statement** No restrictions.		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 21	**22. Price** N/A

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Acknowledgments

This study was funded, partially or entirely, by a grant from the National Center for Sustainable Transportation (NCST), supported by the U.S. Department of Transportation (USDOT) through the University Transportation Centers program. The authors would like to thank the NCST and the USDOT for their support of university-based research in transportation, and especially for the funding provided in support of this project. The authors would also like to thank the Executive Committee and members of the Southern California Regional Transit Training Consortium for guiding this training effort.

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Southern California Transit Training Consortium Online Training in Electrical Systems and Battery Electric Safety Training

STATEMENT OF PURPOSE

In partnership with the Southern California Regional Transit Training Consortium (SCRTTC), THE California State University at Long Beach (CSULB) expanded potential audiences and offered program support for the Electric Vehicle Transit Bus High Voltage Safety Awareness class, which was previously developed under the National Center for Sustainable Transportation (NCST). CSULB expanded both the number of online offerings and the geographic reach by opening the class to transit agencies and campus fleet operators within the NCST network. The course was designed to enhance a technician's basic electrical skills and 2-circuit diagnosis while teaching students how to work with a Digital Volt-Ohm Meter (DVOM). The effort supports the broader goal of building the workforce needed to support the transition to alternative energy and zero emission bus fleets.

Overview of SCRTTC and its Members

The Southern California Regional Transit Training Consortium, SCRTTC, is a consortium of Southern California-based community colleges and transit operators, and a leading provider of training for the public transit industry. Its mission is to address Southern California's regional transit training needs, and collaborate with members which include community colleges, universities, transit agencies, and public and private sector organizations.

SCRTTC transit members include the Anaheim Transportation Network, LA DOT, LA Metro, Santa Clarita Transit, Sunline Transit, and several more California transit organizations. College members of SCRTTC include El Camino College, Fresno City College, Hartnell College (Salinas), LA Trade-Technical College, Long Beach City College, and Rio Hondo College (Whittier). CSULB is a SCRTTC affiliate along with the American Public Transportation Association (APTA), and Advanced Transportation and Logistics (ATL).

The Consortium includes a network of training professionals whose area of expertise makes possible training for SCRTTC's member agencies. The pooled resource membership model allows for training efficiency and effectiveness, particularly for smaller transit agencies with limited training budgets.

The SCRTTC has delivered over 71,000 hours of training over the last 13- years for the transit workforce, particularly for its front-line technicians. For the NCST-funded Online Training for the Transit Industry project, CSULB worked with SCRTTC on course development, beta course delivery, and train-the-trainer exercises to certify instructors.

Partners in Sustainability: Online Training for the Transit Industry

This project builds upon an earlier NCST-funded project also implemented by CSULB and the Consortium. That project, "Partners in Sustainability: Online training for the transit industry" was completed in 2017 and focused on developing learning modules for battery electric bus operators and technicians. This earlier project resulted in the development and refinement of a blended course (online and classroom-based) designed to improve a technician's basic electrical skills including circuit diagnosis. In the class, students worked with a digital volt-ohm meter (DVOM) in actual circuit conditions as well as in virtual simulated conditions. This is a critical component of managing sustainable public transit systems.

The course, titled "EV Transit Bus Safety Awareness and Familiarization," provides a general understanding of safety do's and don'ts when working around all-electric high voltage (HV) transit vehicles. Through the course, students become familiar with all-electric high voltage (HV) transit vehicles including high voltage electrical systems, and learn essential aspects of the high-voltage drive system including safety protection and safe operation. The course is intended for transit agency technicians and mechanics who need to familiarize themselves with all-electric high voltage (HV) transit vehicles. The course outline is provided in Appendix B.

Online Training in Electrical Systems and Battery Electric Safety Training

Under this current project, the earlier eDVOM class was offered to a wider set of students focusing on fleet operators in communities associated with NCST partner institutions. This included campus fleets including the operator of UC Davis' transit system which took part in the training.

The grant also allowed for the development of a new course, EV Transit Bus Safety Awareness and Familiarization, offered both in-person and online, in response to manufacturer recommendations and subject matter experts (SME). The course is designed to guide and prepare the student for troubleshooting, diagnosing, and repairing battery electric transit vehicles. Overall, the performance period for development and delivery of the course was 36 weeks. Subject matter expert (SME) critique of the courseware was conducted during beta development. A Train-the-Trainer (T-t-T) course was also provided that certifies the instructors and enables the course to be validated and cataloged for delivery to all transit agencies. Course descriptions for both the self-paced online and in-person instructor-led versions can be found at the end of this report.

The courseware development was completed late August 2017 and presented to the Beta Team for Review. Under SCRTTC procedures, when courseware is developed and presented to the Beta Team, if 25% of the content requires changes a second Beta Review is required.

In September, the Beta Team reviewed the content with less than (<10%) changes to the courseware. This allowed the Beta Team to proceed to the Train-the-Trainer phase. There were few changes required by this latter phase so there was no requirement for a second beta review.

The following personnel were part of the Beta Review Team:

- Mike Brock, Immersed Technology Inc.
- Joel Frankwick, Immersed Technology Inc.
- Mike Conner, BYD now working at Antelope Valley Transit Authority
- Mike Finnern, Proterra Inc.
- Carlos Rojas, LA Trade Tech College

The Train-the-Trainer component consisted of the following personnel who certified the instructor for delivery of the courseware.

- Mike Conner, Antelope Valley Transit Authority
- Mike Finnern, Proterra Inc.
- Obed Mejia, LA Metro
- George Martinez, Santa Monica Big Blue Bus
- Carlos Rojas. LA Trade Tech College

- Marty Kennedy, San Diego Miramar College
- Bob Vannix, Immersed Technology

Post-Beta, the course was formally catalogued and SCRTTC began marketing it for delivery in the 4th Quarter of 2017.

Impacts/Benefits of Implementation

The implementation of the eDVOM and the EV Transit Bus Safety Awareness and Familiarization courses resulted in the following:

- Two sessions of the eDVOM online course were provided by CSULB in partnership with SCRTTC in October and November 2017. Ten students attended for a total of 160 student hours.
- CSULB provided 496 student hours of training as part of EV Transit Bus Safety Awareness Familiarization course rollout.
- In addition, one on-the-ground class was held at Monterey-Salinas Transit in March 2019, where 88 student training hours were completed.
- Furthermore, CSULB offered three additional SCRTTC courses using its virtual class platform: eElectrical I in November 2017, with 10 students for a total of 80 student hours; eCNG Transit Vehicle Safety in October 2017, with 10 students for a total of 80 student hours; and Cummins eINSITE Electronic Diagnostics in December 2017, with 10 students for a total of 88 student hours.

The work under this project allowed CSULB to contribute to the development of sustainable transit training curricular materials in partnership with the SCRTTC, and to further refine the effectiveness of these materials in the online environment which prior to the pandemic was still a relatively new format of instructional delivery for this sector. In addition, we furthered our understanding of workforce and training development needs in transit.

Appendix A. Course Name: Digital Volt-Ohm Meter (DVOM) and ITS

Course Item Number: #SC-eDV-2700-I

Prerequisites: Personal Experience with Digital Volt-Ohm Meter Desired

Course Description: The Digital Volt-Ohm Meter (DVOM) and ITS self-paced distance learning course is designed to improve technicians' understanding of basic DVOM functions. Students will be working with a virtual DVOM to learn its safe usage and best practices. Course includes both knowledge topics and knowledge activities. Reference Material will be provided as Resources.

Course Benefits: Students will be exposed to the most commonly used capabilities of the DVOM. Students will gain knowledge about the functions and usage of the DVOM using the virtual meter in a controlled environment.

Who Should Attend: TBD by Supervisor

What One Will Learn: By the end of this course the student will be able to:

- Use the functions of the DVOM
- Properly hookup the DVOM for each function
- Interpret basic DVOM digital displays
- Perform voltage measurements
- Perform current measurements
- Perform resistance measurements
- Identify open circuits and high resistance
- Understand Min/Max, diode and other special functions

Course Times: Self-paced and self-directed.
(SUBJECT TO CHANGE – CHECK REGISTRATION)

Students are required to attend a 1-hour orientation at the start of the course and 1-hour closing session at the end of the course.

Number of Hours/Days: 16 Hours over 4-week period

Continuing Education Units (CEU): 0

Register Online Today: www.scrttc.com

CSULB BeachBoard Access Requirements

How to access your course for the first time?

Everyone will be issued a California State University, Long Beach Campus Identification Number (BeachID User Account). Your Campus Identification Number, along with instructions on how to log in, will be emailed to you. Along with how to access your course for the first time, an orientation module will be available that will contain the following useful information:

1. How to access your course for the first time?
2. Beachboard ID Activation/Login Procedure
3. How to Find Your Course?
4. My Home
5. Course Home
6. Accessing Course Content
7. Taking Assessments
8. How to track your assessment progress (grades)?
9. Beachboard (Desire2Learn) Resources for Instructors and Students

If you have any issues, please contact your training facilitator.

Digital Volt Ohm Meter (DVOM) and Intelligent Transportation Systems (ITS) Course Outline

1) Introduction
    a) Course Overview
2) ITS Overview
    a) ITS Introduction
    b) Federal Legislation
    c) ITS Agencies
3) ITS Implementation
    a) ITS Uses
    b) ITS Advantages
    c) Typical ITS
    d) ITS Reliability
4) ITS Subsystems
    a) Subsystems
    b) Communication Systems
    c) Data Systems
    d) Mobile Data Terminals
    e) Vehicle Operating Systems
    f) Maintenance Management Systems
5) Smart Bus
    a) ATMS
    b) Integrated Systems
    c) Automatic Vehicle Locator
    d) AVL Interconnectivity
    e) Computer-Aided Dispatch
    f) Computerized Vehicle Performance Data
    g) Traffic Signal Priority Systems
    h) Passenger Counting and Announcement Systems
    i) Surveillance Systems
6) ITS Summary
    a) Summary
7) Introduction
    a) DVOM Introduction
8) DVOM Overview
    a) Multimeters
    b) Advantages
    c) Layout

9) Meter Functions
    a) Input Terminals
    b) Rotary Switch
    c) Pushbuttons
    d) Display
    e) Auto Range
    f) Over-Limit Measurement
    g) Multipliers
    h) Multipliers
    i) Knowledge Activity
    j) Knowledge Activity

10) Safety
    a) DVOM Safety
    b) Current Safety
    c) DVOM Care and Maintenance
    d) Electrostatic Discharge (ESD)

11) Voltage
    a) Meter Settings
    b) Voltage Types
    c) Source Voltage
    d) Available Voltage
    e) Voltage Drops
    f) Converting Voltage Values
    g) Knowledge Activity
    h) Knowledge Activity
    i) Knowledge Activity

12) Amps
    a) Meter Settings
    b) Measuring Current
    c) Parasitic Draw
    d) Inductive Current Probe
    e) Converting Amperage Values
    f) Knowledge Activity

13) Ohms
    a) Meter Settings
    b) Resistance Measurements
    c) How to Read Resistors
    d) Converting Resistance Values
    e) Knowledge Activity
    f) Knowledge Activity
    g) Knowledge Activity

h) Knowledge Activity

14) Circuit Diagnosis
   a) Types of Faults
   b) Open Circuits
   c) Short Circuits
   d) High Resistance
   e) Knowledge Activity
   f) Knowledge Activity

15) Other DVOM Functions
   a) Introduction
   b) Diodes
   c) Forward and Reverse Bias
   d) Frequency
   e) Duty Cycle
   f) Min/Max
   g) Temperature
   h) Knowledge Activity
   i) Knowledge Activity

16) Test Lights and Probes
   a) Test Lights and Probes
   b) How to Connect a Test Light
   c) Piercing Probes

17) Conclusion
   a) Course Completion

Appendix B. Course Name: EV Transit Bus Safety Awareness and Familiarization

Course Item Number: #SC-BEV-5000-I

Prerequisites: DVOM Course (preferred) or thorough understanding of meters or equivalent experience.

Course Description: This course will provide a general understanding of safety do's and don'ts when working around all-electric high voltage (HV) transit vehicles. This course is not intended as a replacement for manufacture specific training and does not qualify the student to diagnose, repair, and work on HV vehicles.

Course Benefits: Students will become familiar with all-electric high voltage (HV) transit vehicles to include high voltage electrical systems and their safe operation. Students will learn essential aspects of the high-voltage drive system including safety protection and safe operation.

Who Should Attend: Transit agency technicians/mechanics who need to familiarize themselves with all-electric high voltage (HV) transit vehicles.

What you will learn: By the end of this course the student will be able to:

- Identify the vehicles high-voltage components
- Explain the required Personal Protective Equipment (PPE)
- Describe the preparations prior to working on or near any high-voltage systems
- Explain the vehicle safety systems
- Identify HV Components and cables in an EV transit bus
- Understand the definitions, terminology, and units of measure, of electrical energy storage and consumption

Course Times: In-class 8am to 4pm (SUBJECT TO CHANGE – CHECK REGISTRATION)

Number of Hours/Days: 16 hours in-class for 2-day instructor facilitated training.

Continuing Education Units (CEU): 0

Register Online Today: www.scrttc.com

EV Transit Bus Safety Awareness and Familiarization Course Outline

1) Similarities & Differences of Transit Bus Equipment
    a) Similar Components in both transit bus systems
        a) Braking Systems
        b) Air Suspension System
        c) Interior and Exterior Lighting, Exterior Mirrors
        d) Cooling System Operation
        e) Door System
        f) Low Voltage
        g) Multiplexer (MUX) & CAN (Controller Area Network)
        h) Grounding
    b) Different Bus Components with HV Systems
        i) Heating unit - electrically powered
        j) A/C compressor
        k) Air Compressor
        l) Power steering unit
        m) Electrical wheel hub drive motor
        n) Regenerative braking
2) High Voltage System Overview
    a) HV Components
    b) HV Power Distribution
    c) Regenerative Braking
    d) HV Defrosters
    e) Contactor Box (High Voltage distribution)
    f) On-Board Chargers (VtoG or Inverters)
    g) HV Battery
3) Safety and Personal Protective Equipment (PPE)
    a) Safety Precautions
    b) Understanding NFPA 70E
    c) Lock out Tag out
    d) HV Power down
    e) HVIL - High Voltage Interlock Loop
    f) Rooftop Access Safety
    g) Appropriate PPE and Tools
    h) High Voltage Safety Equipment
4) Units of Energy – Differences between fuel and electrical energy
    a) Energy Units of Measure
    b) Energy Equivalent

5) Facility Considerations for EV transit vehicles
    a) Fluid change
    b) Oil change
    c) Charging Equipment Systems
        a) J1772 CCS Type 1
        b) Overhead charging (Proterra buses)

Appendix C. Course Name: eEV Transit Bus Safety Awareness and Familiarization

Course Item Number: #SC-eBEV-5000-DE-I

Prerequisites: DVOM Course (preferred) or thorough understanding of meters or equivalent experience.

Course Description: This course will provide a general understanding of safety do's and don'ts when working around all-electric high voltage (HV) transit vehicles. This course is not intended as a replacement for manufacture specific training and does not qualify the student to diagnose, repair, and work on HV vehicles.

Course Benefits: Students will become familiar with all-electric high voltage (HV) transit vehicles to include high voltage electrical systems and their safe operation. Students will learn essential aspects of the high-voltage drive system including safety protection and safe operation.

Who Should Attend: Transit agency technicians/mechanics who need to familiarize themselves with all-electric high voltage (HV) transit vehicles.

What you will learn: By the end of this course the student will be able to:

- Identify the vehicles high-voltage components
- Explain the required Personal Protective Equipment (PPE)
- Describe the preparations prior to working on or near any high-voltage systems
- Explain the vehicle safety systems
- Identify HV Components and cables in an EV transit bus
- Understand the definitions, terminology, and units of measure, of electrical energy storage and consumption

Course Times: Self-paced and self-directed. (SUBJECT TO CHANGE – CHECK REGISTRATION)

Number of Hours/Days: 8 hours online over a 3 week period.

Continuing Education Units (CEU): 0

Register Online Today: www.scrttc.com

eEV Transit Bus Safety Awareness and Familiarization Course Outline

1) Similarities & Differences of Transit Bus Equipment
    a) Similar Components in both transit bus systems
        a) Braking Systems
        b) Air Suspension System
        c) Interior and Exterior Lighting, Exterior Mirrors
        d) Cooling System Operation
        e) Door System
        f) Low Voltage
        g) Multiplexer (MUX) & CAN (Controller Area Network)
        h) Grounding
    b) Different Bus Components with HV Systems
        i) Heating unit - electrically powered
        j) A/C compressor
        k) Air Compressor
        l) Power steering unit
        m) Electrical wheel hub drive motor
        n) Regenerative braking
2) High Voltage System Overview
    a) HV Components
    b) HV Power Distribution
    c) Regenerative Braking
    d) HV Defrosters
    e) Contactor Box (High Voltage distribution)
    f) On-Board Chargers (VtoG or Inverters)
    g) HV Battery
3) Safety and Personal Protective Equipment (PPE)
    a) Safety Precautions
    b) Understanding NFPA 70E
    c) Lock out Tag out
    d) HV Power down
    e) HVIL - High Voltage Interlock Loop
    f) Rooftop Access Safety
    g) Appropriate PPE and Tools
    h) High Voltage Safety Equipment
4) Units of Energy – Differences between fuel and electrical energy
    a) Energy Units of Measure
    b) Energy Equivalent

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    a) Fluid change
    b) Oil change
    c) Charging Equipment Systems
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