Auxiliary Power Supply
and Battery Systems

Introduction and Overview

Course 104

INSTRUCTOR GUIDE

Module 2: Power Collection and Shop Power

RAIL CAR TRAINING CONSORTIUM
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### Agenda

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<th>Topic Title</th>
<th>Duration</th>
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<tr>
<td>1</td>
<td>Overview</td>
<td>10 min</td>
</tr>
<tr>
<td>2</td>
<td>Power Collection</td>
<td>30 min</td>
</tr>
<tr>
<td>3</td>
<td>Shop Power</td>
<td>30 min</td>
</tr>
<tr>
<td>4</td>
<td>Summary</td>
<td>5 min</td>
</tr>
<tr>
<td>5</td>
<td>Quiz</td>
<td>15 min</td>
</tr>
</tbody>
</table>

**TOTAL TIME**

90 min (1.5 hours)
MODULE 2

POWER COLLECTION AND SHOP POWER

Outline

2.1 Overview
2.2 Power Collection
2.3 Shop Power
2.4 Summary

Purpose and Objectives

The purpose of this module is to provide participants with an overview of power collection, its distribution in the train vehicle and in the maintenance shop.

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

- Identify input sources of power to a rail vehicle.
- Explain and differentiate between input and grounding.
- Recognize high and low voltage systems in a rail vehicle.
- Diagram the flow of power from high voltage to low voltage in a rail vehicle.

Key Terms

- Catenary
- Collector Shoe
- Intermediate Voltage Power Supply (IVPS)
- Knife Switch
- Low Voltage Power Supply (LVPS)
- Pantograph
- Running rails
- Shop Power
- Stynger
- Third Rail
- Three-Phase Inverter (TPINV)

2-1 OVERVIEW

Energy is an essential element for our lives and for the rail vehicles on which passengers depend. The work of the rail vehicle technician is to ensure that the vehicle’s energy is available for passengers and train operators not only for convenience but also for safety, reliability, and efficient operation.

Figure 2.1 is a schematic representation of the distribution of power in a rail vehicle in MBTA’s shop. Other transit agencies may have different voltages than those illustrated in this diagram but the concept is similar. Further on in this module, the participant will see a table comparing the varying power configurations across several Consortium transit agencies.

![Diagram of Power Distribution]

Figure 2.1 Distribution of Power from Catenary to Vehicle - courtesy MBTA

This module focuses on the power collected by the rail vehicle as well as the power used in the shop where the rail vehicle is maintained by trained technicians. In the above schematic the participant will walk through from catenary to shop power as highlighted by the shaded area in Figure 2.1.
**Instructor’s Guide**

**Module Length:** 90 min  
**Time remaining:** 90 min  
**This section:** 10 min (7 slides)  
**Section start time:**  
**Section End Time:**

<table>
<thead>
<tr>
<th>DO</th>
<th>SAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVIEW slides</td>
<td><strong>In your own words:</strong> Welcome to Module 2 of Course 104: Power Collection and Shop Power. The purpose of this module is to provide participants with an overview of power collection, its distribution in the rail vehicle and in the maintenance shop.</td>
</tr>
<tr>
<td>Instructor’s Notes</td>
<td><strong>Advance Slide.</strong> Energy is an essential element for our lives and for the rail vehicles on which passengers depend. The work of the rail vehicle technician is to ensure that the vehicle’s energy is available for passengers and train operators not only for convenience but also for safety, reliability, and efficient operation.</td>
</tr>
</tbody>
</table>

**Materials Needed**

- PPT Slides 1, 2
2-2 POWER COLLECTION

Light and heavy rail transit vehicles are dependent on high voltage feed from an external source (typically 600 to 1000 Vdc). Because the vehicles are in motion, a sliding contact is necessary to collect this high voltage power. This is typically accomplished with one of two methods:

1. Overhead catenary with pantograph, or
2. Third rail and collector shoes (paddles).

Whichever method is used, the running rails serve as the ground return. The participant should recall that the running rails are the two rails of the track upon which the wheels of the train rest and which provide the guidance for the train.

Catenary and Pantograph

The catenary is an overhead bare copper wire suspended from above and parallel to the running rail. A pantograph mounted on the roof of the vehicles is hinged to provide up and down motion. A spring pushes the pantograph upward to maintain the proper force against the catenary. The surface of the pantograph that rides against the catenary is comprised of a replaceable carbon element that collects power from the catenary for the operation of the rail vehicle.

Figure 2.3 Catenary and Pantograph – courtesy Denver RTD

Figure 2.4 Pantograph on Rail Vehicle in Maintenance Facility – courtesy Denver RTA
### Introduction and Overview to APS & Batteries

#### Instructor’s Guide

**Materials Needed**

- PPT Slides 8, 9

| **DO** | **SAY** | **In your own words:** Light and heavy rail transit vehicles are dependent on high voltage feed from an external source (typically 600 to 1000 Vdc). Because the vehicles are in motion, a sliding contact is necessary to collect this high voltage power. This is typically accomplished with one of two methods:  
Overhead catenary with pantograph, or  
Third rail and collector shoes (paddles). Whichever method is used, the running rails serve as the ground return. The participant should recall that the running rails are the two rails of the track upon which the wheels of the train rest and which provide the guidance for the train.  
*Advance slide*

Here’s another view of the overhead catenary with pantograph.  
*Advance slide*  
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#### Instructor’s Notes

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PARTICIPANT GUIDE VIEW

INTRODUCTION AND OVERVIEW OF AUXILIARY POWER SUPPLY AND BATTERIES

MODULE 2: POWER COLLECTION AND SHOP POWER

Some shops have source power available to the rail vehicles while they are being maintained or repaired. In the two case studies below, both transit agencies have overhead catenary systems in their repair shops as well as shop power from stinger cables.

Case Study 2.1: Charlotte Area Transit System (CATS)
The primary power source for the vehicle is the overhead catenary system (OCS) which provides high voltage (750 Vdc) to the Light Rail Vehicle (LRV) through the pantograph mounted on the roof of its C section. The 750 Vdc is routed through the main fuse (250 A) to a knife switch, then distributed to the auxiliary power supply (APS) and to the A, B, and C cars' heater circuits. The knife switch enables application of "shop power" (stinger) in place of the OCS supply during maintenance operations.

Case Study 2.2: Greater Cleveland Regional Transportation Authority (GCRTA)
The GCRTA rail shop has nine available tracks for rail vehicle maintenance and repair. Shop power is supplied to four of tracks by 600 Vdc overhead catenary systems. On these tracks, rail cars can be moved in and out of the shop through normal operation. The majority of testing, troubleshooting, and inspection occurs on these tracks.

The other five tracks where overhead catenary is not present, shop power is supplied via 600 Vdc stinger cables. GCRTA uses these tracks primarily for long term repairs that do not require power. However, if power is needed, stinger cables can supply 600 Vdc to the vehicle by inserting the stinger plug into the car's side receptacle. Additional steps have to be taken in order for safe operation. If the wrong receptacle or knife switch placement is used, high voltage potential will be present in the propulsion system, including the pantograph. The GCRTA rail shop will generally move a rail car to a powered track before using a stinger cable to energize that vehicle.

Powering a rail vehicle in this manner can be equivalent to using the overhead catenary power if additional steps are not taken to isolate the high voltage propulsion circuits.

In the following table the participant can see a list of five Consortium transit agencies and their various configurations of collected and shop power.

<table>
<thead>
<tr>
<th>Transit Agency City</th>
<th>Collected Power Voltage</th>
<th>Shop Power Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATS Charlotte</td>
<td>Overhead Catenary 750 Vdc</td>
<td>750 Vdc routed through main fuse (250 A) to a knife switch then distributed to auxiliary power supply. Shop plug on roof of train.</td>
</tr>
<tr>
<td>GCRTA Cleveland</td>
<td>Overhead Catenary 600 Vdc</td>
<td>GCRTA rail cars currently use a DC to DC static converter. The converter accepts high voltage input at 600 VDC and converts it to 75.5 VDC low voltage output. The step down in voltage is accomplished by using transistor switched transformers. The low voltage output is used to supply the essential and non-essential low voltage needs within the car as well as charge the storage batteries.</td>
</tr>
<tr>
<td>RTD Denver</td>
<td>Catenary 750 Vdc</td>
<td>750 Vdc Does not use shop power. Catenary throughout shop.</td>
</tr>
<tr>
<td>BART San Francisco</td>
<td>Third Rail 1000 Vdc</td>
<td>Two kinds of shop power:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 208 Vdc 3-phase shop power for L VPS systems on rail vehicle.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 1000 Vdc checking full operation of APSE and HVAC. Shop plug under car.</td>
</tr>
<tr>
<td>MBTA Boston</td>
<td>Overhead Catenary 620 Vdc</td>
<td>620 Vdc Shop plug on side of train.</td>
</tr>
<tr>
<td>San Diego</td>
<td>Overhead Catenary 740 Vdc</td>
<td>740 Vdc Shop plug on roof of train.</td>
</tr>
</tbody>
</table>
**DO**

INDIVIDUAL ACTIVITY

REFER participants to coursebook

**SAY**

In your own words:
Using the chart on page 26 as an example, define the shop power route from the collected power source to the shop.

*Allow time for participants to complete the activity.*

Knowledge Check answers appear behind “white out” blocks. Click through slide to reveal answers.

Read knowledge check and solicit responses.

Advance slide.

**Materials Needed**

- PPT Slide 21
- Coursebook