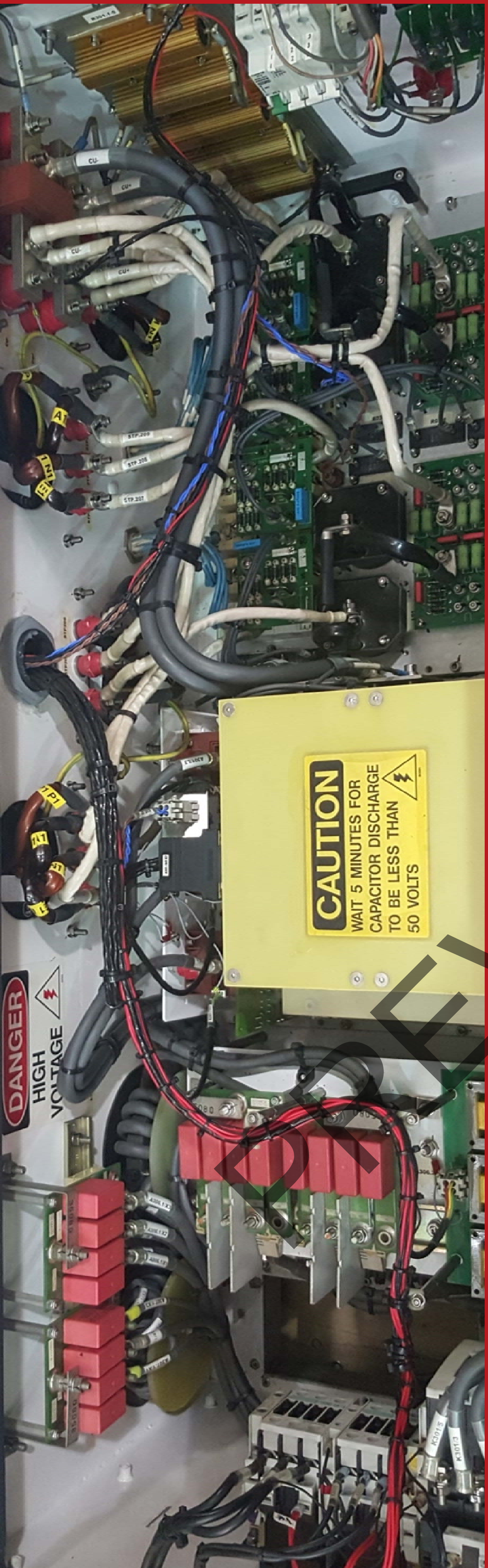

Auxiliary Power Supply and Battery Systems

Troubleshooting and Repair

Course 304

PARTICIPANT GUIDE

RAIL CAR TRAINING CONSORTIUM

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MODULE 1

Troubleshooting the APS System

Outline

Purpose and Objectives

The purpose of this module is to provide participants with an overview to troubleshooting auxiliary power supply systems on rail cars within the context of general troubleshooting and best practices.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Explain the use of computer-aided diagnostics
- Remove and replace the APS ventilation fan
- Troubleshoot common reported problems including ground faults, overvoltage, and lost phase.
- Apply troubleshooting principles to faulty IGBTs
- Apply troubleshooting principles to other faulty APS components

Key Terms

- Line Replaceable Unit (LRU)
- Portable Test Equipment (PTE)
- Portable Test Unit (PTU)
- Troubleshooting

Each APS system must have some kind of computer interface or controller board which communicates between the **portable test unit** (PTU), also known in some agencies as **portable test equipment** (PTE) and the APS controller. In some cases the PTU is a laptop or notebook computer such as the one shown in Figure 1.2 and may be connected via a serial Ethernet cable to the controller installed on the APS. Some rail transportation agencies can retrieve live diagnostic data wirelessly.

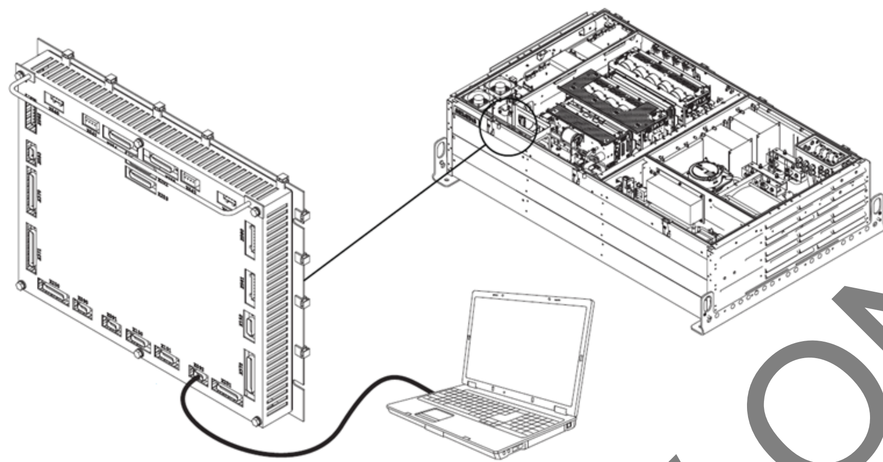


Figure 1.2 Laptop connected via Ethernet port to computer interface installed on APS –courtesy SDMTS

The controller board relays information via some kind of diagnostic visual display software. Each agency uses its own APS diagnostic software depending on OEM requirements. For example, SDMTS, CATS, and Denver RTS have Siemens APS installed on their rail cars and use Sibmon®, a Siemens product, as their diagnostic display software. Another example, CTA uses diagnostic software that comes with its Turbo Power Systems™ APS systems installed on the agency's latest 5000 series train.

Some transportation agencies use their own proprietary software. For example, CTA uses proprietary software developed by General Electric, wPTU®, on its older 2600 and 3200 series rail cars. The APS system controller communicates to various subsystems within the APS such as, in some cases, a battery monitor circuit and/or an IVPS.

It is important to note that the PTU directs the technician to *possible or likely* faults within the APS. The job of the troubleshooter is to pair the fault with the actual reported incident thereby trying to isolate the problem.

Classroom Activity

What is the APS diagnostic software used in your transportation agency?

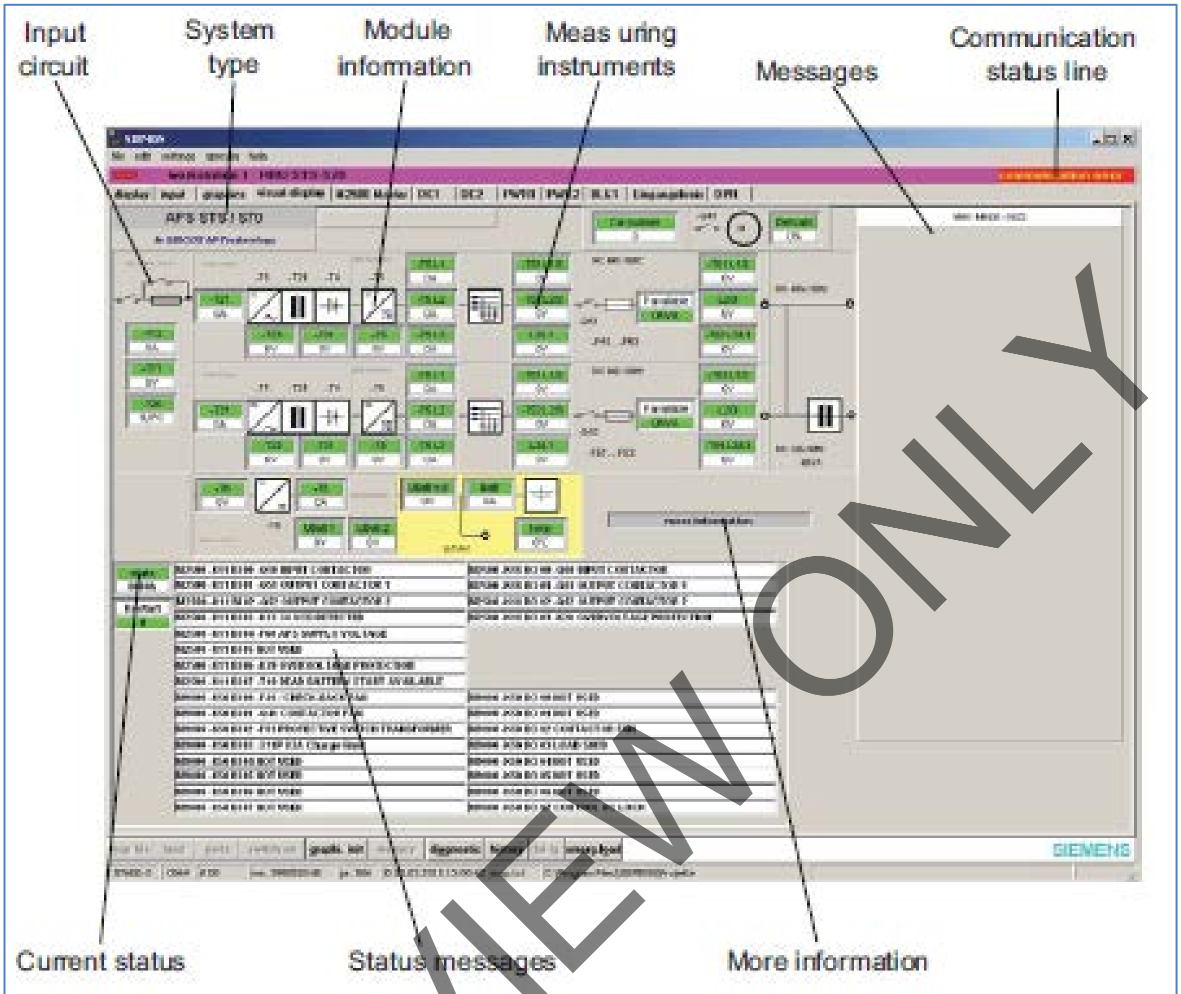


Figure 1.5 Sibmon® PTU Display Screen –courtesy SDMTS

Classroom Activity

What are some of the similarities and differences between the PTU displays you use in your transportation agency compared to the screen shots shown in this section?

Classroom Activity

Using what you already know about APS system controllers, how similar or different is your transportation agency to BART described in Case Study 1.1.

Case Study 1.1: **Bay Area Rapid Transit (BART)**

The Bombardier™ APSE consists of four major subsystems:

- Intermediate Voltage Power Supply (IVPS)
- Low Voltage Power Supply (LVPS)
- Three-Phase Inverter (TPINV)
- System Controller

System Controller

The System Controller and the IVPS have their own control logic circuit. The LVPS and TPINV are packaged onto one Line Replaceable Unit (LRU) and have a combined control logic circuit.

Communication to the FIMS[*] is also accomplished through this controller. The system controller reports the health of the APSE, operating condition of the HVAC system heaters, and other event situations to the FIMS.

The system controller also oversees the operation of the APSE by communicating with the IVPS and LVPS/TPINV controllers. Commands, operational data, and status data are passed between the controller boards. The system controller board also maintains data and event logs that can be used to evaluate operational performance and to perform diagnostic analysis. Full data and event logs for each subsystem controller reside on each board and can be acquired through the local Portable Test Unit (PTU) ports.

All software modules are copied to computer network that facilitates easy backup and setup on newer PTU laptops.

[*] FIMS Fault Indication and Monitoring System

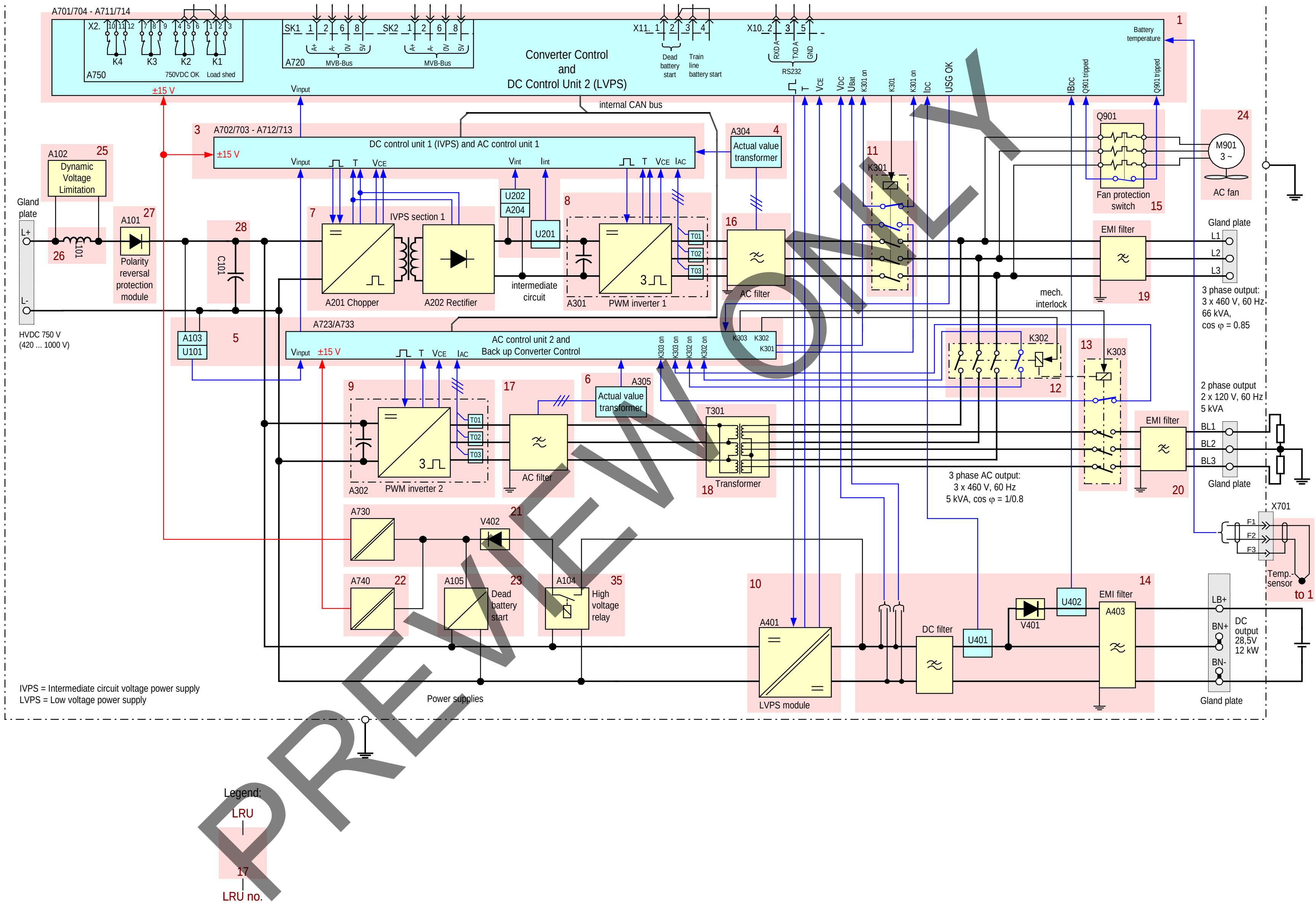


Figure 1.7 Siemens™ APS System with identified LRUs –courtesy CATS

Validating the reported fault and replacing the faulty LRU is illustrated in Figure 1.8. This can be referred to as a "Level 1" troubleshooting approach.

But if the reported fault is not validated then the rail car troubleshooter will have to consider next steps to fixing the problem.

APS diagnostic software in many cases helps confirm a reported fault by applying advanced diagnostic tests. It is now up to the troubleshooter to aim to get to the root cause of the problem. Often this involves swapping out LRU components one-by-one as Figure 1.9 illustrates.

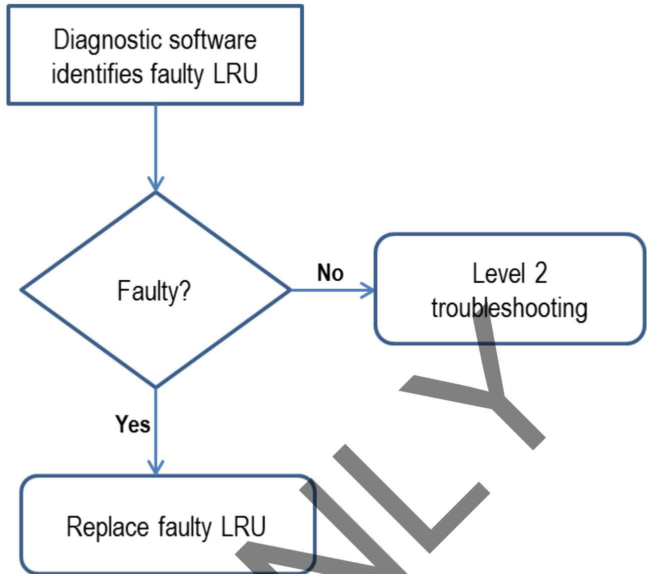


Figure 1.8 Level 1 Troubleshooting of APS LRUs– courtesy CATS

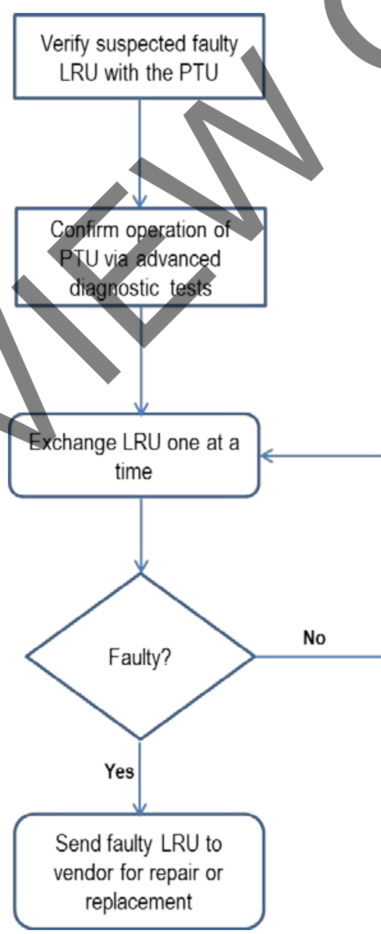


Figure 1.9 Level 2 Troubleshooting of APS LRUs –courtesy CATS

Overvoltage

Overvoltage is the condition when the voltage in a circuit is raised above its upper design limit. This can be a hazardous situation if the condition if its duration is longer and leading to a power surge.

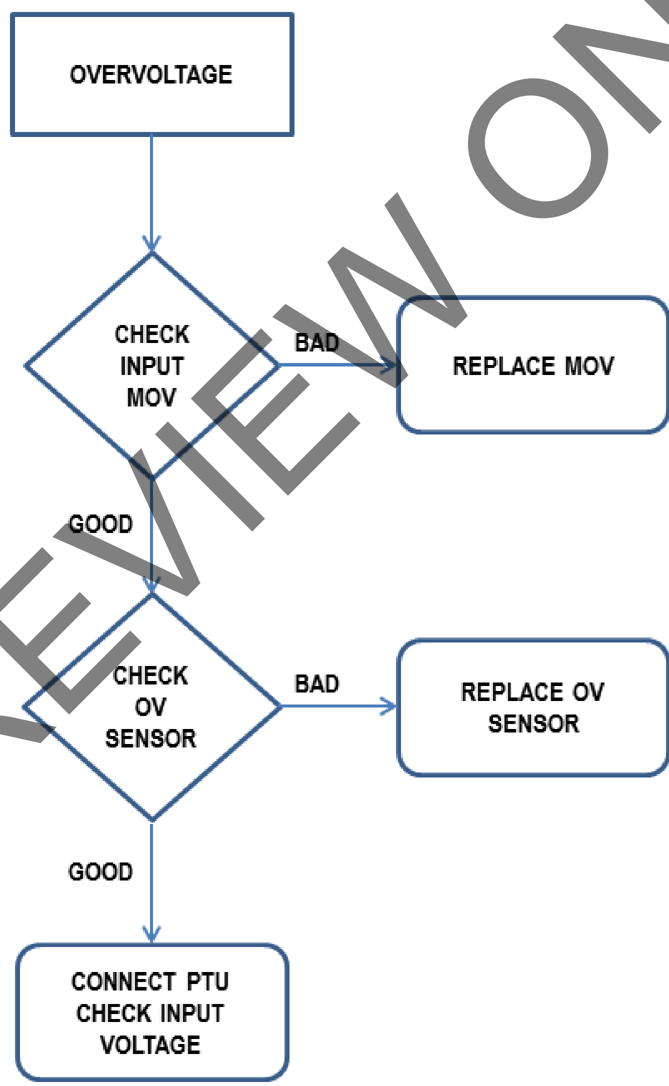
Classroom Activity

Using the Overvoltage Troubleshooting Note Record below, what are some of the likely findings and resolution to overvoltage situation pertaining to the rail car's auxiliary power supply system. In the space below the notes in each row, write down comparable information pertinent to your agency.

Overvoltage Troubleshooting Note Record	
Initial Problem or Complaint:	Indicator from PTU. Warning light. Railcar will shut down - loss of propulsion power. *Your agency:*
Other Relevant information	Reported by operator. Confirmed during inspection. *Your agency*
All Possible Causes:	Power supply not sufficient. Spike in input voltage - voltage exceeded what can be handled. Consider possible "sympathy overload" as described in a third rail system described below in Case Study 1.2 *Your agency:*

Scenario 2

Problem	Likely causes	What to do
Over voltage	• Malfunctioning input Metal-Oxide Varistor or MOV. The MOV is a component that protects the APS system from damaging power surges. MOVs wear out with use. • Malfunctioning Over-Voltage Sensor or OVS. • For some APS systems, PTU sends message of low voltage to specific component.	• Check input MOV. Using a multimeter, test for optimal resistance or if there is a shorted reading. If resistance is too low or reading is shorted, replace with new MOV.



MODULE 2

Troubleshooting the Battery System

Outline

Purpose and Objectives

The purpose of this module is to provide participants with and overview to troubleshooting battery systems on rail cars within the context of general troubleshooting and best practices.

Following the completion of this module, the participant should be able to complete the objectives with an accuracy of 75% or greater:

- Apply troubleshooting principles to the battery charger and LVPS
- Identify probable causes of NiCd battery malfunction and repair NiCd Batteries
  - Replace NiCd batteries
  - Charge NiCd batteries
  - Troubleshoot shorted cells
  - Diagnose charging rates and non-charging rates

Key Terms

- Commissioning the battery
- Emergency Lighting Activation
- Erratic output
- Excessive water consumption
- Insufficient water consumption
- Low current output
- Under voltage
- Weak battery

Ground Fault

Ground faults are frequently the result of insulation breakdown and equipment on the rail car, other than the battery, can cause fault. The rail car technician would need to troubleshoot this problem by checking the battery charging system. This may involve isolating loads on the rail car and, if required, isolate cars in order to locate ground.

Under voltage

Under voltage occurs when the average voltages provided to and generated by the LVPS drops below intended levels.

Problem	Likely causes	What to do
Under voltage	Low battery voltage	Check battery voltage. Check battery charger.
	Bad fuse	Replace fuse.
	Poor connections on APS	Check if HVPS is available and LVPS is working. Check all fuses and breaker on LVPS. Check connections on APS and LVPS. Using PTU check applicable codes on APS and LVPS.

Classroom Activity

With help from your instructor, discuss common reported problems that are likely the result of an under voltage situation. Use the following blank Under Voltage Troubleshooting Note Record to help with defining the problem, its likely causes, and potential ways to resolve the problem.

Under Voltage Troubleshooting Note Record	
Initial Problem or Complaint:	E.g., Who typically reports this problem?
Other Relevant information	E.g., What is the history of this fault on this battery on this rail car?

Weak Battery

Problem	Likely causes	What to do
Weak battery	Low charge voltage	Check charger output to battery.
	Low Electrolyte	Check level of electrolyte.
	Low capacity	Check battery cells for zero volts or very low voltage.
	Loads left with charger off	Checks switch panels and circuit breakers. Recharge batteries per OEM recommendation.
	Current leakage due to foreign matter on battery	Clean batteries. Recharge battery after cleaning per OEM recommendation.

Excessive Water Consumption

Problem	Likely causes	What to do
Excessive water consumption	Charge voltage too high	Check charger output to battery. Recalibrate charging system. Top up electrolyte per OEM recommendation.
	One or more cells shorted causing a higher charging voltage on rest of cells in battery	Check for cells with zero voltage. Remove battery and replace defective cell per OEM recommendation.
	Small leak or cracks causing cell to dry out	Check for wetness in battery box, battery. Using a voltmeter check which parts of the battery has lowest potential to ground. Clean and dry battery and battery box per OEM recommendation.
	Elevated outside temperature and/or no compensation on charging voltage	Top up electrolyte levels per OEM recommendation. Check charging system.

2-3 TROUBLESHOOTING REDUCED BATTERY PERFORMANCE

Reduced battery performance deserves its own section in this module because it is one reported problem with many probable causes. This section identifies corrective actions for probable causes of reduced peak performance of NiCd batteries. All corrective actions should be performed per OEM recommendations as well as per agency requirements and procedures.

NiCd batteries benefit from conditioning cycles. Battery conditioning is a means of depleting and recharging the battery over a period of time. This cleans the battery cells and restores battery life. For the types of batteries used on rail cars, this conditioning is a slow process sometimes taking an entire day. Some rail car maintenance facilities are equipped with battery commissioning units while others send out the batteries to a third party for conditioning.

Commissioning instructions vary across agencies and by rail car battery manufacturers so the rail car technician must follow their agencies' procedures and OEM recommendations.

Reduced Peak Performance – Probable Causes and Correction Actions	
Probable Cause	**Corrective Action**
1. Rupture of several internal cell connections.	Replace damaged cell(s). Commission battery. Clean and dry battery and battery box. Check for correct polarity connections.
2. Ruptured cell(s), tube(s), connection(s).	Replace damaged cell(s), tube(s) or connection(s). Commission battery. Clean and dry battery and battery box
3. Metallization, performance, or oxidation of separators.	Replace damaged cell(s). Commission battery. Clean and dry battery and battery box.
4. Several sheets of separator missing.	Replace damaged cell(s). Commission battery. Clean and dry battery and battery box.
5. Hydrogen ignition outside cell(s) due to presence of flame or spark.	Replace battery. Commission battery. Clean and dry battery and battery box.
6. Open circuit due to cell(s) dry out or internal corrosion due to use of acid or other water contaminants.	Commission battery. Clean and dry battery and battery box.

2-4 SUMMARY

Troubleshooting NiCd battery systems is a given as far as rail car maintenance work. This module also presented some common reported problems with battery systems and offered corrective actions to follow to resolve these issues. This module presented the participant with troubleshooting charts collected from various Consortium transit agencies. These charts helped guide the rail car technician towards diagnosing and troubleshooting a malfunction in the battery system.