P3010
Los Angeles LRV

VEHICLE SYSTEMS

Section 0100
RUNNING MAINTENANCE & SERVICING MANUAL

LIST OF EFFECTIVE PAGES

Insert latest changed pages; dispose of superseded pages in accordance with applicable regulations.

NOTE: On a changed page, the portion of the text affected by the latest change is indicated by a vertical line.

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Draft....................................Final Draft.........................September 2015
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Draft....................................Final Draft-B ....November 2019
Draft....................................Final Draft-C ....January 2020
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Draft....................................Final Draft-E ....June 2023
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SAFETY SUMMARY

Some of the procedures in this section are preceded by warnings/cautions regarding potential hazards in handling this equipment. These warnings/cautions should be carefully read and understood before proceeding. Failure to observe these precautions may result in serious injury to personnel performing the work and/or bystanders.

While troubleshooting take care to avoid personal injury. Avoid situations that present the danger of electrical shock or injury from moving equipment. Exercise extreme care when working around equipment with the wiring and electronics exposed. Notify others before leaving an open system unattended. Disconnect power if the system / equipment will be unattended.

While working on the system / equipment, the vehicle could unexpectedly move, possibly causing damage or injury. Warn others to stay clear of the vehicle since it could become activated without notice.

Follow all Metro Rules and Guidelines. They take precedence over any instruction found in this manual.

The key warnings for this equipment are as follows:

Electrical - The electrical equipment described in this section operates at voltages and currents that are extremely dangerous to life. Personnel should closely observe all generally prescribed cautions and warnings before performing any work on the LRV.

Location – Special caution should be taken when accessing or servicing equipment located on the roof and under the car.

Weight – To prevent possible personal injury when attempting to remove or install equipment on the vehicle, adequate support of a lifting device must be used to prevent the equipment from falling. Personnel’s failure to heed these warnings could result in severe injury or death and or damage to the equipment.

Contact – Some components in this equipment attain temperatures that can cause severe burns. Closely follow all warnings and recommended procedures for handling these components.

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CHAPTER 1.0

GENERAL DESCRIPTION

1.1 Introduction

This section of the Running Maintenance and Servicing Manual (RMSM) presents an overview of the vehicle and top-level troubleshooting guidelines. Scheduled maintenance is covered in Section 0000, Introduction of the RMSM and in the individual RMSM sections that relate to the systems. Detailed system descriptions, troubleshooting and programming instructions are included in the subsystems respective RMSM sections. Schematic descriptions and wiring details are included in the ***Schematics and Narrative Manual*** which is an essential text for maintainers doing electrical troubleshooting and should be used in conjunction with this manual.

1.2 Acronyms and Abbreviations

Acronym	Description
AADS	Automatic Announcement and Display System
AC	Alternating Current
AD	Air Dryer
ADU	Aspect Display Unit
AMV	Apply Magnet Valve
APC	Automatic Passenger Counter
APS	Auxiliary Power Supply
ASTS	Hitachi, formerly Ansaldo STS
ASU	Air Supply Unit
ATC	Automatic Train Control
ATO	Automatic Train Operation
ATP	Automatic Train Protection
BC	Battery Charger
BCCO	Brake Cylinder Cutout
BCT	Brake Cylinder Transducer
BCU	Brake Control Unit
BR	Brake Reservoir
BRR	Brake Release Relay
CBG	Car Body Ground
CCB	Communications Control Board
CCH	Communication Control Head
CCTV	Closed Circuit Television
CHMM	Crash Hardened Memory Module
CM	Coast Motoring
COTS	Commercial Off-the-Shelf
CPS	Conditional Power Supply
CSRD	Cab Signal Receiver Demodulator

Acronym	Description
CVT	Control Volume Transducer
DBA	Dynamic Brake Achieved
DC	Direct Current
DCU	Door Control Unit
DMS	Deadman Switch
DPC	Digital Pressure Controller
EB	Electronic Brake
ECU	Electronic Control Unit
EEIM	Enhanced Ethernet Interface Manager
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMD	Electrical Middle Distance
EMI	Electromagnetic Interference
EMV	Emergency Magnet Valve
ER	Event Recorder
ESN	Ethernet Consist Network
ESRA	Electronic System for Railway Applications
ETB	Ethernet Train Backbone
ETH	Ethernet
FBCV	Friction Brake Cutout Valve
FBF	Friction Brake Fault
FBFR	Friction Brake Fault Relay
FLT	Air Filter
FSB	Full Service Braking
ft	Feet
FWD	Forward
GPS	Global Positioning System
HRSB	High Rate Service Brake
HSCB	High Speed Circuit Breaker
HVAC	Heating Ventilation and Air Conditioning
I/O	Input / Output
IGBT	Insulated Gate Bipolar Transistors
In.	Inch
IRMA	Infrared Motion Analyzer
kg	Kilogram
KS	Knife Switch
kW	Kilowatt
LACMTA	Los Angeles County Metropolitan Transportation Authority
lb	Pound
LED	Light Emitting Diode
LLV	Load Pressure-Limiting Valve
LRV	Light Rail Vehicle
LVPS	Low Voltage Power Supply
LWT	Load Weigh Transducer
MBL	Metro Blue Line
MDS	Monitoring and Diagnostic System

Acronym	Description
MGL	Metro Green Line
MIMO	Multi-Input-Multi-Output
MM	Millimeter
MOV	Metal Oxide Varistor
MPH	Miles per Hour
mphps	Miles per hour per Second
MR	Main Reservoir
MRP	Main Reservoir Pipe
MRT	Main Reservoir Transducer
MTO	Manual Train Operation
MVB	Multifunction Vehicle Bus
NVR	Network Video Recorder
OCS	Overhead Catenary System
PA	Public Address
PBED	Power / Brake Effort Demand
PBMV	Parking Brake Magnet Valve
PCB	Printed Circuit Board
PGL	Pasadena Gold Line
PIC	Passenger Intercom Communication
PID	Passenger Interior Information Display
PLU	Propulsion Logic Unit
POST	Power On Self Test
PTU	Portable Test Unit
PWM	Pulse Width Modulation
REV	Reverse
RMSM	Running Maintenance and Servicing Manual
RMV	Release Magnet Valve
SCEB	Slide Control Emergency Braking
TCN	Train Control Network
TOD	Train Operator Display
TPI	Train Propulsion Inhibit
TWC	Train to Wayside Communication
Vdc	Volts, direct current
VMDS	Vehicle Monitoring and Diagnostic System
VMS	Vehicle Monitoring System
WTB	Wired Train Bus
WWAS	Wayside Worker Alert System

1.3 Subsystems and Equipment

The P3010 Light Rail Vehicle (LRV) is an integrated multi-system railcar platform.

Subsystems and equipment that makes up the vehicle are sourced from many suppliers. Table 1-1 lists the car systems, their respective suppliers and the Running Maintenance and Servicing Manual section reference. These reference manuals contain detailed information for troubleshooting the respective equipment.

Table 1-1. LA P3010 System Suppliers

System	Supplier	RMSM Reference Section
Operator's Seat	USSC Group	RMSM 0200
Stanchions and Windscreens	GG Schmitt	RMSM 0200
Windows	NASG Holdings Inc.	RMSM 0200
Passenger Seating	Kustom Seating	RMSM 0200
Floor Panels	Baultar Concept	RMSM 0200
Articulation Bellows	HUBNER Manufacturing Corporation	RMSM 0200
Carbody and Articulation	Kinki Sharyo Co. Ltd.	RMSM 0200
Coupler	Dellner Inc.	RMSM 0300
Doors	IFE North America, Inc.	RMSM 0400
Heating, Ventilation and Air Conditioning (HVAC)	Merak North America	RMSM 0500
Lighting	Teknoware (formerly Trans-Lite, Inc.)	RMSM 0600
Exterior Destination Signs	Teknoware (formerly Trans-Lite, Inc.)	RMSM 1400
Propulsion	Toyo Denki USA, Inc.	RMSM 0700
Pantograph	TransTech Power Transfer Systems	RMSM 0800
Auxiliary Inverter	PowerTech Converter Corporation (formerly KB Powertech Corp. USA)	RMSM 0900
Track Brakes	Knorr Brake Company, LLC	RMSM 1000
Battery	Saft America Inc.	RMSM 1100
Truck and Suspension	Kinki Sharyo Co. Ltd / Penn Machine Company	RMSM 1200
Friction Brakes	Knorr Brake Company, LLC	RMSM 1300
Communications / Passenger Information Displays	Rail Transit Consultants, Inc.	RMSM 1400
Communications / Passenger Information Displays	TOA Engineering Corporation	RMSM 1401
ATC / TWC	Hitachi, STS – USA (formerly Ansaldo STS)	RMSM 1500
Event Recorder (ER)	SAIRA FAR Americas, Inc.	RMSM 1600
Data Communications (TCN)	SAIRA FAR Americas, Inc.	RMSM 1700
Monitoring and Diagnostic Systems (MDS)	Rail Transit Consultants, Inc.	RMSM 1800
Closed Circuit Television (CCTV)	Rail Transit Consultants, Inc.	RMSM 1900
Automatic Passenger Counters	INIT Innovations in Transportation, Inc.	RMSM 0200
Wayside Worker Alert System (WWAS)	ProTran Technology, LLC	RMSM 1400

The Light Rail Vehicles (LRVs) were designed and built by KINKISHARYO International, LLC, a subsidiary of The Kinki Sharyo Co. Ltd. The LRV is designed to operate on all Metro LRV lines without restriction. The vehicle is equipped with signaling equipment that permits it to operate in Manual ATP Operating Mode, Type I and in ATO (Automatic Train Operation) Mode, Type II. There are no weight restrictions.

Each vehicle consists of two units, designated A and B, joined by an articulation section over the center truck. The A and B-Units are similar, except for the placement of some specific vehicle equipment or systems. The vehicles are bi-directional, with a full width operating cab at each end. The maximum vehicle operating speed is 65 mph. The speed is normally limited by the ATP system.

1.3.1 Carbody

The carbody is manufactured from stainless steel which is painted or has decals applied to match the vehicle branding requirements. It is designed in accordance with the structural design requirements of the Technical Specification and CPUC-143B. The flooring material is Baultar AbrastopTM / Foam Floor and the underfloor incorporates a stainless-steel floor pan for fire resistance.

The vehicle can accommodate 68 seated passengers, with four (4) wheelchair spaces, and a space for strollers and or bicycles. Passenger seats are a transverse, full-width cantilever with angle support design separated by a center aisle of maximum width. Flip-up style longitudinal seating are provided adjacent to the doorways to provide wheelchair spaces in compliance with ADA. Storage for bicycles or strollers is also provided adjacent to the center doorway of the B-Unit.

1.3.2 Coupler

The LRVs are designed to be operated singly or in trains of up to three vehicles. Each end of the vehicle is equipped with a self-centering, automatic mechanical coupler, electric portions and draft gear. The coupler is mechanically compatible (including the main reservoir pipe) with the existing couplers used on the present LA Metro LRV vehicles. Retractable electric portions / heads are used to isolate the trainline circuits and a loop switch in the cab is provided in place of an underfloor drum switch to configure trainline circuits. See Figure 1-1.

The couplers provide for trainlining of electrical control signals and vehicle air system supply when vehicles are coupled. The coupler loop switch is provided in the cab to electrically couple and isolate LRVs. Normal operation of the loop switch is automatic as part of the coupling / uncoupling sequence.

1.3.3 Pantograph

Operating power from the 750 Vdc overhead catenary system is provided through a single arm pantograph located on the A-Unit, and is distributed to traction control unit inverters for propulsion power to the two ac induction traction motors on each of the powered trucks of the A and B-Units. The center or trailer truck is not powered. Additionally, overhead catenary power is supplied to the auxiliary inverter via a roof mounted auxiliary supply fuse. See Figure 1-7.

1.3.4 Propulsion

The propulsion equipment is located on the underfloor of the A and B-Units of the vehicles and is the major subsystem of the car, driving the wheels and controlling the vehicle acceleration in powering mode and deceleration via dynamic braking in brake mode. See Figures 1-9 and 1-10.

The propulsion inverter converts the DC voltage supply to a variable frequency, variable three-phase AC voltage that controls / powers the AC traction motors. The propulsion system consists of dual propulsion inverters, line reactors, brake resistors, traction motors, gear units and other support equipment.

Service braking is an electronically-blended combination of dynamic braking and friction disc braking. The dynamic portion is regenerative through the propulsion system and provides primary vehicle braking. Friction braking is provided by electro-pneumatic controlled disc brakes. Each truck is also equipped with electro-magnetic track brakes and with bi-directional sanding units ahead of the power truck leading wheelset.

1.3.5 Friction Brake

The friction brake system is a microprocessor controlled electro-pneumatic friction brake system. This system utilizes disc brake units equipped with spring applied parking brake units on each axle of the powered truck and two disc brake units per axle without parking brake on the center non-powered truck. The system provides computer controlled electro-pneumatic brake blending, wheel slide control, and diagnostic functions for monitoring performance and reporting status information. All functions are performed on a per truck basis. Additionally, each truck is equipped with electro-magnetic track brakes.

1.3.6 APS / Battery

The auxiliary inverter provides both 208 / 120 Vac and low voltage (28.5Vdc) power. The low voltage is used to operate car control systems and for charging voltage for the batteries which supply back-up low voltage power.

A 20-cell battery assembly is housed in a ventilated, stainless steel battery box located under the car on the A-Unit. The battery is the primary source of emergency power when primary power or LVPS output is lost for more than 30 seconds. It is also sized to provide emergency power for a period of one (1) hour. See Figure 1-9. Breakers to disconnect battery power and battery trainline power are located in the breaker box attached to the battery box. The battery trainline provides a means to share battery power between cars trained together. A thermostat is mounted to a battery cell interconnection to detect battery overtemperature and to actuate a shunt trip circuit breaker to disconnect the batteries.

1.3.7 Trucks

The trucks are located underneath each section of the car. Each LRV is equipped with three, two-axle trucks: one unpowered truck mounted under the articulation unit center line, and a powered truck under each end of the vehicle. See Figure 1-12 and 1-13.

The trucks provide support for the carbody, traction motors, gear units and friction brake equipment. The trucks also provide automatic height control and leveling for the vehicle. The powered trucks mount equipment for rail sanding and ATP antennas. Each truck consists of the truck frame assembly, wheels, axles, and leveling air springs.

1.3.8 Doors

Passenger access is through eight, bi-parting, sliding pocket-doors, two on each side of each A and B-Unit. Door system controls, fully operable from the Operator's cab when propulsion and braking interlocks are satisfied, are trainlined through the automatic couplers to all LRVs in a train. When released by the operator, individual doors can be operated from the inside and the outside of the vehicle via pushbuttons for passenger convenience. See Figure 1-11.

The doors nearest the cab on either side of the vehicle can also be operated by crew key switches located on the vehicle's exterior to enable crew members to enter or leave unattended vehicles.

An emergency release handle is provided over each door to enable manual opening, and the cab-end doors on each side are equipped with an exterior emergency release. A "Door Out of Service" light is mounted over each door, and exterior door indicator lights are provided to show when a door is open at that location.

1.3.9 HVAC / Air Comfort System

The air comfort system automatically provides filtered, conditioned air from two, roof-mounted HVAC units, one each on the A and B-Units. In response to environmental conditions, the system automatically provides either heated or cooled air. The operating cabs are also equipped with a windshield defroster / demister, controlled by a manually-operated switch in the cab. The HVAC system utilizes scroll compressor technology with environmentally approved refrigerant to provide a lighter weight roof mounted unit. Overhead heat is maximized for available airflow. See Figure 1-7.

1.3.10 Lighting

Lighting in the passenger area is provided by continuous rows of LED fixtures mounted in the ceiling above the seats, with designated fixtures functioning as emergency lights powered by the vehicle's battery system during loss of primary vehicle power.

Each operating cab has directionally-adjustable lights; and an overhead LED light.

The exterior lighting arrangement includes a roof-mounted light assembly with a silent alarm light, headlights, tail and stoplights, red and amber marker lights, door open indicators and cut-out indicator. See Figure 1-1.

The red and amber marker lights are mounted in the outer sides of the front destination sign and show through the windshield. The red markers indicate the rear of the train and are selected automatically when the direction is established; the amber marker lights, indicating the front of the train, are similarly selected. An assembly combining the headlight, taillight, stoplight, and turn signal is located below the windshield on each side. The taillights and stoplights are activated when the direction of the vehicle is selected. An amber turn signal is also located on each side of the A and B-Units. The turn signals also function as emergency flashers, controlled by a switch in the cab. A blue bypass indicator, mounted above each of the cab's side windows, is activated when designated systems are in bypass mode. The destination sign system consists of two front signs and two side signs. All signs are mounted inside the vehicle directed outward through glazing and are LED with a color block to indicate the line selected.

All lights are LED except the headlights (halogen) and roof headlight (incandescent).

1.3.11 Cab

Vehicle operation is controlled from a full width cab on each end, separated from the passenger compartment by a lockable door. See Figures 1-3 through 1-6. The cab seat is positioned just left of center and faces a console array of vehicle controls and indicators, Aspect Display Unit (ADU), a primary and secondary Train Operator Display (TOD). In trains, all control signals are fully trainlined between vehicles through the automatic couplers. LRV operation is enabled by a single-handle Master Controller for acceleration and braking, a keyed Transfer Switch to select the cab's activity status, and a Reverser Switch to determine the vehicle's direction of travel. Left and right turn signals on the leading and trailing units are controlled from the cab, and stop lights on the trailing unit are automatically actuated during brake applications.

1.3.12 Data Communications

The data communications network consists of multiple redundant trainline and carline networks. There are two types of networks:

- Train Communication Network (TCN) which consists of the Wired Train Bus (WTB) and Multi Vehicle Bus (MVB) networks, and
- Ethernet Network which consists of the Ethernet Train Backbone (ETB) and the Ethernet Consist Network (ECN).

The TCN performs control functions such as Tractive Effort Command, brake blending, load weigh and other control signals.

The Ethernet Network is used for high bandwidth demand systems like the communication system, CCTV, MDS diagnostic data and other applications requiring high bandwidth.

1.3.13 Automatic Train Control (ATC)

The Automatic Train Control (ATC) system is a microprocessor and electronic based cab signaling system that is functionally separated into four subsystems:

- Automatic Train Protection (ATP) subsystem prevents the train from exceeding the authorized speed limit to provide safe train separation.
- Automatic Train Operation (ATO) subsystem commands propulsion and braking in order to control the train speed and station stopping position. ATO operation is in use on the Green Line and the Crenshaw Line only.
- Train-to-Wayside Communications (TWC) subsystem provides two-way communication between the wayside and the carborne ATC system. The Type I TWC system one type of frequency and has its own antenna equipment and the Type II utilizes a second set of frequencies and also has separate antenna equipment This two-way communication is considered Train-to-Wayside Communication (TWC),
- Aspect Display Unit (ADU) provides the Operator with ATP, ATO and TWC related controls and indications. This unit has a single LCD screen for showing all ATC system indications. Pushbuttons are located around the LCD display to allow the Operator to interface with the ATC system. The ADU is also equipped with an audible alarm for various conditions such as ATP overspeed.

The P3010 ATC is designed for compatible functional operation on the Metro lines listed below:

- Metro Blue Line (MBL) (Type I),
- Metro Green Line (MGL) (Type II),
- Pasadena Gold Line (PGL), including the Eastside Extension (Type I),
- Exposition (Type I),
- Crenshaw Line (Type II),
- Foothill Extension (Type I),
- Regional connector (Type I).

A line selector switch on the vehicles provides the method for properly configuring the ATC for operation on the desired line and type of operation. In general, Type I operation has ATP and TWC functional capabilities while Type II operation has ATP, TWC, and ATO functional capabilities.

The wayside transmits and receives non-vital information through TWC loops situated between the rails at selected track locations. The vehicles TWC system transmits and receives information through the use of TWC antennas mounted at each end of the vehicle. See Figures 1-9 and 1-10. The selection of the active antenna is based upon which cab end is actively keyed.

The TWC performs the following major functions across all lines:

- Route Control and Indication,
- Over-loop Detection and Indication,
- Train Identification,
- Provides input to the ATO subsystem.

The TWC functionality is non-vital and is 100% compatible with the H&K HSC-V TWC equipment (Type I) and the Hitachi (Ansaldo) TWC systems (Type II). These two types provide different operations to the ATC / TWC equipment. The operation of the TWC is covered in detail in Section 1500, ATC / TWC of the LA P3010 manuals.

1.3.14 Event Recorder

The Event Recorder (ER) is a memory module specially designed to protect the operating data in the event of a collision or incident. The event recorder performs power up diagnostics. Upon power up, a sequence of tests is executed that test the event recorder while remaining transparent to the operation of the event recorder. Should any error occur that affects the functionality of the event recorder it will be annunciated to the Train Operator's Display. The event recorder maintains a record of over 140 monitored signal and parameters in its memory recorded on a continuous basis. This data is typically used for accident investigation and equipment / system fault analysis.

1.3.15 Communications

The vehicle's communication system functions include train radio, intercom, P.A., silent alarm, automated announcements, and interior LCD automated displays and exterior destinations signs. The system enables the Operator to make announcements to passengers inside and outside the vehicle, and to talk to individual passengers via the intercoms in the passenger compartment. Automatic station announcements are played through the passenger compartment speakers along with visually through the Passenger Information Displays. The communication system is controlled by controls integrated into the console, provides all the communication system, including the required Communication Control Head (CCH) functionality. The following are the functions provided:

- In-Dash microphone interface to the CCH,
- Public Address (PA) automatically and manually, selective for interior and exterior speakers, or both, via the TOD or Cab Console switches,
- Passenger Intercom Communication (PIC),
- Passenger Information Control including Interior Information Signs control, Exterior Destination Signs control, Station Announcements (Automatic and Manual), Audio, Automatic Announcement and Display System (AADS) for Pre-recorded messages, station and route announcements,
- Operator interface to the Communication System modes of operation via the CCH and console buttons,

- Radio audio system interface with the vehicle PA system,
- Synchronization of time and date for all subsystems,
- Location coordinates (from the GPS) provided to all subsystems.

1.3.16 Monitoring and Diagnostic (MDS)

The Monitoring and Diagnostic System (MDS) and associated Train Operator Displays (TODs) collect, process, and report information to the operator and maintenance personnel regarding vehicle status. The operation of the MDS and TOD is covered in detail in Section 1800, Train Controls & Diagnostics (MDS) of the LA P3010 manuals.

1.3.17 Video and Audio Surveillance System

CCTV cameras are used to record video and audio in the passenger compartment, cabs, forward facing, and rear views to a Network Video Recorder (NVR). The CCTV surveillance system, see Figure 1-14, provides the following functions:

- Captures the video and audio from the interior passenger cameras,
- Captures the video for the forward view camera,
- Captures the video and audio from the Cab Monitoring Camera,
- Camera to record pantograph actions (mounting and connector are installed on every LRV, the roof camera is installed by Metro for special conditions such as testing), NVRs must have additional camera licenses to permit recording,
- Rear viewing cameras.

1.3.18 Exterior Equipment

In addition to the rear-view cameras, the exterior of the vehicle is fitted with electrically controlled mirrors on the right and left side of each cab; the mirrors can be folded against the vehicle's side during car washing operations. Hinged access panels cover an assembly containing the forward door crew-key switch and the washer filler. At each of the forward doors, an access step and grab handle are provided for entry from ground level. Four exterior speakers located on each side of the vehicle enable P.A. announcements to passengers on the platform. Each A and B-Unit has four, bi-parting, sliding pocket doors, with exterior pushbuttons for passenger operation. A covered, emergency, door-release handle is located adjacent to the cab-end doors on each side of the vehicle. See Figure 1-1.

Carbody skirts can be unlocked and raised to provide access to undercar equipment. Anti-climbers are located on the car ends to prevent vehicle climbing in a collision. Jacking pads are located at various points on the underframe to facilitate lifting when necessary.

1.3.19 Roof Equipment

The roof area equipment on each A and B-Unit is visually hidden by the side-mounted shrouds. A self-contained air conditioning unit, which also provides overhead heat, and braking resistors are located roof mounted on the A and B-Units. The HVAC system automatically provides a comfortable environment for the passengers and crew while the vehicle is in operation. See Figure 1-7 and 1-8.

The A-Unit roof also contains the pantograph and the High-Speed Circuit Breaker (HSCB), auxiliary fuse box assembly, and lightning arrestor. The pantograph transfers power from the overhead contact system (catenary) to the vehicle. The pantograph is spring-raised and lowered by an electric motor. A hand crank is provided such that in the event of a loss of power the pantograph can be raised or lowered manually. See Figure 1-7. The hand crank is stowed in the articulation locker. The High-Speed Circuit Breaker protects the power distribution to the vehicle propulsion system.

The roof light / silent alarm light assembly, the radio antenna and the Wayside Worker Alert System (WWAS) antenna are located in the forward roof area over each cab on each unit. Roof mounted cable assemblies electrically connect the A and B-Units at the articulation.

1.3.20 Undercar Equipment

Much of the undercar area is occupied by the propulsion and braking systems equipment items, most of which are the same on both units. A powered truck is located in the forward area of each unit, and an unpowered truck is mounted under the articulation portion of the joined A and B-Units. See Figures 1-9 and 1-10.

The horn / gong speaker and the TWC antenna and TWC equipment are mounted outboard of the powered truck on each unit. The A-Unit also contains the knife switch high voltage distribution box and the vehicle’s batteries and auxiliary power inverter. The air compressor and Main Reservoir tanks are mounted under the B-Unit.

1.3.21 Automatic Passenger Counter (APC)

The Automatic Passenger Counter (APC) system counter is located over each doorway and counts passengers as they enter and/or exit a vehicle doorway. See Figure 1-11. In order to count entering and exiting passengers as accurately as possible, the Infrared Motion Analyzer (IRMA) passenger counting subsystem uses a sensor which includes passive and active infrared components. Data is stored on board for download and analysis in the Copilot PC.

1.4 Reference Data

The general characteristics and dimensions of the P3010 LRV are as follows:

General Dimensions

Length of car on center line over anti-climber	26,548mm (87 ft. 1 in.)
Length of car over coupler pulling faces	27,218mm (89 ft. 4 in.)
Width of car, overall	2,652mm (8 ft. 8 in.)
Wheel diameter, new wheels	711mm (28 in.)
Wheel diameter, worn wheels	660mm (26 in.)
Distance, center to center of trucks	8,675mm (28 ft. 6 in.)
Truck wheel base:	
power truck	2,150mm (7 ft. 1 in.)
center truck	2,150mm (7 ft. 1 in.)
Maximum height of car from top of rail with locked down pantograph	3,810mm (12 ft. 6 in.)
Minimum OCS height to operate car	4,039mm (13 ft. 3 in.)
Maximum OCS height to operate car	7,163mm (23 ft. 6 in.)
Height of car floor from top of rail	996mm (3 ft. 3 in.)
Height of center line of coupler face from top of rail	510mm (1 ft. 8 in.)

Vehicle Weight and Capacity

AWO: Empty car operating weight	45,116 kg (99,526 lbs.)
AW1: Seated - 68 Passengers + 1 Operator	49,943 kg (110,174 lbs.)
AW2: Service - 68 Passengers + 1 Operator & 95 Standees	56,591 kg (124,840 lbs.)
AW3: Crush - 68 Passengers + 1 Operator & 143 Standees	59,952 kg (132,254 lbs.)

	B-Truck		C-Truck		A-Truck		Total
	Axle Weight Total (kg)	Rate (%)	Axle Weight Total (kg)	Rate (%)	Axle Weight Total (kg)	Rate (%)	Weight (kg)
AW0	16,140	35.8	12,623	28.0	16,349	36.2	45,116
AW1	17,696	35.4	14,288	28.6	17,957	36.0	49,942
AW2	19,707	34.8	16,980	30.0	19,903	35.2	56,591
AW3	20,725	34.6	18,340	30.6	20,882	34.8	59,952

Vehicle Speed and Acceleration

Maximum Operational Speed	105 km/h (65 mph)
Maximum Design Speed	113 km/h (70 mph)
Car Wash Speed	less than 3.2 km/h (2.0 mph)
Speed Restriction	56 km/h (35 mph)
Maximum Acceleration Rate	1.34 m/s/s (3.0 mphps)
Full-Service Braking Rate	1.56 m/s/s (3.5 mphps)
Emergency Braking Rate (minimum based on average)	2.3 m/s/s (5.2 mphps)

Overhead Catenary System Voltage Conditions

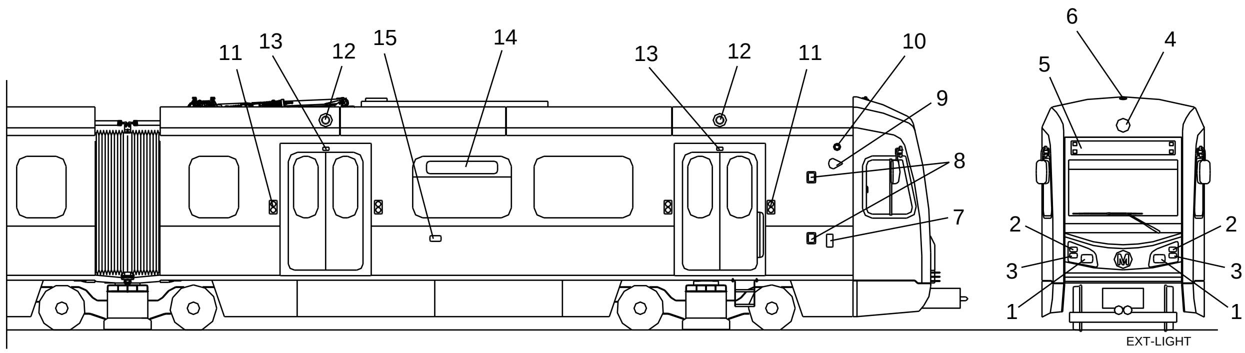
Nominal	750 Vdc
Maximum Sustained	900 Vdc
Maximum Non-Sustained	1000 Vdc
Minimum Sustained	525 Vdc
Minimum Non-Sustained	475 Vdc

1.5 Equipment Locations

The following sections illustrate the equipment locations for the LA P3010 LRV.

1.5.1 Exterior Car Arrangement

See Figure 1-1 shows the exterior LRV equipment locations for the P3010 LRV.



LEGEND

1. Headlight
2. Turn Signal/Marker Light (Amber)
3. Tail/Stop Light (Red)
4. Roof Headlight
5. Front Destination Sign w/Marker Light (Amber/Red)
6. Silent Alarm Light (Amber)
7. Exterior Manual Release (Doors)
8. Crew Key Access (Doors)
9. Rear View Camera
10. Cutout Activated Light (Blue)
11. Door Pushbutton
12. Exterior Speaker
13. Door Open Indicator (Red)
14. Side Destination Sign
15. Turn Signal/Marker Light (Amber)

Figure 1-1: Exterior Equipment and Lighting Arrangement

1.5.2 Interior Car Arrangement

See Figure 1-2 shows the interior equipment locations for the P3010 LRV.

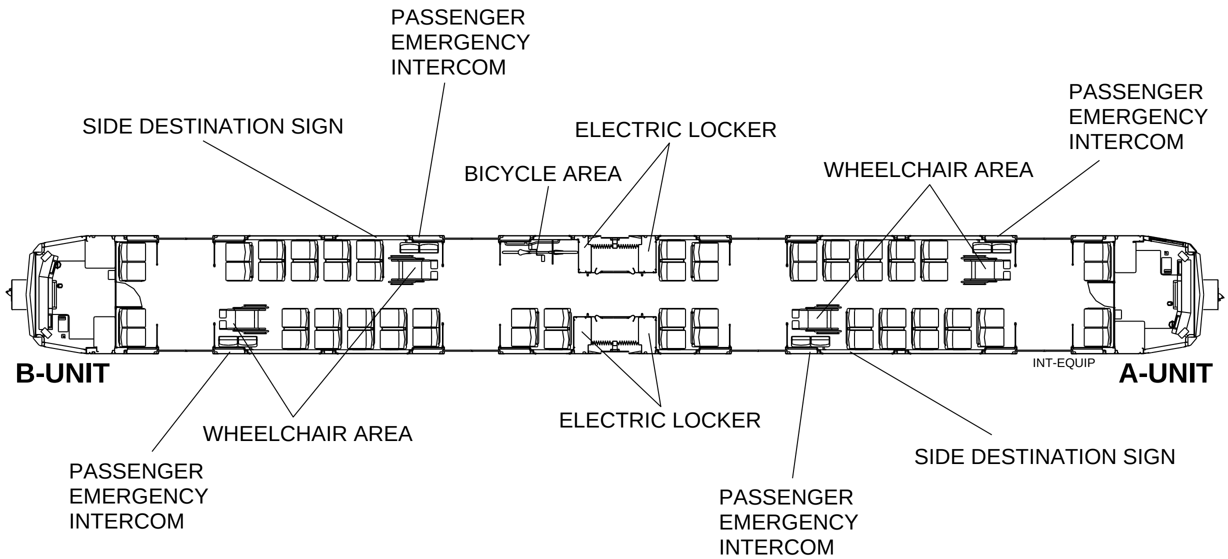


Figure 1-2: Interior Arrangement with Equipment Locations

1.5.3 Cab Equipment

See Figures 1-3 through 1-6 for the equipment locations in the cab of the P3010 LRV.

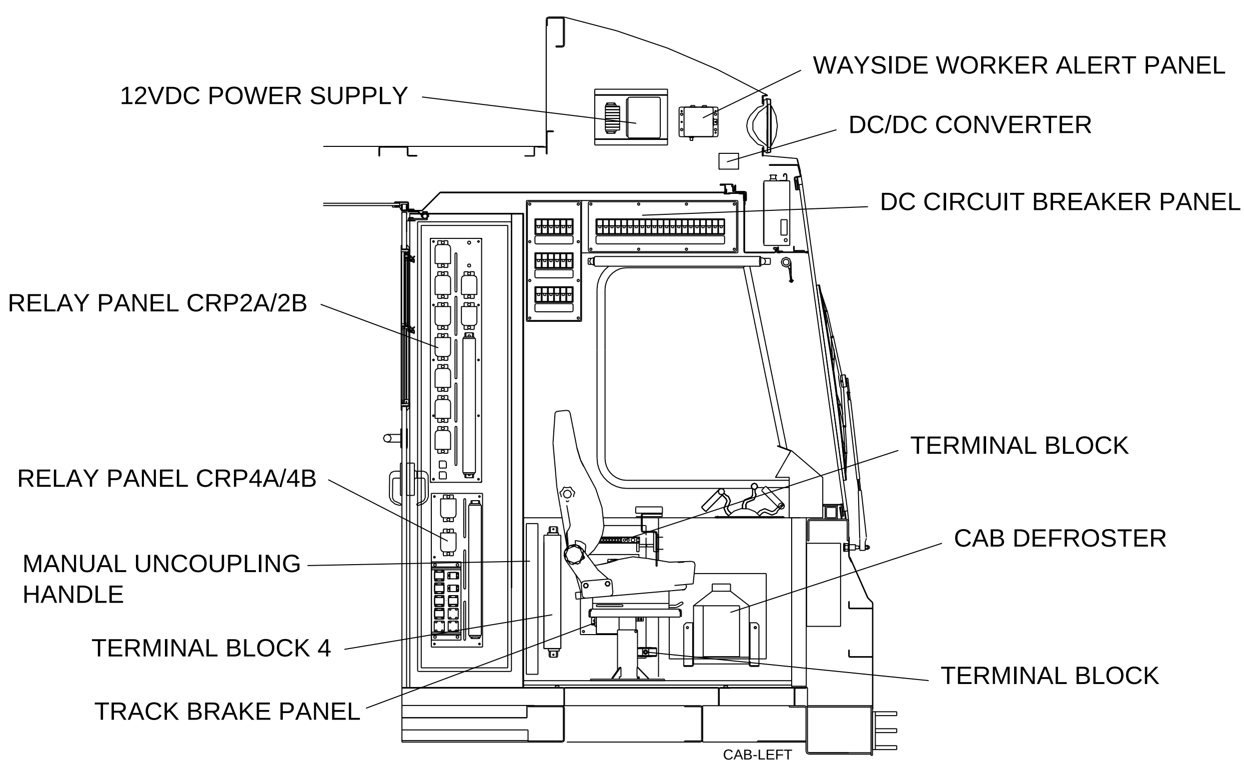


Figure 1-3: Left Side Cab Equipment

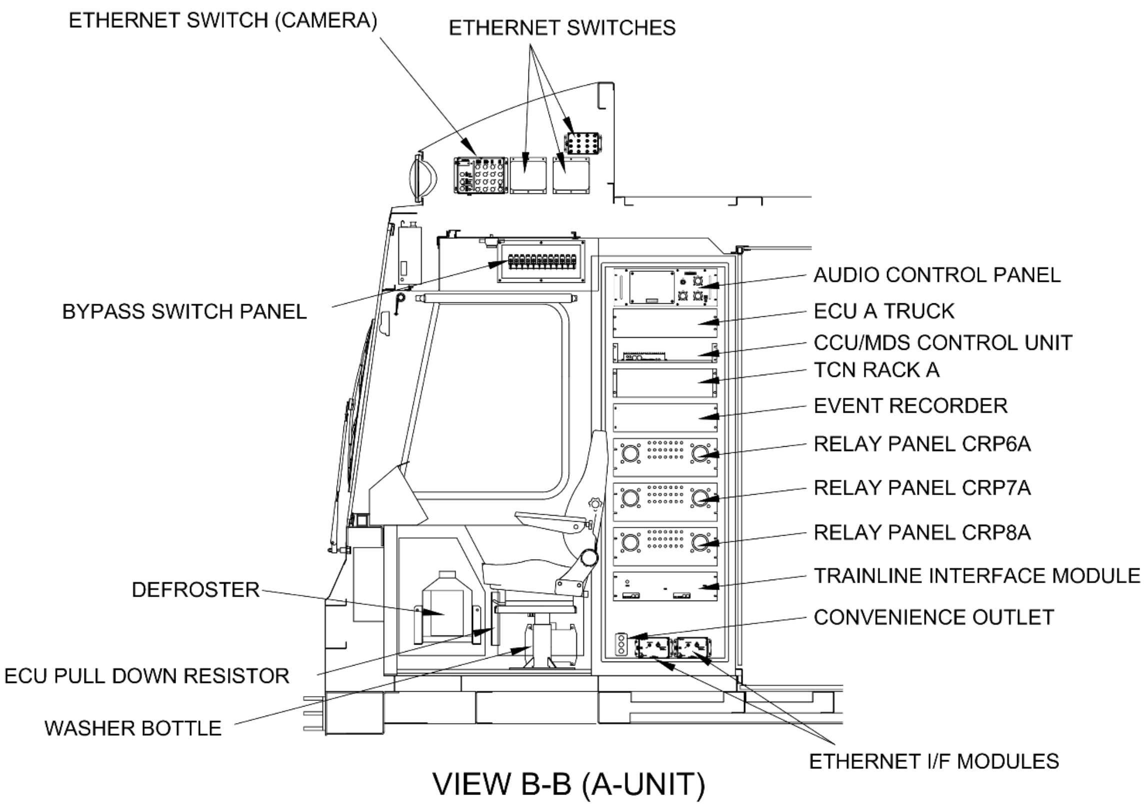


Figure 1-4: Right Side Cab Equipment, A-Unit

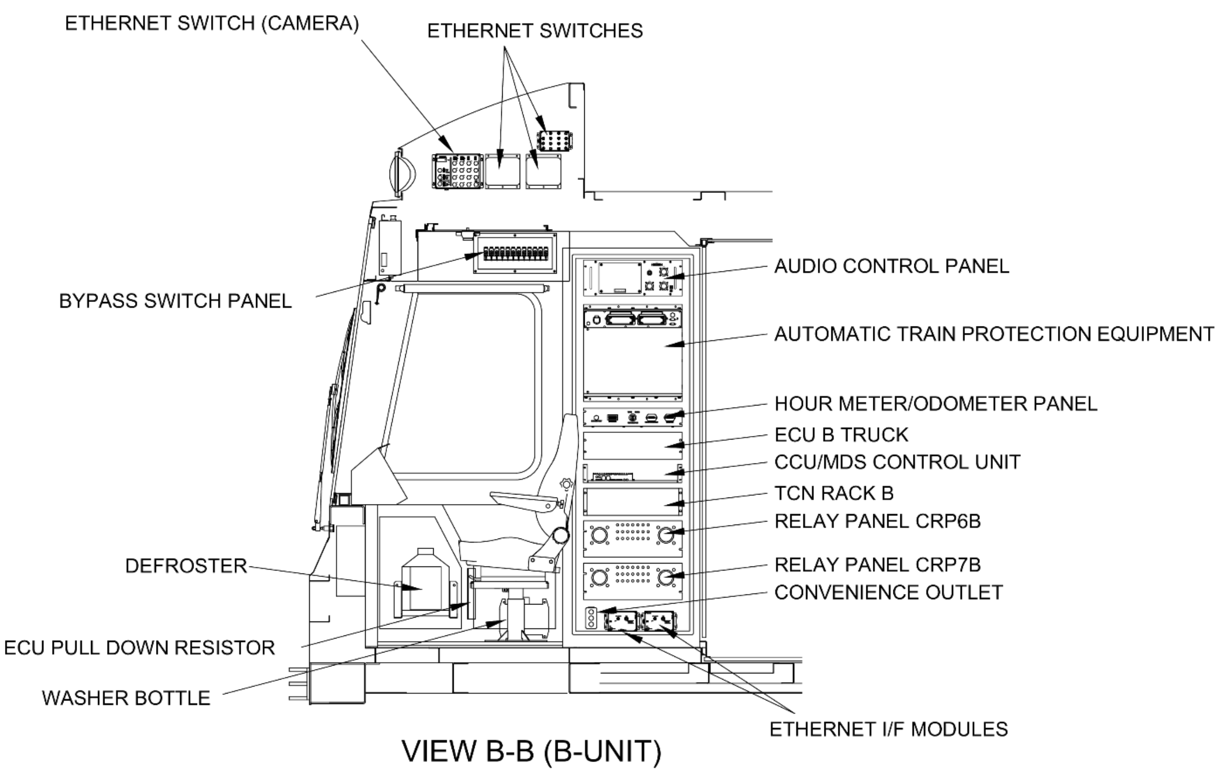


Figure 1-5: Right Side Cab Equipment, B-Unit

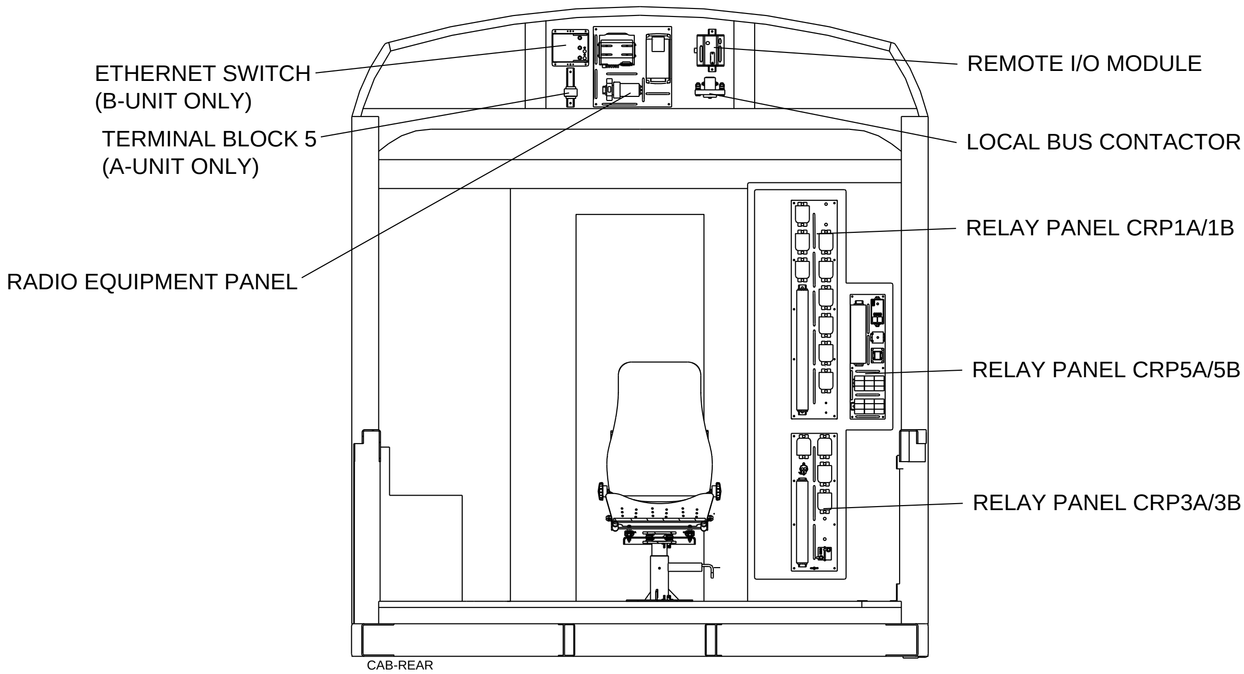


Figure 1-6: Rear View Cab Equipment

1.5.4 Roof Arrangement

See Figure 1-7 through 1-8 for the roof equipment locations for the P3010 LRV.

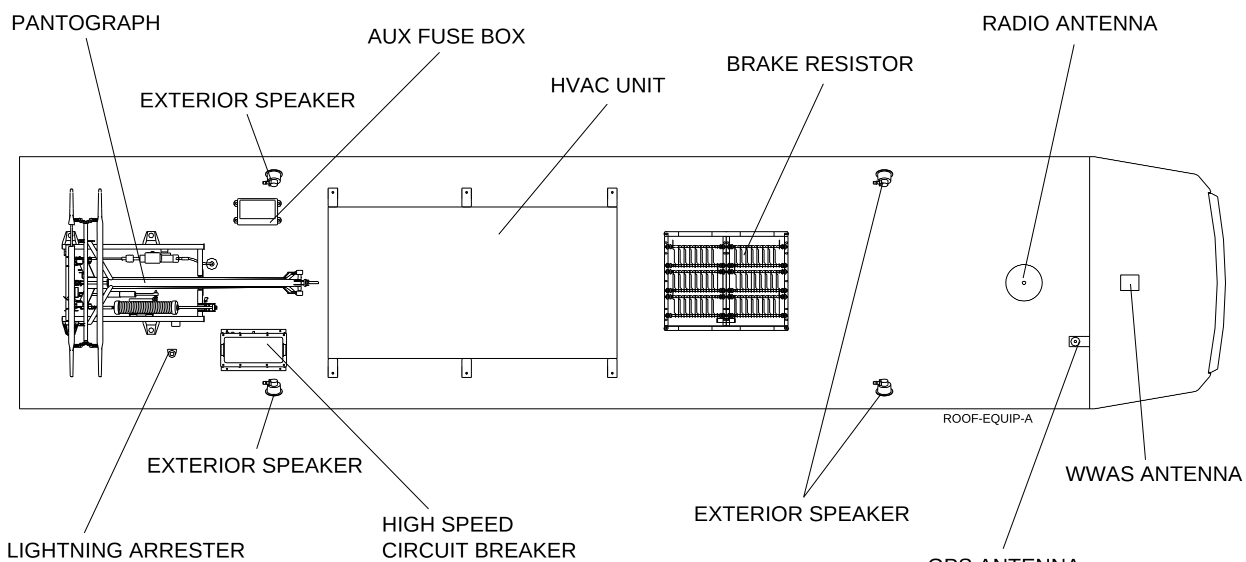


Figure 1-7: Roof Equipment Arrangement, A-Unit

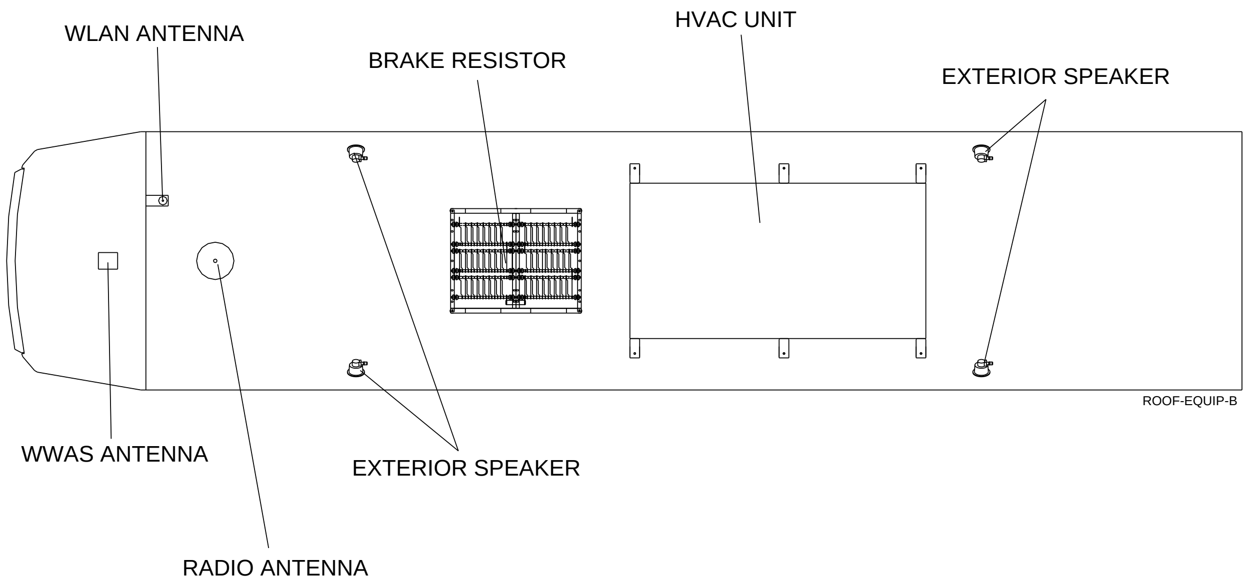


Figure 1-8: Roof Equipment Arrangement, B-Unit

1.5.5 Under Car Arrangement

See Figures 1-9 through 1-10 for the under car equipment locations for the P3010 LRV.

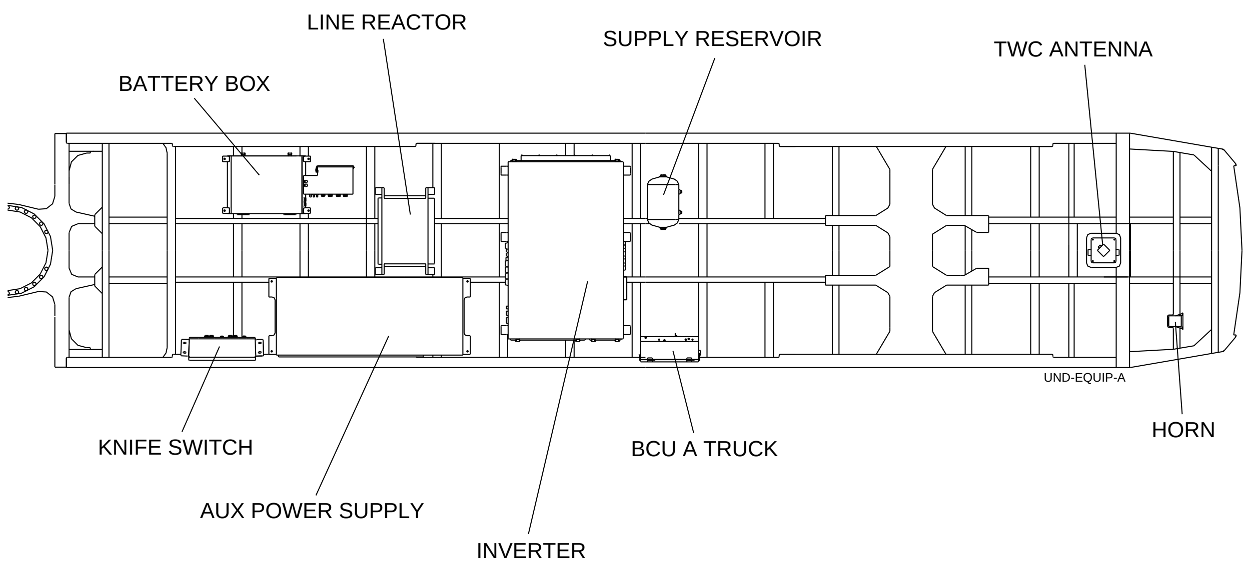


Figure 1-9: Underfloor Equipment Arrangement, A-Unit

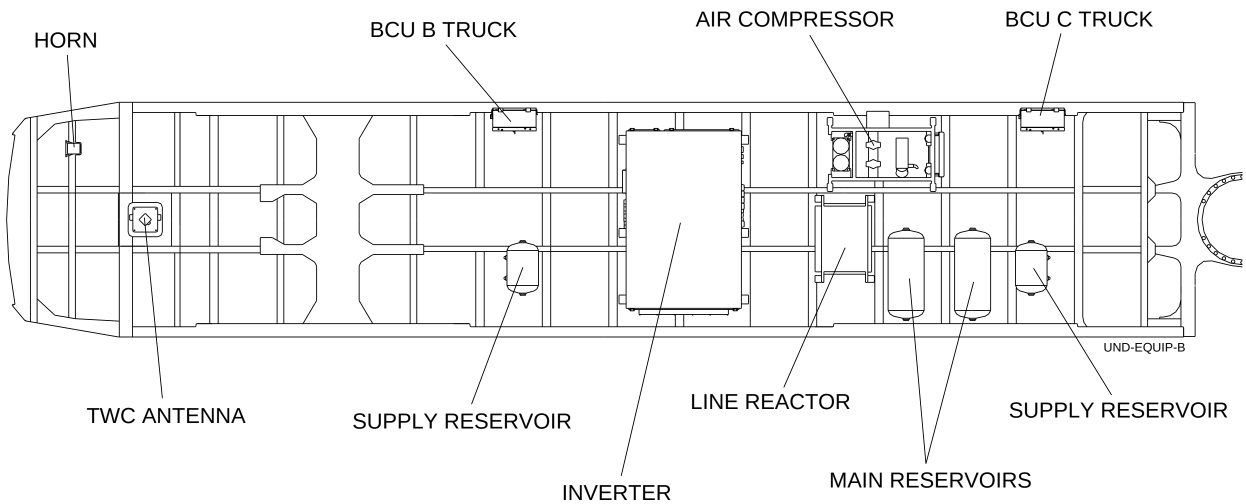


Figure 1-10: Underfloor Equipment Arrangement, B-Unit

1.5.6 Door Equipment

See Figure 1-11 for the door equipment locations on the P3010 LRV.

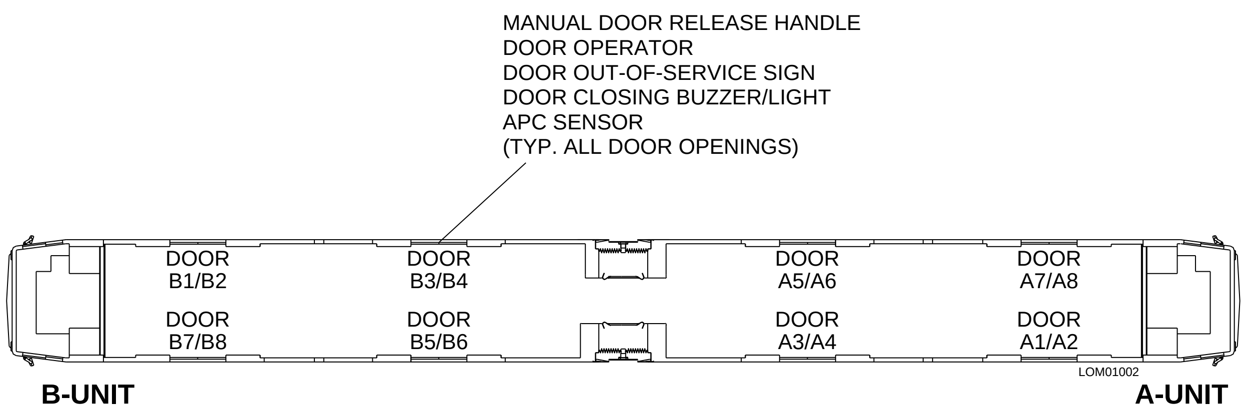


Figure 1-11: Door Equipment Arrangement

1.5.7 Truck and Suspension Equipment

See Figures 1-12 and 1-13 for the truck and suspension equipment on the P3010 LRV.

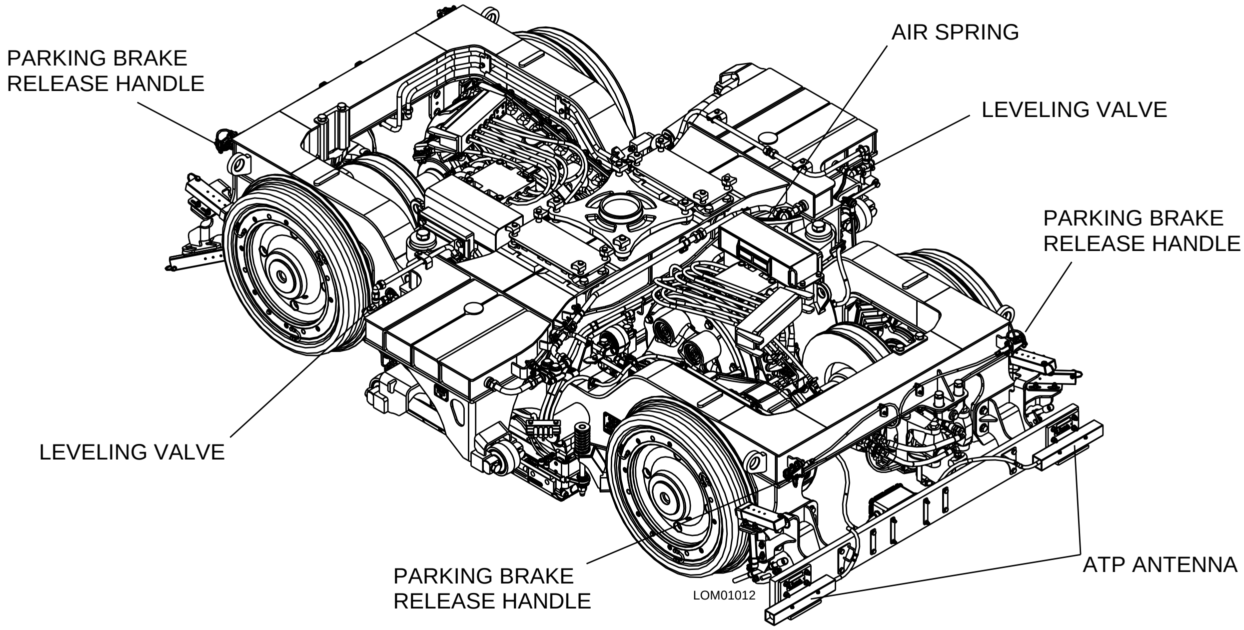


Figure 1-12: A & B Motor Truck

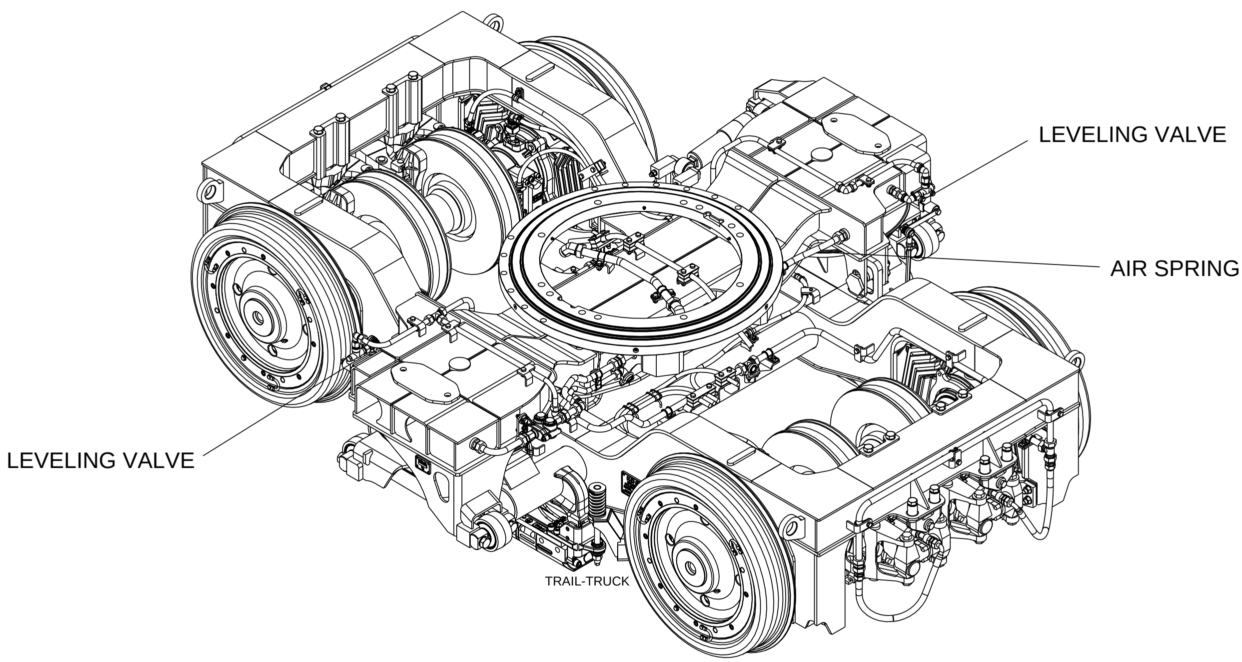


Figure 1-13: Trailing Truck

1.5.8 Closed Circuit TV (CCTV)

See Figure 1-14 for the CCTV equipment locations on the P3010 LRV.

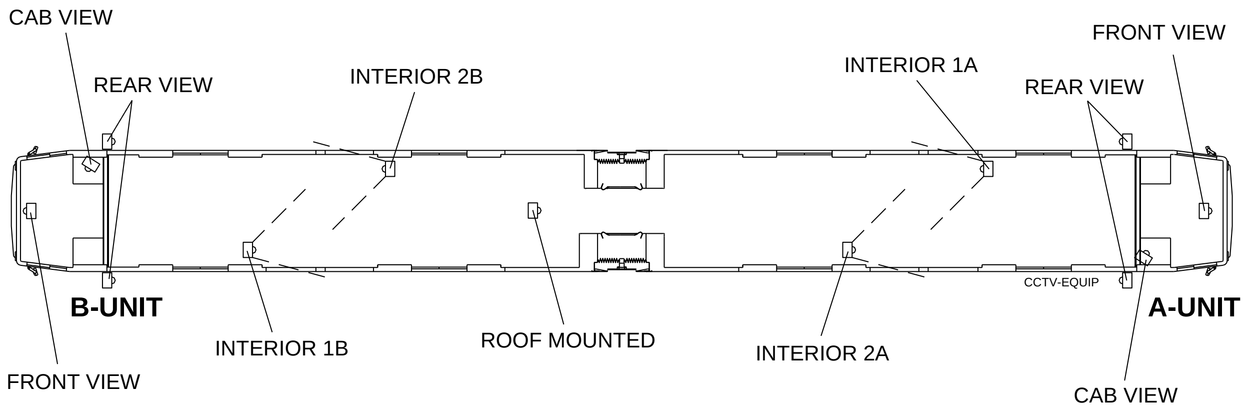


Figure 1-14: CCTV Camera Arrangement

1.5.9 Electric Locker Equipment

See Figures 1-15 through 1-18 for the Electric Locker equipment locations on the P3010 LRV.

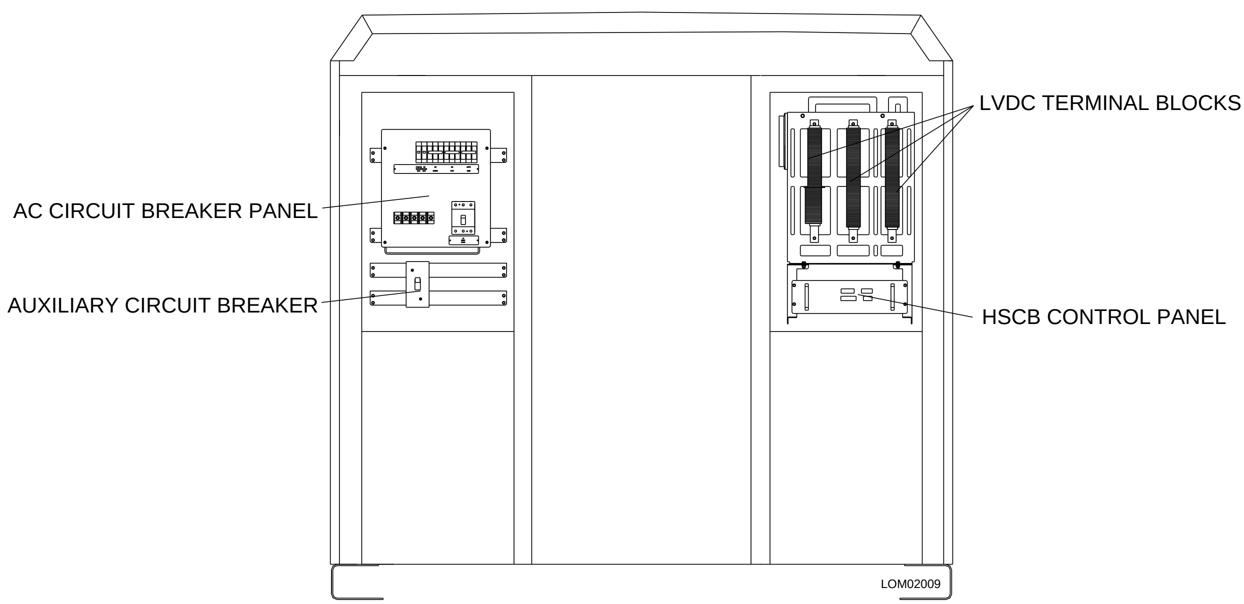


Figure 1-15: Front Articulation Electric Locker, A-Unit

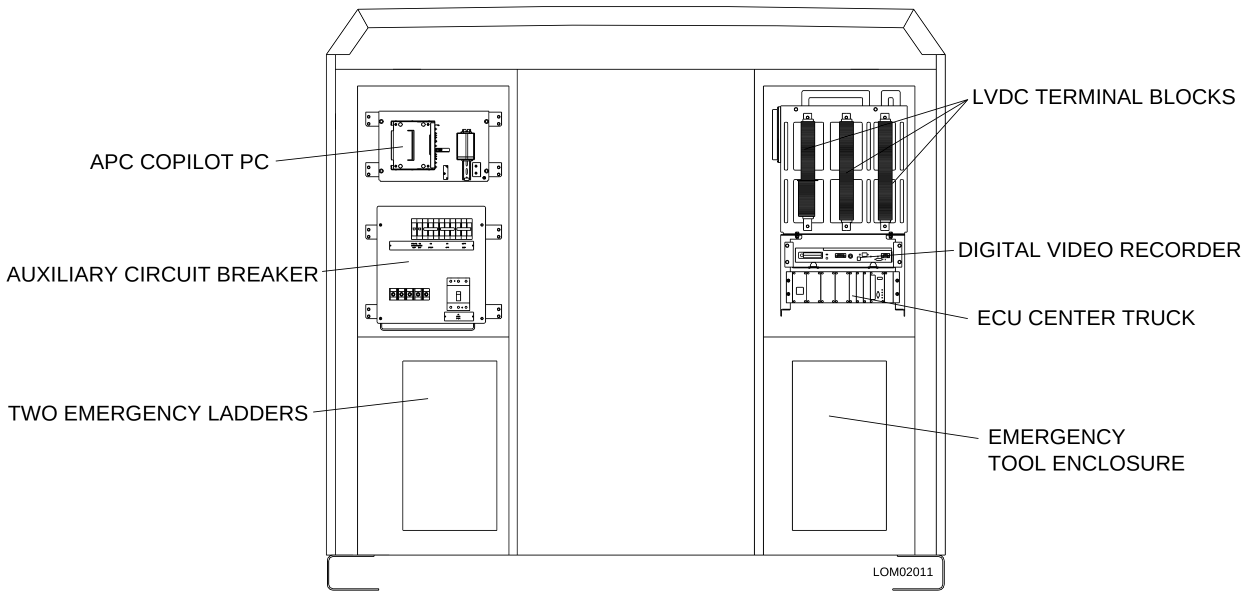


Figure 1-16: Front Articulation Electric Locker, B-Unit

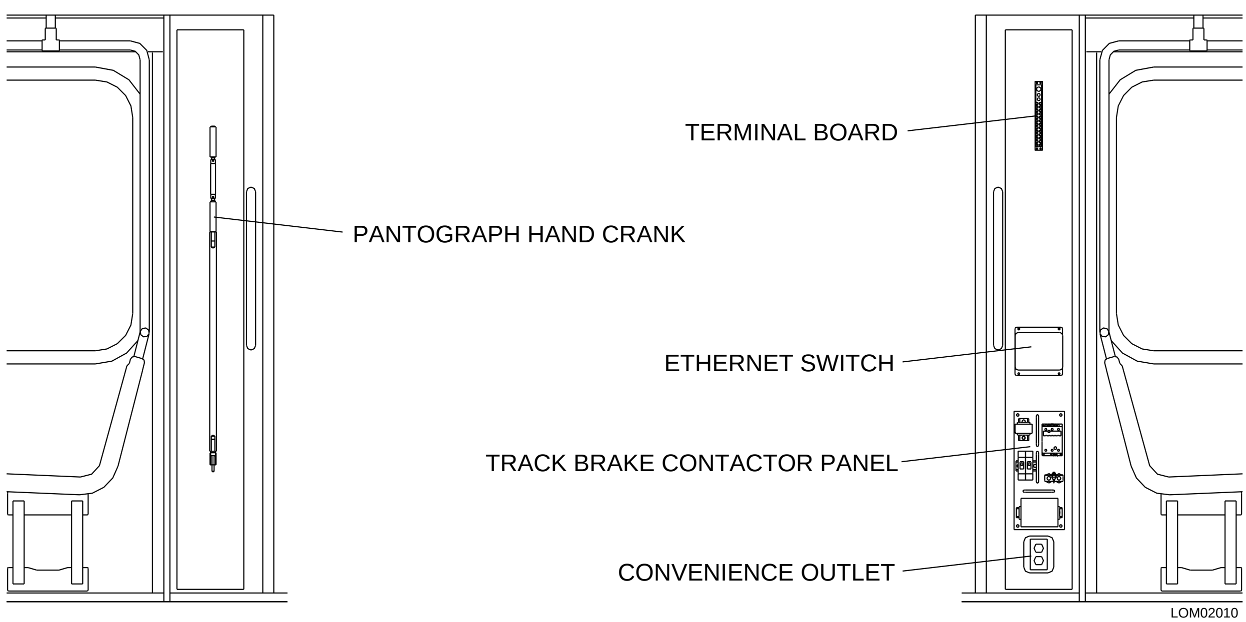


Figure 1-17: Side Articulation Electric Locker, A-Unit

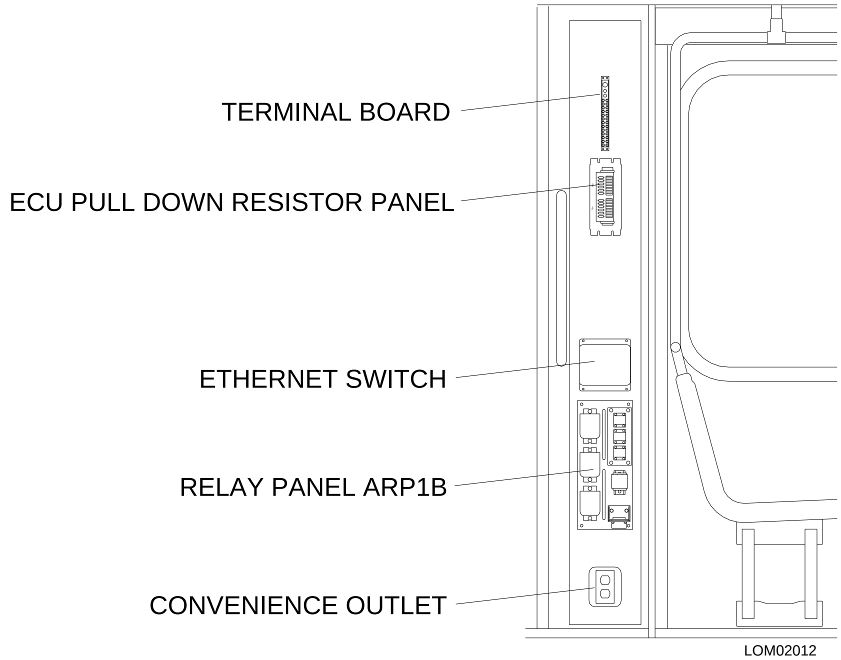
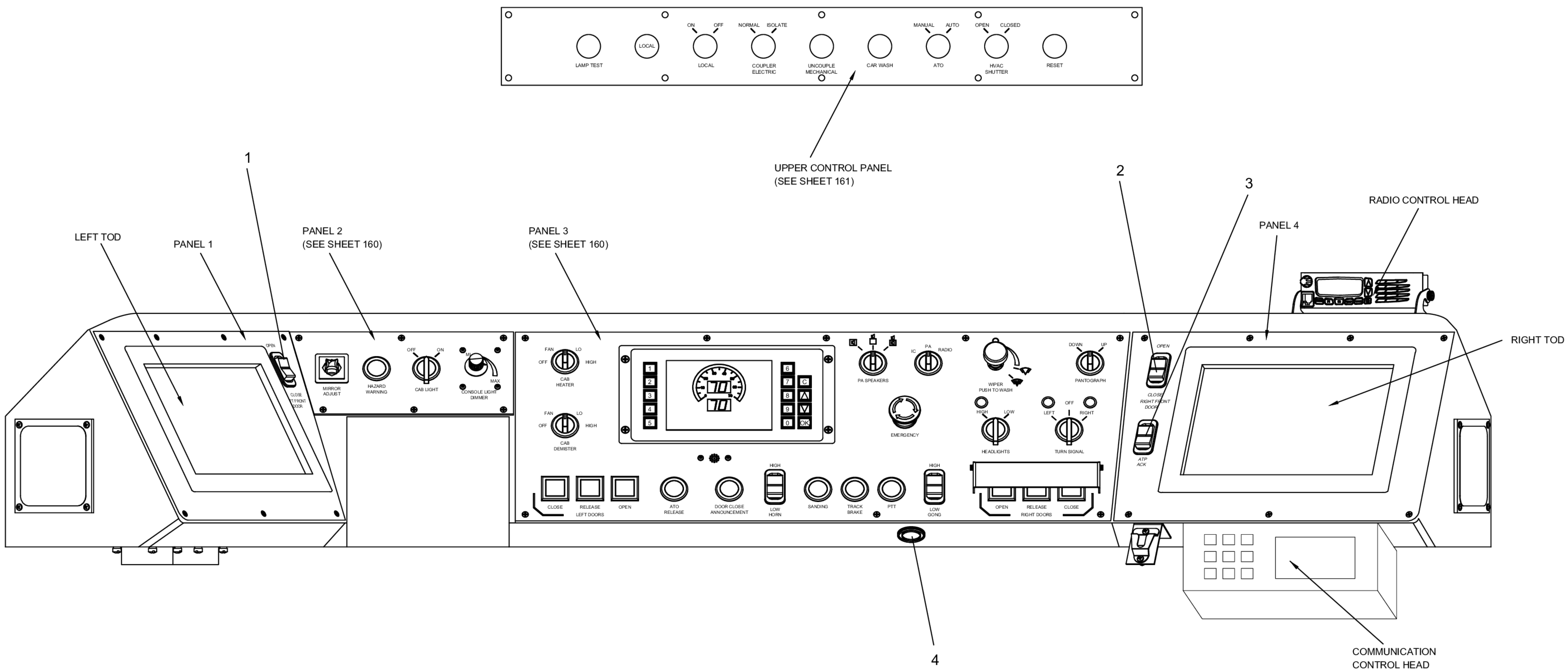


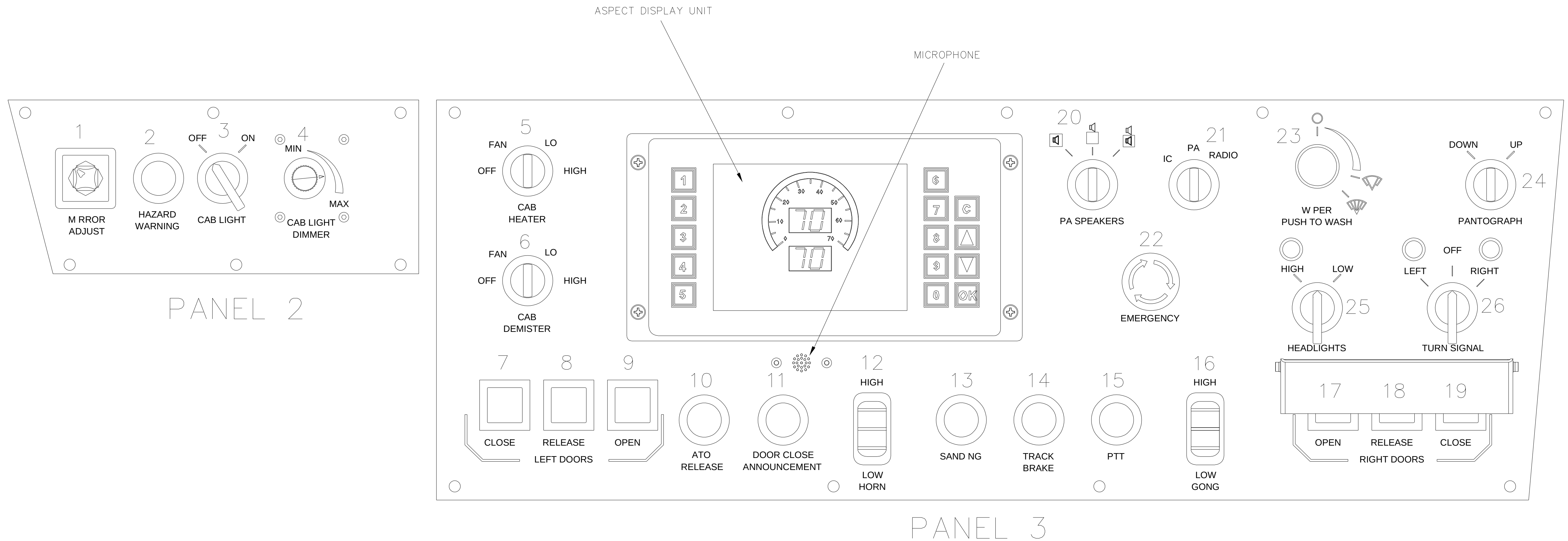
Figure 1-18: Side Articulation Electric Locker, B-Unit



NO.	ABBREVIATION	PANEL READOUT	TYPE
1	FDCS	LEFT FRONT DOOR	3TRC
2	FDCS	RIGHT FRONT DOOR	3TRC
3	ATPAS	ATP ACKNOWLEDGE	3TRC
4	SAPB	SILENT ALARM (NOT SHOWN)	LPB

TYPE LEGEND:
LPB - LATCHED PUSHBUTTON
3TRC - 3 POSITION TOGGLE, RETURN TO CENTER

Figure 1-19: Cab Console
(Sheet 1 of 3)

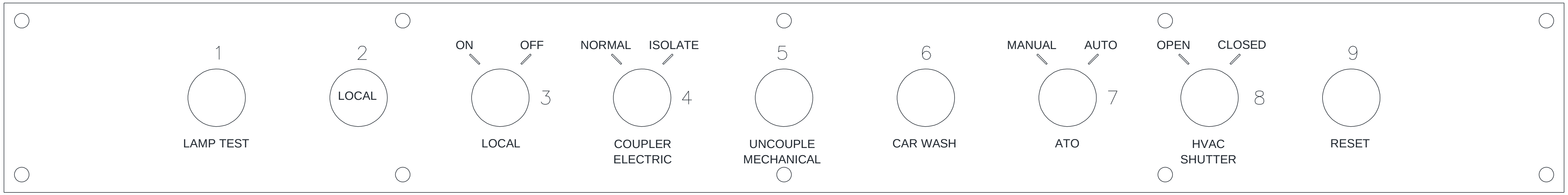


NO.	ABBREVIATION	PANEL READOUT	TYPE
1		MIRROR ADJUST	2R
2	HWPB	HAZARD WARNING	LPB
3	CBLS	CAB LIGHT	2R
4		CAB LIGHT DIMMER	POT
5	CHS	CAB HEATER	4R
6	CDS	CAB DEMISTER	4R
7	DLCPB	LEFT DOORS CLOSE	MPB
8	DLRPB	LEFT DOORS RELEASE	MPB
9	DLOPB	LEFT DOORS OPEN	MPB
10	ATORPB	ATO RELEASE	MPB
11	DCAS	DOOR CLOSE ANNOUNCEMENT	MPB
12	HS	HORN	3TRC
13	SPB	SANDING	MPB
14	TBPB	TRACK BRAKE	MPB
15	PTT	PTT	MPB

NO.	ABBREVIATION	PANEL READOUT	TYPE
16	GS	GONG	3TRC
17	DROPB	RIGHT DOORS OPEN	MPB
18	DRRPB	RIGHT DOORS RELEASE	MPB
19	DRCPB	RIGHT DOORS CLOSE	MPB
20	SMS	PA SPEAKERS	3R
21	PAMS	IC/PA/RADIO	3RRC
22	EPB	EMERGENCY	PP
23		WIPER	POT
24	PUDS	PANTOGRAPH	3RRC
25	HLS	HEADLIGHTS	2R
26	TSS	TURN SIGNAL	3R

TYPE LEGEND:
LPB – LATCHED PUSHBUTTON
MPB – MOMENTARY PUSHBUTTON
POT – POTENTIOMETER
PP – PUSH/PULL MUSHROOM
2R – 2 POSITION ROTARY
3R – 3 POSITION ROTARY
3RRC – 3 POSITION ROTARY, RETURN TO CENTER
3TRC – 3 POSITION TOGGLE, RETURN TO CENTER
4R – 4 POSITION ROTARY

Figure 1-19: Cab Console
(Sheet 2 of 3)



NO.	ABBREVIATION	PANEL READOUT	TYPE
1	LTPB	LAMP TEST	MPB
2		LOCAL (INDICATOR)	
3	LCS	LOCAL	2R
4	ECS	COUPLER ELECTRIC	3RRC
5	UCPB	UNCOUPLE MECHANICAL	MPB
6	CWPB	CAR WASH	LPB
7	ATO MODE	ATO	2R
8	HVACSCS	HVAC SHUTTER	2R
9	RPB	RESET	MPB

TYPE LEGEND:
LPB – LATCHED PUSHBUTTON
MPB – MOMENTARY PUSHBUTTON
2R – 2 POSITION ROTARY
3RRC – 3 POSITION ROTARY, RETURN TO CENTER

Figure 1-19: Cab Console
(Sheet 3 of 3)

CHAPTER 2.0

FUNCTIONAL DESCRIPTION

2.1 Introduction

This chapter provides information on the function of equipment on the LA P3010 Light Rail Vehicles (LRVs). It provides an overview of vehicle operation and the equipment required. Detailed descriptions can be found in the respective RMSM sections for each equipment and the Schematic and Narrative Manual.

The P3010 vehicle configuration is a six-axle, two-section, articulated, Light Rail Vehicle (LRV), with passenger boarding by way of high-level entry doors, manufactured by Kinkisharyo for operation on LA Metro's Light Rail Alignments.

These alignments include the following:

- Metro Blue Line (MBL), Type I
- Metro Green Line (MGL), Type II
- Pasadena Gold Line (PGL), Type I, including the Eastside Extension
- Exposition (Type I)
- Crenshaw Line (Type II)
- Foothill Extension (Type I)
- Regional Connector (Type I)

The Automatic Train Control (ATC) system operates in two modes, Type I and Type II.

ATC Type I Mode is defined as Manual Operation (controlled by Master Controller):

The LRV speed regulation and station stopping performance is the responsibility of the train operator. The train operator is given the speed profile that should be followed by the train.

ATC Type II Mode is defined as Automatic Train Operation (ATO):

The LRV automatically traverses the guide way from one station to the next station. The vehicle performs speed regulation and station stopping. The train operator has the responsibility of initiating the control for the correct doors to open and close and releasing the train to traverse to the next station. A manual mode of operation (MTO) is available within Type II operation to permit the operator to manually control the train via the Master Controller.

The P3010 LRV is designed to mechanically and pneumatically couple to the P2550 and P2000 LRVs in Metros fleet.

The P3010 can only electrically couple to other P3010 LRVs. The coupler is designed with a unique coupler switch that will only extend the electrical coupling heads if the P3010 LRV is coupling with another P3010 LRV.

2.2 Power Distribution and Grounding

The nominal voltage power of 750 Vdc is supplied from the catenary system to the pantograph, mounted on the A end roof of the car. This power is distributed through a High-Speed Circuit Breaker (HSCB) and Auxiliary Fuse to the underfloor Knife Switch (KS). At this point, it is distributed to the Propulsion Inverters on the A and B-ends and the APS equipment. Each inverter supplies two three-phase ("squirrel-cage") induction traction motors. The A-end truck and the B-end truck each have two motors, one on each axle. A simplified schematic diagram is shown in Figure 2-1.

During operation the propulsion system i.e. the propulsion traction inverter converts the high voltage direct current supply voltage, supplied from the Overhead Contact System (OCS), into pulse modulated three phase alternating voltage to drive the traction motors. The control of output voltage and output frequency works on the principle of the Pulse Width Modulation (PWM). Insulated Gate Bipolar Transistors (IGBT) modules are used to generate the pulse patterns feeding the asynchronous motors.

A Lightning Arrestor is connected directly to the pantograph. When there is an over voltage event (i.e. a lightning strike or substation supply over voltage) the Lightning Arrestor allows the transient voltage to go through to ground, bypassing the high voltage circuitry. The lightning arrestor is a Metal Oxide Varistor (MOV).

The HSCB and Aux Fuse are over current devices. The High-Speed Circuit Breaker (HSCB) is a protective device that provides rapid interruption of the overhead contact system primary supply to the vehicle when tripped by an over current fault, an internal Propulsion Inverter Control unit fault, or a propulsion ground fault. When too much current goes through the HSCB or the Aux Fuse, they open, protecting the circuitry.

The Knife Switch has a provision to accept high voltage dc power from a shop plug in order to provide power to the Auxiliary Power Supply. This allows the car auxiliaries to be powered in the shop without a catenary connection. The Knife Switch is a four-position switch. The normal operating position connects catenary power from the HSCB to the Propulsion Inverters and catenary power from the Aux Fuse to the high voltage auxiliary circuitry. Dual conductors are utilized in the propulsion supply to have sufficient cable ampacity. The Knife Switch has a position where the feed to the propulsion is disconnected while the auxiliaries are connected to the catenary supply. Also, there is a position where all high voltage supplies are disconnected. Additionally, there is a position where the shop supply is connected to the high voltage auxiliary circuits.

The APS provides the 208 Vac 3-phase and 28.5 Vdc that are used throughout the vehicle for control and power. The Aux current is nominally 125 amps but is heavily dependent upon the HVAC loading, as such the nominal currents vary. The battery will power the LRV for a short time if the pantograph is lowered, if the 750 VDC OCS is off, or if the APS is turned off. See Figure 2-1. A dead battery start function is provided in the event of discharged batteries.

The primary power ground is connected through ground brushes located on each motor truck. The primary power ground is isolated from the car body by insulated ground plates. For the safety grounding, all axles are provided with an independent ground brush that is insulated from the power returns. This safety ground system ties the carbody metallic structure to the safety ground. Additionally, the Battery Negative is connected at one point, via a resistor capacitive network to the Car Body Ground (CBG). These ground brushes are used only to provide the carbody grounding function for the vehicle and truck structures. See Figure 2-2.

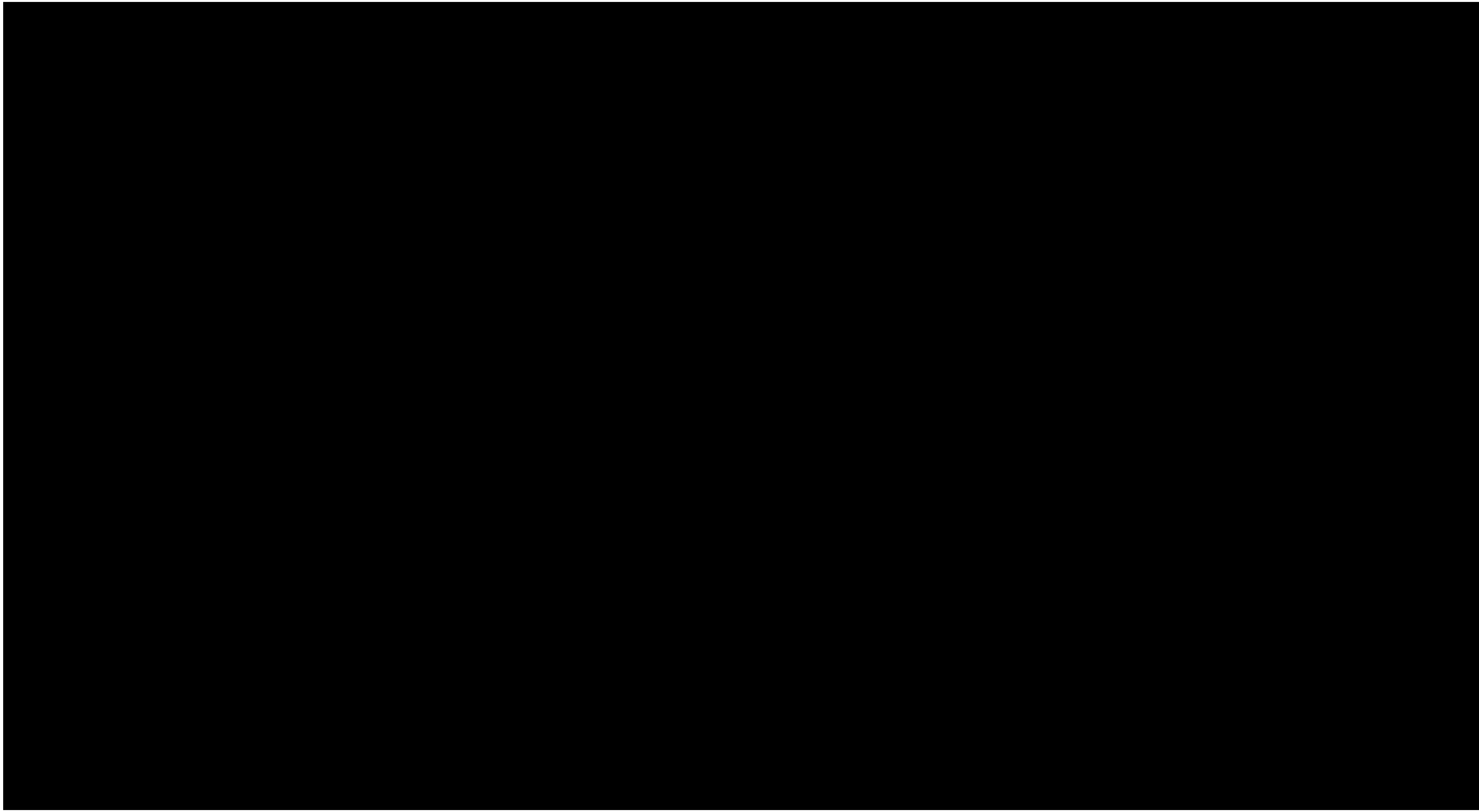


Figure 2-1: Primary Power Distribution

[redacted]

Figure 2-2: Grounding

[redacted]

Figure 2-3: Low Voltage Power Distribution

The size and quantity of ground brushes are sized such that with the loss of one ground brush, the remaining ground brushes have the capacity to safely carry 2.0 times the circuit rms current, and 1.5 times the circuit peak current, without exceeding the ground brush ratings. Each motor truck axle has two primary HVDC return brushes which are connected by cable across the articulation into a balanced High Voltage Grounding system.

Safety ground brushes are provided to carry ground fault return currents to the rail. These brushes are isolated from the high voltage ground return brushes. A ground brush on each motor truck is dedicated to safety grounding along with two ground brushes on the trailer truck. The safety ground brushes were selected such that with the loss of one safety ground brush, the remaining brushes have the capacity to safely carry the maximum fault current until cleared by the respective protective device.

The safety ground wiring design is coordinated with the truck design to ensure that all bearings are protected against stray current flow.

Low voltage is distributed from the APS / Battery to the Essential Bus and via a local bus contactor to the Local Bus. The Essential Bus is used to provide power to subsystems / loads that must be powered all the time. The Local Bus provides power to all connected systems when the car is keyed to the Local Position or the Local Switch on the overhead console is turned on. See Figure 2-3.

2.3 Master Controller

The Master Controller is the main human interface used by the train operator to command propulsion or braking effort to propel or stop the train. The master controller controls traction and brake of the vehicle by the Operator when the LRV is in Type I mode or when the LRV is in Type II mode in manual operation. The Master Controller includes a Deadman feature and includes a Control Switch (Transfer Switch) and Direction Control Switch (Reverser). See Figure 2-4.

Each master controller is provided with a keyed two-position Transfer Switch to select the cab status. There can only be one cab controlling in a properly configured train. The Transfer Switch is mechanically interlocked with the Master Controller and Reverser Switch. The positions are:

- OFF - In the OFF position, all cab controls are non-functional except some specific functions. The key is removable in this switch position.
- ON - In the ON position, console controls are functional, and all other consoles throughout the train are disabled, except for some specific functions. The key is not removable in this position.

A three-position, (FORWARD, NEUTRAL, REVERSE), rotary type Direction Control or Reverser Switch is provided on the Master Controller. The Transfer Switch and the Reverser Switch are mechanically interlocked so that the Reverser Switch cannot be moved from the NEUTRAL position unless the associated Transfer Switch is in the ON position. The Transfer Switch cannot be moved from the ON position by using the Master Controller key unless the Reverser Switch is in the NEUTRAL position.

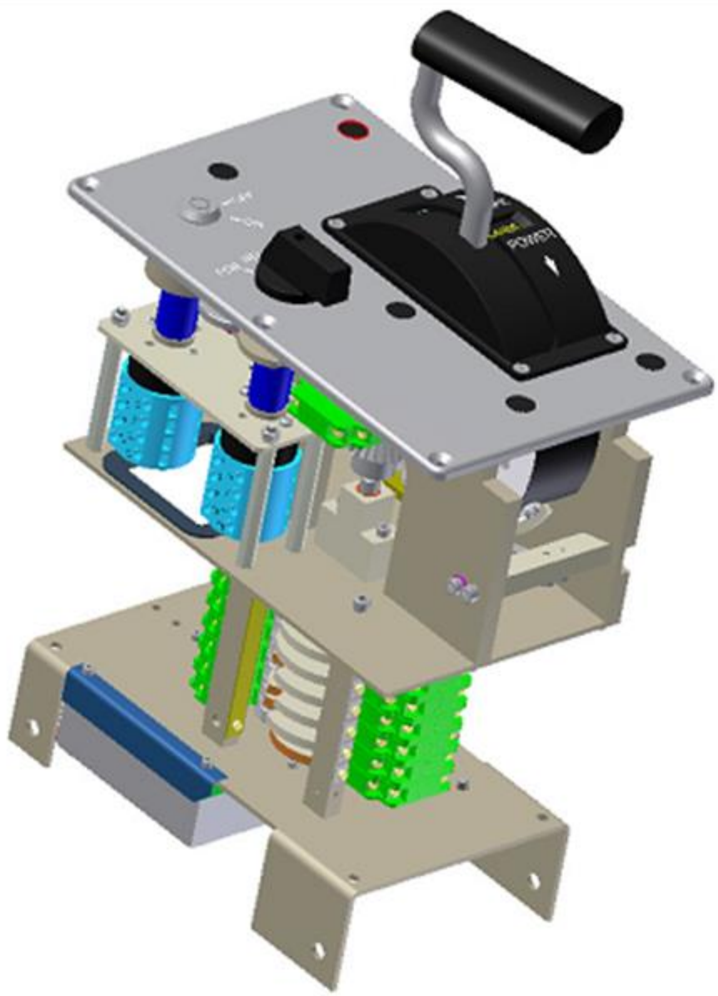


Figure 2-4: Master Controller

The Reverser Switch is interlocked such that the Master Controller handle must be in the Full-Service Brake (FSB) position in order to move the Reverser Switch out of either the FORWARD or REVERSE position.

The Drive / Brake switch is manually operated through the Drive / Brake handle.

The entire deflection range is divided into 45° braking range (38° from coast to High Rate Service Brake (HRSB) and an additional 7° for Slide Controlled Emergency Brake (SCEB) and 45° power range, with a notched neutral (coast) position).

There are handle detents in the EB (SCEB), TB (HRSB), FSB, BMIN, COAST, PMIN, and P5 positions. The end of the acceleration and braking zone are limited by mechanical end stops.

The Master controller generates the key signals that are used for propulsion and brake control. These signals are:

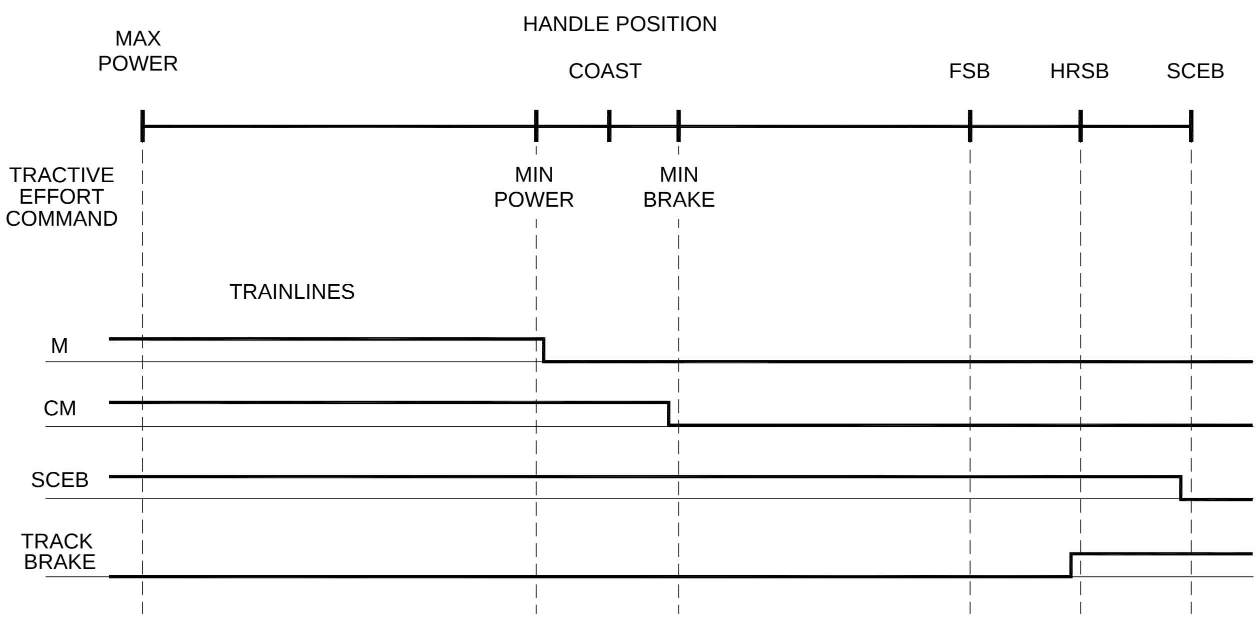
- PBED (Power Brake Effort Demand)
- M (Motoring)
- CM (Coast Motoring)

PBED from the master controller is a PWM signal that is sent to the TCN Controller where it is turned into a data message and transmitted on the WTB network to the MVB network on each car for use by the propulsion and brake logic units. Additionally, the M and CM signals (battery level) are transmitted by trainlines to the propulsion and brake for redundant control signals for braking or powering mode configuration.

The Master Controller, in the active cab, generates the rate commands and controls the trainlines per the graph below. An Emergency Pushbutton in all cabs can initiate an Emergency Brake application, if required.

The Master Controller contains several cams and microswitches. Some microswitches will directly control the trainlines per the figure below:

In ATO operation the ATC system provides similar commands to the propulsion and brake equipment. The ATC equipment generates the digital PBED signal for transmission by the TCN. Additionally, it generates the appropriate M and CM trainline commands and can initiate a service or emergency brake



The braking mode and rate is determined by the state of the MVB network, PBED, and the trainlines in the table below.

PROPULSION AND BRAKE CONTROL TRAINLINES								
	Mode	CM TL	M TL	Track Brake	SCEB	EB	PBED	Remarks/Master Controller Position
Master Controller Operation	Maximum Power	1	1	0	1	1	91.5% >= PBED >= 90.5%	Pmax
	Variable Power	1	1	0	1	1	91.5% >= PBED >= 53.3%	
	Minimum Power	1	1	0	1	1	54.3% >= PBED >= 53.3%	Pmin
	Coast	1	0	0	1	1	53.3% > PBED > 45.9%	Coast
	Minimum Brake	0	0	0	1	1	45.9% >= PBED >= 44.9%	Bmin
	Variable Braking	0	0	0	1	1	45.9% >= PBED >= 16.1%	
	Full Service	0	0	0	1	1	17.1% >= PBED >= 16.1%	FSB
	High Rate Service Brake	0	0	1	1	1	17.1% >= PBED >= 16.1%	HRSB
	Slide Controlled EB	0	0	1	0	1	5.5% >= PBED >= 5.0%	SCEB
	Deadman, Door Open, Speed Governor FSB, or ATP FSB	0	0	0	1	1	0%	FSB in any Position
	Emergency Pushbutton	X	X	1	X	0	0%	Emergency
	Emergency Pushbutton	X	X	1	0	0	0%	Special Test Position

In the above table 1 = trainline high (Battery+) and 0 = trainline low (opened) and the track brake pushbutton on the console is not depressed. An X is either a 0 or 1.

2.4 Tractive Effort Control (Vehicle Control)

The operational performance is achieved by the propulsion system and friction braking system with oversight by the automatic train control system and operator. The primary tractive interface of the LRV with the wayside is the wheel to rail interface. Powering or braking effort must be translated to motion by the interoperation of the wheels with the rails. This effort comes from the traction motors either in powering or dynamic braking or friction braking via the axle mounted pneumatic disc brakes. This effort must be supported by the amount of available adhesion (coefficient of friction) between the wheel rail interface. These systems must act in concert to achieve the operational performance required to accelerate and decelerate the LRV smoothly in response to control commands.

Each propulsion and friction brake controller use the direction control trainlines (FWD / REV) and the main PBED demand to determine the direction requested and then to calculate the amount of tractive effort required.

DIRECTION CONTROL TRAINLINES			
DIRECITON	REVERSER SWITCH POSITION	DIRECTION CONTROL 1 TRAINLINE	DIRECTION CONTROL 2 TRAINLINE
A-END	FORWARD	HIGH	LOW
	REVERSE	LOW	HIGH
B-END	FORWARD	LOW	HIGH
	REVERSE	HIGH	LOW

No central processing is used, eliminating a single mode failure point. The PBED % signal increases from braking to propulsion level. Additionally, Power and Brake battery level trainlines are used for redundant mode selection.

A Train Control Network (TCN) is utilized to provide signals between the Master Controller, propulsion PLUs, and brake ECUs. Figure 2-5 shows the TCN (WTB/MVB) data network that is used for control signals on the LRV. The key signals that are provided include:

- Rate Request from Master Controller
- Load Weigh (car weight) signal from brake ECUs
- Dynamic Brake Effort Achieved from propulsion PLUs
- Stopping Brake from propulsion PLUs
- Roll Back from propulsion PLUs
- Propulsion Slide Detected from PLUs
- Wheel Slip Active from propulsion PLUs and Brake ECUs
- Wheel speed signals from all six axles from the ECUs

In addition, battery level signals are also used to define various states of equipment or controls on the car.

2.4.1 Propulsion Inverter Control

During operation the propulsion system i.e. the propulsion traction inverter (3-phase motor drive unit) converts the supply voltage, supplied from the Overhead Contact System (OCS), into pulse modulated three phase alternating voltage to drive the traction motors. The control of output voltage and output frequency works on the principle of the Pulse Width Modulation (PWM). Insulated Gate Bipolar Transistors (IGBT) modules are used to generate the pulse patterns feeding the traction motors.

To control the IGBT modules the propulsion logic unit (PLU) is used. This electronic unit is microprocessor based and manages all functions of the inverter and controls the whole propulsion system. The propulsion logic unit is part of the propulsion traction inverter package and performs control, monitoring and protective functions of the inverter and manages the data bus communication.

During dynamic braking the braking energy, generated from the traction motors slowing, is fed back into the supply network or dissipated by utilizing a braking resistor (rheostatic) if the network is not able to absorb the whole braking energy. The PLU will report the amount of achieved dynamic braking effort per truck to both the motor truck and center truck friction brake electronic control units via the Dynamic Brake Achieved (DBA) signal. This signal is provided over the local MVB network.

During blended braking, the electro-dynamic brakes produces the majority of the necessary braking effort up to car weights of AW2 and up to 50 mph.

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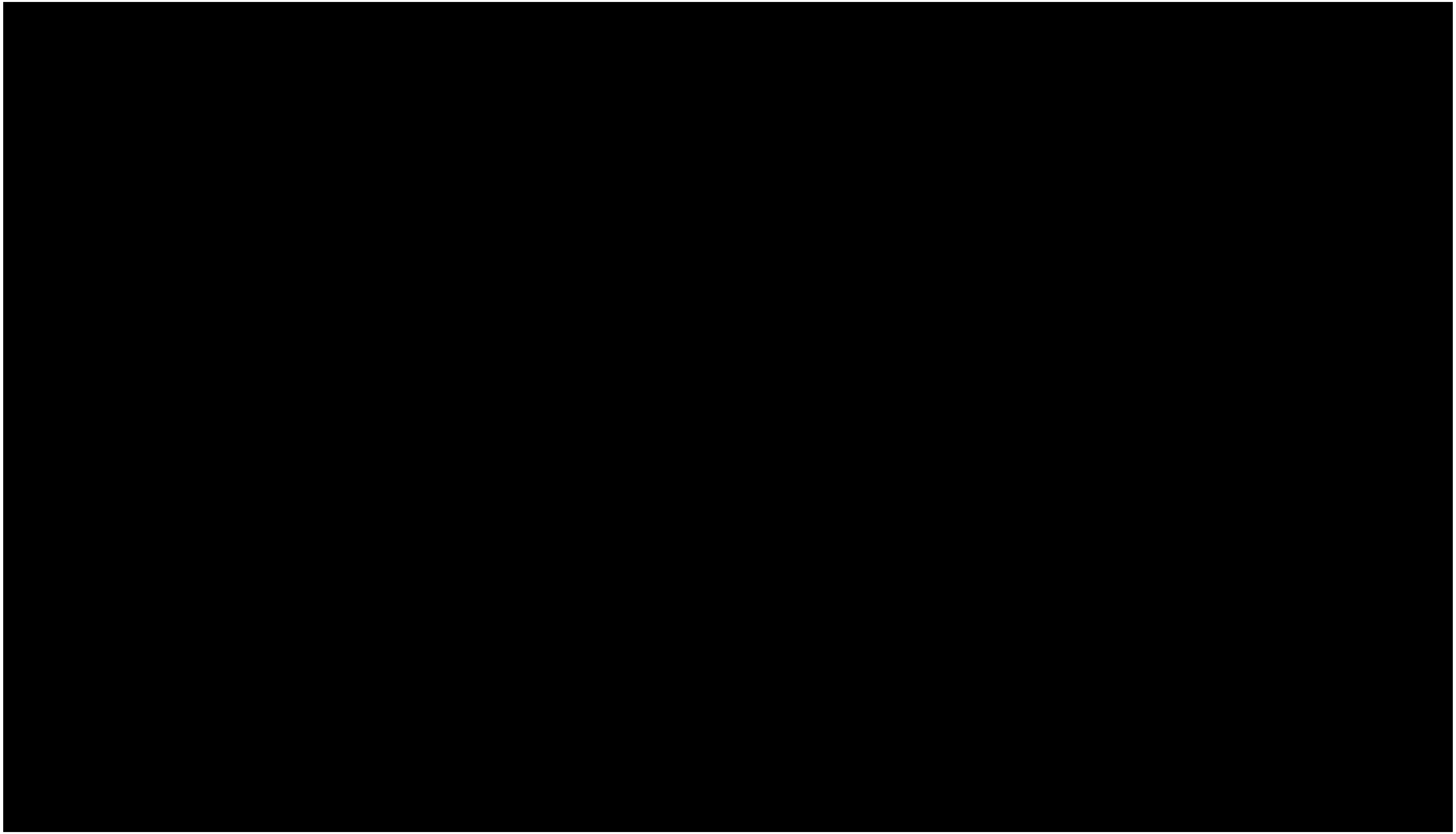


Figure 2-5: TCN (WTB/MVB Data Network)

The normal mode of braking is regenerative dynamic braking, maximizing the amount of braking that is done by the propulsion traction motors acting as generators. Dynamic braking consists of regenerative or resistive braking. Regenerative braking allows the energy generated to be returned (dependent upon line receptivity) to the Overhead Contact System (OCS) or catenary in the form of electrical energy. Resistive braking is when the energy generated is dissipated in the form of heat by the brake resistors carried on the roof of the LRV. Dynamic braking is supplemented by Friction Brake effort when the traction motors cannot generate sufficing braking energy or tractive effort to maintain the requested brake rate. This occurs at speeds above 50 mph and higher vehicle loading and at low speed at the end of a stop as the motor rotation slows.

Service braking is designed to maximize the use of dynamic brake from the propulsion system to provide the braking effort. This results in lower friction brake equipment maintenance as friction braking is used only to supplement the dynamic brake or as a holding brake. The friction brakes on all trucks is applied to supplement the dynamic braking effort when the vehicle weight exceeds AW2.

A Propulsion Logic Unit (PLU) controls the traction motors that are located on the motor trucks at either end of the LRV. This provides two relatively independent propulsion control systems on each LRV. This redundancy in propulsion and braking control permits the vehicle to operate in a degraded mode. This operation is dependent upon Metro Operating rules. Wheel slip control is active in service braking and is normally controlled by the dynamic brakes on the motor trucks and the brake ECU on the center non-powered truck.

2.4.2 Friction Braking

Friction braking is available to supplement dynamic brake when the traction motors cannot generate sufficing braking energy or tractive effort to maintain the requested brake rate. This occurs at higher vehicle loading above 50 mph and at low speed at the end of a stop as the motor rotation slows. Friction brake is also used to replace dynamic brake effort if there is a dynamic brake fault with the propulsion system. If a dynamic brake fault occurs, the vehicle controls will receive a signal from the dynamic fault relay and cause a speed restriction of 35 mph (56.3 kph) for vehicle operation. The friction brakes are sized thermally to permit vehicle operation of one system round trip with this speed restriction. However, it is recommended that when a dynamic brake fault occurs and the automatic speed restriction occurs, that the vehicle be removed from service and operated without passengers to the maintenance shop for repair.

The friction braking system consists of three independent electro-pneumatic braking control systems. Each truck is controlled by independent microprocessor based electronic control units that control independent brake pneumatic control units with their truck mounted disc brakes units. The Electronic Control Units (ECU) are located in cab and articulation electric lockers. Motor trucks utilize one pressure applied disc brake unit on each axle. The center truck is equipped with two pressure applied disc brake units on each axle.

Wheel slip control is active in normal service friction braking. In addition, in the event of a failure of the dynamic brakes, wheel slip control will be provided by the friction brakes.

2.4.3 Blended Braking Distribution

For the normal blending scheme under no slide conditions the dynamic brakes on the motor trucks are utilized up to the adhesion level of 18% and provide the majority of the braking effort. Additional effort is added by the center truck friction brakes as necessary to meet the required rate. The adhesion level was chosen based on normally expected available adhesion.

At speeds above approximately 50 mph (depending on vehicle weight), the motor truck dynamic brake effort is reduced as per the motor characteristic. If the adhesion demand on the motor truck falls below 16%, due to the dynamic brake characteristics at high speed, the motor truck friction brakes are be added to keep the total truck braking effort consistent with an adhesion level of 16%.

The blending can be summarized as follows:

- Maximize dynamic braking up to a maximum level of 18% adhesion,
- Apply center truck friction brakes as required to achieve the requested brake rate up to a maximum level of 16% adhesion on the center truck,
- Apply motor truck friction brakes to maintain a minimum of 16% adhesion on the motor trucks.

At speeds below 5 mph the dynamic braking fades, and the friction braking begins to take over. The friction braking will be applied at low speed on the motor and trailer trucks. This results in an even distribution of braking effort between the three trucks and requires adhesion levels on the order of 16% on all trucks.

The friction brake ECUs constantly monitor the Dynamic Brake Achieved signal along with the Dynamic Brake Failed signal. The ECUs will command friction braking as necessary if dynamic braking is unavailable to meet the requested brake rate.

The following graphs show the efforts of dynamic braking, center truck friction braking, and motor truck friction braking from 105 kph (65 mph) to 0 kph (0 mph). There is one graph for AW0, AW2, and AW3.

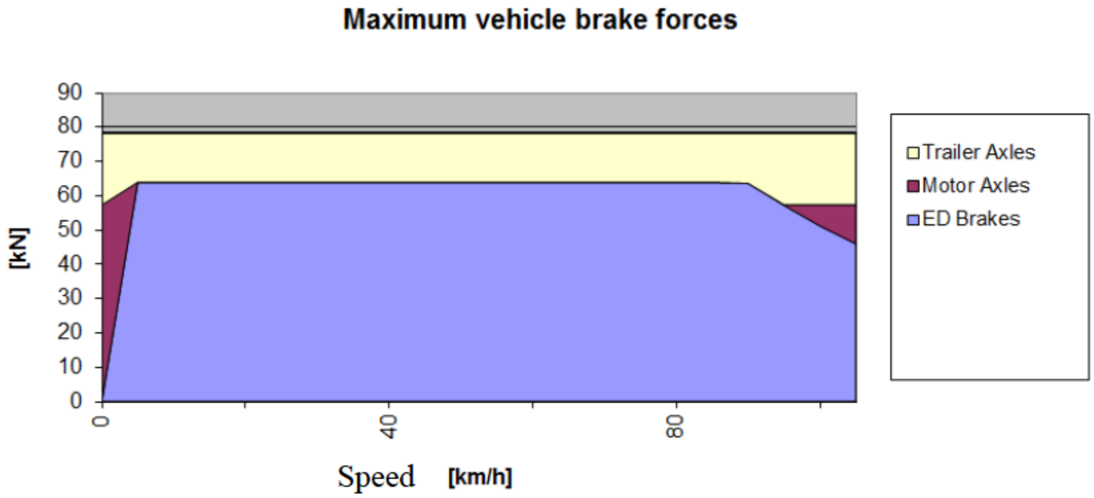
2.4.4 Stopping Brake (Low Speed Blending)

In order to ensure an optimum low speed blend of dynamic and friction brake the design utilizes a Stopping Brake input. The ‘stopping brake’ signal is active high. If this signal is low the ECU reads this signal and the friction brakes are not applied. If this signal is high the friction brakes are applied at a specified jerk limited rate to the level requested. The Stopping Brake signal is provided to the ECU via the TCN network.

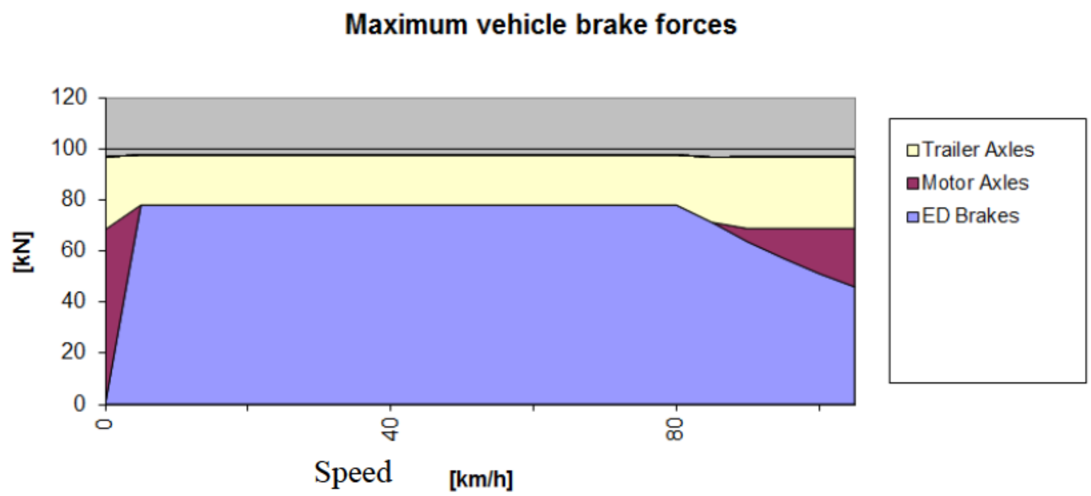
The Stopping Brake signal is also used to release the brakes when first moving. The signal will only go low when the propulsion system has built up sufficient torque to move the train forward. When the signal goes low the friction brakes will be released.

If the TCN Rate Command and Power / Brake trainlines request a brake release but the Stopping Brake input remains high the brakes are not to be released. In addition, a maintenance fault will be declared and the motoring command cancelled.

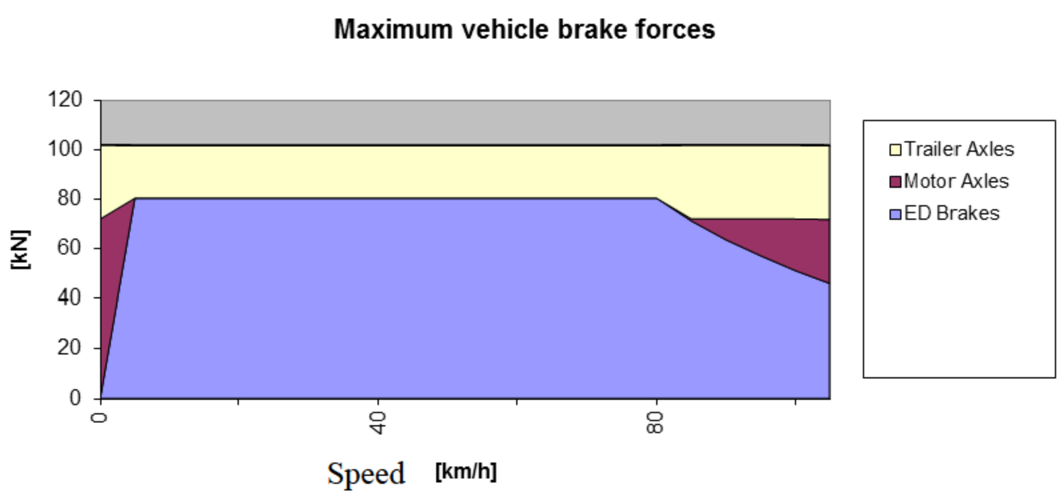
It should be noted that the brakes can be released at zero speed by moving the Master Controller to a Power position and then back to Coast. The friction brakes will release and the vehicle will be free to move. This functionality is sometimes used in a static test.



AW0 Blending



AW2 Blending



AW3 Blending

2.4.5 Roll Back

The Roll Back signal is used to stop the vehicle from rolling backwards. This signal will normally be low. The signal will go high when the propulsion system is in a power or coast mode but has detected that the train is rolling backwards.

The signal will be provided via the TCN from the PLU that detected the rollback to the ECU on that truck as well as the CT ECU. The ECUs will read this signal and immediately apply the brakes irrespective of the TCN status for the M, CM, and PBED inputs. The signal will go low when the operator moves the Master Controller back to the Full Service Brake Coast position, the train is in a No Motion state, and the Friction Brake Release trainline signal is low.

2.4.6 Track Braking

Track braking is provided on each truck. A track brake is an electromagnet with a friction element that is mounted on spring suspension assemblies over the rail between the wheels. This type of braking provides braking effort in proportion to its electromagnetic attractive force against the rail and the sliding friction between the wearing element and the rail.

Track braking is available at any time as long as power is available on the LRV from either the LVPS or battery. It is circuited so that it can be initiated at any time by:

- Depressing a “Track Brake” control push button on the cab console or
- Placing the master controller in the High Rate Service Brake or
- Placing the master controller in the Slide Controlled Emergency Brake position
- Depressing the Emergency Pushbutton

The Emergency Brake Control Circuit initiates the track brakes automatically during an emergency brake application. The track brakes are interlocked with the No Motion Relay to de-energize at the end of the stop for all applications other than the control push button on the console.

2.4.7 Emergency Braking

Emergency Braking (EB) is considered a safety system, and all EB circuits are configured in a fail-safe manner (i.e. no power / open circuit fails to braking mode). The EB trainline circuit requires both energization and continuity throughout the train to allow a permissive state.

EB is controlled by a four wire trainline. The controlling cab provides the positive and negative feeds to the trainlines through the Master Controller, ATP logic and the console EB pushbutton switch. Commanding EB causes the switches in both the positive and negative feeds to open, removing power to the EB inputs. Other EB mushroom switches in the train are provided in the positive and negative emergency loop trainline to cause all cars in the train to apply the emergency brakes regardless of the switch/cab location in the train. Manual application of EB is possible from the console EB push button switch.

EB uses the combination of load compensated friction disc brake plus track brake and sanding to produce a high rate brake application.

The EB provides the following minimum average brake rates:

Entry Speed Range	Average Brake Rate
88 km/h (55 mph) and above	2.0 m/s^2 (4.5 mph/s)
72 km/h (45 mph)	2.3 m/s^2 (5.2 mph/s)
56 km/h (35 mph)	2.0 m/s^2 (4.5 mph/s)
40 km/h (25 mph)	2.0 m/s^2 (4.5 mph/s)
5 km/h (3 mph) to 32 km/h (20 mph)	1.56 m/s^2 (3.5 mph/s)

An EB command is irretrievable to the no motion detection speed. Sand is automatically applied until the no motion detection speed. The track brake command is interlocked with the no motion signal so that EB commanded track brakes are released when no motion is detected.

The spin / slide system functions when EB is commanded by the master controller, and is cut out when the EB is commanded by other means (see Table 2-1 below). This EB initiated by the master controller is called Slide Controlled EB (SCEB) and is initiated by a separate trainline.

Table 2-1. Emergency Braking

EB initiated by:	Manual/Automatic	Spin Slide	Notes
Master controller (SCEB Position)	Manual	Yes	SCEB Trainline (service braking controls at emergency braking rates)
EB pushbutton switch	Manual	No	4 wire EB Trainline
Emergency Brake Relay (ATP)	Automatic	No	
Unintentional uncoupling	Automatic	No	
EB trainline loss of energization or continuity	Automatic	**No**	

Slide Controlled Emergency Brake utilizes the last detent of the main handle position of the Master Controller and achieves the same brake rate as the emergency brake initiated by the console mushroom switch. In this mode wheel slip and load weigh control are both active. SCEB is implemented in a failsafe manner and provides a brake rate equivalent to EB but with slide control.

For a Slide Controlled Emergency Brake stop, the dynamic brakes provide the majority of the braking effort. This effort is supplemented by a load weighed friction brake effort and the track brakes. The Friction Brakes monitor the Dynamic Brake Achieved signal along with the Dynamic Brake Failed signal in the same manner as full-service brake mode. The Friction Brakes will compensate for dynamic brake fade at speeds above 50 mph, low speed fade out, and loss of Dynamic Brakes.

2.4.8 Parking Brake

Parking brake is achieved using the spring applied brake units located on the motor trucks. The parking brake is designed to satisfy a holding requirement of AW3 car on a 7% grade.

The parking brake is controlled via the 3/2-way valve in the PT BCU's. The 3/2-way valve is powered via the car circuitry, not the friction brake control unit. The valve is powered when the reverser is in Forward or Reverse or the Brake Apply relay for either truck is energized.

The parking brakes are applied, as required, with a loss of system air. The parking brakes can be manually released by pulling the parking brake release handles on each motored truck (two places on each motor/end truck).

2.4.9 Deadman

The Master Controller handle has a Deadman feature which if the handle has been released by the Operator a full-service brake application is initiated. The dead-man feature is ineffective when in the full-service brake position with no vehicle motion detected, or when the cab transfer switch is in the OFF position.

To operate the train, it is necessary to rotate the handle counter-clockwise between 75° and 90° from the rest position. The Operator must hold the handle beyond 70° counter-clockwise of the rest position to avoid causing a Deadman brake application.

2.4.10 Limp Home

In case of a control network failure, a "Limp-Home" feature has been incorporated into the control of the LRV. The "Limp Home" function is used to move a vehicle or a train in the situation wherein a train or car has experienced a complete TCN failure. In Limp Home the propulsion and braking respond with a fixed level of powering and braking effort. See the table below. If Limp Home is used the train should be immediately removed from service.

Mode	M Trainline	CM Trainline	Rate m/sec² (mphps)
Braking	0	0	-0.89 m/sec² (-2.0mphps)
Coast	0	1	0
Motor	1	1	0.45 m/sec² (1.0mphps)
Invalid	1	0	-0.89 m/sec² (-2.0mphps)
EB (PB)	X	X	Friction only plus track brake (see Emergency Braking minimum averages)

2.4.11 Automatic Train Control (ATC)

Automatic Train Control (ATC) functionally consists of Automatic Train Protection (ATP) functionality and Automatic Train Operation (ATO) functionality.

The ATP system continuously receives speed commands through truck mounted receiver coils, from the wayside signaling equipment, based on track occupancy or train routing. ATP primary function is speed limiting control to ensure safe train separation via safe braking. This is the overspeed control function. If the train is overspeed the brake assurance function is initiated. The ATP equipment provides the following brake assurance penalty action commands per overspeed system requirements.

- Power-cut
- Full-Service Brake
- Emergency Brake

If a Power-cut does not bring the train underspeed Full-Service Brake is initiated. Brake assurance monitors acceleration via an accelerometer when the train is overspeed to ensure that a safe brake rate is met. If the safe brake rate is not achieved an emergency brake is initiated. When the train is operated in ATO mode the acceleration and braking of the train is controlled by the ATO equipment. The ATO equipment controls the PBED, CM and M trainlines. All tractive effort commands are provided by the ATO equipment via the WTB/MVB. ATP provides the brake assurance function.

2.5 TCN – Train Control Network

The data communication network consists of multiple redundant trainline and vehicle networks, along with a separate wireless data transfer network. There are three types of networks: WTB/MVB, ETB/ECN (Wired Ethernet) and Wireless Ethernet networks. See Figure 2-6.

The WTB/MVB network performs control functions such as Tractive Effort Command, brake blending, load weigh and other control signals. This network is implemented using service proven Gateway and Logic Control equipment. The control network (consisting of redundant WTB and MVB modules) conforms with IEC-61375. This network provides a deterministic means of data transmission.

There are two ETB/ECN networks on the P3010. Collectively, the ETB/ECN networks perform communication system, CCTV, diagnostic data, and other applications requiring high bandwidth. The networks conform to IEEE 1473-E, the IEC-61375-3-4 for the Ethernet Consist Network (ECN) (vehicle local Ethernet network), and the IEC-61375-2-5 for the Ethernet Train Backbone (ETB) (train network). When implemented within constraints, this network provides a pseudo-deterministic type of network that operates at significantly higher speeds than the TCN network.

The Wireless Ethernet network (Wi-Fi) performs train-to-wayside data transfer. The network conforms to IEEE 802.11n. This network provides functionality to initiate automatic and manual data downloads.

Table 2-2. Train Communications Network Designations

Network Designation	Description	Applicable Standards
WTB	Wire Train Bus – TCN Trainline Network (between multiple vehicles)	IEC-61375-1 and UIC Code 556
MVB	Multi Vehicle Bus – TCN Local Network (local to each vehicle)	IEC-61375-1
ETB	Ethernet Train Backbone – TCN Ethernet Trainline Network (between multiple vehicles)	IEC-61375-2-5
ECN	Ethernet Consist Network – TCN Ethernet Local Network (local to each vehicle)	IEC-61375-3-4
Wi-Fi	Wireless Ethernet Network	IEEE 80211n

2.5.1 Network Architecture

The communications equipment, the monitoring and diagnostic equipment, the vehicle network equipment, the exterior signs, and CCTV system **all** utilize the Ethernet network on the vehicle for signaling control and data transmission and are all cross connected / integrated to form an integral network of dependent devices. All subsystems that have microcontrollers utilize the network infrastructure for communication and sharing of various signals. The WTB / MVB network signals are bridged into the Ethernet network to provide additional signals. The various controllers utilize these signals to perform their intended function. The proper operation of the communications system is extremely dependent upon network connectivity and proper software installation.

2.5.1.1 Trainline Network Architecture

The ***trainline*** data communication network consists of two types of networks. Each of these networks are part of the Train Communication Network (TCN):

- A/B Wire Train Bus (WTB) per the IEC 61375-1 standard
- Two (2) Redundant two-wire Ethernet networks per IEEE-1473-E, and IEC 61375-2-5
    - (1) for Monitoring and Diagnostics
    - (1) for Communication System and Sign Control

There are six (6) separate networks through the train consist, providing high level of redundancy and data diversity between coupled vehicles. See Figures 2-7 and 2-8.

The WTB network is part of the Train Communication Network (TCN) and performs control functions such as Tractive Effort Command, brake blending, load weigh, and train inauguration and other control signals. The WTB network communicates using the protocol defined in the IEC 61375-1 and UIC Code 556 standards. The WTB network is provided through two redundant networks: Network A and Network B (shown as WTB A/B in Figure 2-8). The use of multiple networks provides a redundant bus topology with failover capability. Each WTB network provides data at a rate of 1 Mbits/second.

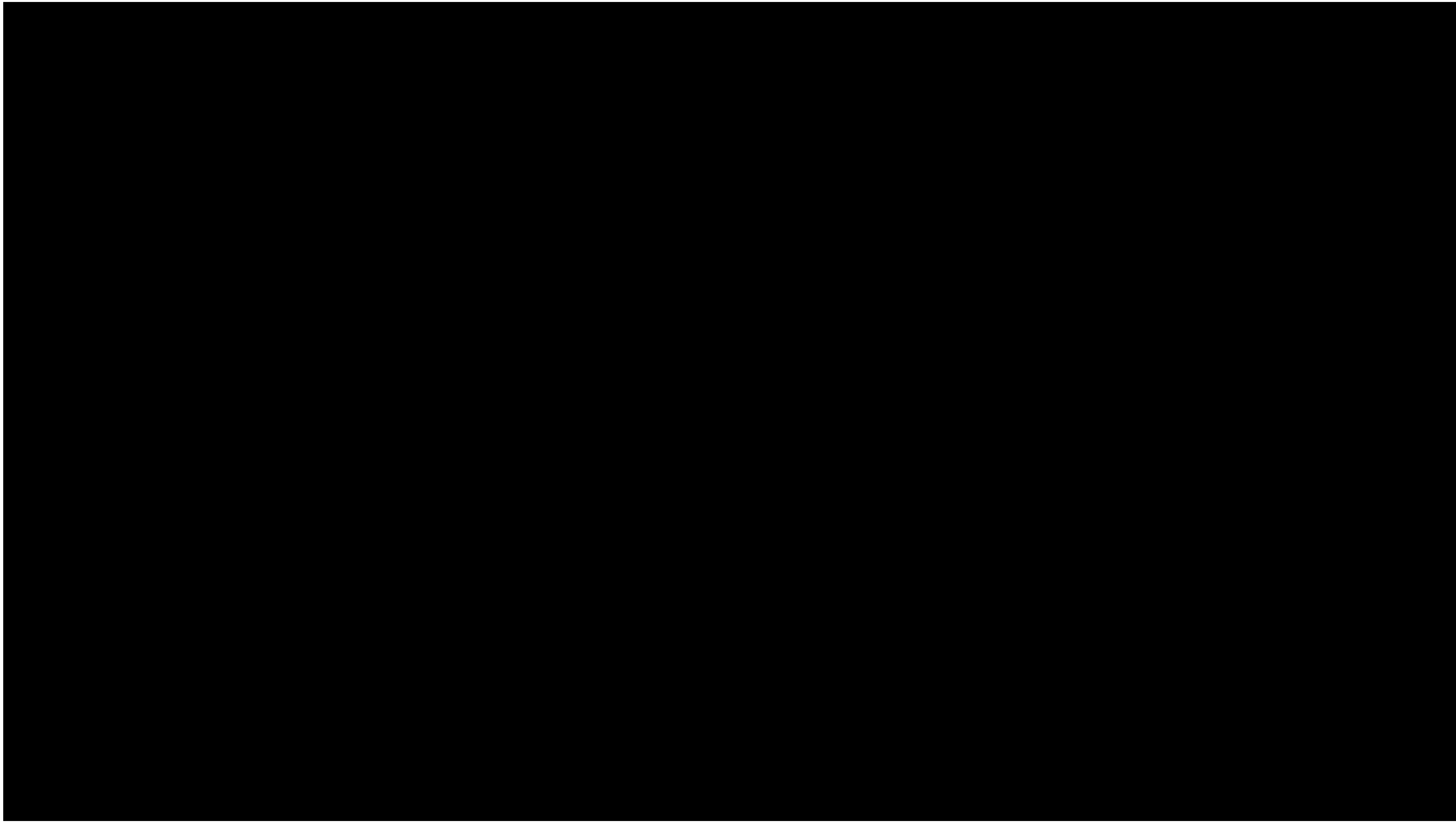


Figure 2-6: TCN - Combined Network Concept

[redacted]

Figure 2-8: LA P3010 ETB Trainline Architecture (Monitoring & Diagnostics)

For the Communications System, Trainline 1 and Trainline 2 provide the wired redundancy (shown in Figure 2-9 as power line connections from EIM1 and EIM2 respectively). The Ethernet network infrastructure, including all the components in the system, are designed to provide data rates of 70 Mbits/second or greater.

[redacted]

2.5.1.2 Vehicle Local Network Architecture

The vehicle local data communication networks consist of two types of networks:

- A/B Multifunction Vehicle Bus (MVB) using the Electrical Middle Distance (EMD medium) physical layer per the IEC 61375-1 standard,
- Two (2) ECN four-wire Ethernet networks per the IEEE-1473-E, and IEC 61375-3-4.
  - (1) for Monitoring and Diagnostics, CCTV, General Information
  - (1) for Communication System and Sign Control

The MVB network is part of the WTB/MVB network system and performs control functions such as Tractive Effort Command, brake blending, load weigh and other control signals. The MVB network communicates using the protocol defined in the IEC 61375-1 standard. The MVB network is provided through two redundant networks: Network A and Network B. The use of multiple networks provides a redundant bus topology with failover capability. Each MVB network provides data at a rate of 1.5 Mbits/second.

The Ethernet Consist Network (ECN) is part of the wired Ethernet network system and performs functions that require high bandwidth such as digital video, digital audio, transfer large amount of diagnostic data, Portable Test Unit operation, wireless communication, and other functions. The ECN communicates using standard TCP/IP and UDP/IP Ethernet protocols, and it is configured per the IEC 61375-3-4 standard - an Ethernet standard for rail vehicles.

The ECN for MDS, CCTV, and general information functions is configured in a redundant ring configuration network (shown in Figure 2-10). The Ethernet network infrastructure, including all the components in the system, are designed to provide data rates of 100 Mbits/second or greater.

[redacted]

Figure 2-10: LA P3010 ECN (Ethernet) Local Network Architecture for MDS, CCTV, and General Info. Note the WLAN (wireless network switch) is shown in this diagram since it communicates to the local vehicle devices through the wired Ethernet network

The ECN for Communication System functions is configured with redundant cables between the network switches (shown in Figure 2-11). The Ethernet network infrastructure, including all the components in the system, are designed to provide data rates of 100 Mbits/second or greater.

[redacted]

2.5.1.3 Wireless Network Architecture

The wireless vehicle data transfer network consists of one type of network:

- Wireless Ethernet network per IEEE 802.11n

The wireless network interfaces with the wired Ethernet network through the Ethernet router and performs train-to-wayside data transfer of vehicle diagnostic (e.g. fault) and subsystem specific (e.g. automatic passenger counter) logs. The wireless network communicates using the IEEE 802.11n standard and is provided through a wireless radio with roof-mounted Multi-Input-Multi-Output (MIMO) antenna. The wireless radio data rates are dependent upon location, obstructions, bandwidth availability and is based on the connection strength to the wayside server.

2.5.2 Network Redundancy

The wired communication networks on the P3010 vehicle, WTB/MVB and ETB/ECN, are equipped with line redundancy features to mitigate the impact from interference and cabling issues. The handling of network sensing and switchover differs between the WTB, MVB, ETB, and ECN, but they all share the following commonalities:

- Network health sensing
- Two independent physical wire connections

2.5.2.1 WTB Redundancy

The WTB network consists of one master gateway with additional slave gateways. On the P3010 vehicles, the A-end gateway in the active car (active cab) within the consist is designated as the master. In the case that the master gateway fails, another gateway on the network becomes elevated to the master.

The WTB network is designed with two communication lines: line A and line B. Each gateway transmits on both lines but only receives from one. The gateways monitor the second line for signal quality. A supervisory task is run to determine which line to receive from.

[redacted]

2.5.2.2 MVB Redundancy

The MVB network consists of one bus master, multiple bus administrators, and slave devices. On the P3010 vehicles, the bus master is the A-end gateway in the active car (active cab) within the consist is designated as the master. The other gateway modules in the consist have bus administrator functionality. If the bus master fails, one of the other gateway modules becomes elevated to the master.

The MVB network is designed with two communication lines: bus line A and bus line B. These lines are provided in a single insulated cable. Each device transmits over both channels (lines) but only receives from one. The secondary line is constantly monitored by each MVB device. A line switchover (receive line) occurs at MVB device based on signal quality and frame overlap.

[redacted]

2.5.2.3 ETB Redundancy

The ETB network for the MDS consists of two parallel communication trainlines: TL1 and TL2. Each module within the panel is designated to a particular communication channel – module 1 communicates on TL1 and module 2 communicates on TL2. One communication line is chosen as the active line while the other remains dormant. If the active line becomes inoperable, the secondary line takes over as the active line.

In order to create an active trainline, one communication trainline is chosen by the Enhanced Ethernet Interface Manager (EEIM) software. A module on that channel within the consist is designated as the master (head-end) while the others remain slaves (repeaters). Once a master is designated, that module remains a master until the consist is powered down or the communication line is deemed inoperable.

[redacted]

2.5.2.4 ECN Redundancy

The ECN for the MDS / CCTV / General Info consists of a ring configuration network with redundant cabling between the two sets of articulation-crossing switches: LAN3A-LAN3B and LAN4A-LAN4B. The redundant cabling provides assurance that network traffic will continue to flow in the predetermined switch-routes. The ring configuration provides two directions of travel for network traffic – leaving a fallback option available if one of the two articulation-crossing switch sets become inoperable.

NOTE: The predetermined switch-routes are established at start-up of the vehicle by the Ethernet switches' routing algorithms. Whenever there is a change to the Ethernet network, the switches recalculate the routes.

The ECN for the Communications System consists of redundant cabling between one set of articulation-crossing switches: LANA-LANB. This architecture provides similar benefits for the other ECN.

2.6 Propulsion and Electro-Dynamic Brake Equipment

During operation the propulsion system i.e. the propulsion traction inverter converts the Direct Current (DC) supply voltage, supplied from the Overhead Contact System (OCS), into pulse modulated three phase alternating voltage to drive the traction motors. The control of output voltage and output frequency works on the principle of the Pulse Width Modulation (PWM). Insulated Gate Bipolar Transistors (IGBT) modules are used to generate the pulse patterns feeding the traction motors. See Figure 2-12.

To control the IGBT modules the Propulsion Logic Unit (PLU) is used. This electronic unit is microprocessor based and manages all functions of the inverter and controls the propulsion system. The propulsion logic unit is part of the propulsion traction inverter package and performs control, monitoring and protective functions of the inverter to drive the traction motors under fully controlled conditions with respect to speed, acceleration and deceleration by regenerative or rheostatic braking (i.e. dynamic braking).

During dynamic braking the braking energy is fed back into the supply network or dissipated by utilizing a braking resistor if the network is not able to absorb the all braking energy generated.

The PLU reports the amount of achieved effort per truck to both the motor truck and center truck friction brake electronic control units via the Dynamic Brake Achieved (DBA) signal. This signal is provided over the MVB network.

During blended braking, the electro-dynamic brakes will produce the majority of the necessary braking effort up to and including AW2 car weight and up to 50 mph.

An input line reactor and a filter capacitor bank, which make up the input filter, provide the front end or link voltage to the inverter power semiconductors. The input filter provides the filtering needed to protect the line from conducted Electromagnetic Interference (EMI).

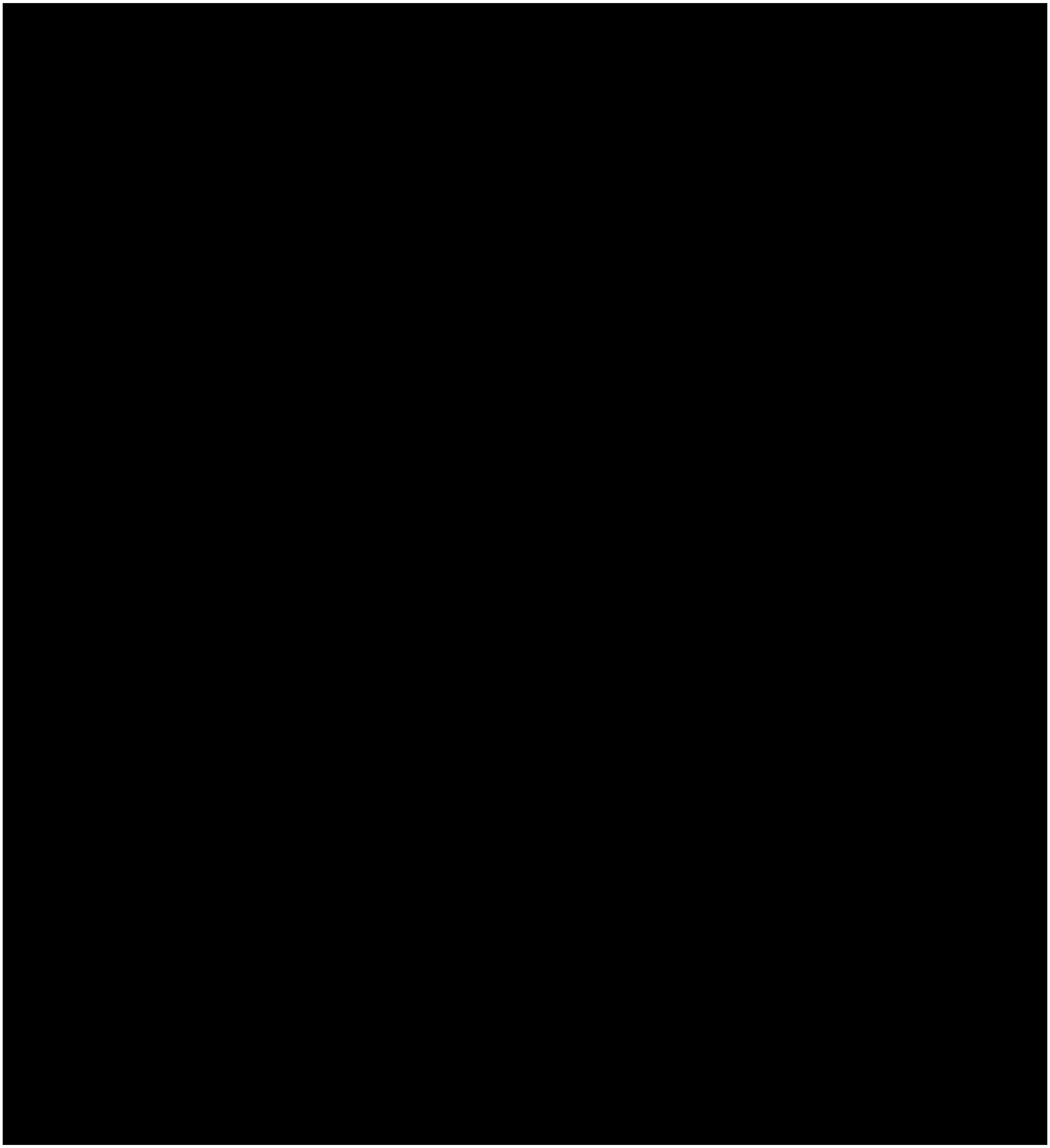
Figure 2-12: Simplified Propulsion Schematic

Each propulsion inverter contains a dynamic brake chopper circuit. The chopper is used in the dynamic braking circuits and each chopper module has both an IGBT / diode and a freewheeling diode. The IGBT / diode connects the brake resistors across the DC link voltage. The freewheeling diode is connected across the inductive brake resistors for freewheeling the energy in the resistors. In normal operation, the dynamic brake chopper is used to control regenerative energy that is fed back into the line during braking, by controlling the voltage to line or brake resistors. The voltage is limited by diverting energy to the brake resistors if it rises to the maximum limits or if the line is not receptive.

The truck mounted propulsion drive consists of a self-ventilated AC traction motor and a double-reduction, parallel drive gear unit. A powering characteristic curve is provided in the figure below. Load weighing will increase the base tractive effort in direct proportion to the weight of the passengers. At voltages above 750 V, the same effort characteristic is maintained. Below 750 V, torque reduces, based upon the reduction in supply voltage. See Figure 2-13 below.

[redacted]

A braking characteristic curve, Figure 2-14, is provided in the figure below. Load weighing will increase the electric brake effort in direct proportion to the weight of the passengers. At maximum speed, and if the load is more than AW2, the friction brake supplements the dynamic brake.



The brake resistors are mounted on the roof of the vehicle and are cooled by a combination of natural convection and air flow from the vehicle's movement. The elements are fully rated for AW3 full service dynamic brake with no regenerative braking.

The traction motor is rated for the worst-case duty cycle of the worst case line profile. The motor is rated at 145 kW for the one (1) hour rating. The traction motor is a self-ventilated design. The traction motor is a squirrel cage induction motor. The traction motor is mated to a double reduction, parallel drive gear unit for each of the four powered axles.

The control electronics provide the following functions:

- Motor control: regulation, protection, pulse generation for inverter,
- Friction Brake Blending: dynamic brake achieved output,
- Communications: network,
- Maintenance: indication, recording,
- Diagnostics,
- LV (Low Voltage): local device and relay control.

The traction / brake rate demand generated by the Operator's controller is decoded and modified within the Inverter controller by the load weigh signal from the vehicle suspension to produce the tractive/brake effort demand. The load compensation provides uniform acceleration and braking between AW0 and AW2. For weights above AW2, the effort is maintained at the AW2 level.

The Propulsion Control Unit transmits the dynamic brake effort achieved (MVB signal) to the brake equipment on the associated truck, and to a second brake unit on the center (trailer) truck. The brake units then modify their output by reducing the friction brake according to the level of the dynamic brake.

The braking control scheme gives priority to the dynamic effort. Only if the dynamic brake effort is not available or is insufficient for commanded levels is the braking effort provided by the friction brake (typically at high speed, high passenger loading, or during fade out).

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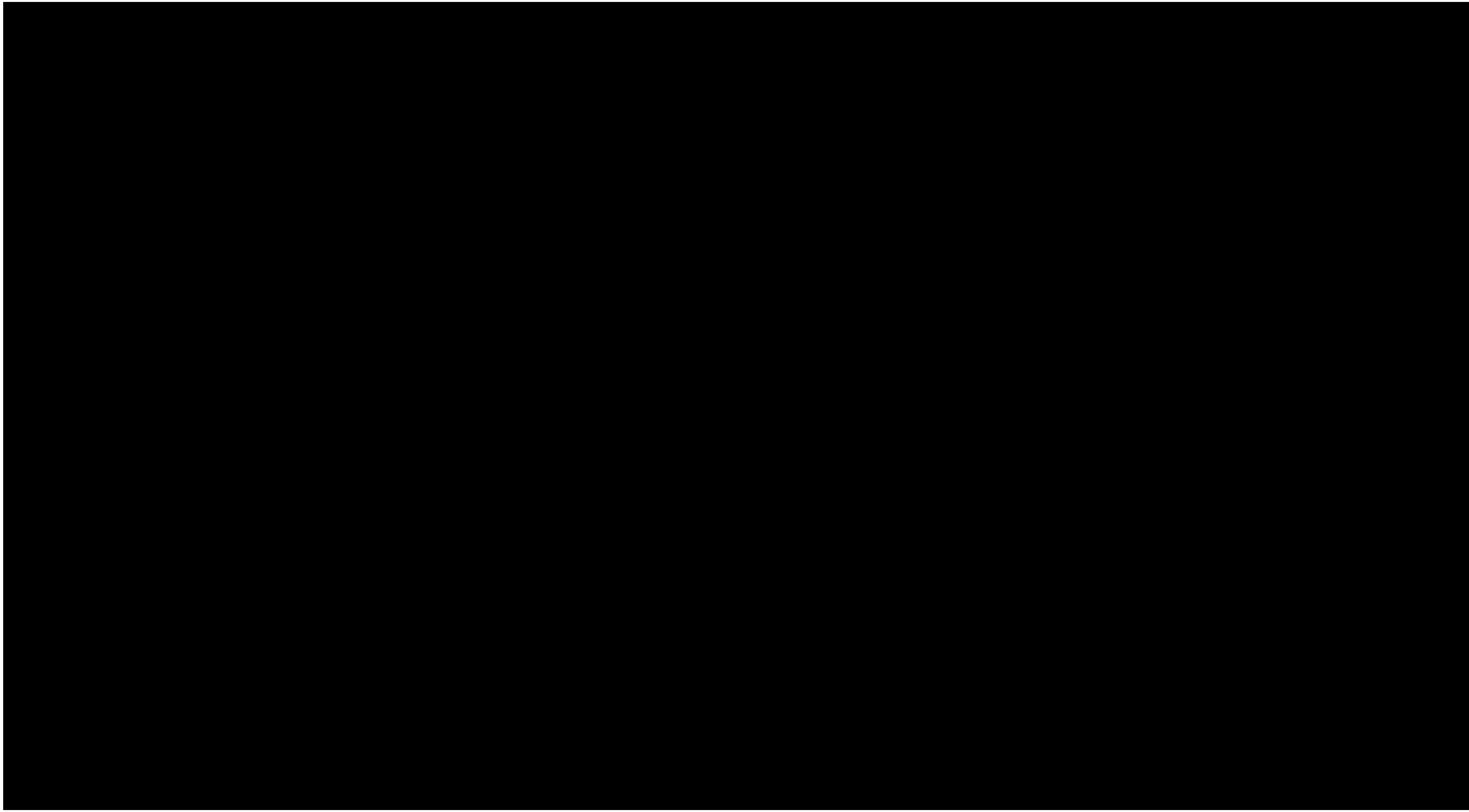

Figure 2-15: Propulsion Interface Block Diagram (typical)

The friction brake unit has the following interfaces to the propulsion system.

The motor truck the propulsion controllers provide:

- The speed of each axle,
- The dynamic brake effort achieved,
- A slide correction command.

The controller receives from the brake controller or vehicle sensors:

- Passenger loading for that car, and
- A slide correction command.

For the trailer truck, the propulsion controllers provide:

- The dynamic brake effort achieved, MVB signal.

Both the propulsion controllers and the friction brake controllers read the PBED signal transmitted on the MVB buss. The demand signal is derived from the master controller position and encoded into a signal for commanding Powering or Braking of the train consist.

Each propulsion inverter continuously monitors the speed of each axle that it drives, plus the speed of the two axles from the center truck. In addition, the speed signal from the other Propulsion Controller is monitored. All speed signals are available through the MVB network.

The Propulsion Control Unit includes a spin/slide detection system. Whenever wheel spin / slide happens, the Control unit quickly reduces the motor torque. Once spin / slide has been corrected, the motor torque is reapplied in a controlled manner.

The equipment also provides an output indicating the presence of wheel spin and slide. This is used to drive indicator lights, the sanding relay, and to ensure that the brake system does not respond to loss of dynamic braking when a slide occurs. The slide recovery function is activated within the propulsion control unit for speeds greater than 5 mph. The brake unit electronic system manages spin control for speeds less than or equal to 5 mph. The slide control mechanism acts on the dynamic brake effort demand for the motor truck. It does not act on the brake effort sent to the brake units. The appropriate friction brake controllers manage slide independently on the trailer axles.

Each propulsion inverter control generates a no motion signal which is set at 2 mph. Both control unit no motion speed outputs are used in series to drive a “Critical” Relay, mounted in an electrical locker on the car. As its own control unit monitors each output and both outputs are necessary to energize the relay, the result is a combination that can be considered to be a vital or safe indication.

Dynamic braking and friction braking are continuously blended to provide the specified service brake rates. Dynamic braking is a blended combination of regenerative and rheostatic braking. The dynamic brake predominates, requesting friction braking only when dynamic capacity is exceeded.

Dynamic brake is available for all speeds from 50 mph to the fade speed (brake rate = -3.5 mphps). Initiating the "fade-out" achieves a seamless low speed blend. Dynamic brake alone provides full-service rate of 3.5 mphps (1.56 m/s^2) for car weights AW0 to AW2, using load weighing. Above AW2 the dynamic brake will provide the same constant braking effort, with the friction brake making up the difference, so that a service brake rate of up to 3.5 mphps (1.56 $m/s^{2)}$ is available.

Supplemental braking effort is provided first by friction braking on the non-powered center trucks up to the appropriate adhesion level, allowing for the lower rotational inertia of the non-powered axles. If necessary, further braking effort will be developed by supplemental friction braking on the powered trucks. Each friction brake controller uses the main PBED demand and the dynamic brake effort achieved (from MVB network) from the adjacent motor truck to calculate the pressure applied to each friction brake. No central processing is used, thereby eliminating a single mode failure point.

2.7 Friction Brake System

The friction brake system contains the following sub systems:

- Air Supply System
- Brake Control System
- Disc Brake System
- Sanding System
- Air Suspension System (refer to RMSM Section 1200 Trucks)
- Track Brake System (refer to RMSM Section 1000 Track Brakes)

The Friction Brake System is a microprocessor controlled electro-pneumatic friction brake system. The system provides computer controlled dynamic / friction brake blending, wheel-slide control, and diagnostic functions for monitoring performance and reporting status information. All functions are performed on a per truck basis.

The Electronic Control Units (ECUs) also perform a variety of diagnostic tasks including checks of the computer hardware, braking equipment, and wheel-slide control devices. These checks are conducted on power up of the system and continuously during normal system operation. Error status information is stored in non-volatile memory for access through a diagnostic maintenance device, PTU, and for passing information to the Vehicle Monitoring and Diagnostic System (MDS).

The Electronic Control Unit includes the logic and electronic interfaces to:

- Interpret trainline brake commands,
- Receive feedback from the propulsion system for dynamic brake effort achieved,
- Command and receive feedback from the Brake Control Unit (BCU),
- Power and receive feedback from the pneumatic system sensors,
- Power and receive feedback from the speed sensors,
- Detect and correct wheel slip during braking,
- Monitor faults and diagnose the friction brake and pneumatic systems,
- Communicate with the Vehicle Monitoring System.

During service braking operation, the ECU reads commands from the vehicle Trainlines and the MVB communication bus. Based on a brake-achieved signal from the propulsion logic, the ECUs command supplemental friction brake to ensure that the brake rate demand is met. The friction brakes can provide 100% of the braking effort required in the event that electric brakes are lost. During emergency braking initiated via the EB push button (mushroom) on the driver's console, all electronic brake control is bypassed and pneumatic controlled friction braking is provided via the emergency brake control devices of each Brake Control Unit (BCU).

Friction brake effort is controlled in the BCU, which operates as a closed-loop pressure regulator. Service and emergency brake friction braking functions are controlled on a per truck basis by individual BCUs. For service braking, brake cylinder pressure is regulated by the ECU, which adjusts BC pressure to compensate for varying vehicle loads. The amount of vehicle loading is calculated using a suspension air spring pressure signal reported by a transducer connected to the equalized load weigh pressure on each truck.

During an Emergency Brake (EB) event, the EB trainline changes to a de-energized state causing the EB valve to bypass the ECU controller logic and supply Brake Supply Reservoir (BSR) air directly to the brake control circuit.

Brake control circuit air is then load weigh compensated using a Pressure Limiting Valve which regulates control pressure to the relay valve in response to air spring suspension pressures.

Using this approach, the Emergency Brake pressure in the brake control circuit is generated through purely electro-mechanical means, requiring no reliance on ECU software.

During a Slide Controlled Emergency Brake (SCEB) event generated by the Master Controller Handle, the EB valve is energized, electro dynamic braking is enabled and track brakes are applied. The ECU and DPC generates load weigh compensated brake control circuit pressures in the same manner as service braking but with higher pressures designed to meet EB brake rates. Unlike EB, in the SCEB mode there is a dependency on ECU software to calculate and control the brake control pressure.

An Air Supply Unit (ASU) located on the B-Unit of the vehicle delivers compressed air at a net rate of 19 CFM. The compressed air feeds the Main Reservoirs and the trainlined MR Pipe throughout the vehicle/consist.

The system is configured to provide independent control of the brake application of each truck in a vehicle. This includes:

- Separate brake ECUs for each truck,
- Separate BCUs for each truck,
- Independent speed monitoring of the truck axles controlled by the ECU as well as at least a single axle from another truck,
- Independent brake cylinder pressure monitoring for each truck is communicated to each ECU on a car,
- Independent load weigh monitoring for each truck. The truck air-spring pressure is provided to each ECU in a car.

The Brake Control Unit (BCU) supply reservoir is protected by a check valve mounted on each BCU manifold so that in the event that there is a loss of Main Reservoir pressure, the Brake Supply Reservoir provides the air capacity for five full-service brake applications and releases at the AW3 passenger loading level. The Brake Supply Reservoirs supply the Brake Control Units with air through manifold mounted cut-out cocks and filters. The cut-out cocks are provided to enable maintenance to isolate the BCU.

All three truck's brake cylinder pressures and the main reservoir pressure are monitored on the TOD's located in the cab on each end of the vehicle.

The truck-mounted equipment includes two pneumatic pressure applied disc-brake units on each Motor Truck and four on the Center Truck. The Motor Truck Calipers are equipped with spring applied park brakes. A total of six magnetic track brakes are also provided, one pair per truck. The Motor Trucks are also provided with sanding equipment for the wheels on the lead axle.

The Brake Caliper unit is an air-operated, direct acting, brake that serves, together with axle-mounted brake discs, as a service-brake in rail vehicles. The Motor Truck contains one caliper with park brake per axle. The Center Truck utilizes all service brake only calipers with two calipers per axle.

The axle mounted brake disc consists of a split 520 x 110 mm gray cast iron friction ring bolted to a steel hub via a 12 bolt plansitz interface. This interface, with a specific bolt torque, allows for free thermal expansion of the friction ring resulting from braking.

During maintenance or in case of a park brake failure all of the park brakes can be released on a per truck basis. To fully release the parking brake, the annunciated cutout cock (PBCO) on the BCU should be in the cut-out position. With cutout cock in the open position, the parking brake cylinders could be re-activated, releasing the brake. With PBCO closed, the parking brake is fully applied and the parking brake can only be mechanically released using remote control cables. Remote control cables are operated with a pull to release the parking brake and are accessible from both sides of each motor truck and must be actuated for each motor truck axle.

Each vehicle is equipped with two articulated electro-magnetic track brake assemblies per truck. Each track brake assembly is mounted between the wheels on each side of each truck and arranged parallel to the rail and segmented so that a maximum contact area is provided between the brake shoe and the rail head when energized

The purpose of the sanding system is to increase wheel to rail adhesion by distributing sand on the rail ahead of the vehicle's lead axle as selected by reverser position. Sand may be requested by the Friction Brakes or by the Propulsion system via the vehicle wiring or Ethernet. The vehicle control system is responsible for closing the sanding relay which opens the sanding magnet valve.

The BCU receives the friction brake effort pressure command from the ECU. The ECU analyzes the MVB signal brake command along with load weigh, dynamic brake effort, speed taper, and jerk limiting. Pressure transducers provide feedback information to the ECU for controlling the proper amount of Brake Cylinder pressure.

The maximum car speed at which performance is to be met is 105 kph (65 mph). Service braking is the brake mode used for normal braking activities. Dynamic braking is the primary brake on Power Trucks, with friction braking automatically blended in as required to meet the commanded rate. At vehicle loadings up to AW2, and speeds from 8 kph to 80.5 kph (5 mph to 50 mph), inclusive, motor truck braking is entirely electric.

Center truck braking is provided entirely by friction braking and is directly proportional to the vehicle weight.

At speeds above 80.5 kph (50 mph), electric braking effort is reduced such that electric braking power is held constant at the 80.5 kph (50 mph) value. Friction braking on the motor trucks is blended in order to achieve the specified deceleration at all speeds.

With electric and friction brakes fully functional, maximum service brakes (Full-Service Brake) will provide an instantaneous 1.56 m/s/s (3.5 mph/s) ±10% deceleration rate from maximum speed down to zero at any load between AW0 and AW3, exclusive of response time and jerk limiting.

The friction disc brake system, when operating without electric braking, will provide an instantaneous brake rate of 1.56 m/s/s (3.5 mph/s) ± 20% from maximum speed down to zero at any load between AW0 and AW3, exclusive of response time and jerk limiting.

Friction Braking on each of the three (3) trucks is in direct proportion to the vehicle weight distribution at each truck, for all braking modes.

Motor truck friction braking without dynamic braking is defined as abnormal duty, and is not rated for continuous duty.

If the truck’s dynamic brakes fail, Propulsion will send an ED NOT OK (ED signal low) to the friction brake ECU. Braking will then be distributed between the power trucks friction brakes and the center truck friction brakes. The LRV’s propulsion system will log a fault error resulting in the LRV going to a degraded mode with speed restrictions. In case of a full electro-dynamic brake failure or loss of dynamic brake force, the friction brakes will be applied to fill in for the missing dynamic brake effort regardless of the ED OK signal.

The system includes a separate check circuit consisting of trainlines arranged to detect the states of: all emergency pushbuttons at all consoles in the train; all coupler circuits; all master controllers at all consoles; and the controlling signal system. An incorrect state in any of these systems anywhere in a train, or a break in the loop circuit for any other reason, will cause both emergency brake power trainlines to become de-energized, propagating an emergency brake application in all cars in the train.

All emergency brake circuits are arranged in a fail-safe manner, with de-energize to a safe state incorporated into the controls.

During a slide condition, the sanding system, depending on the duration and severity of the slide, is used to distribute sand on the rail ahead of the leading axle on the forward power truck of each car in the train. Sand can be requested by the Friction Brakes or by the Propulsion system over the sanding trainline if wheel slip control activity is sensed.

The wheel slide algorithm is used to modulate brake cylinder pressure independently of the service brake pressure command, in response to the speed of the individual axles. The response is based on a comparison of measured axle speeds and calculated acceleration (or deceleration) to a reference deceleration rate, in such a way that the existing wheel/rail adhesion is optimally used.

2.8 Automatic Train Control (ATC)

The Hitachi STS (formerly Ansaldo), Automatic Train Control (ATC) system is a microprocessor and electronic-based cab signaling system. The ATC enclosure and peripheral components provide the hardware and software necessary to implement the functional requirements of the LA P3010 LRV for both Type I and Type II ATC systems. System components comprise the following interconnected and interdependent ATC subsystems:

- Automatic Train Protection (ATP),
- Automatic Train Operation (ATO),
- Train to Wayside Communications (TWC),
- Communications (COMM).

These subsystems share mounting space, power supplies, and interfaces with the vehicle. During vehicle operation, all the subsystems simultaneously perform their assigned functions to exchange data and ensure continuous operation.

A Line Selector Switch on the vehicle provides the method for properly configuring the ATC for operation on desired line and type of operation. In general Type I operation has ATP and TWC functional capabilities while Type II operation has ATP, TWC, and ATO functional capabilities.

There are no differences in the ATC package or in the installation of the ATC system on the P3010 LRV based upon Type I or Type II operation. Each P3010 LRV is equipped with one ATC system. This includes equipment mounted in an electronics cabinet in the vehicle cab and also under car and truck mounted.

The list below provides a brief description of the major hardware components associated with the ATC system. The ATC system for the LACMTA P3010 LRVs consists of the following:

- ATC MicroCab Enclosure – The enclosure incorporates the system's vital logic and interfacing circuits, a decelerometer, and a vital relay for control of a vital output to the emergency brake system. One (1) enclosure is installed in each P3010 vehicle B-End cab electric locker.
- Aspect Display Unit (ADU) – The ADU / TWC Panel is incorporated into a single flat-panel display unit mounted in each cab of the LRV for the vehicle operator. An ADU is installed centered in the cab console on each end, two per car
- Truck-mounted cab signal pick-up coils – Four (4) pick-up coils are mounted on each P3010 vehicle (two on the lead A-End truck and two on the lead B-End truck). Each pair of coils is wired to a junction box. These devices incorporate two internal coils. One coil detects cab signals from the rails; the other coil is used for testing.
- Vehicle body-mounted TWC antennas – Four (4) TWC antennas are mounted on each vehicle (two on the A-End and two on the B-End); one Type I TWC antenna and One Type II TWC Antenna is mounted at each end.

Refer to Figure 2-16 for an overview of ATC system equipment in the P3010 LRV.

The ATC unit for the P3010 LRV is mounted in the B-End Cab and the speed sensor for the powered truck is mounted to the B-End truck.

2.8.1 ATP Subsystem

Refer to Figure 2-17. The ATP functionality performs the following major functions across all Metro lines:

- Cab Signal Reception and Decoding,
- Vehicle Speed Determination,
- Over Speed Protection,
- Braking and Propulsion Control via penalty enforcement,
- Input / Output Processing,
- Door Control Enable, Type II Mode
- ATP Operating Modes,
- ATP Departure Test,
- Direction Control and Validation.

The ATP equipment includes a fail-safe overspeed detector which continuously compares the actual car speed with the overspeed set point. A penalty full-service brake application will be requested when a brake rate of 0.9 m/s^2 (2 mphps) is not detected within 4 seconds (actual range is 3.6 - 4.4 seconds) after an overspeed condition is detected or if the brake rate falls below 0.9 m/s^2 (2 mphps) during an overspeed condition. A Full-service brake application is initiated by a vital Brake Release Relay (BRR).

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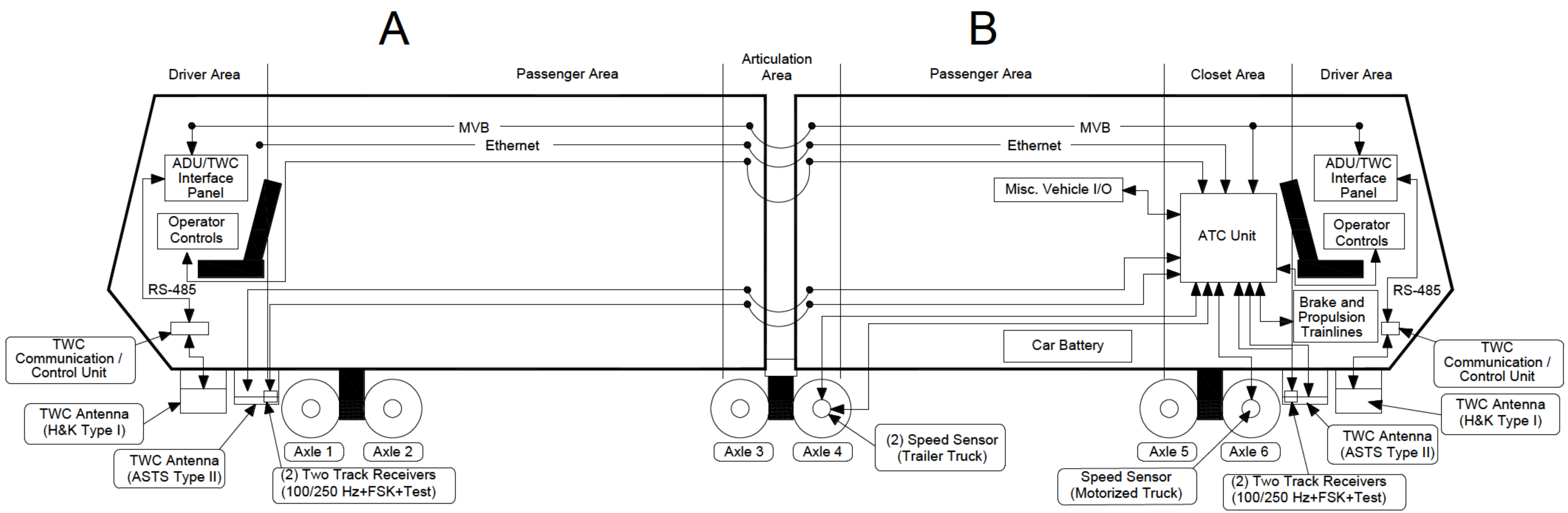


Figure 2-16: Overview of ATC System Equipment

[redacted]

Figure 2-17: ATP Subsystem Block Diagram

In addition, brake assurance provides within the ATP system a monitor of the operator response to overspeed conditions and to monitor brake system response to ATP initiated full-service braking. Brake assurance is based on an inertial type accelerometer and is implemented in fail-safe manner. This brake assurance penalty is an Emergency Brake application initiated by the ATP system by means of the EB trainlines.

The ATP Brake Assurance Functionality functions to provide independent oversight of braking functionality.

2.8.2 ATO Subsystem

The ATO functionality is non-Vital. The major functions performed by the ATO subsystem in Type II mode are:

- Braking and Propulsion Control for Automatic Operations,
- Speed Regulation,
- Programmed Stopping,
- Route Control.

ATO operation is performed only on the MGL and Crenshaw lines (Type II). The function of the ATO allows the LRV to traverse the guide-way automatically from one station to the next. The vehicle performs speed regulation and station stopping in the operating mode: Manual with ATO.

The berthed indication is provided from the wayside when operating on the MGL. The vehicle's onboard ATC system enables the doors on the correct side (left or right) according to the track circuit ID table stored in the ATC system. In addition, the operator must open and close the doors.

2.8.3 TWC Subsystem

The TWC performs the following major functions across all Metro lines:

- Route Control and Indication,
- Over loop Detection and Indication,
- Train Identification,
- Provides input to ATO subsystem.

The TWC functionality is non-vital. The TWC subsystem is 100% compatible with H&K HCS-V TWC equipment and the ASTS TWC systems installed on Metro’s existing alignments through the implementation of two separate Type I and Type II TWC carborne systems. The wayside transmits and receives non-vital information through the use of TWC loops situated between the rails and located at selected track locations. The vehicle TWC subsystem transmits and receives information through the use of TWC antennas mounted at each end of the vehicle. The selection of the active antenna is based upon which cab end is actively keyed. A Line Selector Switch on the vehicle provides the method for properly configuring the TWC for operation on the desired line.

Refer to Figure 2-18. The ATC enclosure is installed in the B-Cab electronics locker located behind the driver on the B-End of the LRV.

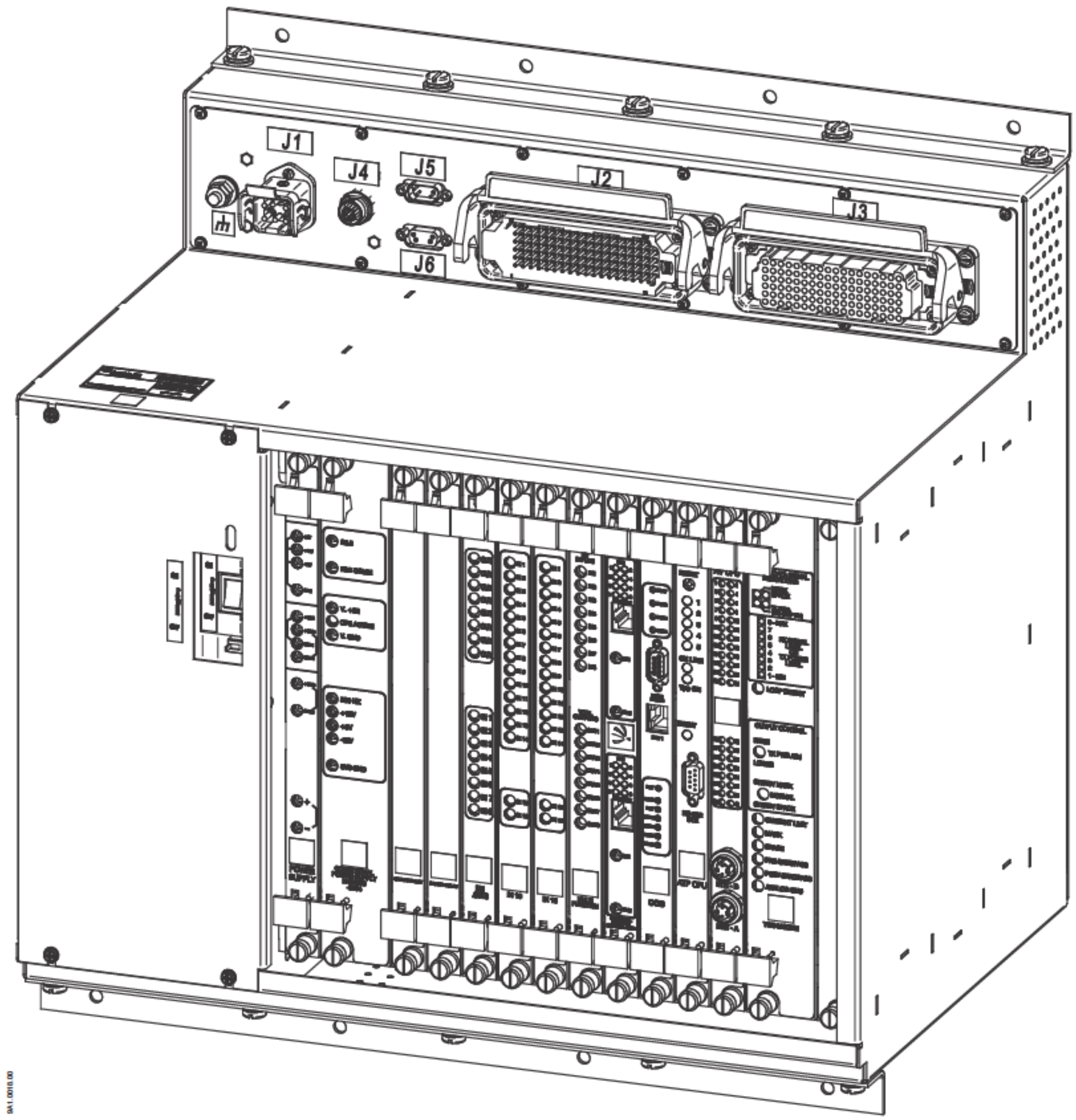


Figure 2-18: ATC System Enclosure

The ATC Enclosure also contains a covered compartment to the left of the PCB card file that contains the following components:

- Decelerometer Sensor and Mounting Assembly
- Vital Relay and mounting base
- Battery Conditioner PCB

2.9 Speed Sensors

There is a total of ten dual channel Smith Systems speed sensors used on the vehicle. There are two speed sensors on both motor truck axles 1 and 6. There are two speed sensors each on both center truck axles 3 and 5. There is one speed sensor on both motor truck axles 2 and 4. See Figure 2-19. The specifications are as follows:

Type of output signal:	digital
Nominal supply voltage:	10 ... 30 VDC
Nominal supply current:	≤ 30 mA
Output current: ≤	20 mA
Output frequency:	0…15 kHz
High level: VCC	(VCC – 3V)
Low level:	0…2 V
Temperature range:	-40°C … +80°C (-140°F … 176°F)

For this application the pin out is as follows:

A-	+VDC1
B-	Channel 1 H output
C-	Channel 1 L output
D-	GND1
E-	+VDC2
F-	Channel 2 H output
G-	Channel 2 L output
H-	GND2

The gear ratio is 1:6.42 and there are 60 teeth on pole wheel. For a new 28 inch wheel this translates to 77.0708 pulses / sec per mph, or 5394.9571 hz at 70 mph. For a worn 26 inch wheel this translates to 82.999 pulses / sec per mph, or 5809.96 hz at 70 mph.

CT Pole wheel has 120 teeth. For a new 28 inch wheel this translates to 24.0095 pulses / sec per mph, or 1680.6711 hz at 70 mph. For a worn 26 inch wheel this translates to 25.8564 pulses / sec per mph, or 1809.9538 hz at 70 mph.

Additionally each individual axle speed is available on the MVB for each axle. These signals originate from the friction brake ECUs.

Note that wheel diameter must be entered in the TOD maintenance screen to calculate the correct speed for control units.

[redacted]

Figure 2-19: Speed Sensors
(Sheet 1 of 2)

Figure 2-19: Speed Sensors
(Sheet 2 of 2)

2.10 Door Controls

Figure 2-20 shows the arrangement of the door entrances on the vehicle. The LRV A and B-Units have four double-leaf, pocket style door entrances. The door entrance assemblies are identical with one exception; an exterior emergency manual release is located outside entrances A1/A2, A7/A8, B1/B2 and B7/B8.

Each door entrance assembly has an overhead door operator assembly controlled by a Door Control Unit (DCU) with an internal microprocessor. The DCU drives an electric motor to transport the doors from open to close and back again in response to various signals. All DCUs perform diagnostics and develop fault codes that are shown locally at the DCU. MVB Master DCU at door entrance B5/B6 communicates the functional data to the train via Multi-Vehicle Bus (MVB) and ETH Master DCU at door entrance A3/A4 communicates the diagnostic data fault codes via Ethernet (ETH).

All eight door entrances function the same way. Each entrance has two door leaves attached to trolleys on the door operator. The door operator opens and closes the door leaves using an electric motor to drive the spindle assembly, causing the trolleys to traverse from closed to open and back again.

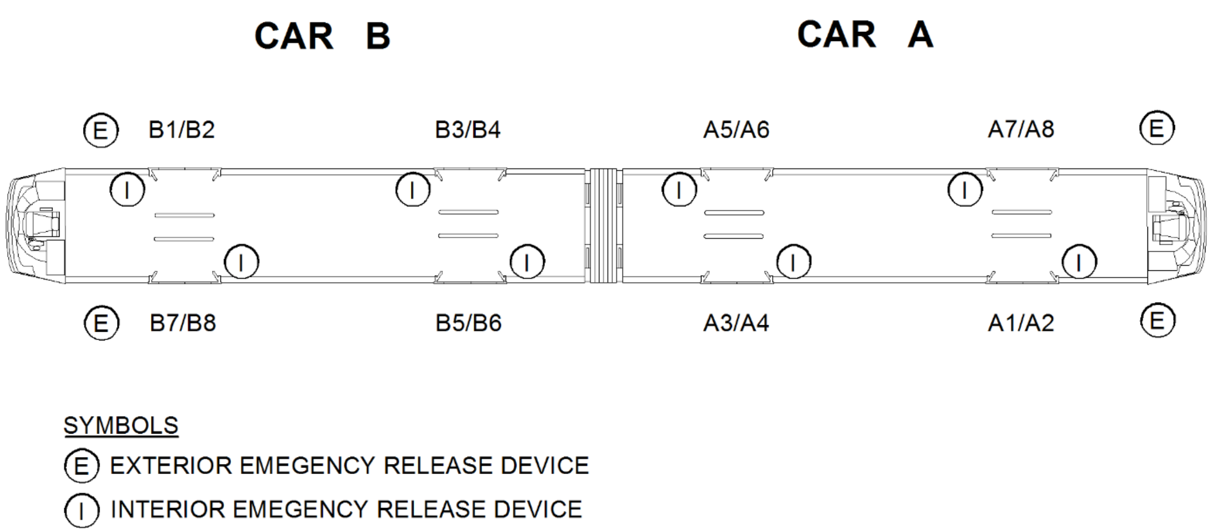


Figure 2-20: Arrangement of Doors on LRV

The Door Control equipment includes device labels that are the same as those used in the electrical diagrams. See Figure 2-21. Each door assembly consists of the following main components:

- Door Operator
- Door Control Unit (DCU)
- Finger Protection Rubber
- Interior Emergency Manual Release with Bowden Cable
- Exterior Emergency Manual Release with Bowden Cable

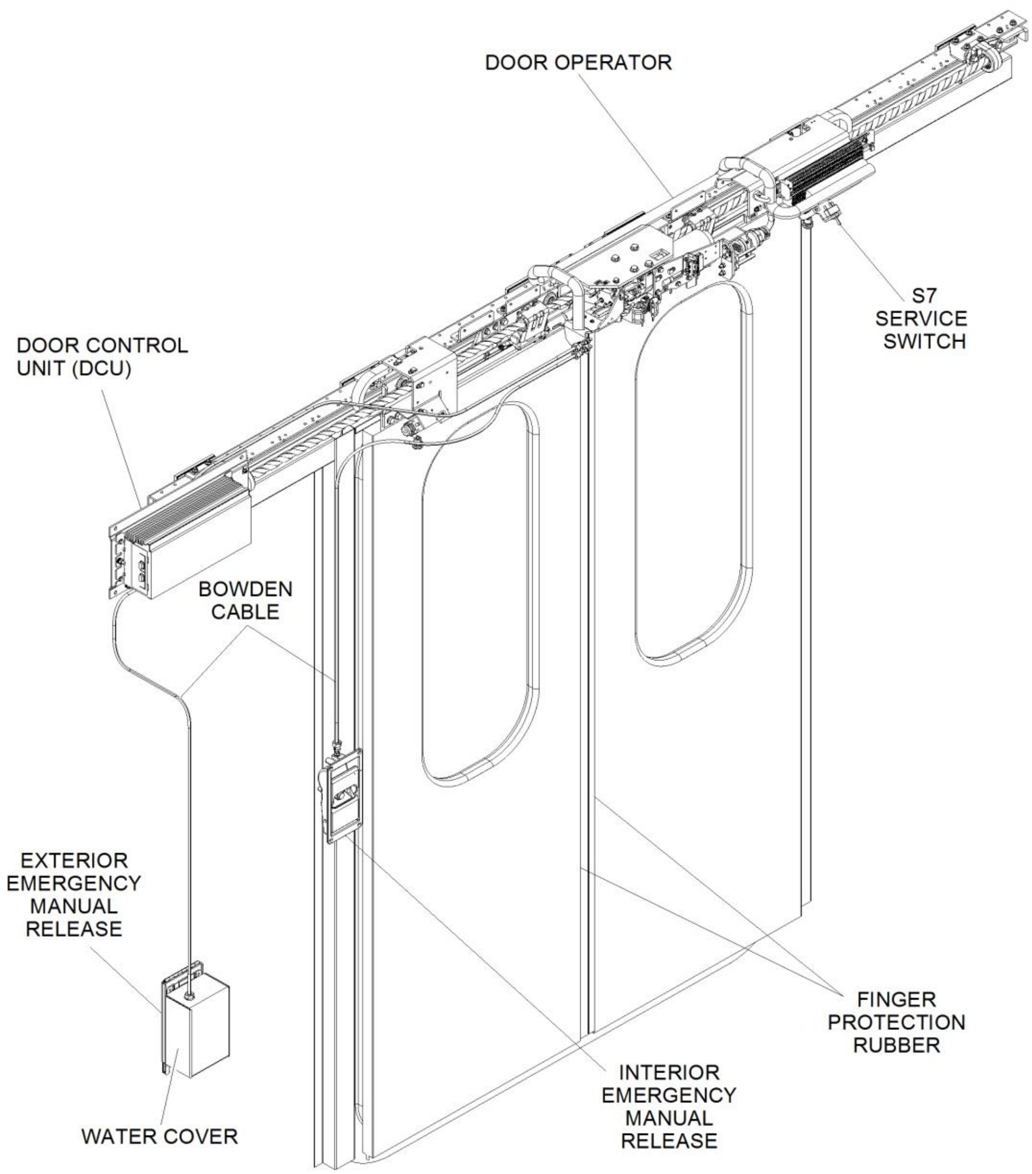


Figure 2-21: Door Control Equipment

The door operator is a car-mounted assembly containing the mechanical components used to open and close the doors. The operator has a rigid metal support bracket that mounts to the car structure. The operator consists of following components:

- Door Control Unit (DCU),
- Drive Motor including motor and position sensor,
- Spindle Assembly,
- Guide Rail / Doorhangers,
- Door locking and limit switches,
- Interior/ Exterior Manual releases,
- Wiring Assembly with Connecting cables and Service Switch.

The basic drive contains a permanent magnet, 24VDC reversible DC motor which controls opening and closing door movements. The motor drives the spindles and the associated trolley / nut assemblies via a planetary gearbox. The gearbox has two outputs; one to drive the spindle and one to actuate the locking mechanism.

The motor has a nominal 24VDC coil and provides the necessary force to open and close the doors. The motor is controlled by an electronic motor control circuit within the DCU. The motor drives the spindle either clockwise or counterclockwise via the gearbox.

The motor has an integral position sensor (Hall Effect sensor) for motor speed, door speed and position detection. The sensor detects movement of the motor and generates a 2-channel pulse signal which is used by the DCU to determine the door speed. By analyzing these pulses, the DCU can detect the actual door position at any time.

The DCU also determines the direction of movement through the phase relationship of channel A and channel B sensor signal. The door position sensor is also used by the DCU for way/time monitoring and backup obstruction detection. The DCU supplies the sensor with 12 VDC power. The DCU controls the operation of the motor movement and locking functions based on inputs from trainlines, passenger door-open pushbuttons, crew switches, and limit switches. The DCU also controls operation of the door indicators including audible and visual warnings, door out-of-service indicator, and door open indicators.

The spindle assembly is a motor-driven shaft that moves the doorhangers, and thereby the door leaves, in the open and closed directions.

The spindle threads on the right and left sides have opposite pitch. Each spindle half has a single hinged spindle nut with matching threads. The opposing threads on each spindle half causes the spindle nuts to move in opposite directions when the spindle is turned. The spindle nuts convert the spindle rotation to linear movement. As the drive motor turns the spindle, the spindle nuts move outwards on the spindle (door opening) or inwards (door closing) depending on motor direction.

The spindle nuts are attached to the doorhangers by pins secured with locknuts. The door leaves mount directly to the door carriers. Consequently, the doors open when the spindle rotates in one direction and close when the spindle rotates in the opposite direction.

The door lock mechanism is located at the center of the operator. The locking pawls are spring loaded to the open positions and are engaged when the door moves to the closed position. A latch to block the pawls once engaged is applied via a separate shaft of the gear box of the same drive motor used for the door open/closing movement. See Figure 2-22.

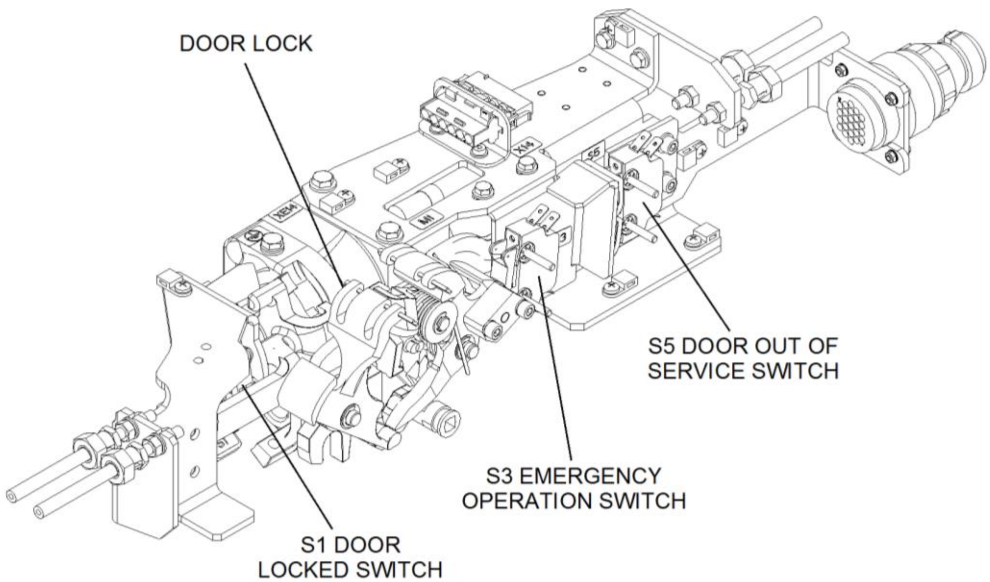


Figure 2-22: Door Lock and Limit Switches

The design of the system allows that even with the loss of power, the door panels can always be manually pushed into the closed and locked position. A relay located within the local Door Control Unit, cuts off the power for the DC-motor and opens the interlock circuit.

The emergency unlocking unit allows the train crew to manually open the doors from inside or outside the car for emergency exit or entry. The emergency unlocking unit is integrated with the operator and is controlled remotely from the interior and exterior emergency release devices via Bowden cable.

The cut-out devices allow the train crew to manually isolate the door. Mechanical and electrical door isolation is achieved by actuation of the cut-out lever. The cut-out lever is integrated with the operator and is accessed via the door operator access panel.

The operator includes a door locked switch that identifies when the door operator is locked in position. The door locked switch is mounted within the locking mechanism. An additional limit switch identifies that the door is in the closed position. The door leaf closed switch is mounted on the operator close to the door panel separate from the locking mechanism.

Installed on the drive motor is a position sensor that identifies to the door control unit the position of the door panels in reference to the rotation of the motor and position sensor. This information aids in determining if the door has driven to an open or closed position or whether it has encountered an obstruction.

Table 2-3. Door Operator Switch Functions

Switch Number	Function
S1	Detects the door locked position.
S3	Detects the emergency release operation.
S5	Detects the cut out door operator.
S8/S9	Detects the door leaf in the fully closed position.

The DCU includes an internal software diagnostic module that monitors door operation, and develops diagnostic codes that identify detected failures in the system. If a diagnostic code occurs, it is indicated on the red LED “Error” on the DCU by a flash code and sent to the TOD via ETH. Additionally, a read out of the DCU diagnostic memory can be obtained via the RS232 interface using a laptop and the IFE ST03A diagnostic software.

The door operator is controlled by the software program stored in the Door Control Unit’s (DCU) Flash Memory (EPROM). Execution of this program produces the software logic to control the door operator based on inputs from the trainlines and limit switches and sensed outputs. In addition, the software logic controls the function of the audible and visual indicators associated with door opening and closing, and provides obstruction detection during door opening and closing. Program execution also determines any fault conditions that are then sent as messages via the MVB and communicated locally.

The DCU at door B5/B6 is the MVB Master DCU and connects to the train control network via the MVB bus by means of a PC104 bus interface (an industry computer standard that allows production of the customized embedded system). The 6 common DCUs are connected via CAN bus to the MVB Master DCU at door B5/B6. Functional data is transmitted on the MVB bus-system.

The ETH Master DCU at door A3/A4 is connected to the Ethernet network via an Ethernet switch by means of an integrated Ethernet interface. Only diagnostic data from all DCU´s (respective door entrances) will be transmitted on the Ethernet network.

2.11 Pantograph

KI's supplier for the pantograph equipment is TransTech Power Transfer Systems of Piedmont, South Carolina, now part of WABTEC. See Figure 2-23.

Figure 2-23: Pantograph

The function of the pantograph is to provide power from the Overhead Catenary System (OCS) to the car; this is achieved by conducting electricity through the carbon assemblies on the collector head, the shunts, the members of the pantograph and ultimately through the power take-off plate(s) on the base frame. The pantograph is electrically insulated from the car roof by insulators which are mounted on the roof and to which the pantograph feet are bolted. The pantograph is spring-raised and lowered by an electric motor drive with a shear pin release in case of large force to the collector. The collector head includes a suspension that allows for optimal wire tracking of the catenary and absorption of obstructions. An adjustable dampener is utilized to ensure proper wire tracking and smooth pantograph raising and lowering. A hand crank is provided such that in the event of a loss of power the pantograph can be raised or lowered manually.

The pantograph is a single arm tube-in-tube design with a damped spring-supported head suspension containing two carbon assemblies for collecting current. The pantograph is capable of bi-directional and in-tunnel operation at all speeds up to and including 70MPH (113km/hr). The pantograph is capable of deriving power from an OCS with nominal voltage of 750VDC and a voltage range of 400-1000VDC.

The pantograph is a spring-raised, electric-down design. The force required to raise the pantograph is provided by two extension springs working in tandem; when lowered, the springs are fully extended, storing potential energy sufficient to raise the pantograph and provide the static contact force on the OCS. No additional energy is required to provide upward or tracking force. The force required to lower the pantograph is provided by the electric motor which is sized and positioned to overcome the force of the raising springs. A velocity-variable dampener is implemented in the system to assist in OCS tracking and to prevent excessive forces when lowering the pantograph.

The pantograph is held down by the electric motor, eliminating the need for a latch. Raising the pantograph is initiated by the Operator where the electric motor is engaged and moved to the up-stop position, allowing the pantograph to rise due to spring tension.

During current collection, positive OCS wire tracking is ensured through a combination of pantograph kinematics and head suspension compliance. The pantograph kinematics handle low-frequency variations in the OCS (such as grades and elevation changes) while the head suspension handles high-frequency variations.

Lowering is initiated by the Operator where the electric motor is engaged and moved to the down position, lowering the pantograph head fully and holding the pantograph down. Raising and lowering times of seven (7) seconds can be achieved with this pantograph.

A shear pin safety feature is be provided to allow the pantograph to drop to the lockdown position, reducing the potential for damage to the OCS and pantograph. In the event of a high-energy impact to the pantograph head, the replaceable shear pin will break due to excessive force. With shear pin breakage, the mechanical release linkage reduces tension on one of the raising springs, allowing the pantograph to drop due to insufficient raising force. The damper is designed to prevent excessive speed of the pantograph drop, preventing damage due to an uncontrolled drop.

2.12 Battery

The Battery Supplier is Saft America. The Battery is assembled in an underfloor mounted sliding tray style battery box. A thermostat is mounted on a battery inter-pole connector and will open a shunt trip circuit breaker if the batteries go over temperature. Additionally, the circuit breaker can be actuated from the car side at track level as a battery disconnect switch. Additionally, a thermistor is mounted to an interpole connector and is used to provide temperature data to the LVPS for use in charging. See Figure 2-24.

The nickel cadmium battery is comprised of 20 medium rate sintered/PBE cells in flame-retardant transparent plastic containers. The battery is rated at a nominal capacity of 180 Ah at the five-hour rate to a cell end voltage of 1.0V at 20°C following a constant current charge per IEC60623. The battery is supplied with standard flame arresting vent caps, intercell connectors, flame retardant terminal covers and inter-crate connecting cables. The battery cells are be clip-locked together as five cell trays and is compliant with ASTM E162, Flammability, ASTM E662, Smoke Generation and Boeing BSS 7239, Toxicity.

Table 2-4. Battery Reference Data

Battery Crate Assembly Model	SMRX200F3 x 20, nickel-cadmium type
Battery Cells	The battery bank of each car is formed with four groups of five cells for a total of 20 cells connected in series. Each car set battery consists of 20 cells installed in a battery slide-out tray
Capacity	200 Ah
Terminals	One negative, one positive per block of five cells
Charging Voltage (20 cells, at battery terminals)	Single Rate: 28.5 V @ 1.47V/cell, 20ºC (68ºF)
Torque	(M12 terminal post; 12 mm / 19mm (1/2”) Top Nut) 15 ± 2 Nm. (11± 1.5 ft.lb)
Electrolyte Type	An alkaline solution of KOH, LiOH and distilled water Designation: E10 (replacement)
Volume of Electrolyte (approximate, per cell)	1.87 liters (1.98 US quarts)

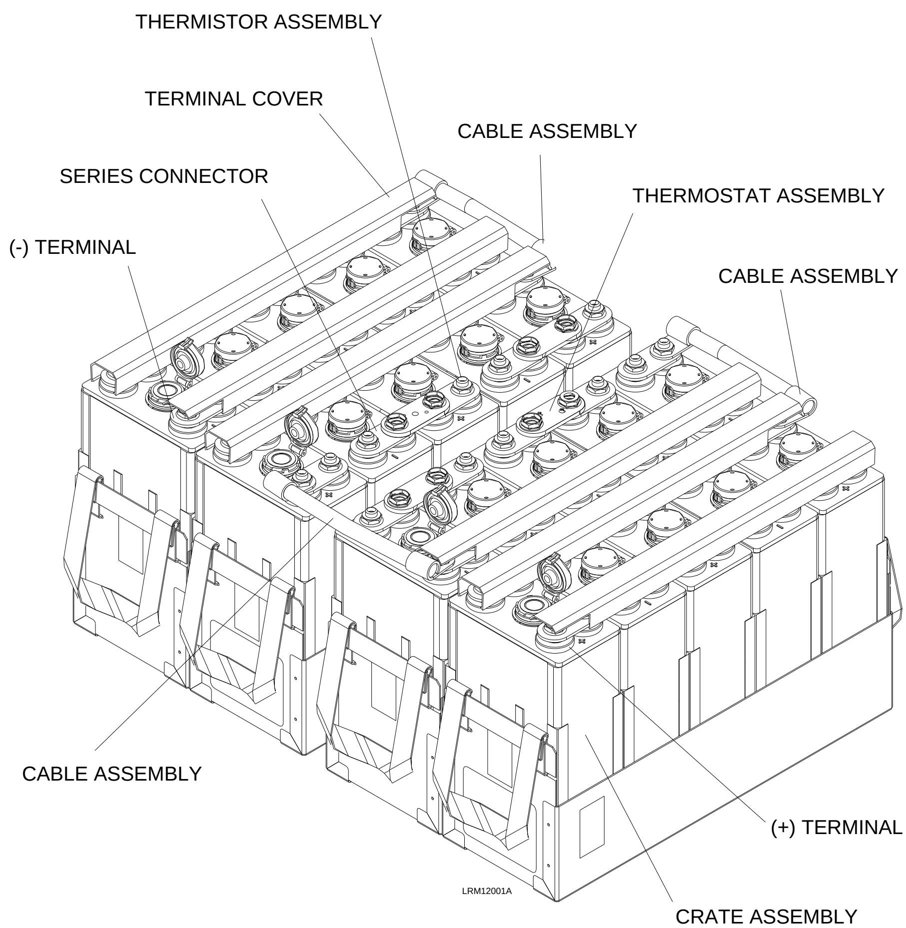
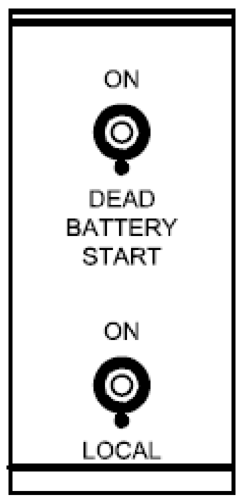


Figure 2-24: Battery Assembly

2.13 Auxiliary Power Supply (APS) - AC Inverter/LVPS

The Auxiliary Power Supply (APS) for the KI vehicle is vital to the operation of the vehicle. In addition to providing power to the AC loads, it is used to power the vehicle subsystems through the Low Voltage Power Supply (LVPS) / Battery Charger (BC) output. The ac voltage is 208 Vac three-phase, 65 KVA and the dc voltage is 28.5 Vdc and 10KW. It is equipped with a dead battery start feature to allow the unit to start up once high voltage is restored.

If the LRV has a dead battery, a maintenance action must occur. Use the Emergency Door Opening to gain access to the car. Confirm the pantograph is in the UP position contacting the OCS Wire. If the pantograph is in the DOWN position the pantograph must be raised manually. The Maintainer must gain access through the cab lockers to CRP1A on the A-Unit. Open the cab electric locker with the maintenance key to gain access to CRP1A. Hold the Dead Battery Start (DBS) toggle switch in the up position for forty-five (45) seconds. With the DBS switch in the UP position, move the local start toggle switch in the UP position for (0.5) seconds. Both switches can now be released to their original position and the LRV should now startup.



The housing of the power converter is manufactured of stainless steel. It is designed for under car mounting. Its sealing satisfies protection class IP54 for the electronics and IP21 for the cooling channel. Ingress of water into the IP21 section has no harmful effect to the power supply.

All maintenance and service work can be carried out without removing the power converter from the vehicle. The input and output connections are brought out via water-tight conduit fittings. Isolated plug-in connectors are provided for the connection of control and indication lines.

The inverter and LVPS are be cooled by an approved highly reliable ventilation system, to minimize the size and the weight of the power components.

The semiconductor elements (especially the power semiconductors) and other components in the electronics compartment of the converter that are subject to heat loss are mounted on heat sinks which project into the air duct. The coil components are mounted directly in the air duct.

2.14 Monitoring and Diagnostic System (MDS)

The Monitoring and Diagnostic System (MDS) is a fully integrated solution comprised of the MDS computer and four (4) Train Operator Displays (TODs). The MDS computer relies on the Ethernet network to exchange data among the TODs and the other onboard subsystem computers.

The MDS computer is responsible for the following tasks:

- Provide control/status data to other Ethernet subsystems (from TCN RIOs/ETH RIOs/etc.)
- Provide subsystem faults to the TOD and record faults for later access.
- Monitor signals on the MVB and WTB networks.
- Gather subsystem software versions.
- Periodic check of subsystem Ethernet health (via HEALTH message).
- Synchronize time among subsystems.

Two TODs are mounted in each cab. The TODs are used by Operators and Maintenance personnel to view the train configuration, check subsystem status, view fault information, answer the Wayside Worker Alert System (WWAS) and a variety of other lower-level maintenance functions.

NOTE: The CCU computer performs a supervisory function which periodically checks whether the MDS computer is online via the HEALTH message. In the event the MDS computer goes OFFLINE, the CCU will flag this and send the updated status directly to the TODs to alert personnel of the issue.

Refer to Section 1400, Communications and Section 1800, Monitoring and Diagnostics of the P3010 manuals for a complete description of the Monitoring and Diagnostic System.

2.15 Trainline and Local Signal Architecture

KI designs trainline control logic and local interfaces using IEEE 1475 as a guideline. Consequently, trainlines consist of discrete wires for selected signals, audio signals, battery common reference, and networks for other signals and data. Car wiring and the resulting terminations are minimized by using serial data communications between equipment where feasible for the application.

Conventional battery level trainlines are used for all safety-critical signals. These are described as Type I circuits in IEEE 1475. These include: emergency brake, door control commands, doors closed signal, friction brake release signals, and overspeed. Discrete trainlines are also used for forward, reverse, track brake control, traction control interlock, car wash control, and the sand control trainlines.

Audio trainlines consist of Public Address, Cab to Cab, and Passenger Emergency Intercom operation. Control of the audio trainlines is digital using independent trainline.

Tractive effort control is performed using a combination of Type I and Type III trainlines. WTB/MVB trainlines are used for the Tractive Effort Command. In addition, Type I trainlines are used for redundancy for Power and Brake mode definition.

Diagnostic data, from the monitoring system, is communicated using an independent, Type III network as described in IEEE 1475.

The Schematic and Narrative Manual provides a more detailed description of the control circuitry implementation and should be used in conjunction with this section of the RMSM.

2.16 Event Recorder

The event recorder rack (Saira Far Systems - Model: RER103-LAP3010-001) interfaces with the Ethernet (ETH) and MVB networks to record signals from the LRV and store them to the crash hardened memory module. See Figure 2-25. The Event Recorder (ER) is connected to the Multifunction Vehicle Bus (MVB) and the Ethernet networks (ETH) and is located in the A-Unit cab locker of the LRV.

The event recorder consists of the following modules:

- Power Supply Board
- CPU Board (with Real Time Clock Battery)
    - EXP Board
    - EMD Board
- Crash Hardened Memory Module

Figure 2-25 shows the front of the Event Recorder Rack. All electrical connections are located on the front of the ER with the power supply located on the far left. This power supply is only for the ER rack and powers both the ER CPU and the Crash Hardened Memory Module (CHMM). The ER CPU is located directly to the right of the power supply and the CHMM is on the far right. The CHMM is mounted to the frame of the rack internally with a cover plate in front of the space it occupies.

Figure 2-25: Event Recorder Rack

The Event Recorder (Saira Far Systems – Model: RER103-LAP3010-001) is a standalone system with its data sourced from the MVB and ETH networks. The Event Recorder is housed in its own stand-alone 19-inch rack and is powered by its own power supply. The event recorder application runs on a dedicated processor located in the event recorder rack. The processor has direct connections to both the Ethernet and MVB networks for the ability to sink and source data from the networks. The CHMM is also located in this rack. Data is transferred from the event recorder processor to the CHMM via the backplane of the standalone event recorder rack.

The functionality of the ER in each LRV of a consist will become automatically activated when the Transfer Switch is moved to the ON position and a direction is selected indicating an active train. The ER system time and date are also updated from the master clock during this time. Time originates from the Monitoring and Diagnostic System (MDS). Once the Transfer Switch is moved to the OFF position and has timed out, the ER will automatically turn off. Data is not recorded unless a direction is selected.

Event Recording is implemented using only variables available on the MVB or Ethernet networks. All required signals are obtained using the TCN I/O (Train Control Network) as well as utilizing signals from other subsystems. The TCN I/O sources all of the wired signals to the MVB/WTB including signals with no other connections such as PBED (directly from the master controller) which operates the LRV. Signals are obtained from the MVB or Ethernet networks. An integrated Event Recorder consisting of a CHMM is used as well as a processor to gather collected signals. The ER is powered from a dedicated circuit breaker located in the A-Cab low voltage circuit breaker panel. This circuit breaker is labeled Event Recorder. It is sourced from the battery low voltage control circuit. A PTU is typically used to extract data utilizing an Ethernet PTU port. A USB port is also provided on the ER for data transfer to a memory stick.

2.17 Lighting

All lighting equipment, except for the headlights, for this LRV is designed to operate from the 28.5 VDC on-board Low Voltage Power Supply (LVPS), or from the 24 VDC battery. The headlights operate from the vehicle 12 VDC power supply. Except where indicated, solid state LED lamps are used throughout.

Figure 2-26 shows the general layout of the LRV interior lighting.

The main passenger area is illuminated by two rows of LED light fixtures flush-mounted above the seats on each side of the center aisle. Each fixture contains one 1220 mm LED tube lamp. There are a total of 32 fixtures.

Under normal lighting conditions, these lights are powered by the LVPS. If a power interruption occurs, eight of the fixtures are wired to provide emergency back-up lighting. Figure 2-27 shows the emergency lighting configuration.

Fixtures are mounted to the car body and have an air diffuser assembly mounted adjacent to their frame. Each fixture contains a retainer spring at each end to secure the LED tube lamps in place.

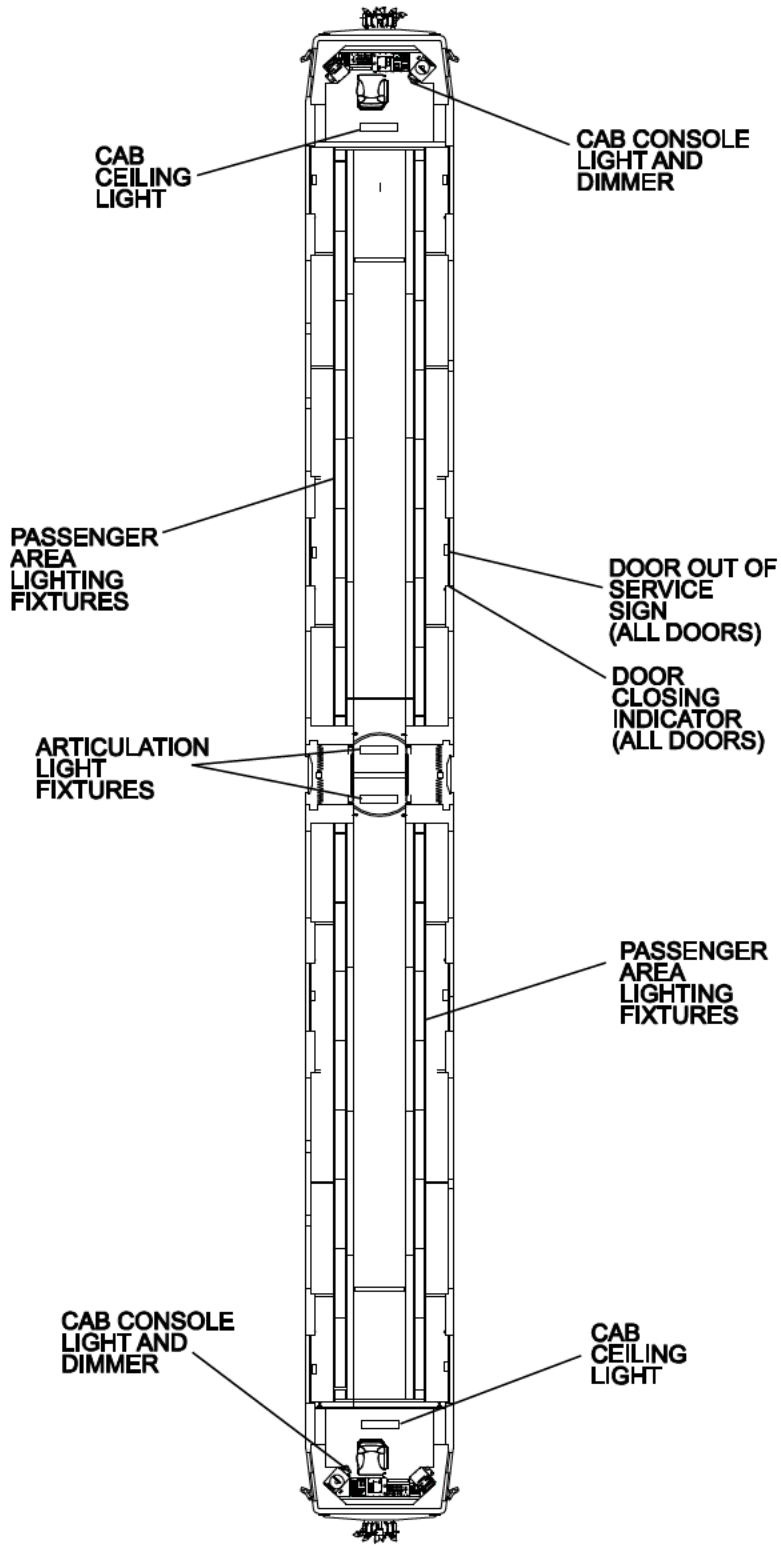


Figure 2-26: Lighting Layout, Interior

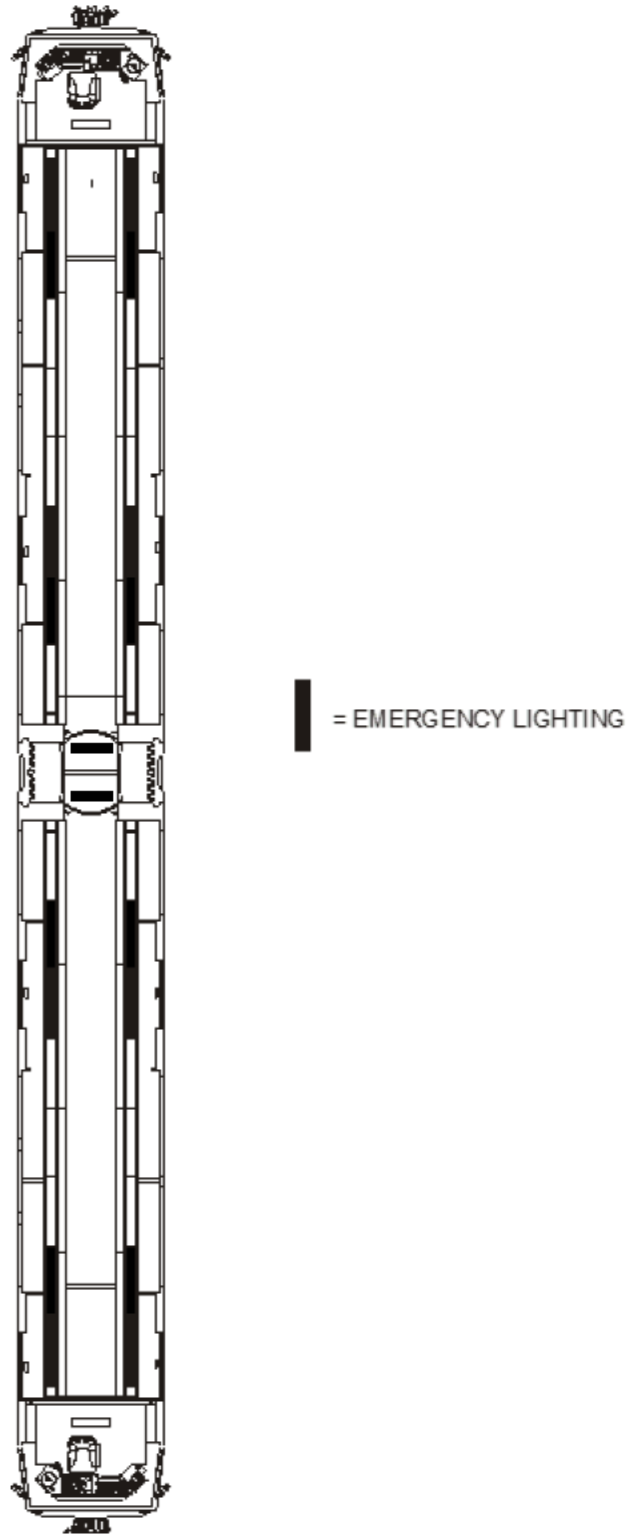


Figure 2-27: Lighting Layout, Emergency

Figure 2-28 shows the configuration of the exterior lighting.

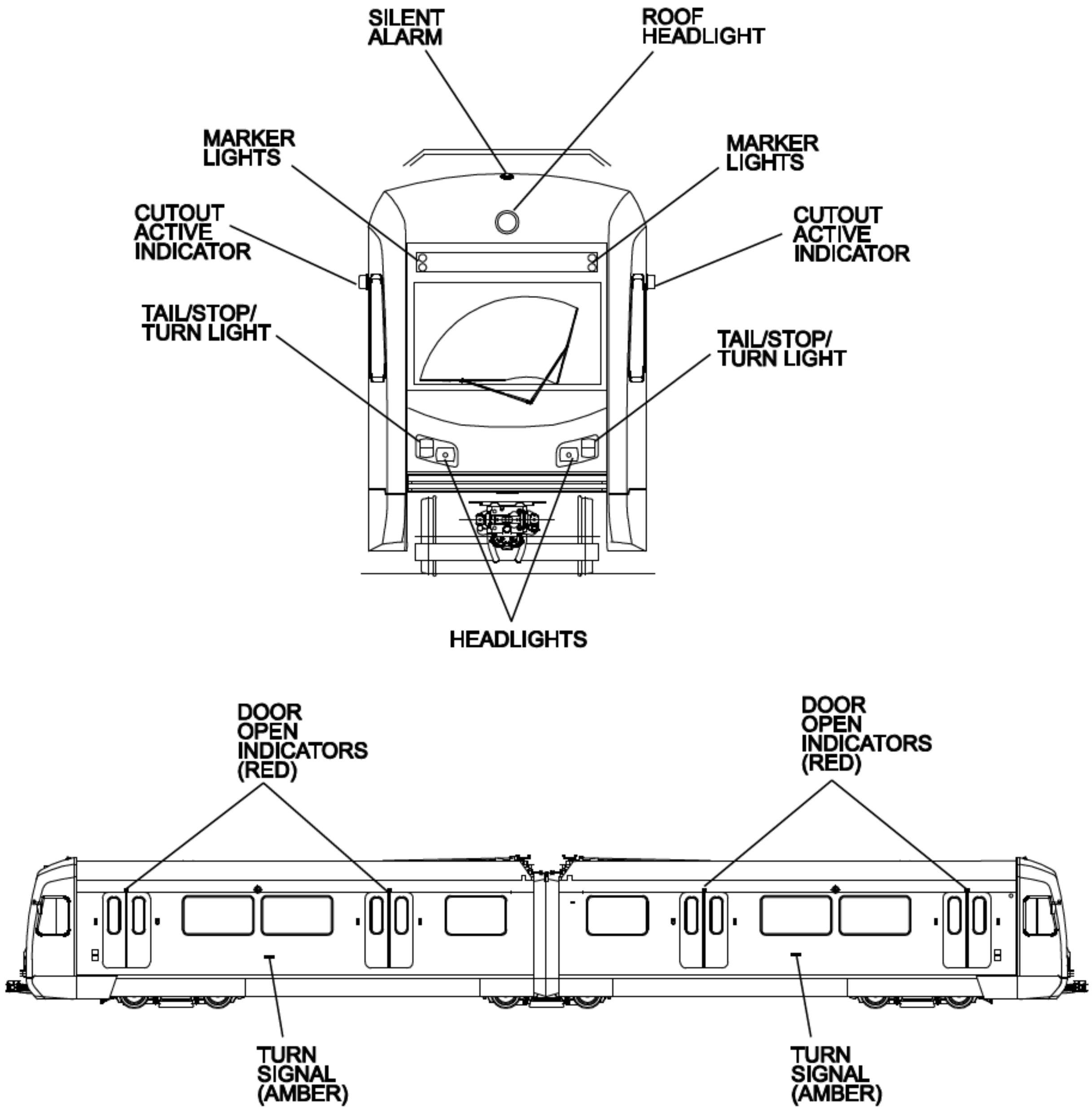


Figure 2-28: Configuration of Exterior Lighting

To illuminate the articulation section of the LRV, there are two ceiling mounted box fixtures. Each fixture contains one 610 mm LED tube lamp.

General illumination of the cab area is provided by a ceiling mounted box fixture. This fixture contains two 610 mm LED tube lamps.

An adjustable cab console light is also located overhead, and can be adjusted manually ±30 degrees from the centerline of the light. Light output from this fixture is also adjustable via a dimmer control located on the console.

At the front of the LRV below the windshield are the headlight and tail light assemblies. The headlight assembly contains a rectangular incandescent halogen lamp that operates from the vehicles 12 VDC power supply. The tail light assembly contains two modules that operate from the 28.5 VDC LVPS:

- A red LED lamp module that has both "stop" and "tail" functionality,
- An amber LED lamp module that serves as a turn signal and emergency flasher.

Centered above the windshield is the roof headlight. This single lamp fixture contains an incandescent sealed-beam lamp.

On the roof of the cab is a silent alarm light. It is a flashing amber high intensity LED module designed to be visible from above the vehicle at a minimum distance of 153 meters.

On the side of the vehicle, above each passenger doorway, is a red LED status indicator that illuminates when the door is open.

At the midpoint of each section of the LRV, just below the window line, is an amber LED turn signal indicator.

At the top right corner of the cab is the cutout active indicator.

2.18 Communication System

The Communication System is controlled by the Audio Control Panel (ACP), located in the cab electric lockers. The operator interfaces with the ACPs via the Communication Control Head (CCH). When a cab is active, the ACP in that cab becomes the master and the other ACPs in the train consist become slaves. When the cab is keyed down, the ACP will remain as a temporary master until another cab is keyed up.

The primary functions provided by the Communication System are handled by the master ACP and include:

- In-Dash microphone interface to the ACPs for manual announcements / PIC communication by the operator using the PTT functionality,
- Public Address (PA) manually, selective for interior and exterior speakers or both via the Cab Console buttons as directed by the operator selecting the audio routing via the selector switch,

- Passenger Intercom Communication (PIC), Operator controlled queued conversation,
- Trainline announcements originated from the CCH (“canned messages”),
- Vehicle operator interface to the Communication System modes of operation via the CCH and console buttons,
- Vehicle two-way Radio audio system interface with the vehicle PA system,
- Automatic Station Announcement Audio, and Text Messages to all signs, for pre-recorded messages, station and route announcements,
- Passenger Interior Information Displays (PIDs),
- Exterior Destination Signs control via the control cab CCH,
- Skip Station functionality.

The Communication Control Unit (CCU), located in the A-Cab electric locker, provide the following features:

- Synchronization of time and date for the MDS system,
- Provides location coordinates (from the GPS) to all subsystems as required,
- Performs a supervisory function which periodically checks the MDS computer is online.

There are priorities established for communications system functions. They are illustrated in the System Context Diagram shown in Figure 2-29. They are in importance:

- Radio to Operator
- Train Operator / Passenger Intercom
- Train Operator PA
- Automatic PA announcements

This priority scheme means that announcements or activities that have a higher priority will take precedence (override) a lower priority item.

[redacted]

Figure 2-29: System Context Diagram

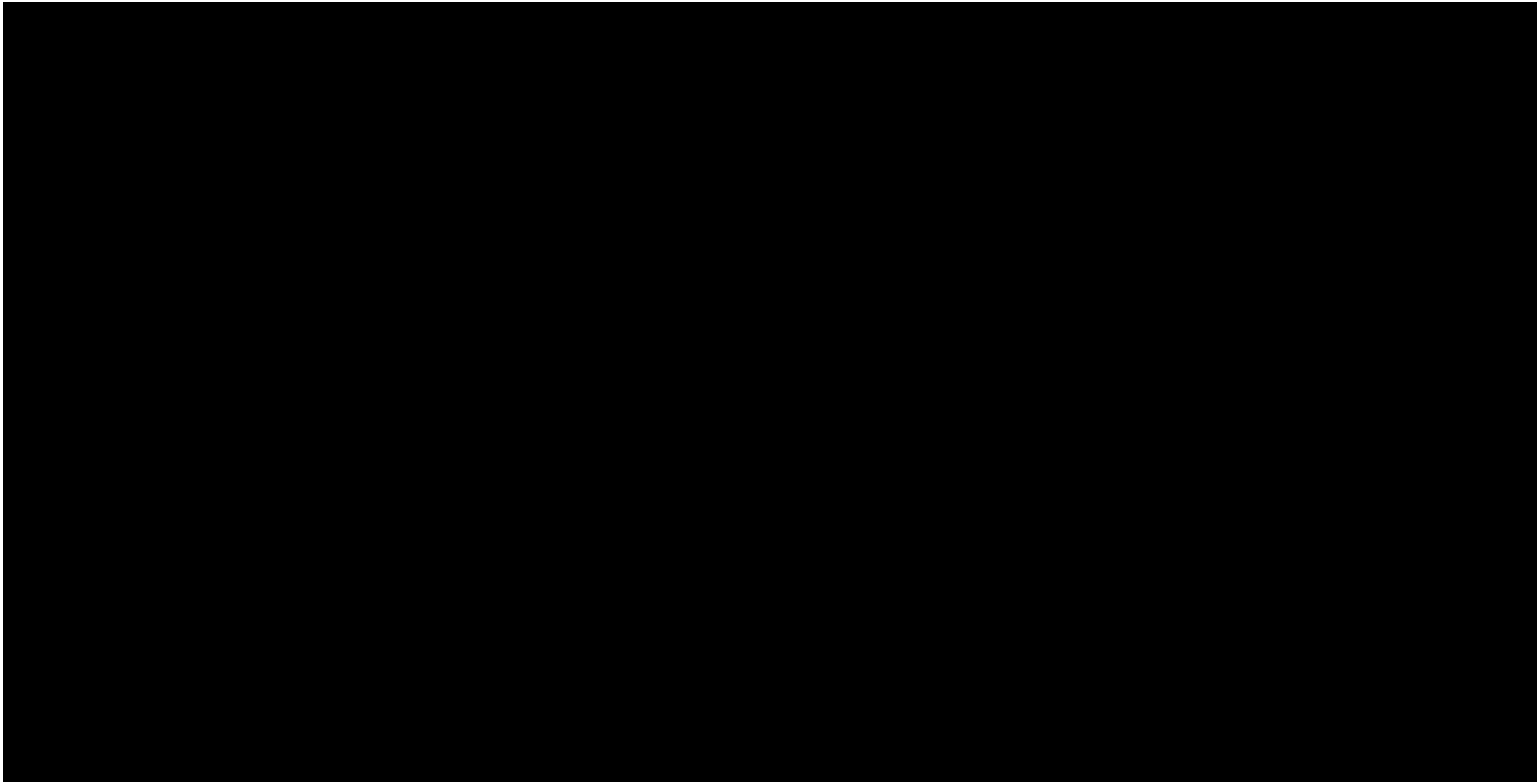


Figure 2-30: Vehicle Management System General Block Diagram

Figure 2-31: PA System Block Diagram

CHAPTER 3.0

SCHEDULED MAINTENANCE

3.1 Introduction

Please refer to the individual system/subsystem sections of this manual for the applicable scheduled maintenance tasks.

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CHAPTER 4.0

CORRECTIVE MAINTENANCE

4.1 Introduction

There are no procedures to be performed at the Running Maintenance level that are applicable for this section.

Please refer to the individual system/subsystem sections of this manual for the applicable corrective maintenance procedures.

4.2 Adjustments

Not applicable to this section.

4.3 Lubrication

Not applicable to this section.

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CHAPTER 5.0

TROUBLESHOOTING

5.1 Introduction

This section presents general system troubleshooting and fault isolation guidelines and procedures to assist maintainers in identifying and replacing faulty or failed system components.

Refer to the individual system/subsystem sections of this manual for more detail on the applicable troubleshooting procedures for the system or equipment that is exhibiting faulty operation.

5.2 Troubleshooting Safety

While troubleshooting take care to avoid personal injury. Avoid situations that present the danger of electrical shock or injury from moving equipment. Exercise extreme care when working around equipment with the wiring and electronics exposed. Notify others before leaving an open system unattended. Disconnect power if the system / equipment will be unattended.

While working on the system / equipment, the vehicle could unexpectedly move, possibly causing damage or injury. Warn others to stay clear of the vehicle since it could become activated without notice.

WARNING

FOLLOW ALL METRO RULES AND GUIDELINES. THEY TAKE PRECEDENCE OVER ANY INSTRUCTION FOUND IN THIS MANUAL!

5.3 General Troubleshooting Guidelines

Before fault isolation, perform a thorough visual equipment inspection to determine if a malfunction is being caused by some obvious defect such as a damaged component, defective wiring, loose connector, tripped circuit breaker, etc. Otherwise, fault isolation should follow a logical sequence designed to isolate a malfunction to a single subsystem / equipment / component.

Symptoms of a fault are typically identified by a loss of function. The function lost, inoperative or malfunctioning, will provide a means to identify a course of troubleshooting. The vehicle schematics will provide information to troubleshoot wiring and connectivity issues. Intermittent connectivity issues are the most difficult to troubleshoot. Ensure that all connectors are properly installed and properly tightened.

Before deciding that a system/subsystem is malfunctioning, check the TOD for fault indications, check that all related circuit breakers, switches, control devices are set properly for normal operation.

If a circuit breaker is found tripped (handle in the middle position) use the circuit diagram to see which devices are connected to the tripped breaker. Before resetting the circuit breaker, inspect the devices, wires, cables, and connectors which are part of the tripped circuit. During the inspection, check for the following:

- Broken and/or damaged parts
- Discoloration, burn marks, or melted components
- Odor of burnt electronics
- Short circuits – check inside connectors/cables, at terminal blocks, and relays

Consider the answers to these questions and guidelines before troubleshooting any problem. By following these guidelines, it may be possible to quickly resolve a problem.

1. Under what circumstances did the fault or failure occur?

   Was it during normal operation, during preventive maintenance, during a diagnostic procedure, or while changing a parameter setting? This information could help to repeat the failure and isolate the problem.

   Is the issue a trainline issue or a local car issue? Divide the train to isolate the fault to an individual car. If the fault is resolved by separating the LRVs the issue is a trainline issue and should be troubleshot at the train level.

   The TOD maintenance screens contain a coupling history. This history may provide insight on which car, when coupled, causes a fault.

2. Did something change?

   Has this system worked previously or is this a startup problem? If the system worked properly in the past, has anything changed? Has there been hardware, software, or wiring changes?

3. Could the problem be coming from something external that is interfering with system / equipment operation?

   Verify the problem. Check the major system functions to verify that there really is a problem.

   De-energize the system for 30 seconds and then reapply power to the system. Allow the system CPUs to reset completely. It could be an intermittent or single-occurrence problem. If the problem continues, proceed further with troubleshooting activities.

4. Try the simple things first.

   With the faulty system powered off, if applicable, remove and reseat each card file PCB assembly. As the PCBs are removed, observe each one for obvious problems such as hot spots and burn marks. Check all PCB connectors to ensure they are firmly attached and connector pins are straight. Check cables for damage and signs of wear.

5. Avoid complicating the problem.

   While troubleshooting the problem, avoid making the problem more difficult to isolate. Take care not to create more problems, in which case multiple symptoms and a much more difficult troubleshooting situation may result.

6. After completing troubleshooting corrective activities, and especially after replacing any system components, perform a functional verification test prior to releasing the LRV for service.

7. It should be noted that all possible paths of fault determination are not described in this chapter. A combination of Running Maintenance and Servicing Manual sections may need to be referenced and utilized to accurately troubleshoot the LRV. This section provides general guidelines.

The vehicle circuit schematics should always be on hand when troubleshooting!

5.4 TOD Troubleshooting Tools

The Train Operator Display (TOD) is a valuable tool for troubleshooting. From the TOD, the maintainer can quickly check the status of trainlines and other control signals along with a subsystem's status.

The table below shows the correlation between trainline state and indicator color displayed on the TOD Operating Screen.

	Indicator State		
	Green	Red	Blue
Emergency Brake TL	Not Active	Active	-
Propulsion Fault TL	Not Active	Active	-
Friction Brakes Apply TL	Not Active	Active	-
Friction Brakes Release TL	Not Active	-	Active
Friction Brake Fault TL	Not Active	Active	-
Car Wash TL	Not Active	Active	-
Bypass Activated TL	Not Active	Active	-
CM	Not Active	-	Active
M	Not Active	-	Active
Track Brake TL	Not Active	Active	-
No Motion	Not Active	Active	-
HSCB Tripped	Not Active	Active	-
Dead Man Relay	Not Active	Active	-
Cab Propulsion Inhibit Relay	Not Active	Active	-
Network Control Relay	Not Active	Active	-

The TOD displays the Ethernet Health Monitor subsystem status. A flashing yellow subsystem indicator represents an Ethernet connectivity issue with the subsystem that is flashing. The fault could be that the equipment is offline or a connectivity issue. Pressing the subsystem indicator pushbutton provides additional details.

If the subsystem status indicator on the TOD is red, this indicates that a fault is being communicated to the Monitoring and Diagnostic System. Check the list of active faults to determine if there is an active fault that impacts the suspect subsystem / equipment or network equipment. Additionally, from the Maintenance Tab, the Fault Log Screen will also provide information on faults that have occurred over time. This screen can provide an indication of intermittent faults that have cleared.

NOTE: If the NVR is flashing yellow (offline) or solid red (fault), the CCTV system is not functioning properly. Follow Metro SOPs before releasing the vehicle for service, as the NVR may not be recording video.

The Vehicle Management System (VMS) pushbutton indicator will provide a status of Ethernet Connectivity to the MDS, see Figure 5-1. The Ethernet connection status of the CCU, TODs, and PIDs controllers can also be found under the VMS pushbutton, see Figure 5-2.

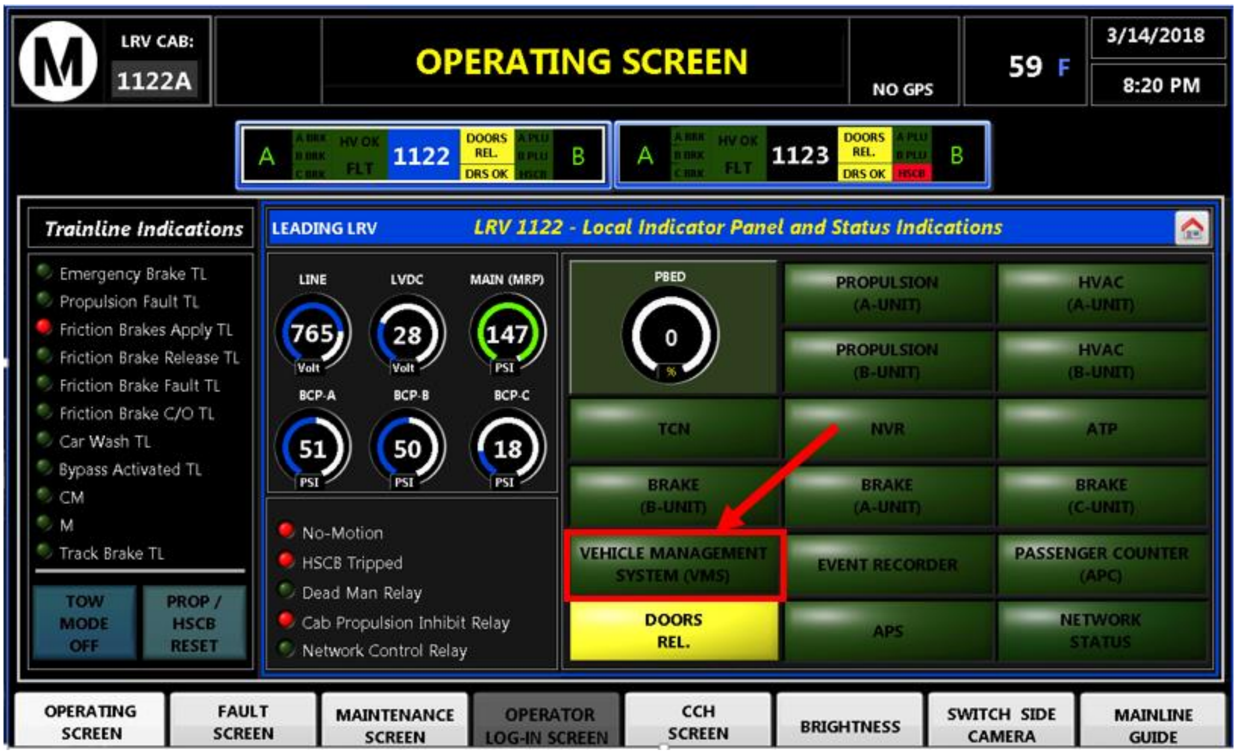


Figure 5-1: Operating Screen VMS Indicator

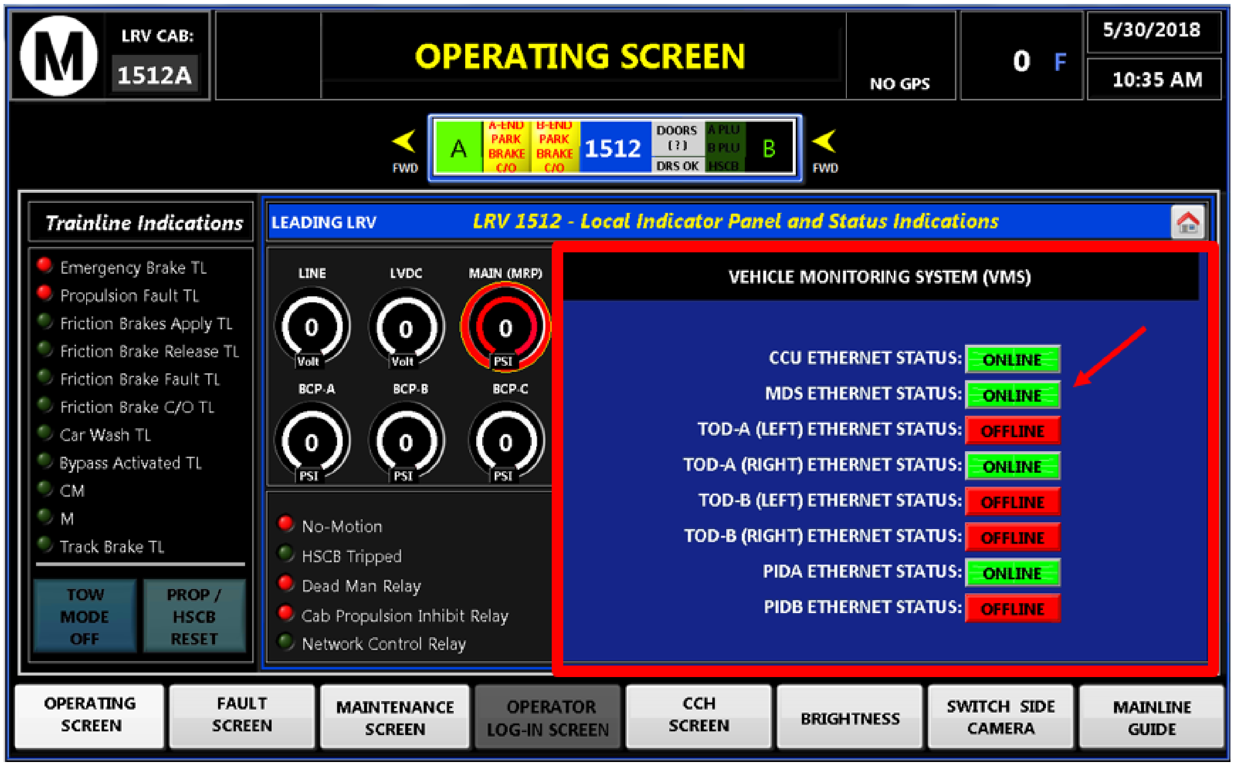


Figure 5-2: Vehicle Management System Indicator Pushbutton Screen

In addition to the VMS pushbutton indicator, an Ethernet test is available from the Network Status button for all Ethernet connected devices, see Figure 5-3.

The Ethernet test can be used to ping any device on the Ethernet network, see Figure 5-4. The “Start Complete Network Test” pushbutton will ping every device on the local car network. If the device fails the test it will be placed in the Device Not Connected table. By pressing the device in the table, it will automatically retest the communication between the TOD and the selected device. If the device passes the retest, the device will be removed from this table and a green PASS will replace the red FAIL that is beside the device name in the “List of Devices” table. If the device fails the retest then it will remain in the table of devices not connected. Alternatively, the “Ping Device” pushbutton can be used to test the connection status of individual device instead of the entire network of devices.

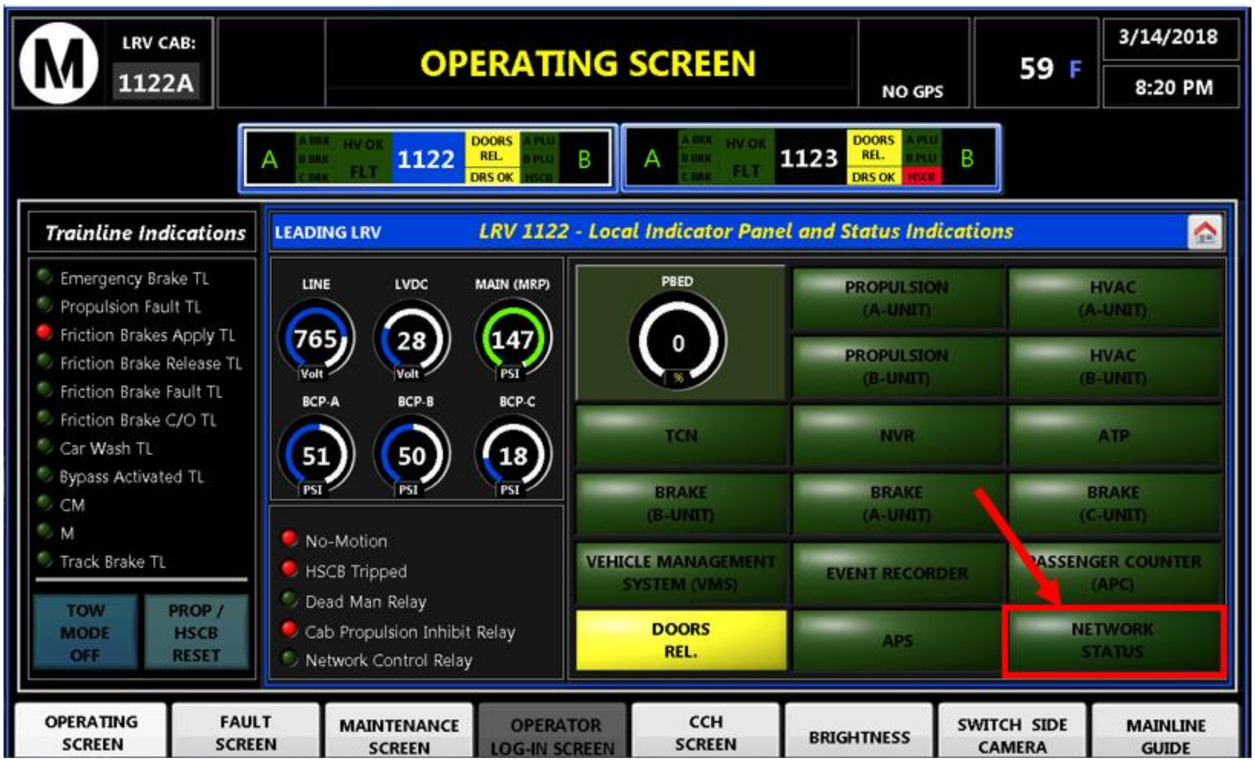


Figure 5-3: Network Status

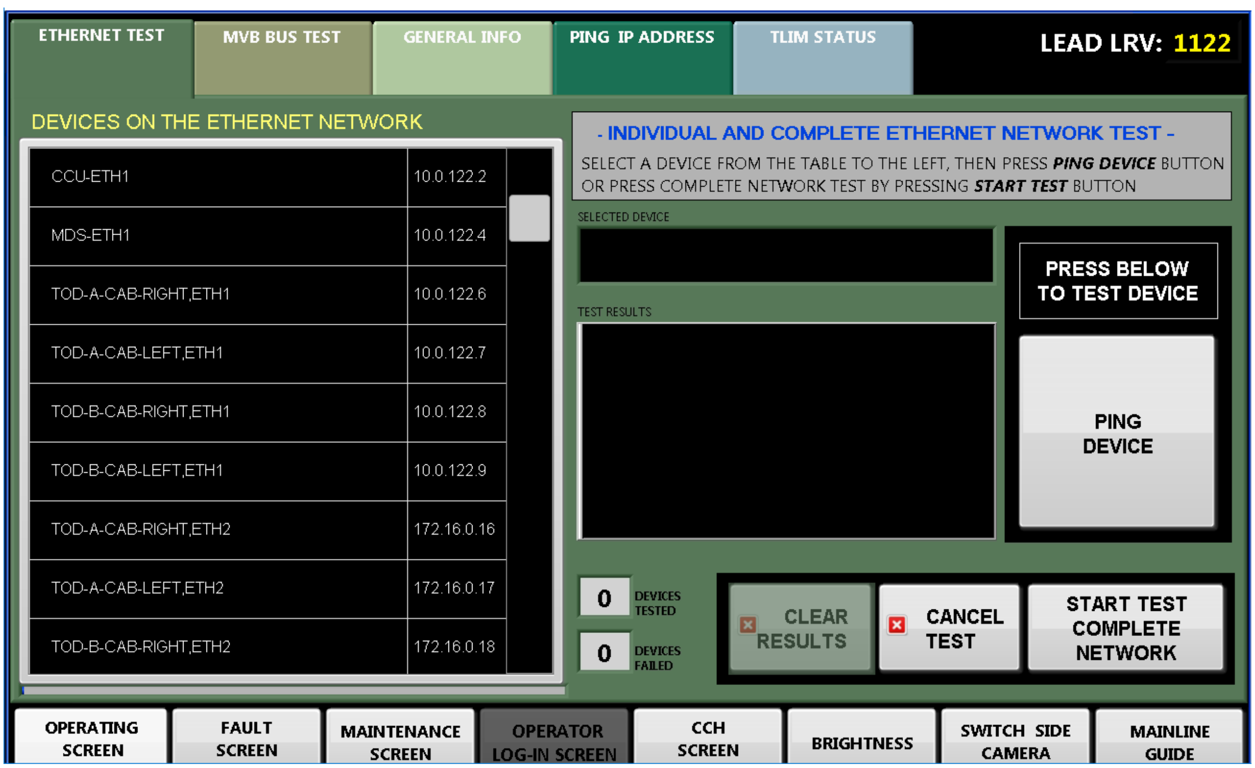


Figure 5-4: Ethernet Test

If a device fails to connect after multiple attempts, the P3010 LRV Circuit Diagrams can be used to troubleshoot the connection. Circuit sheets 800-849 show the communications and networking section of the circuits, this includes the Ethernet network connections. The switch and port locations that the devices use to connect to the Ethernet network can be found amongst these circuit sheets.

Look for groupings of lost functionality. If an Ethernet Switch is lost, all items connected to that switch would provide an indication to troubleshoot that switch or the signal source to that switch.

5.5 Ethernet Health Monitor

The subsystem Ethernet health status is defined by the HEALTH message. This message is periodically sent from each subsystem to the MDS. It provides the status of the connectivity of most subsystems on the LRV.

The subsystem indicators, on the status panel portion of the TOD screen (Refer to Figure 5-1), are defined by the *ESTA* message. This message is sent from the MDS to the TODs. The *ESTA* message is used to provide the TODs the status of the Ethernet connectivity between subsystems in the vehicle and the MDS.

The MDS tracks this status based on the arrival of *HEALTH* messages from each subsystem.

For network issues, refer to Section 1700, Data Communications (TCN) of the Running Maintenance and Servicing Manual.

Generally, there are two reasons that for loss of connectivity (i.e. not healthy):

- Connectivity – hardware fault / wiring / connector fault in the Ethernet connection,
- Subsystem fault – A fault that takes the subsystem off line (i.e. controller fault, system controller off, etc.)

Results from the TOD Network Test should be used in conjunction with the Ethernet Health Monitor to draw conclusions on the cause of loss of connectivity. If the test results do not provide a clear indication of the problem, take a general troubleshooting strategy like the one provided below.

1. Check the end-device (i.e. subsystem or component other than the Ethernet switch) is powered on. Most devices are equipped with a power LED for inspection.
2. Visually inspect the Ethernet connector on the end-device to ensure it is seated properly and not damaged.
3. Check the Ethernet switch, which the specific end-device connects to, is powered on.
4. Visually inspect the Ethernet connector on the Ethernet switch to ensure it is seated properly and not damaged.
5. Check the Connection and Activity Status LEDs on the corresponding port of the Ethernet Switch. For Ethernet Switch status LEDs, refer to Section 1700, Data Communications (TCN) of the Running Maintenance and Servicing Manual.

6. If the Connection and Activity Status LEDs on are not indicating a connection, test the Ethernet cable (e.g. for breaks, miswires, etc.). Use of a network cable tester is recommended to ensure cable quality.

Lack of health message will result in the affected System registering a System Ethernet Failure fault entry in the fault logs.

General Description:

This feature provides the Ethernet connection status (ONLINE/OFFLINE) of all the following 22 sub-systems:

- APS
- APC
- PLUA
- PLUB
- ECUA
- ECUB
- ECUC
- DCU Ethernet Gateway
- NVR*
- HVAC A
- HVAC B
- ATC
- TCN RIO A-END
- TCN RIO B-END
- TOD RIGHT A-CAB
- TOD LEFT A-CAB
- TOD RIGHT B-CAB
- TOD LEFT B-CAB
- TOA
- Event Recorder
- CCU
- MDS

The subsystem health status is defined by the *HEALTH* message. This message is periodically sent from the sub-system to the MDS.

MDS Detection Description:

The MDS continuously (about 100 msec period) listens for *HEALTH* messages from each of the sub-systems.

During a period of 10 minutes, the MDS tracks each *HEALTH* message and accumulates them. Note that health messages from various subsystems differ in period. Once the 10 minutes period elapses, the MDS sets/clear the ESTA bits according to the *HEALTH* message analysis. Each sub-system is analyzed independently. A bit is SET if the MDS received at least 1 new *HEALTH* message from the subsystem (meaning ONLINE) during the 10-minute period. If a subsystem did not send a new message within this check period, then its bit will be CLEARED (meaning OFFLINE).

Note that if a subsystem did not send the *HEALTH* message during the appropriate time, but it recovered later, the OFFLINE status will remain active until the next MDS check period elapses (10 minutes).

TOD Display Description:

During start-up, (from Local off / completely powered off LRV) the first 10 minutes (plus MDS startup time) of operation the Ethernet Health status is not defined, therefore the TOD status indicator buttons will not reflect the Ethernet connectivity status and the Ethernet Status field will be inactive (grayed out) 

. Unless a subsystem has a FAULT, which sets the subsystem status indicator button to RED, all the buttons will remain Grayed-out until the TOD receives the first *ESTA* message.

After the first MDS Ethernet check, and the TOD receives the first *ESTA* message, the TOD will take the following actions for each subsystem:

1. If the subsystem *ESTA* bit is set to 1, the subsystem's status indicator button turns GREEN, and the ETHERNET STATUS indicator within the subsystem status indicator screen button will be changed to a GREEN ONLINE text box. 

2. If the subsystem *ESTA* bit is set to 0, the subsystem's status indicator button will FLASH YELLOW/GREEN, and the ETHERNET STATUS indicator within the subsystem status indicator button will be changed to a RED OFFLINE textbox. Press the system status indicator push button on the TOD to view Status Indicator. 

3. Example: If the subsystem had a FAULT prior to going OFFLINE, the subsystem's indicator status button would be solid RED, then as the MDS determined the subsystem was OFFLINE, and the TOD received the *ESTA* message, the subsystem indicator status button would FLASH YELLOW/RED.

4. Note: the subsystem Ethernet OFFLINE condition will display a pop-up window on the TOD, these events are recorded in the FLOG on the MDS, however, they are not shown on the Active Faults screen accessed from the TOD Menu Bar.

5.6 Downloading Fault Logs

1. Fault Logs can be reviewed for faults that will provide symptoms of ongoing or repetitive fault activity. Using a PTU with the FileZilla client program, download the LRV fault logs from the MDS for review.

2. The Host should be the IP address of the LRV's MDS computer (10.0.XX.4). For example, Figure 5-5 shows the individual connecting the MDS of LRV 1122. Note that device addressing is included in Appendix A of Section 1700, Data Communications (TCN) of the Running Maintenance and Servicing Manual.

3. The Username is User1, the Password is P3010, and the Port should be left blank. This does not change from one LRV to another.

4. After this information is entered press the quick connect button. The connection window should be used to verify you are connected.

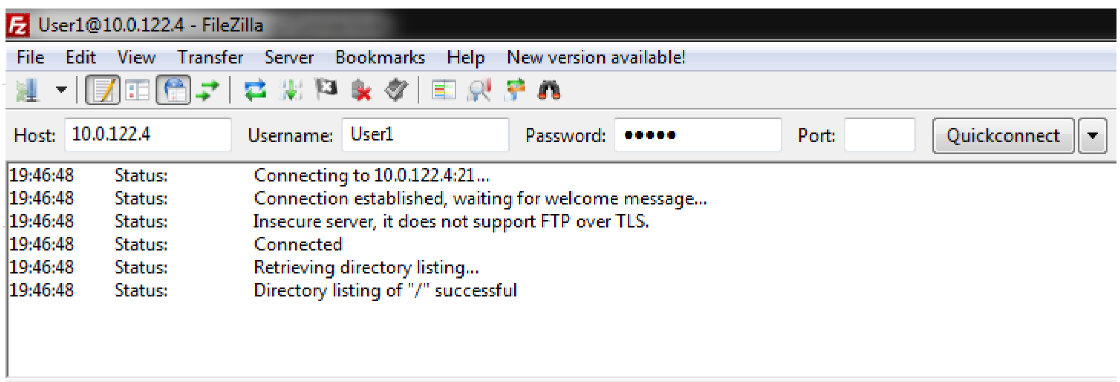


Figure 5-5: FileZilla Client Connection Interface

5. Below the connection window the screen will be split into two partitions by a vertical divider. The left partition represents the local computer you are using to access the network. The right partition represents the MDS computer (Figure 5-6). From here you can drag and drop the date folders required from the MDS computer to an appropriate location on your local computer.

6. When you have saved the fault logs required, exit the FileZilla client program.

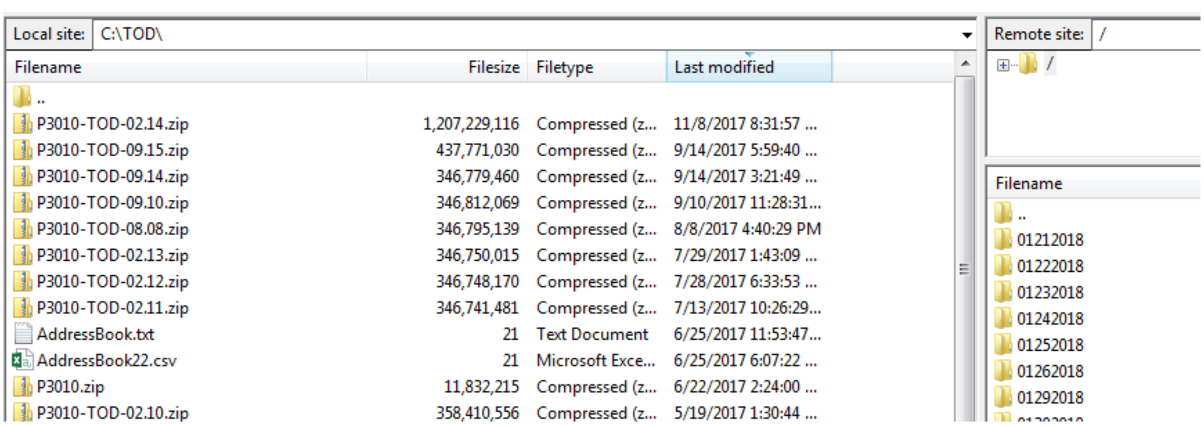


Figure 5-6: FileZilla Client File Transfer Interface

7. Review the logs, examine for unexpected events, symptoms and follow troubleshooting procedures per the subsystem manual for the suspected faulty device.

Appendix A of the MDS Running Maintenance Manual (Section 1800) contains a complete fault list that can be used for reference. For MVB-based communication faults, refer to Chapter 7.2 of the TCN Running Maintenance Manual (Section 1700).

5.7 Troubleshooting Control Circuits

5.7.1 General Technique

Symptoms and reports may be helpful for finding a fault, but be wary of another person's report of the symptoms. The most reliable analysis is gained by personally recreating and observing the symptoms. Log the time, date, and details associated with observed problems.

Most system faults can be observed in the event log system accessible with the MDS Fault Log (FLOG) or the specific systems Portable Test Unit (PTU).

An apparent system fault may actually be due to broken or damaged vehicle wiring or harness connectors improperly seated. This may be especially important to remember if a fault first appears after work was performed on or near the vehicle wiring or system harness connectors.

When troubleshooting a circuit, each control must be evaluated to determine its function in the system. Using the symptoms identified, for the suspect system / equipment, perform a functional test to recreate the faulty system / equipment behavior. This testing will help identify problems within specific subsystems and functional areas.

Recognizing the control and its purpose requires understanding of the schematic and/or electro-mechanical system in question. The ability to stop and study a circuit and its function before taking action will save maintenance and troubleshooting time. Study the car schematics to determine how the suspect circuit operates. When studying a control circuit for the first time, see what it actually does. See if the control stops and starts a motor, energizes or de-energizes a relay or contactor, operates a heater or light, or provides some other function.

Electrical devices can be considered as power consuming or power passing. Power consuming devices use power and have typically either a magnetic coil or a resistance element. They are wired in parallel with the power source.

Power passing devices do not consume power. These terms can be described with a simple light bulb circuit with a switch. The light bulb in the circuit consumes power, and the switch passes the power to the light bulb. The object is to wire the light bulb to both sides of the power supply. This will ensure that the light bulb is in parallel with the power supply, and will complete a circuit. The switch is a power passing device. It is wired in series with the light bulb. To understand this troubleshooting method, realize that for any power consuming device to consume power it has to have a potential difference or voltage applied. A potential difference is the voltage indicated on a voltmeter between two power legs (such as line + to line -) of a power supply. Voltage can be thought of as electrical pressure.

Using a simple circuit as an example, suppose that the resistance element was to be used as a heater to prevent freezing in the winter. To prevent the heater from being energized (heating) all the time, a thermostat is installed in the circuit. A fuse must also be installed in the line to protect the circuit. A switch must be provided to allow the circuit to be serviced. See the figure below. Note that the power now must pass through three power passing devices to reach the resistance element. The fuse is a safety control device, and the thermostat turns the heater ON and OFF. The switch is not a control but a service convenience device. Note that on typical railcar circuits the service switch and fuse are replaced by a circuit breaker that performs both functions. Suppose that the light resistance element does not get warm. Which component is interrupting the power to the heater: the switch, the fuse, or the thermostat? Or is the heating resistance element itself at fault?

To troubleshoot the circuit in the previous paragraph a voltmeter may be used in the following manner. Turn the voltmeter to a voltage setting higher than the voltage of the supply. In this case the supply voltage should be 28.5 Vdc, so the 200 Vdc scale is a good choice. Follow the diagram shown below as you read the following.

[redacted]

Place the red lead of the voltmeter on the plus (+) line and the black lead on the negative (-). The meter will read 28.5 Vdc.

Place the red lead, the lead being used to find and detect power in the positive line, on the load side of the switch. The load side of the switch is the side of the switch to which the load is connected.

The other side of the switch, where the line is connected, is the line side of the switch. The black lead should remain in contact with the negative line. The meter will read 28.5 Vdc.

Place the red lead on the line side of the fuse. The meter will read 28.5 V.

Place the red lead on the load side of the fuse. The meter will read 28.5 V.

Place the red lead on the line side of the thermostat. The meter will read 28.5 V.

Place the red lead on the load side of the thermostat. The meter will read 0 V. There is no power available to energize the resistance element. This means that the thermostat contacts are open. Now ask the question, is the ambient temperature cold enough to cause the thermostat contacts to close? If the ambient temperature is below 35 degrees F, the contacts should be closed and the circuit should be completed.

NOTE: The red lead was the only one moved. It is important to note that if the meter had read 28.5 V at the resistance element connection when the red lead was moved to this point, then further tests should be made.

Sometimes checking the active or power consuming device (subsystem) first is the best method to start troubleshooting. This will determine if the device or the electrical supply to the device should be checked first.

Another step is necessary to reach the final conclusion. Suppose that the thermostat is good and 28.5 V is indicated at point 6.

The meter lead can now be moved to the terminal on the left of the resistance element. Suppose it reads 28.5 V, move the black lead to the resistance element terminal on the right. If there is no voltage, the negative wire is open between the source and the load. If there is voltage at the resistance element and it will not heat, the resistance element is defective. This can be confirmed by a continuity check of the resistance element.

Continuity testing may be used for unpowered circuits. Similar techniques can be used when troubleshooting ac circuits. Keep in mind that with ac circuits meters are not polarity sensitive.

The key to troubleshooting circuits in this manner is to divide the circuit to isolate the fault. On the LRV circuits can be divided / isolated at junction boxes, terminal boards, relay panels or any location that a conductor can be disconnected in the circuit under investigation. Isolate the fault to a single car to start.

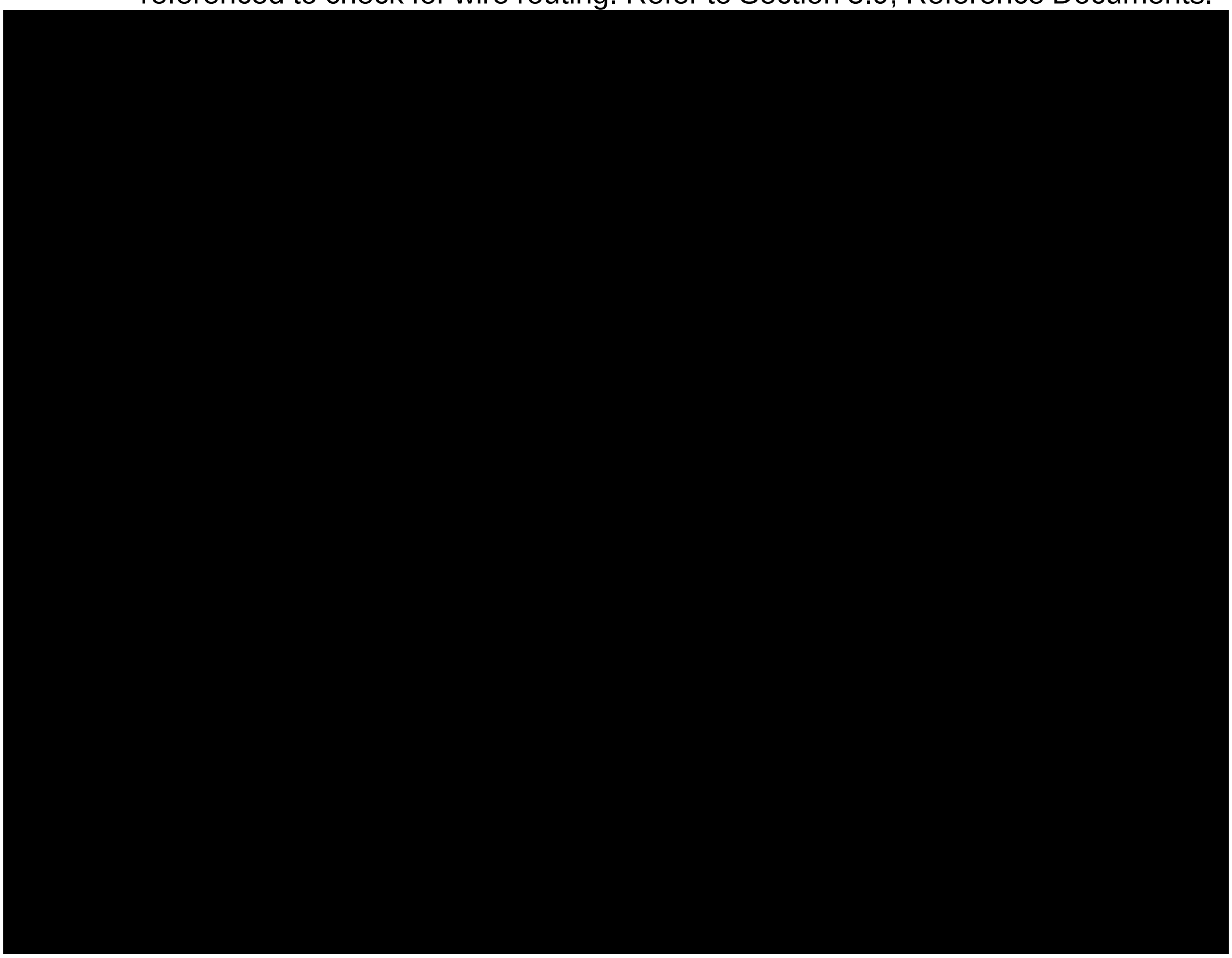
5.7.2 Relay Guide

A collection of different relay models and types are used on the P3010 based on the intended application and available mounting location. A complete list of the relays is found in the reference document ***P3010 Tabulations***. The relays can be categorized into the following main types: Plug-In, Critical & Non-Critical Vapor, Contactor, and Timer.

Plug-In Type

These relays are hermetically sealed. They are mounted using an adapter socket, either in the upright or horizontal position. These relays do not provide a visual indication to indicate their state. Included on Cab Relay Panels CRP6A/B, CRP7A/B, and CRP8A are indication LEDs. These LEDs are wired in parallel with the relay coil terminals to illuminate when the relay coil is ENERGIZED.

NOTE: Due to the mounting socket, not all relay pins are easily accessible. In those cases, it is recommended to see if wire connected to that terminal is routed to a terminal block on the panel, to one of the panel CN connectors, or to an LED. A routed wire may provide easier access to perform the necessary measurements that directly on the relay pins. The individual relay panel schematic should be referenced to check for wire routing. Refer to Section 5.9, Reference Documents.



Contactor Type

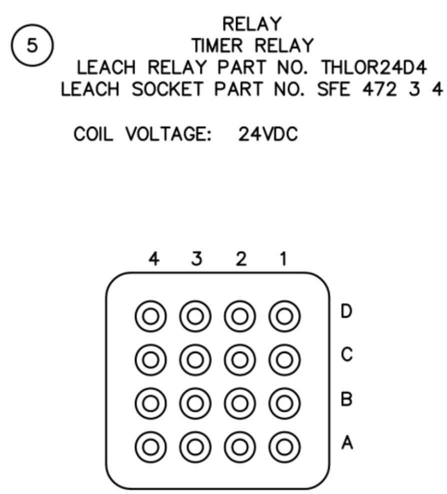
These relays are mounted either in the upright or horizontal position. These relays are generally used on the P3010 in high current applications, for example the Track Brakes.

Critical & Non-Critical Vapor Type

These relays are mounted in the upright position. They provide a small colored visual indicator window to indicate the relay coil state (Green = DE-ENERGIZED / Red = ENERGIZED). These relays are used on the P3010 for some of the critical control circuitry, for example the Emergency Brake Trainline.

[redacted]

Timer relays are their own branch of relays, which include different types within the family. The most common timer relays are On-Delay and Off-Delay Timer Relays. On-Delay Timer Relays will energize the load a set amount of time after the control voltage is applied (delayed started). Off-Delay Timer Relays continue to energize the load for a set amount of time after the control voltage is removed (delayed stop). The P3010 uses Off-Delay Timers for some of the control circuitry, for example the Local Bus Timer.



5.8 Troubleshooting Procedures

Top level troubleshooting procedures are presented in the following tables that correspond to the electrical circuit groups that are categorized in the vehicle schematic diagram. Individual subsystem troubleshooting procedures are covered *in detail* in the specific Running Maintenance and Servicing Manual sections.

Observation of status information on the TOD should be the first step in determining potential causes, before performing detailed voltage measurements. Refer to Section 5.4. Operation of a bypass switches may also be used to eliminate or confirm potential causes.

Table	Application
Table 5-1 General	Use this table for general/common faults.
Table 5-2 Main Circuit Circuit Sheets 200-249	Use this table when loss of primary input is evident in the auxiliary or Traction Drive Functions.
Table 5-3 Auxiliary Power Circuit Sheets 200-249	Use this table when a problem is suspected in the 28 vdc and 120/208 vac voltage distribution paths.
Table 5-4 Drive/Brake Control Circuit Sheets 250-299	Use this table to isolate problems in the Drive/Brake and Traction Control functions, train on, Emergency Brake (EB) loop control, cab propulsion, Deadman control, propulsion cutout, propulsion ventilation, propulsion supervision, propulsion fault interface, no motion, panel indicators, control hotel loads, trailing cab checking, and cab on/local and no motion checking
Table 5-5 HVAC Circuit Sheets 700-799	Use this table to isolate a problem in the HVAC and cab heater and defroster.
Table 5-6 Doors Circuit Sheets 500-599	Use this table to isolate problems in the doors and crew key switches.
Table 5-7 Lighting Circuit Sheets 600-699	Use this table to isolate problems in the 12 vdc power supplies, exterior lights control, head light, roof light, tail lights, stop lights, marker lights, SILENT ALARM lights, BYPASS ACTIVATED lights, interior lights, cab lights, and a-c articulation lights.
Table 5-8 Communications, APC, Radio Circuit Sheets 800-849	Use this table to isolate problems with the communications, automatic passenger counter, and radio.
Table 5-9 Coupler Control Circuit Sheets 850-899	Use this table to isolate problems in coupler control
Table 5-10 Start-Up Conditions	Use this table for problems after initial vehicle start-up conditions.

This chapter assumes that the Propulsion Logic Units (PLUs), Electronic Control Units (ECUs), and vendor supplied subassemblies have been checked out and no malfunctions exist in any of these units, and/or:

1. It has been determined that the vehicle is not supplying the necessary power or input signals to these units.

2. The PLU and ECU input-output circuits are OK, but the vehicle control circuits on the output side are not responding as directed.

5.8.1 General

The table below presents general symptoms common to the P3010 and possible causes of the faults. The table refers to sections of this chapter and other system Running Maintenance and Servicing Manuals for more detailed instructions.

Table 5-1. General Troubleshooting of Common Faults

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not move or Invalid PBED (valid range 5.0% - 91.5%) <u>Assumptions:</u> Active cab and direction selected.	Direction Control Trainline	1. Use TOD to check status of Direction Control TLs a. Check for 'FWD' / 'REV' arrows to the left & right of the consist display icon at the top of the Operating Screen. b. Check the status of the following variables on the Maintenance Screen > MVB Ports > MVB-100: • Direction1_TL • Direction2_TL (Ref. table in Section 2.4)	1a. If status is not OK, See Section 5.8.4 Drive/Brake Control. If status is OK, proceed to next Probable Cause
			1b. If status is OK, proceed to next Probable Cause
	Emergency Brake Applied	2. Use TOD to check status of EB. Check the 'Emergency Brake TL' indication on the Operating Screen	2a. If active, proceed to next Tests & Checks
			2b. If not active, proceed to next Probable Cause.
		3. Check Mixed I/O Vital Output LED 4 on ATC rack for EB.	3a. If illuminated, EB is applied by ATC. See RMSM, Section 1500 for ATC Troubleshooting.
		ATP bypass can be used to confirm ATP if related.	3b. If not illuminated, EB is NOT applied by ATC. Proceed to next Probable Cause.
		4. Check all cabs to ensure Push Button is not depressed	4a. If depressed, restore EB Push Button to non-actuated state
			4b. See Section 5.8.4 Drive / Brake Control for Emergency Brake Loop Control
	Cab Propulsion Inhibit	5. Use TOD to check status of Cab Propulsion Inhibit Relay (CPIR) Check the 'Cab Propulsion Inhibit Relay' indication on the Operating Screen (Ref. table in Section 5.4~~e~~)	5a. If active, proceed to next Tests & Checks
			5b. If not active, proceed to next Probable Cause.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not move or Invalid PBED (valid range 5.0% - 91.5%) (cont'd.)	Cab Propulsion Inhibit (cont'd.)	6. Use TOD to check status of doors. Check the 'DOORS' Subsystem indication. Door Interlock bypass can be used to confirm if door related.	6a. If not closed, see Section 5.8.6 Door Controls. See RMSM, Section 0400 for Doors Troubleshooting.
			6b. If closed, proceed to next Tests & Checks.
		7. Use TOD to check status of Dead Man Relay (DMR) Check the 'Dead Man Relay' indication on the Operating Screen (Ref. table in Section 5.4)	7a. If not active, See Section 5.8.4 Drive / Brake Control for Table 5-4d Deadman Control
			7b. If active, proceed to next Tests & Checks
		8. Check Mixed I/O Vital Output LED 3 on ATC rack for FSB. ATP bypass can be used to confirm ATP related.	8a. FSB is applied by ATC. See RMSM, Section 1500 for ATC Troubleshooting.
			8b. See Section 5.8.4 Drive / Brake Control for Table 5-4e Cab Propulsion Inhibit
	Train Propulsion Inhibit	9. Use TOD to check for friction bake faults. Check the 'Friction Brake Fault TL' indication on the Operating Screen Brake Inhibit Bypass can be used to confirm if brake related.	9a. If active, see Section 5.8.4 Drive / Brake Control for Table 5-4f Train Propulsion Inhibit. See RMSM, Section 1300 for Friction Brakes Troubleshooting.
			9b. If not active, proceed to next Tests & Checks
		10. Use TOD to check status of doors. Check the 'DOORS' Subsystem indication. Door Interlock Bypass can be used to confirm if door related.	10a. If not closed, see Section 5.8.6 Door Controls Table 5-6c. Also see RMSM, Section 0400 for Doors Troubleshooting
			10b. If closed, proceed to next Probable Cause.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not move or Invalid PBED (valid range 5.0% - 91.5%) (cont'd.)	(Type II, ATO) No TWC Route / Vehicle Hold	11. Use ADU to confirm a valid route is entered.	11a. If not OK, enter route on ADU.
			11b. If OK, proceed to next Probable Cause.
	Other	12. Check for other common symptoms listed in this table (e.g. no primary power, no cab signal, etc.).	12a. See Section 5.8.4 Drive / Brake Control for Table 5-4c Propulsion and Braking.
			12b. Perform operational test before returning LRV to service.
Brakes will not release	Emergency Brake Applied, Train Propulsion Inhibit, Or other open trainlines	1. Check for shared symptoms with No Movement / Invalid PBED (valid range 16.5% - 91.5%).	1a. If not OK, follow the corresponding Corrective Actions.
			1b. If OK, proceed to next Probable Cause.
	Low main reservoir pressure. (Below 90 psi)	2. Use TOD to check Main Reservoir Pressure. Check the 'MAIN (MRP)' gauge on the Operating Screen	2a. If low (< 90 psi), see RMSM, Section 1300 for Friction Brakes Troubleshooting.
			2b. If OK, proceed to next Probable Cause.
	Stuck brake or parking brake hose leaking.	3. During powering, power cut occurs after short time delay (approx. 7 sec). Using the TOD, observe the BCP gauges on the Operating Screen for one or more not releasing.	3a. Cut out affected brake unit and remove train from service and repair
			3b. Perform operational test before returning LRV to service.
Smoke / smell from brakes	Propulsion Fault resulting in friction braking on truck associated with failed propulsion unit. Dynamic brakes on that truck are non-functional causing friction brake operation.	1. Friction brake smell will indicate truck / propulsion unit in question. Use TOD to check for Propulsion faults. Check the 'Propulsion Fault TL' indication on the Operating Screen (Ref. table in Section 5.4)	1a. Remove Train from service and repair Propulsion Fault. See RMSM, Section 0700 Propulsion for specific system troubleshooting.
			1b. If OK, proceed to next Probable Cause.
	Stuck brake, parking brake hose leaking.	2. Power cut occurs after short time delay (approx. 7 sec). Using the TOD, observe the BCP gauges on the Operating Screen for one or more not releasing.	2a. Cut out affected brake unit and remove train from service and repair. See RMSM, Section 1300 Friction Brake for specific system troubleshooting.
			2b. Perform operational test before returning LRV to service.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not reach maximum speed, Slow Train, or Performance Limit. NOTE: - SLC Fault (35 mph) - FB Fault (10 mph)	HSCB Tripped or locked out, or fault in HSCB Control Panel	1. Use the TOD to check the status of the HSCB. a. Check the HSCB Tripped indicator on the Operating Screen. b. Check the following variables on the Maintenance Screen > MVB Ports > MVB-512 / 640: • HSCB Lockout PLU A/B Status c. Check for HSCB Faults on the Fault Screen.	1a. If tripped reset using TOD. If locked out follow procedures in RMSM 0700.
			1b. If OK, proceed to next Probable Cause.
	Propulsion Fault Causing SLC. (35 mph speed restriction.)	2. Check for Propulsion Faults on TOD. Check for SLC on ADU. Check the 'Propulsion Fault TL' indication on the Operating Screen (Ref. table in Section 5.4)	2a. If present, remove train from service and repair Propulsion Fault. See RMSM, Section 0700 Propulsion for specific system troubleshooting.
			2b. If OK, proceed to next Probable Cause.
	Friction Brake Fault causing speed restriction. (10 mph speed restriction.)	3. Check for Brake Faults on TOD. Check for FB Fault on ADU. Check the 'Friction Brake Fault TL' indication on the Operating Screen (Ref. table in Section 5.4)	3a. If present, remove train from service and repair Friction Brake Fault. See RMSM, Section 1300 Friction Brake for specific system troubleshooting.
			3b. If OK, proceed to next Probable Cause.
	Wheel wear mismatch	4. Measure the wheel diameter and compare against settings on TOD.	4a. If mismatch, correct wheel diameter settings via the TOD.
			4b. If OK, proceed to next Probable Cause.
	ROC imposed speed restriction (Type II)	5. Confirm with ROC there is no restriction in effect	5a. Perform operational test before returning LRV to service.
Train will not exceed 2 mph	Train in Car Wash	1. Check TOD status indicator for Car Wash Mode.	1a. Depress Car Wash Pushbutton.
			1b. Perform operational test before returning LRV to service.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Doors will not open (all doors on a side)	No Motion Signal Not present to enable doors.	1. Try the doors on the other side and see if they work, or try to operate the doors from the other end of the train. Check the 'No-Motion' indication on the Operating Screen (Ref. table in Section 5.4) No Motion Bypass can be used to confirm in No Motion related.	1a. If not working, see Section 5.8.4 Drive / Brake Control for No Motion Interface. See Section 5.8.6 Door Control
			1b. If OK, proceed to next Probable Cause.
	Missing open or unlock trainline signal or missing release or unlock signal.	2. Try to operate the doors from the other end of the train.	2a. If working from other end, see Section 5.8.6 Door Control
			2b. If not OK, proceed to next Probable Cause.
	In ATC type II, this may be caused by the ATC system not enabling the doors	3. Check ADU for Vehicle Berthed Indication. Run predeparture test. Check Friction Brake On inputs to the ATC rack - Illuminated Vital Input LED 12 when A-End active - Illuminated Vital Input LED 13 when B-End active Check EB output of ATC rack is not active. - Mixed I/O Vital Output	3a. See RMSM, Section 1500 for ATC Troubleshooting.
			3b. If OK, proceed to next Probable Cause.
	Door Fault(s)	4. Check TOD / FLOG for door faults.	4a. If present, see RMSM, Section 0400 for Doors Troubleshooting See Section 5.8.6 Door Controls.
			4b. Perform operational test before returning LRV to service.
Door will not open (one door)	Door Operator Fault	1. Check TOD / FLOG for door faults.	1a. If present, see RMSM, Section 0400 for Doors Troubleshooting. See Section 5.8.6 Door Controls.
			1b. If OK, proceed to next Probable Cause.
	Obstruction / debris in door track.	2. Visually inspect, perform obstruction test	2a. Clear debris. See RMSM, Section 0400 for Obstruction Test.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Door will not open (one door) (cont'd.)	Obstruction / debris in door track. (cont'd.)		2b. Perform operational test before returning LRV to service.
Doors will not close (all doors on a side)	Door Fault(s)	1. Check TOD / FLOG for door faults.	1a. If present, see RMSM, Section 0400 for Doors Troubleshooting
			1b. If OK, proceed to next Probable Cause.
	Door Close Relay Fault Or Missing Close Signal.	2. Try to operate the doors from the other end of the train.	2a. If working, see Section 5.8.6 Door Control
			2b. Perform operational test before returning LRV to service.
Door will not close (one door)	Door Operator Fault	1. Check TOD / FLOG for door faults.	1a. If present, see RMSM, Section 0400 for Doors Troubleshooting. See Section 5.8.6 Door Controls.
			1b. If OK, proceed to next Probable Cause.
	Obstruction / debris in door track.	2. Visually inspect, perform obstruction test	2a. Clear debris. See RMSM, Section 0400 for Obstruction Test.
			2b. Perform operational test before returning LRV to service.
No Primary Power	Catenary not powered	1. Confirm catenary power present	1a. If missing, restore catenary power.
			1b. If OK, proceed to next Probable Cause.
	Pantograph down or not touching wire	2. Visually check that Pantograph is making contact (touching) with the catenary	2a. See table 5.2 Main Circuit Troubleshooting
			2b. Perform operational test before returning LRV to service.
No announcements	Fault in TOA for automatic announcements, PA system for mic/console announcements	1. Check TOD / FLOG for Communications faults. Check CCH for faults.	1a. See RMSM, Section 1402 for Communications Troubleshooting and corrective action.
			1b. Perform operational test before returning LRV to service.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No HVAC	HVAC Fault	1. Check TOD / FLOG for HVAC faults.	1a. See Section 5.8.5 HVAC. See RMSM, Section 0500 for HVAC Troubleshooting.
			1b. If OK, proceed to next Probable Cause.
	Circuit Breaker	2. Check Circuit Breaker.	2a. Reset Circuit Breaker.
			2b. Perform operational test before returning LRV to service.
Flat battery	Train not turned off with loss of catenary power	1. Check battery voltage on TOD	1a. If low, wait for the APS to charge battery.
			1b. Start APS with Dead Battery Start Function if needed, Ref section 2.13
			1c. If OK, proceed to next Probable Cause.
	APS Fault	2. Check TOD for APS faults.	2a. See Section 5.8.3 for APS troubleshooting. See RMSM, Section 0900 for APS Troubleshooting.
			2b. Perform operational test before returning LRV to service.
No signs (single)	Faulty Sign	1. Run Sign Test from PTU or Onboard Test from CCH	1a. See RMSM, Section 1402 for Sign Troubleshooting. See Sign PTU manual
			1b. Perform operational test before returning LRV to service.
No signs (all)	APS Load Shed (Line Voltage below 550 VDC)	1. Use TOD to check for Load Shed and the Line Voltage. a. Check the status of the 'Load Shed Command TL' on the Maintenance Screen > MVB Ports > MVB-100. b. Check the 'LINE' gauge indication on the Operating Screen	1a. If Load Shed active, wait for Line Voltage to rise above 570 VDC.
			1b. If OK, proceed to next Probable Cause.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No signs (all) (cont'd.)	Fault in TOA for automatic announcements.	2. Check TOD / FLOG for Communications faults. Check CCH for faults.	2a. See RMSM, Section 1402 for Communications Troubleshooting and corrective action. See Sign PTU manual
			2b. Perform operational test before returning LRV to service.
No lights	Circuit breaker	1. Check Circuit Breaker	1a. See Section 5.8.7 Lighting. See RMSM, Section 0600 for Lighting Troubleshooting
			1b. Perform operational test before returning LRV to service.
No cab signal	Circuit breaker or track receiver fault	1. Run predeparture test	1a. See RMSM, Section 1500 for ATC Troubleshooting,
			1b. Perform operational test before returning LRV to service.
Inaccurate Berthing (ATO type II)	Faulty wayside track circuit or TWC issue	1. Run predeparture test	1a. See RMSM, Section 1500 for ATC Troubleshooting.
			1b. Perform operational test before returning LRV to service.
Unable to couple (mechanical)	Mechanical Hook Faulty	1. Inspect Hook	1a. Repair hook.
			1b. Perform operational test before returning LRV to service.
Unable to couple (electrical)	Electrical Heads not Extended	1. Confirm Electrical Heads are extended on both vehicles. Move the ECS to the 'Normal' position to extend the heads.	1a. See Section 5.8.9 Coupler Control. See RMSM, Section 0300 for Coupler Troubleshooting.
			1b. Perform operational test before returning LRV to service.

Table 5-1. General Troubleshooting of Common Faults (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No trainline indication after coupling	Trainlines did not establish	1. Check Coupler Loop Switch.	1a. See Section 5.8.9 Coupler Control. See RMSM, Section 0300 for Coupler Troubleshooting.
			1b. If OK, proceed to next Probable Cause.
	EEI Modules	2. Check TLIM Status on the TOD.	2a. See Section 5.8.8 Communications. See RMSM, Section 1700 for EEIM Troubleshooting.
			2b. Perform operational test before returning LRV to service.

5.8.2 Main Circuit

Table 5-2 provides troubleshooting procedures for the high voltage (750 vdc) input.

WARNING

THE FOLLOWING TABLE INCLUDES INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY OR DEATH.

Table 5-2: Main Circuit

Symptom	Probable Cause	Tests & Checks	Corrective Action
Dead Vehicle <u>Assumptions:</u> 750 VDC is on catenary and pantograph is in raised position.	Pantograph damaged or has not risen to its full position.	1. Visually inspect Pantograph for signs of obvious damage.	1a. If damage exists, refer to HRMM 0800 for removal and replacement.
			1b. If OK, proceed to next Probable Cause.
	Pantograph not making contact	2. Visually check that Pantograph is making contact (touching) with the catenary.	2a. If Pantograph is not touching catenary, refer to HRMM 0800 for replacement of springs or repair of other mechanical components. Check limit switches.
			2b. If Pantograph appears to be making contact with catenary, proceed to next Probable Cause.
		3. Check TOD for Line Voltage Indication.	3a. If present, APS is working and Aux Fuse is ok.
			3b. If no voltage indication proceed to Auxiliary Fuse below.
	Pantograph collector carbons worn or damaged.	4. <u>**Ensure Pantograph is lowered**</u> (use hand crank). <u>**Ensure vehicle is under unpowered catenary or area away from catenary.**</u> Inspect collector carbons for signs of excessive wear or obvious damage.	4a. If collector carbons are worn or obviously damaged, remove and replace carbons and return vehicle to service.
			4b. If collector carbons are OK, leave vehicle in same (safe) area and proceed to next Probable Cause.

Table 5-2. Main Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Dead Vehicle (cont'd.)	Auxiliary Fuse (roof mounted box)	5. **Ensure Pantograph is lowered** (use hand crank if necessary). Using multimeter, check continuity of Auxiliary Fuse.	5a. If open, remove and replace Auxiliary Fuse and return vehicle to service.
			5b. If OK, proceed to next Probable Cause.
	Knife Switch Faulty	6. Inspect knife switch and knife switch connections.	6a. If not ok, repair or replace as required. See HRM 0700 for procedures.
			6b. If OK, proceed to next Probable Cause.
	High voltage cable open or breaking down under load.	7. Check cable connections at Pantograph and junction point where auxiliary line is tapped.	7a. If connections are loose, tighten. If burnt or corroded, remove and replace.
			7b. If OK, proceed to next **Tests & Checks**.
		8. Disconnect high voltage cable at all junction points. Using a megger, check each cable for continuity.	8a. If cable is breaking down under load, remove and replace cable, as required.
			8b. If OK, proceed to next Probable Cause.
	Lightning Arrestor (LA).	9. Remove high voltage cable from lightning arrester. Using megger, check for continuity.	10a. If lightning arrestor is breaking down under load, remove and replace as required.
			10b. Perform operational test before returning LRV to service.
Pantograph rises from one cab, but not the other. NOTE: Car should be single / separated from train.	Master Controller Key Switch Relay 3 (MCKSR3)	1. Using multimeter, measure for 28 VDC at wire 37AD/37BE.	1a. If not OK, check MCKSR3A/B.
			1b. If OK, proceed to next Probable Cause.
	Console Master Key relay (CMKR)	2. Using multimeter, measure for 28 VDC at wire 36AM/36BD	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 37AD/37BE	3a. If not OK, continue to troubleshoot Cab Console Indication Circuits (ref. sheet 271)
			3b. If OK, remove and replace CMKR in applicable cab console.
	Pantograph Up/Down Switch (PUDS)	4. Hold lead cab PUDS in the UP position. Using a multimeter, measure for 28 VDC at wire 36AB / 36BB.	4a. If not OK, remove and replace PUDS.
			4b. Perform operational test before returning LRV to service.

Table 5-2. Main Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Pantograph does not rise from both cabs. NOTE: Car should be single / separated from train.	Pantograph Control circuit breaker (ensure that breaker is not tripped).	1. Using multimeter, measure for 28 VDC at wire 36AA.	1a. If missing, remove and replace Pantograph Control circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Pantograph Up Diode (PUD)	2. Hold lead cab PUDS in the UP position. Measure for 28 VDC at wire 36AB.	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next Probable Cause.
	Limit Switches	3. Using a multimeter, measure for continuity between wires 36AB and 36AH.	3a. If not OK, adjust Limit Switches or replace as needed.
			3b. If OK, proceed to next Probable Cause.
	Pantograph Down Relay (PDR)	4. Using a multimeter, measure for 28 VDC at wire 36AJ (PDR Contacts NC4).	4a. If missing, proceed to next Tests & Checks.
			4b. If OK, proceed to next Probable Cause.
		5. Using a multimeter, measure for 0 VDC at wire 36AG (PDR Terminal Y).	5a. If voltage present, continue to troubleshoot Pantograph Down Control Circuit.
			5b. If OK, remove and replace relay.
	Pantograph Up Relay (PUR) / Pantograph Motor	6. Hold lead cab PUDS in the UP position. Using a multimeter, measure for continuity between wires 36AA (PUR Contact C2) and 36AK (PUR Contact NO2).	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Tests and Checks.
		7. Hold lead cab PUDS in the UP position. Using a multimeter, measure for continuity between wires 36AL (PUR Contact C3) and 36LVGA (PUR Contact NO3).	7a. If missing, remove and replace relay.
			7b. If OK, remove and replace pantograph motor.
Pantograph lowers from one cab, but not the other. NOTE: Car should be single / separated from train.	Pantograph Up/Down Switch (PUDS).	1. Hold lead cab PUDS in the DOWN position. Using a multimeter, measure for 28 VDC at wire 36AC.	1a. If not OK, remove and replace PUDS.
			1b. Perform operational test before returning LRV to service.

Table 5-2. Main Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Pantograph does not lower from both cabs.	Pantograph Control circuit breaker (ensure that breaker is not tripped).	1. Using multimeter, measure for 28 VDC at wire 36AA.	1a. If missing, remove and replace Pantograph Control circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Pantograph Down Diode (PDD)	2. Hold lead cab PUDS in the DOWN position. Measure for 28 VDC at wire 36AC.	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next Probable Cause.
	Limit Switches	3. Using a multimeter, measure for continuity between wires 36AC and 36AF.	3a. If not OK, adjust Limit Switches or replace as needed.
			3b. If OK, proceed to next Probable Cause.
	Pantograph Up Relay (PUR)	4. Using a multimeter, measure for 28 VDC at wire 36AG (PUR Contacts NC4).	4a. If missing, proceed to next Tests & Checks.
			4b. If OK, proceed to next Probable Cause.
		5. Using a multimeter, measure for 0 VDC at wire 36AJ (PUR Terminal Y).	5a. If voltage present, continue to troubleshoot Pantograph Up Control Circuit.
			5b. If OK, remove and replace relay.
	Pantograph Down Relay (PDR) / Pantograph Motor	6. Hold lead cab PUDS in the DOWN position. Using a multimeter, measure for continuity between wires 36AA (PDR Contact C2) and 36AL (PDR Contact NO2).	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Tests and Checks.
		7. Hold lead cab PUDS in the DOWN position. Using a multimeter, measure for continuity between wires 36AK (PDR Contact C3) and 36LVGA (PDR Contact NO3).	7a. If missing, remove and replace relay.
			7b. If OK, remove and replace pantograph motor.

5.8.3 Auxiliary Power Supply

Table 5-3 provides troubleshooting procedures for auxiliary power, both Low Voltage dc (28.5 Vdc) and AC (208 Vac) outputs from the APS, and the vehicle Local Bus control circuitry. Before troubleshooting the auxiliary power, refer to circuit sheets on Power Distribution, Sheets 200 – 250 of the vehicle circuit diagrams. Additionally, the APS Running Maintenance and Service Manual, Section 0900, should be consulted for detailed troubleshooting information. For user convenience, this table is sub-divided as follows:

- Table 5-3a Auxiliary Power
- Table 5-3b Local Control Bus

WARNING

THE FOLLOWING TABLE INCLUDES INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY OR DEATH.

NOTE: Auxiliary 28 vdc power (Local) is divided into Essential Bus battery power and Local Bus battery power. Battery direct power at 24 vdc is provided directly from the battery when the Auxiliary Power Supply (APS) is off. When the APS is on the APS-LVPS supplies the 28 vdc power, charges the battery and supplies 208 Vac to the vehicle circuits.

The Essential Bus circuits are always powered and include Low Voltage Control, Auxiliary Power Supply (APS), Emergency Lighting, Track Brake Control, Digital Video Recorder (DVR), and Data Acquisition. The two Local Bus circuits provide the non-essential battery power to all other subsystems and devices on the car. These circuits receive 28 vdc power via two methods. The first method is when the A-Unit or B-Unit master controller is keyed on to be the lead car. The second method is via the A-Unit or B-Unit LOCAL ON switch, which applies 28 vdc power to the circuits without turning on the LRV. In both methods if the APS-LVPS is on the power to the loads is from the LVPS. If the APS (LVPS) is off the power to the loads is from the battery.

Table 5-3a. Auxiliary Power

Symptom	Probable Cause	Tests & Checks	Corrective Action
APS will not start-up: No 750 VDC input to Auxiliary Power Supply. NOTE: Loss of 750 vdc will be indicated on the Line Voltage indicator on the TOD.	Main circuit.	1. If no 750 VDC is seen on TOD, check Knife Switch to ensure it is in RUN or AUX position or is in SHOP position, with a shop stinger attached and shop power on.	1a. If OK, proceed to the next probable cause.
			1b. Repair as directed by Table 5–2. Perform operational test before returning LRV to service.
	Roof Aux Fuse	**WARNING: Disable OCS.** 2. Check fuse for continuity.	2a. Fuse is open. Repair as directed by Table 5-2.
			2b. Perform operational test before returning LRV to service.
APS will not start-up: APS will not start on application of 750 VDC.	Dead Battery	1. Using a multimeter, measure DC voltage at wire 25BA (LVCCB)	1a. If below around 17 VDC, try the Dead Battery Start procedure.
			1b. If OK, proceed to next probable cause.
	APS Enable/Reset Circuit	2. Using multimeter, measure for continuity between wires 26AL (APS X701b -5) and 26AM (APS X701b -6).	2a. If missing, proceed to Table 5-3b for Local Control Bus troubleshooting.
			2b. If OK, proceed to next Probable Cause.
	Fault in Auxiliary Power Supply	3. Use the TOD for APS faults. NOTE: If the unit is completely OFF, it won't be able to report any faults.	3a. Refer to RMSM Section 0900 to troubleshoot APS.
			3b. Perform operational test before returning LRV to service.
APS will not start-up: Dead battery start (DBS) circuit inoperative. <u>Assumptions:</u> 750 VDC input to APS is provided and the battery voltage is below around 17 VDC.	Dead Battery Start Switch (DBSS)	1. Hold down the DBSS. Using multimeter, measure for continuity between wires 26AL (DBSS Terminal 2) and 26AM (DBSS Terminal 3).	1a. If not OK, remove and replace switch.
			1a. If OK, proceed to next Probable Cause.
	Fault in Auxiliary Power Supply Dead Battery Start Module.	2. Hold down the DBSS. Using a multimeter, measure the voltage at wire 26AA (APSCB). See if the voltage begins to increase.	2a. If voltage does not increase, refer to RMSM Section 0900 to troubleshoot APS.
			2b. If OK, proceed to next probable cause.
	Dead Battery Local Switch (DBLS)	3. Hold down the DBLS. Using multimeter, measure for continuity between wires 25AA (DBLS Terminal 2) and 25AZ (DBLS Terminal 3).	3a. If not OK, remove and replace switch.
			3a. If OK, proceed to next Probable Cause.

Table 5-3a. Auxiliary Power (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
APS will not start-up: Dead battery start (DBS) circuit inoperative. (cont'd.)	APS Enable/Reset Circuit	4. Using multimeter, measure for continuity between wires 26AL (APS X701b -5) and 26AM (APS X701b -6).	4a. If missing, proceed to Table 5-3b for Local Control Bus troubleshooting.
			4b. Perform operational test before returning LRV to service.
No 208 VAC output from Auxiliary Power Supply	Inverter in Auxiliary Power Supply.	1. Loss of AC will be indicated on the APS Maintenance screen on the TOD. NOTE: The indication on the APS Screen is Line-to-Neutral (120 VAC nominal).	1a. Refer to RMSM Section 0900 to troubleshoot APS.
			1b. Perform operational test before returning LRV to service.
No 28 VDC output from Auxiliary Power Supply / Low Voltage Bus Supply	LVPS in Auxiliary Power Supply.	1. Loss of DC will be indicated on TOD screen and the APS Maintenance screen on the TOD.	1a. If no 28 VDC output on TOD refer to RMSM Section 0900 to troubleshoot APS
			1b. If APS DC output is 28 VDC proceed to next Probable Cause
	Battery Temperature Sensor	2. Battery over-temperature will trip Battery Circuit Breaker shunt trip	2a. Check battery circuit breaker. If battery circuit breaker is tripped there is a major circuit issue that require investigation before resetting. Isolate circuits using circuit breaker(s) and gradually restore.
			2b. If battery circuit breaker is not tripped then DC voltage is available.
	Battery Diode Open	3. Check for 28 VDC battery diode output. Refer to Circuit Diagram sh 210.	3a. If missing, replace Battery Diode.
			3b. If OK, proceed to next Probable Cause.
	Low Voltage Bus Contactor Fault	4. Using a multimeter, measure for 28 VDC at wire 30AA/BA (LBCA/B Contact A2)	4a. If missing, proceed to Table 5-3b for Local Control Bus troubleshooting.
			4b. Perform operational test before returning LRV to service.

Table 5-3b. Local Control Bus

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not turn on using Local Control Switch, A car	**NOTE:** First check if 750 VDC is applied to the APS and the APS will start. See 'APS will not start-up' symptoms in table 5-3a.		
	Low Voltage Control Circuit Breaker (LVCCB)	1. Using a multimeter, measure for 28 VDC at wire 25BA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Local Control Switch (LCS)	2. Hold the LCS in the ON position. Using a multimeter, measure for continuity between wires 25AA (LCS Contact 13) and 25AB (LCS Contact 14).	2a. If missing, remove and replace switch.
			2b. If OK, proceed to symptom 'Local Control Bus not energized, Local On will energize.'.
Train will not turn on using Local Control Switch, B car	**NOTE:** First check if 750 VDC is applied to the APS and the APS will start. See 'APS will not start-up' symptoms in table 5-3a.		
	Low Voltage Control Circuit Breaker (LVCCB)	1. Using a multimeter, measure for 28 VDC at wire 25BA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Local Control Switch (LCS)	2. Hold the LCS in the ON position. Using a multimeter, measure for continuity between wires 25AB (LCS Contact 13) and 25BB (LCS Contact 14).	2a. If missing, remove and replace switch.
			2b. If OK, proceed to symptom 'Local Control Bus not energized, Local On will energize.'.

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not turn on using Transfer Switch, A car	**NOTE:** First check if 750 VDC is applied to the APS and the APS will start. See 'APS will not start-up' symptoms in table 5-3a.		
	Coupler Loop Switch (CLS), visual inspection	1. Perform a visual inspection to confirm both CLS are in the Uncoupled position.	1a. If not, AUX OFF the car (if needed), move to the UNCOUPLE position, and AUX ON the car (if needed).
			1b. If OK, proceed to next probable cause.
	Low Voltage Control Circuit Breaker (LVCCB)	2. Using a multimeter, measure for 28 VDC at wire 25BA.	2a. If missing, remove and replace circuit breaker.
			2b. If OK, proceed to next Probable Cause.
	Cab Front Interlock Relay A (CFIRA)	3. Using a multimeter, measure for 28 VDC at wire 25AN.	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using a multimeter, measure for 28 VDC at wire 25AK (CFIRA Terminal Y)	4a. If missing, proceed to symptom 'Cab Front Interlock A Circuit not energized'.
			4b. If OK, remove and replace relay.
	Cab Rear Interlock Relay A (CRIRA)	5. Using a multimeter, measure for 28 VDC at wire 25AP.	5a. If missing, proceed to next Tests & Checks.
			5b. If OK, proceed to next Probable Cause.
		6. Using a multimeter, measure for 28 VDC at wire 25AJ (CRIRA Terminal Y)	6a. If missing, proceed to symptom 'Cab Rear Interlock A Circuit not energized'.
			6b. If OK, remove and replace relay.
	Train On Diode A (TODA)	7. Using a multimeter, measure for 28 VDC at wire 25AR.	7a. If missing, remove and replace diode.
			7b. If OK, proceed to symptom 'Local Control Bus not energized, Train On will energize.'

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train will not turn on using Transfer Switch, B car	**NOTE:** First check if 750 VDC is applied to the APS and the APS will start. See 'APS will not start-up' symptoms in table 5-3a.		
	Coupler Loop Switch (CLS), visual inspection	1. Perform a visual inspection to confirm both CLS are in the Uncoupled position.	1a. If not, AUX OFF the car (if needed), move to the UNCOUPLE position, and AUX ON the car (if needed).
			1b. If OK, proceed to next probable cause.
	Low Voltage Control Circuit Breaker (LVCCB)	2. Using a multimeter, measure for 28 VDC at wire 25BA.	2a. If missing, remove and replace circuit breaker.
			2b. If OK, proceed to next Probable Cause.
	Cab Front Interlock Relay B (CFIRB)	3. Using a multimeter, measure for 28 VDC at wire 25DC.	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using a multimeter, measure for 28 VDC at wire 25BX (CFIRB Terminal Y)	4a. If missing, proceed to symptom 'Cab Front Interlock B Circuit not energized'.
			4b. If OK, remove and replace relay.
	Cab Rear Interlock Relay B (CRIRB)	5. Using a multimeter, measure for 28 VDC at wire 25DD.	5a. If missing, proceed to next Tests & Checks.
			5b. If OK, proceed to next Probable Cause.
		6. Using a multimeter, measure for 28 VDC at wire 25BZ (CRIRB Terminal Y)	6a. If missing, proceed to symptom 'Cab Rear Interlock B Circuit not energized'.
			6b. If OK, remove and replace relay.
	Train On Diode B (TODB)	7. Using a multimeter, measure for 28 VDC at wire 25DE.	7a. If missing, remove and replace diode.
			7b. If OK, proceed to symptom 'Local Control Bus not energized, Train On will energize.

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Local Control Bus not energized, Local On will energize.	**NOTE:** This symptom is a continuation from 'Train will not turn on using Local Control Switch'		
	Local On Relay (LONR)	1. Hold the LCS in the ON position. Using a multimeter, measure for continuity between wires 25AA (LONR Contact C2) and 25CX (LONR Contact C1).	1a. If missing, remove and replace relay.
			1b. If OK, proceed to next Tests & Checks.
		2. Hold the LCS in the ON position. Using a multimeter, measure for continuity between wires 25AY (LONR Contact A2) and 25AZ (LONR Contact A1).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Probable Cause.
	Local Off Relay (LOFR)	3. Using a multimeter, measure for 0 VDC at wire 25AC (LOFR Terminal X1).	3a. If voltage present, continue troubleshooting the LOCAL OFF circuit.
			3b. If OK, proceed to next Tests & Checks.
		4. Using a multimeter, measure for continuity between wires 25CX (LOFR Contact C3) and 25AB (LOFR Contact D3).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Tests & Checks.
		5. Using a multimeter, measure for continuity between wires 25AA (LOFR Contact A3) and 25AY (LOFR Contact B3).	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Local Bus Timer (LBT)	6. Using a multimeter, measure for 28 VDC between wires 25CC (LBT Contact D2) and 25CE (LBT Contact D3).	6a. If missing, remove and replace timer.
			6b. If OK, proceed to next Probable Cause.
	Local Bus Diode 2 (LBD2)	7. Using a multimeter, measure for 28 VDC between wires 25CD (LTDR Terminal X1) and 25CE (LTDR Terminal X2).	7a. If missing, remove and replace diode.
			7b. If OK, proceed to next Probable Cause.

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Local Control Bus not energized, Local On will energize. (cont'd.)	Local Time Delay Relay (LTDR)	8. Using a multimeter, measure for continuity between wires 25AA (LTDR Contact C2) and 25CL (LTDR Contact C1).	8a. If missing, remove and replace relay.
			8b. If OK, proceed to next Probable Cause.
	Local Bus Diode 3 (LBD3)	9. Using a multimeter, measure for 28 VDC at wire 25CP (MRSR Contact C2).	9a. If missing, remove and replace diode.
			9b. If OK, proceed to next Probable Cause.
	Master Reset Relay (MRSR)	10. Using a multimeter, measure for 28 VDC at wire 25AF (MRSR Contact NC2).	10a. If missing, continue to troubleshoot Reset Trainline Circuit (ref. sheet 268).
			10b. If OK, proceed to next Probable Cause.
	Local Bus Contactor A (LBCA)	11. Using a multimeter, measure for continuity between wires 20AG (LBCA Contact A1) and 30AA (LBCA Contact A2).	11a. If missing, remove and replace contactor.
			11b. If OK, proceed to next Probable Cause.
	Local Bus Contactor B (LBCB)	12. Using a multimeter, measure for continuity between wires 20BC (LBCB Contact A1) and 30BA (LBCA Contact A2).	12a. If missing, remove and replace contactor.
			12b. Perform operational test before returning LRV to service.

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Local Control Bus not energized, Train On will energize.	**NOTE:** This symptom is a continuation from 'Train will not turn on using Transfer Switch'		
	Train On Relay (TONR)	1. Using a multimeter, measure for continuity between wires 25AY (TONR Contact A2) and 25AZ (TONR Contact A1).	1a. If missing, remove and replace relay.
			1b. If OK, proceed to next Tests & Checks.
		2. Using a multimeter, measure for continuity between wires 25AA (TONR Contact D2) and 25CJ (TONR Contact D1).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Probable Cause.
	Local Bus Diode 4 (LBD4)	3. Using a multimeter, measure for 28 VDC at wire 25CP.	3a. If missing, remove and replace diode.
			3b. If OK, proceed to next Probable Cause.
	Master Reset Relay (MRSR)	4. Using a multimeter, measure for 28 VDC at wire 25AF (MRSR Contact NC2).	4a. If missing, continue to troubleshoot Reset Trainline Circuit (ref. sheet 268).
			4b. If OK, proceed to next Probable Cause.
	Local Bus Contactor A (LBCA)	5. Using a multimeter, measure for continuity between wires 20AG (LBCA Contact A1) and 30AA (LBCA Contact A2).	5a. If missing, remove and replace contactor.
			5b. If OK, proceed to next Probable Cause.
	Local Bus Contactor B (LBCB)	6. Using a multimeter, measure for continuity between wires 20BC (LBCB Contact A1) and 30BA (LBCA Contact A2).	6a. If missing, remove and replace contactor.
			6b. Perform operational test before returning LRV to service.

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Front Interlock A Circuit not energized. (Assumes Coupler Loop Switch is in UNCOUPLED position and Transfer Switch is ON).	**NOTE:** This symptom is a continuation from 'Train will not turn on using Transfer Switch, A car.		
	Coupler Loop Switch (CLS), A-End	1. Using multimeter, measure for 28 VDC at wire 25AG (CLS Contact 21)	1a. If missing, remove and replace CLS
			1b. If OK, proceed to next Probable Cause.
	Transfer Switch TS-4, A-End / Cab Front Interlock Relay A (CFIRA)	2. Using multimeter, measure for 28 VDC at wire 25AK (TS-4 Contact 7)	2a. If missing, remove and replace Transfer Switch
			2b. If OK, remove and replace relay.
Cab Front Interlock B Circuit not energized. (Assumes Coupler Loop switch is in UNCOUPLED position and Transfer Switch is ON).	**NOTE:** This symptom is a continuation from 'Train will not turn on using Transfer Switch, B car.		
	Coupler Loop Switch (CLS), B-End	1. Using multimeter, measure for 28 VDC at wire 25BW (CLS Contact 21)	1a. If missing, remove and replace CLS
			1b. If OK, proceed to next Probable Cause.
	Transfer Switch TS-4, B-End / Cab Front Interlock Relay B (CFIRB)	2. Using multimeter, measure for 28 VDC at wire 25BX (TS-4 Contact 7)	2a. If missing, remove and replace Transfer Switch
			2b. If OK, remove and replace relay.

Table 5-3b. Local Control Bus (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Rear Interlock A Circuit not energized. Assumptions: Coupler Loop Switch is in UNCOUPLED position and Transfer Switch is ON.	**NOTE:** This symptom is a continuation from 'Train will not turn on using Transfer Switch, A car.		
	Coupler Loop Switch (CLS), B-End	1. Using multimeter, measure for 28 VDC at wire 25BW (CLS Contact 21)	1a. If missing, remove and replace CLS
			1b. If OK, proceed to next Probable Cause.
	Transfer Switch TS-2, B-End	2. Using a multimeter, measure for continuity between TS-2 Contacts 3 and 4.	2a. If missing, remove and replace Transfer Switch
			2b. If OK, proceed to next Probable Cause.
	Reverser Switch RS-6, B-End	3. Using a multimeter, measure for continuity between RS-6 Contacts 11 and 12.	3a. If missing, remove and replace Reverser Switch
			3b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-15, B-End	4. Using a multimeter, measure for continuity between MCS-15 Contacts 1 and 2.	4a. If missing, remove and replace Reverser Switch
			4b. If OK, proceed to next Probable Cause.
	Transfer Switch TS-3, A-End / Cab Rear Interlock Relay A (CRIRA)	5. Using a multimeter, measure for continuity between TS-3 Contacts 5 and 6.	5a. If missing, remove and replace Transfer Switch
			5b. If OK, remove and replace relay.
Cab Rear Interlock B Circuit not energized. Assumptions: Coupler Loop Switch is in UNCOUPLED position and Transfer Switch is ON.	**NOTE:** This symptom is a continuation from 'Train will not turn on using Transfer Switch, B car.		
	Coupler Loop Switch (CLS), A-End	1. Using multimeter, measure for 28 VDC at wire 25AG (CLS Contact 21)	1a. If missing, remove and replace CLS
			1b. If OK, proceed to next Probable Cause.
	Transfer Switch TS-2, A-End	2. Using a multimeter, measure for continuity between TS-2 Contacts 3 and 4.	2a. If missing, remove and replace Transfer Switch
			2b. If OK, proceed to next Probable Cause.
	Reverser Switch RS-6, A-End	3. Using a multimeter, measure for continuity between RS-6 Contacts 11 and 12.	3a. If missing, remove and replace Reverser Switch
			3b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-15, A-End	4. Using a multimeter, measure for continuity between MCS-15 Contacts 1 and 2.	4a. If missing, remove and replace Reverser Switch
			4b. If OK, proceed to next Probable Cause.
	Transfer Switch TS-3, B-End / Cab Rear Interlock Relay B (CRIRB)	5. Using a multimeter, measure for continuity between TS-3 Contacts 5 and 6.	5a. If missing, remove and replace Transfer Switch
			5b. If OK, remove and replace relay.

5.8.4 Drive/Brake Control

The troubleshooting procedures for the drive/brake control circuits are provided in this subsection. Refer to the Vehicle Schematic diagram, specifically the circuit series starting on Sheet 250. Table 5-4 has been provided for user convenience; this table is sub-divided as follows:

- Table 5-4a. Train Run
- Table 5-4b. Emergency Brake Loop Control
- Table 5-4c. Propulsion and Braking
- Table 5-4d. Deadman Control
- Table 5-4e. Cab Propulsion Inhibit
- Table 5-4f. Train Propulsion Inhibit
- Table 5-4g. No Motion Circuit Interface

WARNING

THE FOLLOWING TABLES INCLUDE INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY OR DEATH.

Table 5-4a. Train Run

Symptom	Probable Cause	Tests & Checks	Corrective Action
No Direction Control Trainline. A car leading. Train will not move in the FORWARD direction. <u>Assumptions:</u> Reverser Switch is in the FORWARD position.	**TIP:** Change the Reverser Switch to the REVERSE position. If the car moves, the DCFR1A relay is likely the culprit.		
	Cab Control Circuit Breaker A (CCCBA)	1. Using a multimeter, measure for 28 VDC at wire 31AA (CFIRA Contact C2).	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Propulsion Control Circuit Breaker A (PCCBA)	2. Using a multimeter, measure for 28 VDC at wire 35AA (CFIRA Contact C4).	2a. If missing, remove and replace circuit breaker.
			2b. If OK, proceed to next Probable Cause.
	Cab Front Interlock Relay A (CFIRA)	3. Using a multimeter, measure for 28 VDC at wire 31AJ (CFIRA Contact NO2).	3a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			3b. If OK, proceed to next Tests & Checks.
		4. Using a multimeter, measure for 28 VDC at wire 35GN (CFIRA Contact NO4).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Cab Rear Interlock Relay A (CRIRA)	5. Using a multimeter, measure for 28 VDC at wire 31AK (CRIRA Contact NO2).	5a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			5b. If OK, proceed to next Tests & Checks.
		6. Using a multimeter, measure for 28 VDC at wire 35GP (CRIRA Contact NO4).	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Train Run Diode A (TRDA)	7. Using a multimeter, measure for 28 VDC at wire 31AL (DCFR1A Contact C1).	7a. If missing, remove and replace diode.
			7b. If OK, proceed to next Probable Cause.
	Direction Control Front Relay 1A (DCFR1A)	8. Using a multimeter, measure for 28 VDC at wire 35AD (DCFR1A Terminal X1).	8a. If missing, proceed to next Probable Cause.
			8b. If OK, proceed to next Tests & Checks.
		9. Using a multimeter, measure for 28 VDC at wire 25AS (DCFR1A Contact D1).	9a. If missing, remove and replace relay.
			9b. Perform operational test before returning LRV to service
	Reverser Switch RS-4, A-end / ATO Mode Relay A (ATOMRA)	10. Using a multimeter, measure for 28 VDC at wire 35AC (ATOMRA Contact E3).	10a. If missing, remove and replace switch.
			10b. If OK, continue to troubleshoot ATO Mode Selection (ref. sheet 269).

Table 5-4a. Train Run (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No Direction Control Trainline. B car leading. Train will not move in the FORWARD direction. Assumptions: Reverser Switch is in the FORWARD position.	**TIP:** Change the Reverser Switch to the REVERSE position. If the car moves, the DCFR1B relay is likely the culprit.		
	Cab Control Circuit Breaker B (CCCBB)	1. Using a multimeter, measure for 28 VDC at wire 31BA (CFIRB Contact C2).	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Propulsion Control Circuit Breaker B (PCCBB)	2. Using a multimeter, measure for 28 VDC at wire 35BA (CFIRB Contact C4).	2a. If missing, remove and replace circuit breaker.
			2b. If OK, proceed to next Probable Cause.
	Cab Front Interlock Relay B (CFIRB)	3. Using a multimeter, measure for 28 VDC at wire 31BJ (CFIRB Contact NO2).	3a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			3b. If OK, proceed to next Tests & Checks.
		4. Using a multimeter, measure for 28 VDC at wire 35KL (CFIRB Contact NO4).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Cab Rear Interlock Relay B (CRIRB)	5. Using a multimeter, measure for 28 VDC at wire 31BK (CRIRB Contact NO2).	5a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			5b. If OK, proceed to next Probable Cause.
		6. Using a multimeter, measure for 28 VDC at wire 35KM (CRIRB Contact NO4).	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Train Run Diode B (TRDB)	7. Using a multimeter, measure for 28 VDC at wire 31BL (DCFR1B Contact C1).	7a. If missing, remove and replace diode.
			7b. If OK, proceed to next Probable Cause.
	Direction Control Front Relay 1B (DCFR1B)	8. Using a multimeter, measure for 28 VDC at wire 35BE (DCFR1B Terminal X1).	8a. If missing, proceed to next Probable Cause.
			8b. If OK, proceed to next Tests & Checks.
		9. Using a multimeter, measure for 28 VDC at wire 25DF (DCFR1B Contact D1).	9a. If missing, remove and replace relay.
			9b. Perform operational test before returning LRV to service
	Reverser Switch RS-4, B-end / ATO Mode Relay 1B (ATOMR1B)	10. Using a multimeter, measure for 28 VDC at wire 35BC (ATOMR1B Contact E3).	10a. If missing, remove and replace switch.
			10b. If OK, continue to troubleshoot ATO Mode Selection (ref. sheet 269).

Table 5-4a. Train Run (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No Direction Control Trainline. A car leading. Train will not move in the REVERSE direction. <u>Assumptions:</u> Reverser Switch is in the REVERSE position.	**TIP:** Change the Reverser Switch to the FORWARD position. If the car moves, the DCRRA relay is likely the culprit.		
	Cab Control Circuit Breaker A (CCCBA)	1. Using a multimeter, measure for 28 VDC at wire 31AA (CFIRA Contact C2).	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Propulsion Control Circuit Breaker A (PCCBA)	2. Using a multimeter, measure for 28 VDC at wire 35AA (CFIRA Contact C4).	2a. If missing, remove and replace circuit breaker.
			2b. If OK, proceed to next Probable Cause.
	Cab Front Interlock Relay A (CFIRA)	3. Using a multimeter, measure for 28 VDC at wire 31AJ (CFIRA Contact NO2).	3a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			3b. If OK, proceed to next Tests & Checks.
		4. Using a multimeter, measure for 28 VDC at wire 35GN (CFIRA Contact NO4).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Cab Rear Interlock Relay A (CRIRA)	5. Using a multimeter, measure for 28 VDC at wire 31AK (CRIRA Contact NO2).	5a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			5b. If OK, proceed to next Probable Cause.
		6. Using a multimeter, measure for 28 VDC at wire 35GP (CRIRA Contact NO4).	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Train Run Diode A (TRDA)	7. Using a multimeter, measure for 28 VDC at wire 31AL (DCFR1A Contact C1).	7a. If missing, remove and replace diode.
			7b. If OK, proceed to next Probable Cause.
	Direction Control Reverse Relay A (DCRRA)	8. Using a multimeter, measure for 28 VDC at wire 35AE (DCRRA Terminal X1).	8a. If missing, proceed to next Probable Cause.
			8b. If OK, proceed to next Tests & Checks.
		9. Using a multimeter, measure for 28 VDC at wire 25AS (DCRRA Contact D1).	9a. If missing, remove and replace relay.
			9b. Perform operational test before returning LRV to service.
	Reverser Switch RS-3, A-end / ATO Mode Relay A (ATOMRA)	10. Using a multimeter, measure for 28 VDC at wire 35AB (ATOMRA Contact D3).	10a. If missing, remove and replace switch.
			10b. If OK, continue to troubleshoot ATO Mode Selection Circuit (ref. sheet 269).

Table 5-4a. Train Run (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No Direction Control Trainline. B car leading. Train will not move in the REVERSE direction. <u>Assumptions:</u> Reverser Switch is in the REVERSE position.	**TIP:** Change the Reverser Switch to the FORWARD position. If the car moves, the DCRRB relay is likely the culprit.		
	Cab Control Circuit Breaker B (CCCBB)	1. Using a multimeter, measure for 28 VDC at wire 31BA (CFIRB Contact C2).	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Propulsion Control Circuit Breaker B (PCCBB)	2. Using a multimeter, measure for 28 VDC at wire 35BA (CFIRB Contact C4).	2a. If missing, remove and replace circuit breaker.
			2b. If OK, proceed to next Probable Cause.
	Cab Front Interlock Relay B (CFIRB)	3. Using a multimeter, measure for 28 VDC at wire 31BJ (CFIRB Contact NO2).	3a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			3b. If OK, proceed to next Tests & Checks.
		4. Using a multimeter, measure for 28 VDC at wire 35KL (CFIRB Contact NO4).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Cab Rear Interlock Relay B (CRIRB)	5. Using a multimeter, measure for 28 VDC at wire 31BK (CRIRB Contact NO2).	5a. If missing, remove and replace relay. (Note circuit energizing relay is OK since train turns on via Transfer Switch).
			5b. If OK, proceed to next Probable Cause.
		6. Using a multimeter, measure for 28 VDC at wire 35KM (CRIRB Contact NO4).	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Train Run Diode B (TRDB)	7. Using a multimeter, measure for 28 VDC at wire 31BL (DCFR1B Contact C1).	7a. If missing, remove and replace diode.
			7b. If OK, proceed to next Probable Cause.
	Direction Control Rear Relay B (DCRRB)	8. Using a multimeter, measure for 28 VDC at wire 35BE (DCFR1B Terminal X1).	8a. If missing, proceed to next Probable Cause.
			8b. If OK, proceed to next Tests & Checks.
		9. Using a multimeter, measure for 28 VDC at wire DF (DCRRB Contact D1).	9a. If missing, remove and replace relay.
			9b. Perform operational test before returning LRV to service.
	Reverser Switch RS-3, B-end / ATO Mode Relay 1B (ATOMR1B)	10. Using a multimeter, measure for 28 VDC at wire 35BB (ATOMRA Contact D3).	10a. If missing, remove and replace switch.
			10b. If OK, continue to troubleshoot ATO Mode Selection (ref. sheet 269).

Emergency Brake Loop Control

NOTE: The Emergency Brake (EB) loop control is a closed loop that is designed to open when a potentially dangerous situation is detected. An open EB loop may not be an EB loop malfunction, but is a notification of a situation that requires inspection in another subgroup. The EB loop actually consists of four trainlines that run through all the cars in the LRV. When cars are coupled, these four trainlines continue through all the coupled cars. When the EB loop is closed, *EMERGENCY Loop* relay (ELR) and three *EMERGENCY BRAKE r*elays (EBR1A, EBR1B, & EBR1C) are energized. When the ELR opens, relays EBR1A, EBR1B, & EBR1C de-energize. As a result, power is removed from the Power & Brake trainlines and the PBED signal generator, and the propulsion PLUs and brake ECUs are notified of a condition that requires emergency braking. The operator can open the EB loop by depressing the console EMERGENCY mushroom switch. In order to reset an applied EB, the master controller must be moved to the Full Service Brake (FSB) position.

TIP: The Emergency Brake Loop Control Circuit can be broken down into three sub-circuits as follows:

- The Emergency Loop Relay (ELR) Energizing Circuit – this consists of the circuit path through the MCKSR1, the Master Controller Switches MCS-8 & MCS-9, the ATP EBR, and the ELR. This path is opened ATP applied EB applications.
- The Emergency Brake Relay 1A,1B,1C Energizing Circuit – this consists of the path through MCKSR1, the Master Controller Switches MCS-10 & MCS-13, NMR1, and EBR1A,1B, 1C. This path is opened when the Master Controller is not in the Full Service Brake (FSB) position or when in motion (no motion not active).
- The Emergency Brake Relay 1A,1B,1C Latching Circuit – this consists of the path that is formed once both energizing circuits are energized. This path ties in to the ELR Energizing Circuit through ELR, passes through EBR1B, Emergency Push Buttons (EPB), EBR1A and the Coupler Loop Switch (CLS). This path is opened when the EPB is depressed, along with the shared conditions of the ELR Energizing Circuit.

Table 5-4b. Emergency Brake Loop Control

<table>
<tr><th>Symptom</th><th>Probable Cause</th><th>Tests & Checks</th><th>Corrective Action</th></tr>
<tr><td rowspan="3">EB Loop open while at no motion, A car leading. Train will not move.

<u>Assumptions:</u>
Master Controller in the FSB Position.</td><td colspan="3">TIP: If this is only occurring from the A car, the A-End Master Controller or MCKSR1A are the likely culprits.</td></tr>
<tr><td rowspan="2">Emergency Brake Relay 1A, 1B, 1C Energizing Circuit Fault, A-End</td><td rowspan="2">1. Ensure Master Controller is in the FSB Position. Using a multimeter, measure for 28 VDC between wires 33AL (EBR1A Terminal Y) and 33AN (EBR1A Terminal Z).</td><td>1a. If missing, proceed to the Symptom ‘Emergency Brake Relay 1A, 1B, 1C Energizing Circuit Fault, A-End’ for detailed troubleshooting.</td></tr>
<tr><td>1b. Perform operational test before returning LRV to service</td></tr>
<tr><td rowspan="3">EB Loop open while at no motion, B car leading. Train will not move.

<u>Assumptions:</u>
Master Controller in the FSB Position.</td><td colspan="3">TIP: If this is only occurring from the B car, the B-End Master Controller or MCKSR1B are the likely culprits.</td></tr>
<tr><td rowspan="2">Emergency Brake Relay 1A, 1B, 1C Energizing Circuit Fault, B-End</td><td rowspan="2">1. Ensure Master Controller is in the FSB Position. Using a multimeter, measure for 28 VDC between wires 33BP (EBR1B Terminal Y) and 33BS (EBR1B Terminal Z).</td><td>1a. If missing, proceed to the Symptom ‘Emergency Brake Relay 1A, 1B, 1C Energizing Circuit Fault, B-End’ for detailed troubleshooting.</td></tr>
<tr><td>1b. Perform operational test before returning LRV to service</td></tr>
</table>

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
EB loop opens during motion (EB loop closes at no motion), A car leading. <u>Assumptions:</u> All Emergency Brake Pushbuttons are released.	**TIP:** If this is only occurring from the A car, the A-End Master Controller or MCKSR1A are the likely culprits.		
	Emergency Loop Relay Energizing Circuit Fault, A-End	1. Ensure Master Controller is in the FSB Position. Using a multimeter, measure for 28 VDC between wires 33BF (ELR Terminal Y) and 33BX (ELR Terminal Z).	1a. If missing, proceed to the Symptom 'Emergency Loop Relay Energizing Circuit Fault, A-End' for detailed troubleshooting.
			1b. If OK, proceed to next probable cause.
	Emergency Brake Relay 1A, 1B, 1C Sustaining Circuit Fault	2. Ensure Master Controller is in the FSB Position. Using a multimeter, measure for continuity between wires 33BJ (ELR Contact C1) and 33BW (EBR1A Contact C3).	2a. If missing, proceed to the Symptom 'Emergency Brake Relay 1A, 1B, 1C Latching Circuit Fault' for detailed troubleshooting.
			2b. Perform operational test before returning LRV to service
EB loop opens during motion (EB loop closes at no motion), B car leading. <u>Assumptions:</u> All Emergency Brake Pushbuttons are released.	Emergency Loop Relay Energizing Circuit Fault, B-End	1. Ensure Master Controller is in the FSB Position. Using a multimeter, measure for 28 VDC between wires 33BF (ELR Terminal Y) and 33BX (ELR Terminal Z).	1a. If missing, proceed to the Symptom 'Emergency Loop Relay Energizing Circuit Fault, B-End' for detailed troubleshooting.
			1b. If OK, proceed to next probable cause.
	Emergency Brake Relay 1A, 1B, 1C Sustaining Circuit Fault	2. Ensure Master Controller is in the FSB Position. Using a multimeter, measure for continuity between wires 33BJ (ELR Contact C1) and 33BW (EBR1A Contact C3).	2a. If missing, proceed to the Symptom 'Emergency Brake Relay 1A, 1B, 1C Latching Circuit Fault' for detailed troubleshooting.
			2b. Perform operational test before returning LRV to service

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Brake Relay 1A / 1B / 1C Energizing Circuit Fault, A-End	Emergency Brake Control Circuit Breaker A (EBCCBA)	1. Using a multimeter, measure for 28 VDC at wire 33AA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 1A (MCKSR1A)	2. Using a multimeter, measure for continuity between wires 33AA (MCKSR1A Contact C1) and 33AB (MCKSR1A Contact NO1).	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to **Step 4** Tests & Checks.
		3. Using a multimeter, measure for 28 VDC at wire 25AP (MCKSR1A Terminal Y)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
		4. Using a multimeter, measure for continuity between wires 33AZ (MCKSR1A Contact C4) and EBC LVGA (MCKSR1A Contact NO4).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-10, A-unit	5. Using a multimeter, measure for continuity between wires 33AB (MCS-10 Contact 1) and 33AD (MCS-10 Contact 2).	5a. If missing, remove and replace MCS-10.
			5b. If OK, proceed to next Probable Cause.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Brake Relay 1A / 1B / 1C Energizing Circuit Fault, A-End (cont'd)	No Motion Relay 1A (NMR1A)	6. Using a multimeter, measure for continuity between wires 33AD (NMR1A Contact C1) and 33AL (NMR1A Contact NO1).	6a. If missing, proceed to next Tests & Checks.
			6b. If OK, proceed to **Step 8** Tests & Checks.
		7. Using a multimeter, measure for 28 VDC between wires 32AD (NMR1A Terminal Y) and 32AE (NMR1A Terminal Z).	7a. If missing, continue to troubleshoot No Motion Circuit (ref. sheet 304). Also see Table 5-4g.
			7b. If OK, remove and replace relay.
		8. Using a multimeter, measure for continuity between wires 33AN (NMR1A Contact C2) and 33AY (NMR1A Contact NO2).	8a. If missing, remove and replace relay.
			8b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-13, A-Unit	9. Using a multimeter, measure for continuity between wires 33AY (MCS-13 Contact 1) and 33AZ (MCS-13 Contact 2).	9a. If missing, remove and replace MCS-13.
			9b. Perform operational test before returning LRV to service.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Brake Relay 1A / 1B / 1C Energizing Circuit Fault, B-End	Emergency Brake Control Circuit Breaker B (EBCCBB)	1. Using a multimeter, measure for 28 VDC at wire 33BA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 1B (MCKSR1B)	2. Using a multimeter, measure for continuity between wires 33BA (MCKSR1B Contact C1) and 33BB (MCKSR1B Contact NO1).	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to **Step 4** Tests & Checks.
		3. Using a multimeter, measure for 28 VDC at wire 25DD (MCKSR1B Terminal Y)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
		4. Using a multimeter, measure for continuity between wires 33DE (MCKSR1B Contact C4) and EBC LVGB (MCKSR1B Contact NO4).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-10, B-unit	5. Using a multimeter, measure for continuity between wires 33BB (MCS-10 Contact 1) and 33BC (MCS-10 Contact 2).	5a. If missing, remove and replace MCS-10.
			5b. If OK, proceed to next Probable Cause.
	No Motion Relay 1A (NMR1A)	6. Using a multimeter, measure for continuity between wires 33AD (NMR1A Contact C1) and 33AL (NMR1A Contact NO1).	6a. If missing, proceed to next Tests & Checks.
			6b. If OK, proceed to **Step 8** Tests & Checks.
		7. Using a multimeter, measure for 28 VDC between wires 32AD (NMR1A Terminal Y) and 32AE (NMR1A Terminal Z).	7a. If missing, continue to troubleshoot No Motion Circuit (ref. sheet 304). Also see Table 5-4g.
			7b. If OK, remove and replace relay.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Brake Relay 1A / 1B / 1C Energizing Circuit Fault, B-End (cont'd.)	No Motion Relay 1A (NMR1A)	8. Using a multimeter, measure for continuity between wires 33AN (NMR1A Contact C2) and 33AY (NMR1A Contact NO2).	8a. If missing, remove and replace relay.
			8b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-13, B-unit	9. Using a multimeter, measure for continuity between wires 33DD (MCS-13 Contact 1) and 33DE (MCS-13 Contact 2).	9a. If missing, remove and replace MCS-13.
			9b. Perform operational test before returning LRV to service.
Emergency Loop Relay Energizing Circuit Fault, A-End	Emergency Brake Control Circuit Breaker A (EBCCBA)	1. Using a multimeter, measure for 28 VDC at wire 33AA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 1A (MCKSR1A)	2. Using a multimeter, measure for continuity between wires 33AA (MCKSR1A Contact C2) and 33AC (MCKSR1A Contact NO2).	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to **Step 4** Tests & Checks.
		3. Using a multimeter, measure for 28 VDC at wire 25AP (MCKSR1A Terminal Y)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
		4. Using a multimeter, measure for continuity between wires 33AX (MCKSR1A Contact C3) and EBC LVGA (MCKSR1A Contact NO3).	4a. If missing, remove and relay.
			4b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-8, A-unit NOTE: This switch is jumpered.	5. Using a multimeter, measure for continuity between wires 33AC (MCS-8 Contact 1) and 33AE (MCS-8 Contact 2).	5a. If missing, check jumper.
			5b. If OK, proceed to next Probable Cause.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Loop Relay Energizing Circuit Fault, A-End (cont'd.)	Master Controller Switch MCS-8, B-unit NOTE: This switch is jumpered.	6. Using a multimeter, measure for continuity between wires 33BD (MCS-8 Contact 2) and 33BE (MCS-8 Contact 1).	6a. If missing, check jumper.
			6b. If OK, proceed to next Probable Cause.
	ATP Emergency Brake Relay (EBR)	7. Using a multimeter, measure for continuity between wires 33BE and 33BF.	7a. If missing, EB may be applied by ATC. See RMSM, Section 1500 for ATC Troubleshooting.
			7b. If OK, proceed to next Tests & Checks
		8. Using a multimeter, measure for continuity between wires 33BX and 33DB.	8a. If missing, EB may be applied by ATC. See RMSM, Section 1500 for ATC Troubleshooting.
			8b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-9, B-unit NOTE: This switch is jumpered.	9. Using a multimeter, measure for continuity between wires 33DB (MCS-9 Contact 2) and 33DC (MCS-9 Contact 2).	9a. If missing, check jumper.
			9b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-9, A-unit NOTE: This switch is jumpered.	10. Using a multimeter, measure for continuity between wires 33AW (MCS-9 Contact 1) and 33AX (MCS-9 Contact 2).	10a. If missing, check jumper.
			10b. If OK, proceed to next Probable Cause.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Loop Relay Energizing Circuit Fault, A-End (cont'd.)	Emergency Loop Relay (ELR)	11. Using a multimeter, measure for continuity between wires 33BJ and 33BF (ELR Contacts C1-NO1)	11a. If not OK, remove and replace relay.
			11b. If OK, proceed to next Tests & Checks
		12. Using a multimeter, measure for continuity between wires 33BM and 33BN (ELR Contacts C2-NO2)	12a. If not OK, remove and replace relay.
			12b. If OK, proceed to next Tests & Checks
		13. Using a multimeter, measure for continuity between wires 33BW and 33BX (ELR Contacts C3-NO3)	13a. If not OK, remove and replace relay.
			13b. If OK, proceed to next Tests & Checks
		14. Using a multimeter, measure for continuity between wires 33DA and 33DF (ELR Contacts C4-NO4)	14a. If not OK, remove and replace relay.
			14b. Perform operational test before returning LRV to service.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Loop Relay Energizing Circuit Fault, B-End	Emergency Brake Control Circuit Breaker B (EBCCBB)	1. Using a multimeter, measure for 28 VDC at wire 33BA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 1B (MCKSR1B)	2. Using a multimeter, measure for continuity between wires 33BA (MCKSR1B Contact C2) and 33BD (MCKSR1B Contact NO2).	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to **<u>Step 4</u>** Tests & Checks.
		3. Using a multimeter, measure for 28 VDC at wire 25DD (MCKSR1B Terminal Y)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
		4. Using a multimeter, measure for continuity between wires 33DC (MCKSR1B Contact C3) and EBC LVGB (MCKSR1B Contact NO3).	4a. If missing, remove and relay.
			4b. If OK, proceed to next Probable Cause.
	Master Controller Switch MCS-8, B-unit NOTE: This switch is jumpered.	5. Using a multimeter, measure for continuity between wires 33BD (MCS-8 Contact 2) and 33BE (MCS-8 Contact 1).	5a. If missing, check jumper.
			5b. If OK, proceed to next Probable Cause.
	ATP Emergency Brake Relay (EBR)	6. Using a multimeter, measure for continuity between wires 33BE and 33BF.	6a. If missing, EB may be applied by ATC. See RMSM, Section 1500 for ATC Troubleshooting.
			6b. If OK, proceed to next Tests & Checks
		7. Using a multimeter, measure for continuity between wires 33BX and 33DB.	7a. If missing, may be applied by ATC. See RMSM, Section 1500 for ATC Troubleshooting.
			7b. If OK, proceed to next Probable Cause.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Loop Relay Energizing Circuit Fault, B-End (cont'd.)	Master Controller Switch MCS-9, B-unit NOTE: This switch is jumpered.	8. Using a multimeter, measure for continuity between wires 33DB (MCS-9 Contact 2) and 33DC (MCS-9 Contact 2).	8a. If missing, check jumper.
			8b. Perform operational test before returning LRV to service.
	Emergency Loop Relay (ELR)	9. Using a multimeter, measure for continuity between wires 33BJ and 33BF (ELR Contacts C1-NO1)	9a. If not OK, remove and replace relay.
			9b. If OK, proceed to next Tests & Checks
		10. Using a multimeter, measure for continuity between wires 33BM and 33BN (ELR Contacts C2-NO2)	10a. If not OK, remove and replace relay.
			10b. If OK, proceed to next Tests & Checks
		11. Using a multimeter, measure for continuity between wires 33BW and 33BX (ELR Contacts C3-NO3)	11a. If not OK, remove and replace relay.
			11b. If OK, proceed to next Tests & Checks
		12. Using a multimeter, measure for continuity between wires 33DA and 33DF (ELR Contacts C4-NO4)	12a. If not OK, remove and replace relay.
			12b. Perform operational test before returning LRV to service.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Brake Relay 1A / 1B / 1C Latching Circuit Fault	Emergency Loop Relay (ELR)	1. Using multimeter, measure for continuity between wires 33BF (ELR Contact NO1) and 33BJ (ELR Contact C1)	1a. If missing, remove and replace relay.
			1b. If OK, proceed to next Tests & Checks.
		2. Using multimeter, measure for continuity between wires 33BM (ELR Contact NO2) and 33BN (ELR Contact C2)	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Tests & Checks.
		3. Using multimeter, measure for continuity between wires 33BX (ELR Contact NO3) and 33BW (ELR Contact C3)	3a. If missing, remove and replace relay.
			3b. If OK, proceed to next Tests & Checks.
		4. Using multimeter, measure for continuity between wires 33DF (ELR Contact NO4) and 33DA (ELR Contact C4)	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	Emergency Brake Relay 1B (EBR1B)	5. Using multimeter, measure for continuity between wires 33BJ (EBR1B Contact NO1) and 33BH (EBR1B Contact C1)	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Tests & Checks.
		6. Using multimeter, measure for continuity between wires 33BW (EBR1B Contact NO2) and 33BV (EBR1B Contact C2)	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Emergency Push Button (EPB), B-End	7. Using multimeter, measure for continuity between wires 33BH (EPB contact 12) and 33BG (EPB contact 11)	7a. If missing, remove and replace switch.
			7b. If OK, proceed to next Tests & Checks.
		8. Using multimeter, measure for continuity between wires 33BV (EPB contact 22) and 33BU (EPB contact 21)	8a. If missing, remove and replace switch.
			8b. If OK, proceed to next Probable Cause.

Table 5-4b. Emergency Brake Loop Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Brake Relay 1A / 1B / 1C Latching Circuit Fault (cont'd.)	Emergency Push Button (EPB), A-End	9. Using multimeter, measure for continuity between wires 33AG (EPB contact 12) and 33AF (EPB contact 11)	9a. If missing, remove and replace switch.
			9b. If OK, proceed to next Tests & Checks.
		10. Using multimeter, measure for continuity between wires 33AS (EPB contact 22) and 33AR (EPB contact 21)	10a. If missing, remove and replace switch.
			10b. If OK, proceed to next Probable Cause.
	Emergency Brake Relay 1A (EBR1A)	11. Using multimeter, measure for continuity between wires 33AH (EBR1A Contact NO1) and 33AG (EBR1A Contact C1)	11a. If missing, remove and replace relay.
			11b. If OK, proceed to next Tests & Checks.
		12. Using multimeter, measure for continuity between wires 33AT (EBR1A Contact NO2) and 33AS (EBR1A Contact C2)	12a. If missing, remove and replace relay.
			12b. If OK, proceed to next Probable Cause.
	Coupler Loop Switch (CLS), A-End	13. Using multimeter, measure for continuity between wires 33AH (CLS Contact 25) and 33AK (CLS Contact 27)	13a. If missing, remove and replace CLS.
			13b. If OK, proceed to next Tests & Checks.
		14. Using multimeter, measure for continuity between wires 33AT (CLS Contact 41) and 33AV (CLS Contact 43)	14a. If missing, remove and replace CLS.
			14b. If OK, proceed to next Probable Cause.
	Coupler Loop Switch (CLS), B-End	15. Using multimeter, measure for continuity between wires 33BN (CLS Contact 26) and 33BP (CLS Contact 27)	15a. If missing, remove and replace CLS.
			15b. If OK, proceed to next Tests & Checks.
		16. Using multimeter, measure for continuity between wires 33BS (CLS Contact 43) and 33DF (CLS Contact 42)	16a. If missing, remove and replace CLS.
			16b. Perform operational test before returning LRV to service.

Propulsion and Braking

NOTE

There are five circuits that control propulsion and braking:

- Master Controller Key Switch
- Emergency Brake Circuit
- Cab Propulsion Inhibit Circuit
- Train Propulsion Inhibit Circuit
- ATO Mode Selection Circuit

This table troubleshoots the Power & Brake Trainlines and P-signal control circuits. The troubleshooting for the Deadman control circuit is described in Table 5-4d. The troubleshooting for the Cab Propulsion Inhibit Circuit is described in Table 5-4e. The troubleshooting for the Train Propulsion Inhibit Circuit is described in Table 5-4f.

The Power & Brake Trainlines circuit receives 28 vdc via series-connected contacts of Master Controller Keyswitch relay 2A/B, Emergency Brake relay 2A/B, Cab Propulsion Inhibit relay A/B, and Train Propulsion Inhibit relay A/B.

The P-Signal Generator develops a PWM output at 432 Hz from 5.1% to 91% that is proportional to the setting of the Master Controller handle. This output is provided to the TCN network and on to the PLUs and ECUs, as a data message, to control propulsion and braking.

The following SYMPTOMS assume that the EB loop is closed, there is no propulsion cutout condition, and the three truck ECUs and both car PLUs are operating properly.

Table 5-4c. Propulsion and Braking

Symptom	Probable Cause	Tests & Checks	Corrective Action
Invalid PBED (valid range 16.5% - 91.5%) from A-Unit, manual mode.	Propulsion Control Circuit Breaker A (PCCBA)	1. Using multimeter, measure for 28 VED at wire 35AA of PCCBA.	1a. If missing, remove and replace PCCBA.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 2A (MCKSR2A)	2. Using multimeter, measure for 28 VDC at wire 35AF (MCKSR2A Contact NO2)	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR2A Terminal Y)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
	Emergency Brake Relay 2A (EBR2A)	4. Using multimeter, measure for 28 VDC at wire 35AG (EBR2A Contact NO1)	4a. If missing, proceed to next Tests & Checks.
			4b. If OK, proceed to next Probable Cause.
		5. Using multimeter, measure for 28 VDC at wire 44CK (EBR2A Terminal Y)	5a. If missing, continue to troubleshoot Emergency Brake Circuit (ref. sheet 256). Also see Table 5-4b.
			5b. If OK, remove and replace relay.
	Cab Propulsion Inhibit Relay A (CPIRA)	6. Using multimeter, measure for 28 VDC at wire 35AH (CPIRA Contact NO1)	6a. If missing, proceed to next Tests & Checks.
			6b. If OK, proceed to next Probable Cause.
		7. Using multimeter, measure for 28 VDC at wire 35AU (CPIRA Terminal Y)	7a. If missing, continue to troubleshoot Cab Prop Inhibit Circuit (ref. sheet 261). Also see Table 5-4e.
			7b. If OK, remove and replace relay.
	Train Propulsion Inhibit Relay A (TPIRA)	8. Using multimeter, measure for 28 VDC at wire 35AJ (TPIRA Contact NO1)	8a. If missing, proceed to next Tests & Checks.
			8b. If OK, proceed to next Probable Cause.
		9. Using multimeter, measure for 28 VDC at wire 31CC (TPIRA Terminal Y)	9a. If missing, continue to troubleshoot Train Prop Inhibit Circuit (ref. sheet 263). Also see Table 5-4f.
			9b. If OK, remove and replace relay.

Table 5-4c. Propulsion and Braking (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Invalid PBED (valid range 16.5% - 91.5%) from A-Unit, manual mode. (cont'd.)	ATO Mode Relay A (ATOMRA)	10. Using multimeter, measure for 28 VDC at wire 35AK (ATOMRA Contact F3)	10a. If missing, proceed to next Test & Checks.
			10b. If OK, proceed to next Probable Cause.
		11. Using multimeter, measure for 0 VDC at wire 31GR (ATOMRA Contact X1)	11a. If voltage present, continue to troubleshoot ATO Mode Selection Circuit (ref. sheet 269).
			11b. If OK, remove and replace relay.
	P-Signal Generator / TCN Rack	12. Using oscilloscope verify PWM waveform at P1-106 to P1-107	12a. If missing, remove and replace Master Controller.
			12b. If present, remove and replace TCN.
			12c. Perform operational test before returning LRV to service.
Invalid PBED (valid range 16.5% - 91.5%) from B-Unit, manual mode.	Propulsion Control Circuit Breaker B (PCCBB)	1. Using multimeter, measure for 28 VED at wire 35BA of PCCBB.	1a. If missing, remove and replace PCCBB.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 2B (MCKSR2B)	2. Using multimeter, measure for 28 VDC at wire 35BH (MCKSR2B Contact NO2)	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR2B Terminal Y)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
	Emergency Brake Relay 2B (EBR2B)	4. Using multimeter, measure for 28 VDC at wire 35BJ (EBR2B Contact NO1)	4a. If missing, proceed to next Tests & Checks.
			4b. If OK, proceed to next Probable Cause.
		5. Using multimeter, measure for 28 VDC at wire 44FT (EBR2B Terminal Y)	5a. If missing, continue to troubleshoot Emergency Brake Circuit (ref. sheet 256). Also see Table 5-4b.
			5b. If OK, remove and replace relay.

Table 5-4c. Propulsion and Braking (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Invalid PBED (valid range 16.5% - 91.5%) from B-Unit, manual mode. (cont'd.)	Cab Propulsion Inhibit Relay B (CPIRB)	6. Using multimeter, measure for 28 VDC at wire 35BK (CPIRB Contact NO1)	6a. If missing, proceed to next Tests & Checks.
			6b. If OK, proceed to next Probable Cause.
		7. Using multimeter, measure for 28 VDC at wire 35BU (CPIRB Terminal Y)	7a. If missing, continue to troubleshoot Cab Prop Inhibit Circuit (ref. sheet 261). Also see Table 5-4e.
			7b. If OK, remove and replace relay.
	Train Propulsion Inhibit Relay B (TPIRB)	8. Using multimeter, measure for 28 VDC at wire 35BL (TPIRB Contact NO1)	8a. If missing, proceed to next Tests & Checks.
			8b. If OK, proceed to next Probable Cause.
		9. Using multimeter, measure for 28 VDC at wire 31DF (TPIRB Terminal Y)	9a. If missing, continue to troubleshoot Train Prop Inhibit Circuit (ref. sheet 263). Also see Table 5-4f.
			9b. If OK, remove and replace relay.
	ATO Mode Relay 1B (ATOMR1B)	10. Using multimeter, measure for 28 VDC at wire 35BP (ATOMR1B Contact F3)	10a. If missing, proceed to next Test & Checks.
			10b. If OK, proceed to next Probable Cause.
		11. Using multimeter, measure for 0 VDC at wire 31HU (ATOMR1B Contact X1)	11a. If voltage present, continue to troubleshoot ATO Mode Selection Circuit (ref. sheet 269).
			11b. If OK, remove and replace relay.
	P-Signal Generator / TCN Rack	12. Using oscilloscope verify PWM waveform at P1-106 to P1-107	12a. If missing, remove and replace Master Controller.
			12b. If present, remove and replace TCN.
			12c. Perform operational test before returning LRV to service.

Table 5-4c. Propulsion and Braking (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Invalid PBED (valid range 16.5% - 91.5%) from A-Unit, ATO mode (manual mode OK). <u>Assumptions:</u> Line Selector Switch is placed into Type II position and ATO Mode Switch in AUTO Position.	Line Selector Switch (LSS) Contacts 1-13/14 (Type II direct input to ATC)	1. Using multimeter, measure for 28 VDC at wire 56BC (LSS Contact 1-14).	1a. If missing, remove and replace switch.
			1b. If OK, proceed to next Probable Cause
	Line Selector Switch (LSS) Contacts 3-21/22 (ATO Mode indirect input to ATC)	2. Using multimeter, measure for 0 VDC at wire 47FW (LSS Contact 3-21).	2a. If voltage present, remove and replace switch.
			2b. If OK, proceed to next Probable Cause.
	ATO Mode Switch (A-End) / ATO Auto Diode (ATOAD)	3. Using multimeter, measure for 28 VDC at wire 31CL (ATO Mode Switch Contact 14)	3a. If missing, check between switch and diode. Remove and replace faulty component.
			3b. If OK, proceed to next Probable Cause
	Manual Door Relay B (MDRB)	4. Using multimeter, measure for 28 VDC at wire 31HU (MDRB Contact A3)	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	ATO Mode Relay 2B (ATOMR2B)	5. Using multimeter, measure for 28 VDC at wire 56BE (ATOMR2B Contact B1)	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Tests & Checks
		6. Using multimeter, measure for 28 VDC at wire 35HL (ATOMR2B Contact A1)	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Manual Door Relay A (MDRA)	7. Using multimeter, measure for 28 VDC at wire 31GR (MDRA Contact A3)	7a. If missing, remove and replace relay.
			7b. If OK, proceed to next Probable Cause.
	ATO Mode Relay A (ATOMRA)	8. Using multimeter, measure for <u>discontinuity</u> (open circuit) between the following ATOMRA contacts: • D2-D3 • E2-E3 • F2-F3	8a. If continuity measured between any contact pairs, remove and replace relay.
			8b. If OK, perform operational test before returning LRV to service.

Table 5-4c. Propulsion and Braking (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Invalid PBED (valid range 16.5% - 91.5%) from B-Unit, ATO mode (manual mode OK). Assumptions: Line Selector Switch is placed into Type II position and ATO Mode Switch in AUTO Position.	Line Selector Switch (LSS) Contacts 1-13/14 (Type II direct input to ATC)	1. Using multimeter, measure for 28 VDC at wire 56BC (LSS Contact 1-14).	1a. If missing, remove and replace switch.
			1b. If OK, proceed to next Probable Cause
	Line Selector Switch (LSS) Contacts 3-21/22 (ATO Mode indirect input to ATC)	2. Using multimeter, measure for 0 VDC at wire 47FW (LSS Contact 3-21).	2a. If voltage present, remove and replace switch.
			2b. If OK, proceed to next Probable Cause.
	ATO Mode Switch (B-End) / ATO Auto Diode (ATOAD)	3. Using multimeter, measure for 28 VDC at wire 31DR (ATO Mode Switch Contact 14)	3a. If missing, check between switch and diode. Remove and replace faulty component.
			3b. If OK, proceed to next Probable Cause
	Manual Door Relay B (MDRB)	4. Using multimeter, measure for 28 VDC at wire 31HU (MDRB Contact A3)	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
	ATO Mode Relay 2B (ATOMR2B)	5. Using multimeter, measure for 28 VDC at wire 56BE (ATOMR2B Contact B1)	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Tests & Checks.
		6. Using multimeter, measure for 28 VDC at wire 35HL (ATOMR2B Contact A1)	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	ATO Mode Relay 1B (ATOMR1B)	7. Using multimeter, measure for discontinuity (open circuit) between the following ATOMR1B contacts: • D2-D3 • E2-E3 • F2-F3	7a. If continuity measured between any contact pairs, remove and replace relay.
			7b. If OK, perform operational test before returning LRV to service.

Deadman Control

NOTE: The Deadman control circuit interfaces with the Cab Propulsion circuit to enable propulsion. In Type I operation (and Type II manual mode) Deadman handle must be engaged to energize the control circuit. In Type II ATO operation the ATC equipment controls the Power/Brake trainlines and the PBED signal generator. The master controller must remain in the FSB position. As such, the Deadman handle does not need to be engaged to energize the control circuit. In either mode of operation, the Deadman Control Circuit must be operational to operate the train as there is no bypass available for Deadman.

Table 5-4d. Deadman Control

Symptom	Probable Cause	Tests & Checks	Corrective Action
Deadman Control Circuit Failure, A-end	Cab Control Circuit Breaker A (CCCBA)	1. Using multimeter, measure for 28 VDC at wire 31AA of CCCBA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	2. Using multimeter, measure for 28 VDC at wire 31AV (MCKSR6A Contact B1)	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
	Master Controller Switch 4 (MCS-4)	4. Place the Master Controller in the FSB position. Disengage the Deadman handle. Using multimeter, measure for 28 VDC at wire 31AW (MCS-4 Terminal 2).	4a. If missing, remove and replace MCS-4.
			4b. If OK, proceed to next Probable Cause.
	Deadman Relay A (DMRA)	5. Place the Master Controller in the FSB position. Disengage the Deadman handle. Using multimeter, measure for 28 VDC at wire 31AX (DMRA Contact C1)	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Deadman Switch (DMS)	6. Engage the Deadman Handle, then place the Master Controller in the Bmin position. Using multimeter, measure for 28 VDC at wire 31AX (DMS Contact 4)	6a. If missing, remove and replace DMS
			6b. Perform operational test before returning LRV to service.

Table 5-4d. Deadman Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Deadman Control Circuit Failure, B-end	Cab Control Circuit Breaker B (CCCBB)	1. Using multimeter, measure for 28 VDC at wire 31BA of CCCBB.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6B (MCKSR6B)	2. Using multimeter, measure for 28 VDC at wire 31BX (MCKSR6B Contact B1)	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
	Master Controller Switch 4 (MCS-4)	4. Place the Master Controller in the FSB position. Disengage the Deadman handle. Using multimeter, measure for 28 VDC at wire 31BY (MCS-4 Terminal 2).	4a. If missing, remove and replace MCS-4.
			4b. If OK, proceed to next Probable Cause.
	Deadman Relay B (DMRB)	5. Place the Master Controller in the FSB position. Disengage the Deadman handle. Using multimeter, measure for 28 VDC at wire 31BZ (DMRB Contact C1)	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Deadman Switch (DMS)	6. Engage the Deadman Handle, then place the Master Controller in the Bmin position. Using multimeter, measure for 28 VDC at wire 31BZ (DMS Contact 4)	6a. If missing, remove and replace DMS
			6b. Perform operational test before returning LRV to service.

Cab Propulsion Inhibit

NOTE: The cab propulsion inhibit circuit is enabled when multiple conditions are correct. Those conditions are as follows:

- Active Cab (Master Controller Keyswitch relay is energized)
- No Network Control faults (Network Control relay de-energized)
  NOTE: The Network Control Relay (NCRA/B) was initially included to inhibit train operation if the log-in information is invalid from the RFID reader located on the cab console. This function is not implemented at the request of Metro.
- Doors are Closed and Locked (DLCRA/DRCRA or DLCRB/DRCRB are energized)
- Deadman is operational (DMRA/B is energized)
- PLUs have not detected overspeed (Speed Governor Relay is de-energized)
- No Full Service Brake (FSB) requests by ATC

Table 5-4e. Cab Propulsion Inhibit

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Propulsion Inhibit Fault from A-Unit, manual mode. Assumptions: Deadman handle engaged and all doors closed.	Cab Control Circuit Breaker A (CCCBA)	1. Using multimeter, measure for 28 VDC at wire 31AA of CCCBA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 2A (MCKSR2A)	2. Using multimeter, measure for 28 VDC at wire 31AM (MCKSR2A Contact NO3)	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR2A Terminal X1)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
	Network Control Relay A (NCRA) **NOTE:** **The NCRA is expected to be de-energized at all times.**	4. Using multimeter, measure for 28 VDC at wire 31AN (NCRA Contact NC1)	4a. If missing, proceed to next Tests & Checks
			4b. If OK, proceed to next Probable Cause.
		5. Using multimeter, measure for 0 VDC at wire 62AD (NCRA Terminal Y)	5a. If voltage present, remove and replace TCN.
			5b. If OK, remove and replace relay.
	Master Controller switches 2 and 5 (MCS-2, MCS-5)	6. Place Master Controller in FSB position. Using multimeter, measure for 28 VDC at wire 31AS.	6a. If missing, replace MCS-2 or MCS-5.
			6b. If OK, proceed to next Probable Cause.

Table 5-4e. Cab Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Propulsion Inhibit Fault from A-Unit, manual mode (cont'd.)	Deadman Relay A (DMRA)	7. Using multimeter, measure for 28 VDC at wire 31AT (DMRA Contact NO3)	7a. If missing, proceed to next Tests & Checks.
			7b. If OK, proceed to next Probable Cause.
		8. Using multimeter, measure for 28 VDC at wire 31AW (DMRA Terminal Y)	8a. If missing, continue to troubleshoot Deadman Control (ref. sheet 262). Also see Table 5-4d.
			8b. If OK, remove and replace relay.
	Speed Governor Relay A (SGRA)	9. Using multimeter, measure for 28 VDC at wire 31EM (SGRA Contact D3)	9a. If missing, proceed to next Tests & Checks.
			9b. If OK, proceed to next Probable Cause.
		10. Using multimeter, measure for 0 VDC at wire 35AY (SGRA Terminal X1)	10a. If voltage present, see RMSM, Section 0700 for Propulsion Troubleshooting.
			10b. If OK, remove and replace relay.
	ATC FSB Relay	11. Using multimeter, measure for 28 VDC at wire 31AU (CPIRA Terminal Y)	11a. If missing, see RMSM, Section 1500 for ATC Troubleshooting.
			11b. If OK, proceed to next Probable Cause.
	Door Left Close Relay A (DLCRA)	**FOLLOW ALL LACMTA SAFETY PROCEDURES.** 12. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 31AP (DLCRA Contact A1).	12a. If missing, proceed to next Tests & Checks.
			12b. If OK, proceed to next Probable Cause.
		FOLLOW ALL LACMTA SAFETY PROCEDURES. 13. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 49AR (DLCRA Terminal X1).	13a. If missing, continue to troubleshoot Door Close Indication TL (ref. sheet 529). Also see Table 5-6c.
			13b. If OK, remove and replace relay.

Table 5-4e. Cab Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Propulsion Inhibit Fault from A-Unit, manual mode (cont'd.)	Door Right Close Relay A (DRCRA)	**FOLLOW ALL LACMTA SAFETY PROCEDURES.** 14. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 31AR (DRCRA Contact A1).	14a. If missing, proceed to next Tests & Checks.
			14b. If OK, proceed to next Probable Cause.
		FOLLOW ALL LACMTA SAFETY PROCEDURES. 15. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 49AP (DRCRA Terminal X1).	15a. If missing, continue to troubleshoot Door Close Indication TL (ref. sheet 529). Also see Table 5-6c.
			15b. If OK, remove and replace relay.
	Cab Propulsion Inhibit Relay A (CPIRA)	**FOLLOW ALL LACMTA SAFETY PROCEDURES.** 16. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 31AS (CPIRA Contact NO2).	16a. If missing, remove and replace relay.
			16b. Perform operational test before returning LRV to service.

Table 5-4e. Cab Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Propulsion Inhibit Fault from B-Unit, manual mode. <u>Assumptions:</u> Deadman handle engaged and all doors closed.	Cab Control Circuit Breaker B (CCCBB)	1. Using multimeter, measure for 28 VDC at wire 31BA of CCCBB.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 2B (MCKSR2B)	2. Using multimeter, measure for 28 VDC at wire 31BM (MCKSR2B Contact NO3)	2a. If missing, proceed to next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR2B Terminal X1)	3a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			3b. If OK, remove and replace relay.
	Network Control Relay B (NCRB) **<u>NOTE:</u>** **The NCRB is expected to be de-energized at all times.**	4. Using multimeter, measure for 28 VDC at wire 31BN (NCRB Contact NC1)	4a. If missing, proceed to next Tests & Checks
			4b. If OK, proceed to next Probable Cause.
		5. Using multimeter, measure for 0 VDC at wire 62BD (NCRB Terminal Y)	5a. If voltage present, remove and replace TCN.
			5b. If OK, remove and replace relay.
	Master Controller switches 2 and 5 (MCS-2, MCS-5)	6. Place Master Controller in FSB position. Using multimeter, measure for 28 VDC at wire 31BS.	6a. If missing, replace MCS-2 or MCS-5.
			6b. If OK, proceed to next Probable Cause.

Table 5-4e. Cab Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Propulsion Inhibit Fault from B-Unit, manual mode (cont'd.)	Deadman Relay B (DMRB)	7. Using multimeter, measure for 28 VDC at wire 31FS (DMRB Contact NO3)	7a. If missing, proceed to next Tests & Checks.
			7b. If OK, proceed to next Probable Cause.
		8. Using multimeter, measure for 28 VDC at wire 31BY (DMRB Terminal Y)	8a. If missing, continue to troubleshoot Deadman Control (ref. sheet 262). Also see Table 5-4d.
			8b. If OK, remove and replace relay.
	Speed Governor Relay B (SGRB)	9. Using multimeter, measure for 28 VDC at wire 31BT (SGRB Contact D3)	9a. If missing, proceed to next Tests & Checks.
			9b. If OK, proceed to next Probable Cause.
		10. Using multimeter, measure for 0 VDC at wire 35DB (SGRB Terminal X1)	10a. If voltage present, see RMSM, Section 0700 for Propulsion Troubleshooting.
			10b. If OK, remove and replace relay.
	ATC FSB Relay	11. Using multimeter, measure for 28 VDC at wire 31BU (CPIRB Terminal Y)	11a. If missing, see RMSM, Section 1500 for ATC Troubleshooting.
			11b. If OK, proceed to next Probable Cause.
	Door Left Close Relay B (DLCRB)	**FOLLOW ALL LACMTA SAFETY PROCEDURES.** 12. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 31BP (DLCRB Contact A1).	12a. If missing, proceed to next Tests & Checks.
			12b. If OK, proceed to next Probable Cause.
		FOLLOW ALL LACMTA SAFETY PROCEDURES. 13. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 49BK (DLCRB Terminal X1).	13a. If missing, continue to troubleshoot Door Close Indication TL (ref. sheet 529). Also see Table 5-6c.
			13b. If OK, remove and replace relay.

Table 5-4e. Cab Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Cab Propulsion Inhibit Fault from B-Unit, manual mode (cont'd.)	Door Right Close Relay B (DRCRB)	**FOLLOW ALL LACMTA SAFETY PROCEDURES.** 14. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 31BR (DRCRB Contact A1).	14a. If missing, proceed to next Tests & Checks.
			14b. If OK, proceed to next Probable Cause.
		FOLLOW ALL LACMTA SAFETY PROCEDURES. 15. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 49BL (DRCRB Terminal X1).	15a. If missing, continue to troubleshoot Door Close Indication TL (ref. sheet 529). Also see Table 5-6c.
			15b. If OK, remove and replace relay.
	Cab Propulsion Inhibit Relay B (CPIRB)	**FOLLOW ALL LACMTA SAFETY PROCEDURES.** 16. With the wheels choked, move the Master Controller to the COAST position. Using multimeter, measure for 28 VDC at wire 31BS (CPIRB Contact NO2).	16a. If missing, remove and replace relay.
			16b. Perform operational test before returning LRV to service.

Train Propulsion Inhibit

NOTE: The train propulsion inhibit circuit is enabled when multiple conditions are correct. Those conditions are as follows:

- Active Cab Head End relay is energized
- End of train Tail End relay is energized
- Friction Brake Cutout relay is energized (No ECU faults)
- Friction Brake Fault relay is energized (No brakes are manually or electrically cutout)
- Door Right Closed Summary relay is energized
- Door Left Closed Summary relay is energized
- Train Propulsion Inhibit relay is energized

Table 5-4f. Train Propulsion Inhibit

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train Propulsion Inhibit Fault, Train propulsion inoperative from A-Unit, manual mode.	Cab Control Circuit Breaker B (CCCBB)	1. Using multimeter, measure for 28 VDC at wire 31BA of CCCBB.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Train Propulsion Inhibit Diode B (TPIDB)	2. Using multimeter, measure for 28 VDC at wire 31DA (TER1B Contact C1)	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next Probable Cause
	Tail End Relay 1B (TER1B)	3. Using multimeter, measure for continuity between wires 31DA and 31DB (TER1B Contacts C1-NO1).	3a. If missing, proceed to **<u>Step 5</u>** Tests & Checks.
			3b. If OK, proceed to next Tests & Checks.
		4. Using multimeter, measure for continuity between wires 31DH and 31LVGB (TER1B Contacts C2-NO2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
		5. Using multimeter, measure for 28 VDC at wire 31BE (TER1B Terminal Y)	5a. If missing, continue to troubleshoot Head and Tail End Control (ref. sheet 251).
			5b. If OK, remove and replace relay.

Table 5-4f. Train Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train Propulsion Inhibit Fault, Train propulsion inoperative from A-Unit, manual mode. (cont'd)	Friction Brake Cutout Relay (FBCOR)	6. Using multimeter, measure for continuity between wires 31DB and 31DC (FBCOR Contacts A2-A1)	6a. If missing, proceed to **Step 8** Tests & Checks.
			6b. If OK, proceed to next Tests & Checks
		7. Using multimeter, measure for continuity between wires 31DH and 31DJ (FBCOR Contacts B2-B1)	7a. If missing, remove and replace relay.
			7b. If OK, proceed to next Probable Cause.
		8. Using multimeter, measure for 28 VDC at wire 44HP (FBCOR Terminal X1)	8a. If missing, continue to troubleshoot Head and Tail End Control (ref. sheet 406).
			8b. If OK, remove and replace relay.
	Friction Brake Fault Relay (FBFR)	9. Using multimeter, measure for continuity between wires 31DC and 31DD (FBFR Contacts A2-A1)	9a. If missing, proceed to **Step 11** Tests & Checks.
			9b. If OK, proceed to next Tests & Checks
		10. Using multimeter, measure for continuity between wires 31DJ and 31DK (FBFR Contacts B2-B1)	10a. If missing, remove and replace relay.
			10b. If OK, proceed to next Probable Cause.
		11. Using multimeter, measure for 28 VDC at wire 44BR (FBFR Terminal X1)	11a. If missing, continue to troubleshoot Head and Tail End Control (ref. sheet 406). See RMSM, Section 1300 for Brakes Troubleshooting.
			11b. If OK, remove and replace relay.
	Door Right Closed Signal Relay (DRCSR)	12. Using multimeter, measure for continuity between wires 31CB and 31CA (DRCSR Contacts NO2-C2)	12a. If missing, proceed to **Step 14** Tests & Checks.
			12b. If OK, proceed to next Tests & Checks
		13. Using multimeter, measure for continuity between wires 31CF and 31CG (DRCSR Contacts C3-NO3)	13a. If missing, remove and replace relay.
			13b. If OK, proceed to next Probable Cause.
		14. Using multimeter, measure for 28 VDC at wire 49AG (DRCSR Contact Y)	14a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			14b. If OK, remove and replace relay.

Table 5-4f. Train Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train Propulsion Inhibit Fault, Train propulsion inoperative from A-Unit, manual mode. (cont'd)	Door Left Closed Signal Relay (DLCSR)	15. Using multimeter, measure for continuity between wires 31CA and 31AZ (DLCSR Contacts NO2-C2)	15a. If missing, proceed to **Step 17** Tests & Checks.
			15b. If OK, proceed to next Tests & Checks
		16. Using multimeter, measure for continuity between wires 31CF and 31CE (DLCSR Contacts NO3-C3)	16a. If missing, remove and replace relay.
			16b. If OK, proceed to next Probable Cause.
		17. Using multimeter, measure for 28 VDC at wire 49AD (DLCSR Contact Y)	17a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			17b. If OK, remove and replace relay.
	Head End Relay 1A (HER1A)	18. Using multimeter, measure for continuity between wires 31AZ and 31CC (HER1A Contacts C1-NO1)	18a. If missing, proceed to **Step 20** Tests & Checks.
			18b. If OK, proceed to next Tests & Checks.
		19. Using multimeter, measure for continuity between wires 31CD and 31CE (HER1A Contacts C2-NO2)	19a. If missing, remove and replace relay.
			19b. If OK, proceed to next Probable Cause.
		20. Using multimeter, measure for 28 VDC at wire 31AC (HER1A Terminal Y)	20a. If missing, continue to troubleshoot Head and Tail End Control Circuit (ref. sheet 251).
			20b. If OK, remove and replace relay.
	Train Propulsion Inhibit Relay A (TPIRA)	21. Using multimeter, measure for continuity between wires 35AH and 35AJ (TPIRA Contacts C1-NO1)	21a. If missing, remove and replace relay.
			21b. Perform operational test before returning LRV to service.

Table 5-4f. Train Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train Propulsion Inhibit Fault, Train propulsion inoperative from B-Unit, manual mode.	Cab Control Circuit Breaker A (CCCBA)	1. Using multimeter, measure for 28 VDC at wire 31AA of CCCBA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Train Propulsion Inhibit Diode A (TPIDA)	2. Using multimeter, measure for 28 VDC at wire 31AY (TER1A Contact C1)	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next Probable Cause
	Tail End Relay 1A (TER1A)	3. Using multimeter, measure for continuity between wires 31AY and 31AZ (TER1A Contacts C1-NO1).	3a. If missing, proceed to **<u>Step 5</u>** Tests & Checks.
			3b. If OK, proceed to next Tests & Checks.
		4. Using multimeter, measure for continuity between wires 31CE and 31LVGA (TER1A Contacts C2-NO2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Probable Cause.
		5. Using multimeter, measure for 28 VDC at wire 31AE (TER1A Terminal Y)	5a. If missing, continue to troubleshoot Head and Tail End Control (ref. sheet 251).
			5b. If OK, remove and replace relay.

Table 5-4f. Train Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train Propulsion Inhibit Fault, Train propulsion inoperative from B-Unit, manual mode. (cont'd)	Door Left Closed Signal Relay (DLCSR)	6. Using multimeter, measure for continuity between wires 31CA and 31AZ (DLCSR Contacts NO2-C2)	6a. If missing, proceed to **Step 8** Tests & Checks.
			6b. If OK, proceed to next Tests & Checks.
		7. Using multimeter, measure for continuity between wires 31CF and 31CE (DLCSR Contacts NO3-C3)	7a. If missing, remove and replace relay.
			7b. If OK, proceed to next Probable Cause.
		8. Using multimeter, measure for 28 VDC at wire 49AD (DLCSR Contact Y)	8a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			8b. If OK, remove and replace relay.
	Door Right Closed Signal Relay (DRCSR)	9. Using multimeter, measure for continuity between wires 31CB and 31CA (DRCSR Contacts NO2-C2)	9a. If missing, proceed to **Step 11** Tests & Checks.
			9b. If OK, proceed to next Tests & Checks.
		10. Using multimeter, measure for continuity between wires 31CF and 31CG (DRCSR Contacts C3-NO3)	10a. If missing, remove and replace relay.
			10b. If OK, proceed to next Probable Cause.
		11. Using multimeter, measure for 28 VDC at wire 49AG (DRCSR Contact Y)	11a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			11b. If OK, remove and replace relay.
	Friction Brake Fault Relay (FBFR)	12. Using multimeter, measure for continuity between wires 31DC and 31DD (FBFR Contacts A2-A1)	12a. If missing, proceed to **Step 14** Tests & Checks.
			12b. If OK, proceed to next Tests & Checks
		13. Using multimeter, measure for continuity between wires 31DJ and 31DK (FBFR Contacts B2-B1)	13a. If missing, remove and replace relay.
			13b. If OK, proceed to next Probable Cause.
		14. Using multimeter, measure for 28 VDC at wire 44BR (FBFR Terminal X1)	14a. If missing, continue to troubleshoot Head and Tail End Control (ref. sheet 406). See RMSM, Section 1300 for Brakes Troubleshooting.
			14b. If OK, remove and replace relay.

Table 5-4f. Train Propulsion Inhibit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Train Propulsion Inhibit Fault, Train propulsion inoperative from B-Unit, manual mode. (cont'd)	Friction Brake Cutout Relay (FBCOR)	15. Using multimeter, measure for continuity between wires 31DB and 31DC (FBCOR Contacts A2-A1)	15a. If missing, proceed to **Step 17** Tests & Checks.
			15b. If OK, proceed to next Tests & Checks.
		16. Using multimeter, measure for continuity between wires 31DH and 31DJ (FBCOR Contacts B2-B1)	16a. If missing, remove and replace relay.
			16b. If OK, proceed to next Probable Cause.
		17. Using multimeter, measure for 28 VDC at wire 44HP (FBCOR Terminal X1)	17a. If missing, continue to troubleshoot Head and Tail End Control (ref. sheet 406).
			17b. If OK, remove and replace relay.
	Head End Relay 1B (HER1B)	18. Using multimeter, measure for continuity between wires 31AZ and 31CC (HER1B Contacts C1-NO1)	18a. If missing, proceed to **Step 20** Tests & Checks.
			18b. If OK, proceed to next Tests & Checks.
		19. Using multimeter, measure for continuity between wires 31CD and 31CE (HER1B Contacts C2-NO2)	19a. If missing, remove and replace relay.
			19b. If OK, proceed to next Probable Cause.
		20. Using multimeter, measure for 28 VDC at wire 31AC (HER1B Terminal Y)	20a. If missing, continue to troubleshoot Head and Tail End Control Circuit (ref. sheet 251).
			20b. If OK, remove and replace relay.
	Train Propulsion Inhibit Relay B (TPIRB)	21. Using multimeter, measure for continuity between wires 35BK and 35BL (TPIRB Contacts C1-NO1)	21a. If missing, remove and replace relay.
			21b. Perform operational test before returning LRV to service.

No Motion Circuit Interface

The No Motion circuit is enabled when multiple conditions are correct. Those conditions are as follows:

- Both PLUs detect No motion and close NMRK relay contacts
- Both motor truck ECUs detect No motion and close R05 relay contacts
- No Motion relay C is energized
- Four other No Motion relays are then energized

Table 5-4g. No Motion Circuit Interface

Symptom	Probable Cause	Tests & Checks	Corrective Action
No Motion is inoperative.	Propulsion Logic CB A (PLCBA)	1. Using multimeter measure for 28 VDC at wire 32AA of PLCBA.	1a. If missing, remove and replace PLCBA.
			1b. If OK, proceed to next Probable Cause.
	Propulsion Logic Unit A	2. Check status of NMRK relay. Using multimeter measure for 28 VDC at wire 32AB	2a. If voltage is absent, check Section 0700 RMSM for Propulsion troubleshooting. Removal and replacement of NMRK relay may be necessary.
			2b. If OK, proceed to next Probable Cause.
	Electronic Control Unit A	3. Check status of R05 relay. Using multimeter measure for 28 VDC at wire 32AC	3a. If voltage is absent, check Section 1300 RMSM for Brakes troubleshooting. Removal and replacement of the EB01A board may be necessary.
			3b. If OK, proceed to next Probable Cause.

Table 5-4g. No Motion Circuit Interface (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No Motion is inoperative. (cont'd.)	Propulsion Logic Unit B	4. Check status of NMRK relay. Using multimeter measure for continuity between wire 32BH and 32BJ.	4a. If not OK, check Section 0700 RMSM for Propulsion troubleshooting. Removal and replacement of NMRK relay may be necessary.
			4b. If OK, proceed to next Probable Cause.
	Electronic Control Unit B	5. Check status of R05 relay. Using multimeter measure for continuity between wire 32BJ and 32LVGB.	5a. If not OK, check Section 1300 RMSM for Brakes troubleshooting. Removal and replacement of the EB01A board may be necessary.
			5b. If OK, proceed to next Probable Cause.
	No Motion Relay C (NMRC)	6. Measure for continuity between wires 32BB (NMRC Contact C2) and wire 32BC (NO2)	6a. If not OK, remove and replace relay. (Note: circuit energizing relay was checked in previous Tests & Checks.)
			6b. If OK, proceed to next Tests & Checks.
		7. Measure for continuity between wires 32BD (NMRC Contact C1) and wire 32LVGB (NO1)	7a. If not OK, remove and replace relay.
			7b. If OK, proceed to next Probable Cause.
	Four other No Motion Relays	8. Check status of NMR1A, NMR2A, NMR1B, and NMR2B	8a. If not energized, remove and replace that relay.
			8b. If energized, perform operational test before returning LRV to service.

5.8.5 HVAC

The troubleshooting procedures for the HVAC are provided in Table 5-4. For user convenience, this table is sub-divided as follows:

- Table 5-5a HVAC
- Table 5-5b Cab Heater and Defroster

WARNING

THE FOLLOWING TABLES INCLUDE INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A HOT VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY OR DEATH.

Table 5-5a. HVAC

Symptom	Probable Cause	Tests & Checks	Corrective Action
HVAC A/B Fault (Red on TOD Indicator)	Fault on one unit.	1. Use TOD to check HVAC Fault.	1. Troubleshoot per Fault Code and Chapter 0500 of RMSM
A-Unit and B-Unit HVAC units do not turn on	AC Voltage fault.	1. Use the TOD to check APS AC output voltage. • APS Subsystem indicator on Operating Screen NOTE: The indication on the APS Screen is Line-to-Neutral (120 VAC nominal).	1a. If no AC output voltage on TOD, refer to Table 5‑3 to troubleshoot the auxiliary power circuit.
			1b. If OK, proceed to next Probable Cause.
	Load Shed (APSOK circuit)	2. Use the TOD to check HVAC AC Faults / Load Shed • HVAC Subsystem Indicator on Operating Screen • Fault Screen (Loss of 208 VAC)	2a. If Load Shed / Loss of AC Voltage detected by HVACs, continue to the next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Use the TOD to check for APS Faults • APS Subsystem Indicator on Operating Screen • Fault Screen	3a. If present, refer to RMSM Section 0900 to troubleshoot APS.
			3b. If OK, proceed to next Test & Checks.
		4. Check the APS Load Shed Circuit is energized. Using a multimeter, measure for 28 VDC at wire 26AC (APSOKA Terminal X1)	4a. If missing, refer to RMSM Section 0900 to troubleshoot APS.
			4b. If present, proceed to next Test & Checks.

Table 5-5a. HVAC (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A-Unit and B-Unit HVAC units do not turn on (cont'd.)	APSOKA/B Relays	5. Using a multimeter, measure for continuity between wires 41AA and 41AC (APSOKA Contacts E1-F1)	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Tests & Checks.
		6. Using a multimeter, measure for continuity between wires 41BA and 41BC (APSOKB Contacts E1-F1)	6a. If missing, remove and replace relay.
			6b. If OK, proceed to next Probable Cause.
	Air Comfort circuit breakers (AC) at the articulations	7. Check to ensure neither breaker has tripped	7a. If tripped, reset the circuit breaker.
			7b. If OK, proceed to next Probable Cause.
	Air Comfort Control circuit breakers (DC) in the cabs	8. Check to ensure neither breaker has tripped	8a. If tripped, reset the circuit breaker.
			8b. Perform operational test before returning LRV to service.

Table 5-5b: Cab Heater and Defroster

NOTE: The cab heater and defroster circuits are active in the controlling cab of the lead unit only when the TRANSFER switch is set to ON. The A-Unit and B-Unit each contain identical heater and defroster units. The heater units are two-stage heaters at 1KW per stage. The left and right side defrosters are also 1KW per stage. The heater and both defrosters use a three-phase blower motor.

Symptom	Probable Cause	Tests & Checks	Corrective Action
A (B) unit leading, heater blower motor inoperative with Cab Heat switch set to FAN.	Circuit breaker Cab Heater /Defroster A/B.	1. Using multimeter, measure for 28 vdc at wire 34AA (34BA).	1a. If missing, remove and replace Cab Heater /Defroster A/B.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch relay 3A/B	2. Check to ensure MCKSR3A/B relays are both energized	2a. If not, proceed to the next Tests & Checks
			2b. If OK, proceed to next Probable Cause
		3. Using a multimeter, measure for 28 VDC at wire 25AP / 25DD	3a. If OK, remove and replace relay
			3b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
	Load Shed (APSOK circuit)	4. Use the TOD to check AC Faults / Load Shed • Fault Screen (Loss of 208 VAC)	4a. If Load Shed / Loss of AC Voltage detected by HVACs or Propulsion, continue to the next Tests & Checks.
			4b. If OK, proceed to next Probable Cause.
		5. Use the TOD to check for APS Faults • APS Subsystem Indicator on Operating Screen • Fault Screen	5a. If present, refer to RMSM Section 0900 to troubleshoot APS.
			5b. If OK, proceed to next Test & Checks.
		6. Check the APS Load Shed Circuit is energized. Using a multimeter, measure for 28 VDC at wire 26AC (APSOKA Terminal X1)	6a. If missing, refer to RMSM Section 0900 to troubleshoot APS.
			6b. If present, proceed to next Test & Checks.
	APSOK Relays	7. Using a multimeter, measure for continuity between wires 41AA and 41AC (APSOKA Contacts E1-F1)	7a. If missing, remove and replace relay.
			7b. If OK, proceed to next Tests & Checks.
		8. Using a multimeter, measure for continuity between wires 41BA and 41BC (APSOKB Contacts E1-F1)	8a. If missing, remove and replace relay.
			8b. If OK, proceed to next Probable Cause.

Table 5-5b: Cab Heater and Defroster (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A (B) unit leading, heater blower motor inoperative with Cab Heat switch set to FAN. (cont'd.)	Cab Heater Switch	9. Using multimeter, measure for 28 VDC at wire 34AD/BD at TB1-3 on Cab Heater/Defroster Control Panel	9a. If missing, remove and replacing Cab Heater Switch.
			9b. If OK, proceed to next Probable Cause.
	Cab Fan Relay	10. Confirm CFR on Cab Heater/Defroster Control Panel energizes	10a. If CFR does not energize remove and replace CFR Relay.
			10b. If OK, proceed to next Probable Cause.
	Circuit breaker Cab Heater A/B (AC Breaker).	11. Using multimeter, measure for 208 VAC at wires 14AA/BA. 14AB/BB, 14AC/BC	11a. If missing, remove and replace Cab Heater A/B circuit breaker.
			11b. If OK, proceed to next Probable Cause.
	CFR relay or Fan Motor.	12. Using multimeter, measure for 208 VAC at wires 14AK/BK, 14AL/BL, 14AM/BM	12a. If missing, remove and replace Cab Fan relay (CFR)
			12b. If OK, remove and replace Cab Heater (incl. Fan Motor).

Table 5-5b: Cab Heater and Defroster (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A (B) unit leading, left and right blower motors inoperative with Cab Defroster switch set to FAN.	Circuit breaker Cab Heater /Defroster A/B.	1. Using multimeter, measure for 28 vdc at wire 34AA (34BA).	1a. If missing, remove and replace Cab Heater /Defroster A/B.
			1b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch relay 3A/B	2. Check to ensure MCKSR3A/B relays are both energized	2a. If not, proceed to the next Tests & Checks
			2b. If OK, proceed to next Probable Cause
		3. Using a multimeter, measure for 28 VDC at wire 25AP / 25DD	3a. If OK, remove and replace relay
			3b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
	Load Shed (APSOK circuit)	4. Use the TOD to check AC Faults / Load Shed • Fault Screen (Loss of 208 VAC)	4a. If Load Shed / Loss of AC Voltage detected by HVACs or Propulsion, continue to the next Tests & Checks.
			4b. If OK, proceed to next Probable Cause.
		5. Use the TOD to check for APS Faults • APS Subsystem Indicator on Operating Screen • Fault Screen	5a. If present, refer to RMSM Section 0900 to troubleshoot APS.
			5b. If OK, proceed to next Test & Checks.
		6. Check the APS Load Shed Circuit is energized. Using a multimeter, measure for 28 VDC at wire 26AC (APSOKA Terminal X1)	6a. If missing, refer to RMSM Section 0900 to troubleshoot APS.
			6b. If present, proceed to next Test & Checks.
	APSOK Relays	7. Using a multimeter, measure for continuity between wires 41AA and 41AC (APSOKA Contacts E1-F1)	7a. If missing, remove and replace relay.
			7b. If OK, proceed to next Tests & Checks.
		8. Using a multimeter, measure for continuity between wires 41BA and 41BC (APSOKB Contacts E1-F1)	8a. If missing, remove and replace relay.
			8b. If OK, proceed to next Probable Cause.

Table 5-5b: Cab Heater and Defroster (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A (B) unit leading, left and right blower motors inoperative with Cab Defroster switch set to FAN. (cont'd.)	Cab Defroster Switch	9. Using multimeter, measure for 28 vdc at wire 34AH/BH at TB1-8 on Cab Heater/Defroster Control Panel	9a. If missing, remove and replacing Cab Defroster Switch.
			9b. If OK, proceed to next Probable Cause.
	Cab Defroster Fan Relay	10. Confirm CDFR on Cab Heater/Defroster Control Panel energizes	10a. If CDFR does not energize remove and replace CDFR Relay.
			10b. If OK, proceed to next Probable Cause.
	Circuit breaker Cab Defroster A/B (AC Breaker).	11. Using multimeter, measure for 208 VAC at wires 15AA/BA. 15AB/BB, 15AC/BC	11a. If missing, remove and replace Cab Defroster A/B circuit breaker.
			11b. If OK, proceed to next Probable Cause.
	CDFR relay or Fan Motor.	12. Using multimeter, measure for 208 Vac at wires 15AK/BK, 15AL/BL, 15AM/BM	12a. If missing, remove and replace Cab Defroster Fan relay (CDFR)
			12b. If OK, remove and replace Cab Defroster (incl. Fan Motor).

Table 5-5b: Cab Heater and Defroster (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE The following SYMPTOMS are no low or high heat. Each heater and defroster unit contain a temperature-activated switch, which opens when an over-temperature condition is detected in the associated unit. The temperature-activated switches in each unit are connected in series with contacts of the associated fan on relay. This provides two levels of protection. First, it prevents an over-temperature condition. Second, it ensures that the associated heaters and defrosters are not activated without the blower motor operating.			
No low heat, blower motor OK.	Cab Heater Switch	1. Using multimeter, measure for 28 vdc at wire 34AE/BE at TB1-2 on Cab Heater/Defroster Control Panel	1a. If missing, remove and replacing Cab Heater Switch.
			1b. If OK, proceed to next Probable Cause.
	Cab Heater Low Relay	2. Confirm CHLR on Cab Heater/Defroster Control Panel energizes	2a. If CHLR does not energize remove and replace CHLR Relay.
			2b. If OK, proceed to next Probable Cause
	Over-temperature condition detected in Cab Heater Unit	3. Using multimeter, measure for continuity between TB1-5 and TB1-11 on Cab Heater/Defroster Control Panel	3a. If a reading is open an over-temperature condition has been detected or the over-temperature switch contacts are open. Remove and replace the associated switch in the Cab Heater.
			3b. If OK, proceed to next Probable Cause
	Stage 1 Heater elements in Cab Heater Unit	4. Using multimeter, measure for resistance between TB2-11 and TB2-12 and TB2-13 on Cab Heater/Defroster Control Panel	4a. If a reading is open the heater is open. Remove and replace the Cab Heater.
			4b. Test to ensure low heat is available
No high heat, blower motor OK.	Cab Heater Switch	1. Using multimeter, measure for 28 vdc at wire 34AF/BF at TB1-1 on Cab Heater/Defroster Control Panel	1a. If missing, remove and replacing Cab Heater Switch.
			1b. If OK, proceed to next Probable Cause.
	Cab Heater High Relay	2. Confirm CHHR on Cab Heater/Defroster Control Panel energizes	2a. If CHHR does not energize remove and replace CHHR Relay.
			2b. If OK, proceed to next Probable Cause

Table 5-5b: Cab Heater and Defroster (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No high heat, blower motor OK. (cont'd.)	Over-temperature condition detected in Cab Heater Unit	3. Using multimeter, measure for continuity between TB1-5 and TB1-11 on Cab Heater/Defroster Control Panel	3a. If a reading is open an over-temperature condition has been detected or the over-temperature switch contacts are open. Remove and replace the associated switch in the Cab Heater.
			3b. If OK, proceed to next Probable Cause
	Stage2 Heater elements in Cab Heater Unit	4. Using multimeter, measure for resistance between TB2-14 and TB2-15and TB2-166 on Cab Heater/Defroster Control Panel	4a. If a reading is open the heater is open. Remove and replace the Cab Heater.
			4b. Test to ensure high heat is available
No low defroster, blower motors OK.	Cab Defroster Switch	1. Using multimeter, measure for 28 vdc at wire 34AJ/BJ at TB1-7 on Cab Heater/Defroster Control Panel	1a. If missing, remove and replacing Cab Defroster Switch.
			1b. If OK, proceed to next Probable Cause.
	Cab Defroster Low Relay	2. Confirm CDLR on Cab Heater/Defroster Control Panel energizes	2a. If CDLR does not energize remove and replace CDLR Relay.
			2b. If OK, proceed to next Probable Cause
	Over-temperature condition detected in Cab Heater Unit	3. Using multimeter, measure for continuity between TB1-10 and TB1-11 on Cab Heater/Defroster Control Panel	3a. If a reading is open an over-temperature condition has been detected or the over-temperature switch contacts are open. Remove and replace the associated switch in the Cab Defroster.
			3b. If OK, proceed to next Probable Cause
	Stage 1 Defroster elements in Cab Defroster Unit	4. Using multimeter, measure for resistance between TB2-20 and TB2-21 and TB2-22 on Cab Heater/Defroster Control Panel	4a. If a reading is open the heater is open. Remove and replace the Cab Defroster.
			4b. Test to ensure low heat is available

Table 5-5b: Cab Heater and Defroster (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
No high defroster, blower motors OK.	Cab Defroster Switch	1. Using multimeter, measure for 28 vdc at wire 34AK/BK at TB1-6 on Cab Heater/Defroster Control Panel	1a. If missing, remove and replacing Cab Defroster Switch.
			1b. If OK, proceed to next Probable Cause.
	Cab Defroster High Relay	2. Confirm CDHR on Cab Heater/Defroster Control Panel energizes	2a. If CDHR does not energize remove and replace CDHR Relay.
			2b. If OK, proceed to next Probable Cause
	Over-temperature condition detected in Cab Heater Unit	3. Using multimeter, measure for continuity between TB1-10 and TB1-11 on Cab Heater/Defroster Control Panel	3a. If a reading is open an over-temperature condition has been detected or the over-temperature switch contacts are open. Remove and replace the associated switch in the Cab Defroster.
			3b. If OK, proceed to next Probable Cause
	Stage2 Defroster elements in Cab Heater Unit	4. Using multimeter, measure for resistance between TB2-23 and TB2-24 and TB2-25 on Cab Heater/Defroster Control Panel	4a. If a reading is open the heater is open. Remove and replace the Cab Defroster.
			4b. Test to ensure high heat is available

5.8.6 Door Controls

The troubleshooting procedures for the doors are provided in the following tables. For user convenience, this table is sub-divided as follows:

- Table 5-6a Door Controls
- Table 5-6b Crew Key Switches
- Table 5-6c Door Summary Circuit

LEFT TRAINLINE DOOR CONTROL PANEL CIRCUIT THEORY OF OPERATION

In Type I operation (Manual Mode) the Manual Door Relay (MDRA/B, sheet 269) will be energized. The Master Controller Key Switch relay 6 (MCKSR6A/B, sheet 257) will be energized in the active cab. Therefore, in Type I mode the left trainline door control panel circuit will be energized by the door control 1 circuit breaker (DC1CB) provided that the vehicle is at no motion (sheets 503 and 506).

In normal operation three signals are required to open the doors:

1) Hardwired signal via the trainline (left open control),
2) Hardwired signal via the trainline (left lock control),
3) No Motion hardware signal

In normal operation three signals are required to release the doors:

1) Hardwired signal via the trainline (left release control),
2) Hardwired signal via the trainline (left lock control),
3) No Motion hardware signal

In Type II operation (Auto Mode) the Manual Door Relay will be de-energized. Power to the left trainline door control panel circuit will be provided from the ATC Interconnect Circuit (sheet 908). The operator will only be able to operate the doors when permitted by the ATC system.

NOTE: The door control trainline signals are referenced with respect to the A-cab. For example, the LEFT OPEN CONTROL trainline is energized from A-end cab console door left open pushbutton (DLOPB) or B-end cab console door right open pushbutton (DROPB).

At no motion, if the B-end is keyed on and operator's door right open pushbutton (DROPB) is depressed the door left open relay (DLOR) is energized. Once energized, the relay is self-maintained via the path from a door left close relay (DLCR) normally closed contact and a normally open contact from itself. Power and ground are provided through contacts of NMR1A (sheet 304). The DLOR also energizes the LEFT OPEN CONTROL trainline. This signal provides an input to the TCN (sheet 838) for logging on the Event Recorder, and to the DCUs on that side (sheets 503, 504, 505, and 506).

NOTE: The NMR1A contacts can be bypassed with the no motion bypass.

When the B-end operator's door right open pushbutton (DROPB) is depressed, the door left limp home relay (DLLHR) is also energized via the secondary pushbutton contacts 24-23. Once energized, the relay is self-maintained via the path from a door left close relay (DLCR) normally closed contact and a normally open contact from itself. Power and ground are provided through contacts of NMR1A (sheet 304). The DLLHR relay energizes the LEFT LOCK CONTROL trainline. This signal provides an input to the TCN (sheet 838), for logging on the Event Recorder, and to the DCUs on that side (sheets 503, 504, 505, and 506).

When the DCUs receive a B+ on the LEFT OPEN CONTROL, LEFT LOCK CONTROL, and no motion trainline inputs (received locally at each DCU) the left-side doors will open with respect to the A-cab.

When the B-end operator's door right release pushbutton (DRRPB) is depressed, the door left enable relay (DLER) is energized. Once energized, the relay is self-maintained via the path from a door left close relay (DLCR) normally closed contact and a normally open contact from itself. Power and ground are provided through contacts of NMR1A (sheet 304). The DLER also energizes the LEFT RELEASE CONTROL trainline. This signal provides an input to the TCN (sheet 838), for logging on the Event Recorder, and to the DCUs on that side (sheets 503, 504, 505, and 506).

In a similar manner to the door open pushbutton, when the B-end operator's door right release pushbutton (DRRPB) is depressed, the door left limp home relay (DLLHR) is also energized via the secondary pushbutton contacts 24-23.

When the DCUs receive B+ on the LEFT RELEASE CONTROL, LEFT LOCK CONTROL, and no motion trainline inputs (received locally at each DCU) the left-side doors will release with respect to the A-cab.

When the B-end operator's door right close pushbutton (DRCPB) is depressed, the door left close relay (DLCR) is momentarily energized. Contacts from the DLCR de-energize the self-maintaining circuits of the DLER, DLOR, and DLLHR. Contacts of the DLCR, DLER, DLOR, and DLLHR de-energize the door left open control, door left release control, and door left lock control trainlines. When the operator's door right close pushbutton (DRCPB) is depressed a Door Close command is also provided directly to the four DCUs (**hard wired input**) on that side to close the doors (sheets 503, 504, 505, and 506). Additionally, the door closed left signal provides an input to the TCN (sheet 838) for logging on the Event Recorder.

The door close pushbutton also removes power from the door right open (DROPB) and door right release (DRRPB) pushbuttons to ensure that both an open and close request cannot simultaneously occur.

The Door Open, Door Release, and Door Close pushbuttons are momentary pushbuttons, but only the Open Control and Release Control trainlines are latched by the appropriate relay, along with the Locked Control trainline derived from the Open/Release pushbuttons.

The operator can also open or close the right (left) door closest to the cab using the Front Door Control Switch (FDCS) on the cab console. The switch will provide a Door Close or Door Open command directly to the applicable DCU (sheet 511, 517). Opening the front door with the front door control switch will only keep the door open for about 5 seconds. To keep the door open indefinitely, one must press the front door control switch again as soon as the door closing ADA alarm sounds but before the door actually starts moving.

RIGHT TRAINLINE DOOR CONTROL PANEL CIRCUIT THEORY OF OPERATION

In Type I operation (Manual Mode) the Manual Door Relay (MDRA/B, sheet 269) will be energized. The Master Controller Key Switch relay 6 (MCKSR6A/B, sheet 257) will be energized in the active cab. Therefore, in Type I mode the right trainline door control panel circuit will be energized by the door control 2 circuit breaker (DC2CB) provided that the vehicle is at no motion (sheets 507 and 510).

In normal operation three signals are required to open the doors:

1) Hardwired signal via the trainline (right open control),
2) Hardwired signal via the trainline (right lock control),
3) No Motion hardware signal

In normal operation three signals are required to release the doors:

1) Hardwired signal via the trainline (right release control),
2) Hardwired signal via the trainline (right lock control),
3) No Motion hardware signal

In Type II operation (Auto Mode) the Manual Door Relay will be de-energized. Power to the right trainline door control panel circuit will be provided from the ATC Interconnect Circuit (sheet 908). The operator will only be able to operate the doors when permitted by the ATC system.

NOTE: The door control trainline signals are referenced with respect to the A-cab. For example, the RIGHT OPEN CONTROL trainline is energized from A-end cab console door right open pushbutton (DROPB) or B-end cab console door left open pushbutton (DLOPB).

At no motion, if the B-end is keyed on and operator's door left open pushbutton (DLOPB) is depressed the door right open relay (DROR) is energized. Once energized, the relay is self-maintained via the path from a door right close relay (DRCR) normally closed contact and a normally open contact from itself. Power and ground are provided through contacts of NMR1A (sheet 501/304). The DROR also energizes the RIGHT OPEN CONTROL trainline. This signal provides an input to the TCN (sheet 838) for logging on the Event Recorder, and to the DCUs on that side (sheets 507, 508, 509, and 510)

NOTE: The NMR1A contacts can be bypassed with the no motion bypass.

When the B-end operator's door left open pushbutton (DLOPB) is depressed, the door right limp home relay (DRLHR) is also energized via the secondary pushbutton contacts 24-23. Once energized, the relay is self-maintained via the path from a door left close relay (DLCR) normally closed contact and a normally open contact from itself. Power and ground are provided through contacts of NMR1A (sheet 501/304). The DRLHR relay energizes the RIGHT LOCK CONTROL trainline. This signal provides an input to the TCN (sheet 838), for logging on the Event Recorder, and to the DCUs on that side (sheets 507, 508, 509, and 510).

When the DCUs receive a B+ on the RIGHT OPEN CONTROL, RIGHT LOCK CONTROL, and no motion trainline inputs (received locally at each DCU) the right-side doors will open with respect to the A-cab.

When the B-end operator's door left release pushbutton (DLRPB) is depressed, the door right enable relay (DRER) is energized. Once energized, the relay is self-maintained via the path from a door right close relay (DRCR) normally closed contact and a normally open contact from itself. Power and ground are provided through contacts of NMR1A (sheet 501/304). The DRER also energizes the RIGHT RELEASE CONTROL trainline. This signal provides an input to the TCN (sheet 838), for logging on the Event Recorder, and to the DCUs on that side (sheets 507, 508, 509, and 510).

In a similar manner to the door open pushbutton, when the B-end operator's door left release pushbutton (DLRPB) is depressed, the door right limp home relay (DLLHR) is also energized via the secondary pushbutton contacts 24-23.

When the DCUs receive B+ on the RIGHT RELEASE CONTROL, RIGHT LOCK CONTROL, and no motion trainline inputs (received locally at each DCU) the right-side doors will release with respect to the A-cab.

When the B-end operator's door left close pushbutton (DLCPB) is depressed, the door right close relay (DRCR) is momentarily energized. Contacts from the DRCR de-energize the self-maintaining circuits of the DRER, DROR, and DRLHR. Contacts of the DRCR, DRER, DROR, and DRLHR de-energize the door right open control, door right release control, and door right lock control trainlines. When the operator's door left close pushbutton (DLCPB) is depressed a Door Close command is also provided directly to the four DCUs (**hard wired input**) on that side to close the doors (sheets 507, 508, 509, and 510). Additionally, the door closed right signal provides an input to the TCN (sheet 838) for logging on the Event Recorder.

The door close pushbutton also removes power from the door left open (DLOPB) and door left release (DLRPB) pushbuttons to ensure that both an open and close request cannot simultaneously occur.

The Door Open, Door Release, and Door Close pushbuttons are momentary pushbuttons, but only the Open Control and Release Control trainlines are latched by the appropriate relay, along with the Locked Control trainline derived from the Open/Release pushbuttons.

The operator can also open or close the right (left) door closest to the cab using the Front Door Control Switch (FDCS) on the cab console. The switch will provide a Door Close or Door Open command directly to the applicable DCU (sheet 512, 518). Opening the front door with the front door control switch will only keep the door open for about 5 seconds. To keep the door open indefinitely, one must press the front door control switch again as soon as the door closing ADA alarm sounds but before the door actually starts moving.

DOOR CLOSED SUMMARY CIRCUIT THEORY OF OPERATION

The door closed summary circuit is powered by the Door Signal circuit breaker (DSCB, sheet 214). If S1 (DLLS-Door Locked Limit Switch), S3 (EOLS-Emergency Operation Limit Switch), S9 (DRLC- door right leaf closed) and S8 (DLLC- door left leaf closed) are closed, and the safety relay (SR) is de-energized or the door is manually cutout with the Door out of Service (DOS) switch, this indicates that all the doors are closed and locked, energizing the doors left closed summary and doors right closed summary relays (DLCSR and DRCSR).

DLCSR and DRCSR perform the following functions:

- Energize, with other relay contacts, the train propulsion inhibit trainline (sheet 263).
- Energize the door left/right closed indication trainline (sheets 528 or 529).
- Provide an input to the TCN rack (sheet 838) and MVB where it is recorded on the Event Recorder.

WARNING

THE FOLLOWING TABLES INCLUDE INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY.

Table 5-6a. Door Controls

Symptom	Probable Cause	Tests & Checks	Corrective Action
Right and Left Doors Inoperative from A and B car. <u>Assumptions:</u> Line Selector Switch in Type I.	Door Signal Circuit Breaker (DSCB)	1. Using multimeter, measure for 28 VDC at wire 49AA.	1a. If missing, remove and replace DSCB 1b. If OK, proceed to next Probable Cause.
	Door Control Circuit Breaker 1A (DC1CBA)	2. Using multimeter, measure for 28 VDC at wire 47AA (No Motion Relay 2A Contact NO1)	2a. If missing, remove and replace DC1CBA 2b. If OK, proceed to next Probable Cause.
	Door Control Circuit Breaker 2A (DC2CBA)	3. Using multimeter, measure for 28 VDC at wire 48AA (No Motion Relay 2A Contact NO2)	3a. If missing, remove and replace DC2CBA 3b. If OK, proceed to next Probable Cause.
	Door Control Circuit Breaker 1B (DC1CBB)	4. Using multimeter, measure for 28 VDC at wire 47BA (No Motion Relay 2B Contact NO1)	4a. If missing, remove and replace DC1CBB 4b. If OK, proceed to next Probable Cause.
	Door Control Circuit Breaker 2B (DC2CBB)	5. Using multimeter, measure for 28 VDC at wire 48BA (No Motion Relay 2B Contact NO2)	5a. If missing, remove and replace DC2CBB 5b. If OK, proceed to next Probable Cause.
	Line Selector Switch (LSS)	6. Using multimeter, measure for 28 VDC at wire 47FW (LSS Contact 3-21)	6a. If missing, remove and replace switch. 6b. If OK, proceed to next Probable Cause.
	No Motion Relay 1A (NMR1A)	7. Using multimeter, check for continuity between wires 49AA (NMR1A Contact C3) and 49AS (NMR1A Contact NO3)	7a. If missing, refer to Table 5-4g. 7b. If OK, proceed to next Tests & Checks.
		8. Using multimeter, check for continuity between wires 49AT (NMR1A Contact C4) and 49LVGA (NMR1A Contact NO4)	8a. If missing, refer to Table 5-4g for No Motion Circuit Interface. 8b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, left LRV doors do not open.	Door Left Open Push Button Command Circuit, A-End	1. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47AL (DLOPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Left Open Pushbutton Command Missing, A-End'
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47GA (DLOPB Contact 23).	2a. If missing, proceed to Table 5-6a Symptom 'Door Left Open Pushbutton Command Missing, A-End'
			2b. If OK, proceed to next Probable Cause.
	Door Left Open Trainline Control Circuit	3. Press and release the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47AJ.	3a. If missing, proceed to Table 5-6a Symptom 'Door Left Open Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Left Locked Trainline Control Circuit	4. Press and release the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Left Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, right LRV doors do not open.	Door Right Open Push Button Command Circuit, A-End	1. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AL (DROPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Pushbutton Command Missing, A-End'
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48EZ (DROPB Contact 23).	2a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Pushbutton Command Missing, A-End'
			2b. If OK, proceed to next Probable Cause.
	Door Right Open Trainline Control Circuit	3. Press and release the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AJ.	3a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Right Locked Trainline Control Circuit	4. Press and release the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Right Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, left LRV doors do not open.	Door Left Open Push Button Command Circuit, B-End	1. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 48BL (DLOPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Left Open Pushbutton Command Missing, B-End'
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 48FW (DLOPB Contact 23).	2a. If missing, proceed to Table 5-6a Symptom 'Door Left Open Pushbutton Command Missing, B-End'
			2b. If OK, proceed to next Probable Cause.
	Door Right Open Trainline Control Circuit	3. Press and release the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AJ.	3a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Right Locked Trainline Control Circuit	4. Press and release the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Right Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, right LRV doors do not open.	Door Right Open Push Button Command Circuit, B-End	1. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47BL (DROPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Pushbutton Command Missing, B-End'.
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47FX (DROPB Contact 23).	2a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Pushbutton Command Missing, B-End'.
			2b. If OK, proceed to next Probable Cause.
	Door Left Open Trainline Control Circuit	3. Press and release the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47AJ.	3a. If missing, proceed to Table 5-6a Symptom 'Door Left Open Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Left Locked Trainline Control Circuit	4. Press and release the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Left Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, left LRV doors do not release.	Door Left Release Push Button Command Circuit, A-End	1. Press and hold the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 47AM (DLRPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Left Release Pushbutton Command Missing, A-End'.
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 47GA (DLRPB Contact 23).	2a. If missing, remove and replace switch.
			2b. If OK, proceed to Table 5-6a Symptom 'Door Left Release Pushbutton Command Missing, A-End'.
	Door Left Release Trainline Control Circuit	3. Press and release the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 47AH.	3a. If missing, proceed to Table 5-6a Symptom 'Door Left Release Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Left Locked Trainline Control Circuit	4. Press and release the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 47AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Left Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, right LRV doors do not release.	Door Right Release Push Button Command Circuit, A-End	1. Press and hold the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 48AM (DRRPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Right Release Pushbutton Command Missing, A-End'.
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48EZ (DRRPB Contact 23).	2a. If missing, proceed to Table 5-6a Symptom 'Door Right Release Pushbutton Command Missing, A-End'.
			2b. If OK, proceed to next Probable Cause.
	Door Right Release Trainline Control Circuit	3. Press and release the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 48AH.	3a. If missing, proceed to Table 5-6a Symptom 'Door Right Release Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Right Locked Trainline Control Circuit	4. Press and release the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 48AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Right Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, left LRV doors do not release.	Door Left Release Push Button Command Circuit, B-End	1. Press and hold the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 48BM (DLRPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Left Release Pushbutton Command Missing, B-End'.
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 48FW (DLRPB Contact 23).	2a. If missing, proceed to Table 5-6a Symptom 'Door Left Release Pushbutton Command Missing, B-End'.
			2b. If OK, proceed to next Probable Cause.
	Door Right Release Trainline Control Circuit	3. Press and release the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 48AH.	3a. If missing, proceed to Table 5-6a Symptom 'Door Right Open Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Right Locked Trainline Control Circuit	4. Press and release the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 48AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Right Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, right LRV doors do not release.	Door Right Release Push Button Command Circuit, B-End	1. Press and hold the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 47BM (DRRPB Contact 13).	1a. If missing, proceed to Table 5-6a Symptom 'Door Right Release Pushbutton Command Missing, B-End'.
			1b. If OK, proceed to next Test & Check.
		2. Press and hold the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 47FX (DRRPB Contact 23).	2a. If missing, remove and replace switch.
			2b. If OK, proceed to Table 5-6a Symptom 'Door Right Release Pushbutton Command Missing, B-End'.
	Door Left Release Trainline Control Circuit	3. Press and release the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 47AH.	3a. If missing, proceed to Table 5-6a Symptom 'Door Left Release Control Signal Missing'
			3b. If OK, proceed to next Probable Cause.
	Door Left Locked Trainline Control Circuit	4. Press and release the Door Right Release Switch. Using a multimeter, measure for 28 VDC at 47AG.	4a. If missing, proceed to Table 5-6a Symptom 'Door Left Locked Control Signal Missing'
			4b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, left LRV doors do not close or do not remain closed after releasing door close pushbutton.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 47AB (NMR2A Contact C1)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 47CB (MDRA Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 47CA (MCKSR6A Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Left Close Pushbutton (DLCPB)	5. Press and hold the Door Left Close Switch. Using a multimeter, measure for 28 VDC at wire 47AK (DLCPB Contact 13).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	NOTE: The LEFT CLOSE CONTROL TL is OK. The Door Left Close Relay (DLCR) may still be faulty which can prevent the other Control TLs (OPEN, RELEASE, LOCK) from unlatching. If this is the case, the doors would OPEN/RELEASE once the pushbutton is released.		
	Door Left Close Diode (DLCD)	6. Press and hold the Door Left Close Switch. Using a multimeter, measure for 28 VDC at wire 47AN (DLCR Terminal X1).	6a. If missing, remove and replace diode.
			6b. If OK, proceed to next Probable Cause.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, left LRV doors do not close or do not remain closed after releasing door close pushbutton. (cont'd.)	Door Left Close Relay (DLCR)	7. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact A2) and 47AS (DLCR Contact A3).	7a. If continuity (short circuit), remove and replace relay.
			7b. If OK, proceed to next Tests & Checks
		8. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact B2) and 47AT (DLCR Contact B3).	8a. If continuity (short circuit), remove and replace relay.
			8b. If OK, proceed to next Tests & Checks
		9. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact C2) and 47AU (DLCR Contact C3).	9a. If continuity (short circuit), remove and replace relay.
			9b. If OK, proceed to next Tests & Checks
		10. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact D2) and 47AV (DLCR Contact D3).	10a. If continuity (short circuit), remove and replace relay.
			10b. If OK, proceed to next Tests & Checks
		11. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact E2) and 47GE (DLCR Contact E3).	11a. If continuity (short circuit), remove and replace relay.
			11b. If OK, proceed to next Tests & Checks
		12. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact F2) and 47GC (DLCR Contact F3).	12a. If continuity (short circuit), remove and replace relay.
			12b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, right LRV doors do not close or do not remain closed after releasing door close pushbutton.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 48AB (NMR2A Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 48CB (MDRA Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 48CA (MCKSR6A Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Right Close Pushbutton (DRCPB)	5. Press and hold the Door Right Close Switch. Using a multimeter, measure for 28 VDC at wire 48AK (DLCPB Contact 13).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	NOTE: The RIGHT CLOSE CONTROL TL is OK. The Door Right Close Relay (DRCR) may still be faulty which can prevent the other Control TLs (OPEN, RELEASE, LOCK) from unlatching. If this is the case, the doors would OPEN/RELEASE once the pushbutton is released.		
	Door Right Close Diode (DRCD)	6. Press and hold the Door Right Close Switch. Using a multimeter, measure for 28 VDC at wire 47AR (DRCR Terminal X1).	6a. If missing, remove and replace diode.
			6b. If OK, proceed to next Probable Cause.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, right LRV doors do not close or do not remain closed after releasing door close pushbutton. (cont'd.)	Door Right Close Relay (DRCR)	7. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact A2) and 48AS (DRCR Contact A3).	7a. If continuity (short circuit), remove and replace relay.
			7b. If OK, proceed to next Tests & Checks
		8. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact B2) and 48AT (DRCR Contact B3).	8a. If continuity (short circuit), remove and replace relay.
			8b. If OK, proceed to next Tests & Checks
		9. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact C2) and 48AU (DRCR Contact C3).	9a. If continuity (short circuit), remove and replace relay.
			9b. If OK, proceed to next Tests & Checks
		10. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact D2) and 48AV (DRCR Contact D3).	10a. If continuity (short circuit), remove and replace relay.
			10b. If OK, proceed to next Tests & Checks
		11. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact E2) and 48GD (DRCR Contact E3).	11a. If continuity (short circuit), remove and replace relay.
			11b. If OK, proceed to next Tests & Checks
		12. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact F2) and 48GB (DRCR Contact F3).	12a. If continuity (short circuit), remove and replace relay.
			12b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, left LRV doors do not close or do not remain closed after releasing door close pushbutton.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 48BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 48BT (MDRB Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 48BS (MCKSR6B Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Left Close Pushbutton (DLCPB)	5. Press and hold the Door Left Close Switch. Using a multimeter, measure for 28 VDC at wire 48BK (DLCPB Contact 13).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	NOTE: The RIGHT CLOSE CONTROL TL is OK. The Door Right Close Relay (DRCR) may still be faulty which can prevent the other Control TLs (OPEN, RELEASE, LOCK) from unlatching. If this is the case, the doors would OPEN/RELEASE once the pushbutton is released.		
	Door Right Close Diode (DRCD)	6. Press and hold the Door Left Close Switch. Using a multimeter, measure for 28 VDC at wire 47AR (DRCR Terminal X1).	6a. If missing, remove and replace diode.
			6b. If OK, proceed to next Probable Cause.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, left LRV doors do not close or do not remain closed after releasing door close pushbutton. (cont'd.)	Door Right Close Relay (DRCR)	7. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact A2) and 48AS (DRCR Contact A3).	7a. If continuity (short circuit), remove and replace relay.
			7b. If OK, proceed to next Tests & Checks
		8. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact B2) and 48AT (DRCR Contact B3).	8a. If continuity (short circuit), remove and replace relay.
			8b. If OK, proceed to next Tests & Checks
		9. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact C2) and 48AU (DRCR Contact C3).	9a. If continuity (short circuit), remove and replace relay.
			9b. If OK, proceed to next Tests & Checks
		10. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact D2) and 48AV (DRCR Contact D3).	10a. If continuity (short circuit), remove and replace relay.
			10b. If OK, proceed to next Tests & Checks
		11. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact E2) and 48GD (DRCR Contact E3).	11a. If continuity (short circuit), remove and replace relay.
			11b. If OK, proceed to next Tests & Checks
		12. Press and hold the Door Left Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DRCR Contact F2) and 48GB (DRCR Contact F3).	12a. If continuity (short circuit), remove and replace relay.
			12b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, right LRV doors do not close or do not remain closed after releasing door close pushbutton.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 47BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 47BT (MDRB Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 47BS (MCKSR6B Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Right Close Pushbutton (DRCPB)	5. Press and hold the Door Right Close Switch. Using a multimeter, measure for 28 VDC at wire 47BK (DRCPB Contact 13).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	NOTE: The LEFT CLOSE CONTROL TL is OK. The Door Left Close Relay (DRCR) may still be faulty which can prevent the other Control TLs (OPEN, RELEASE, LOCK) from unlatching. If this is the case, the doors would OPEN/RELEASE once the pushbutton is released.		
	Door Left Close Diode (DLCD)	6. Press and hold the Door Right Close Switch. Using a multimeter, measure for 28 VDC at wire 47AN (DLCR Terminal X1).	6a. If missing, remove and replace diode.
			6b. If OK, proceed to next Probable Cause.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, right LRV doors do not close or do not remain closed after releasing door close pushbutton. (cont'd.)	Door Left Close Relay (DLCR)	7. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact A2) and 47AS (DLCR Contact A3).	7a. If continuity (short circuit), remove and replace relay.
			7b. If OK, proceed to next Tests & Checks
		8. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact B2) and 47AT (DLCR Contact B3).	8a. If continuity (short circuit), remove and replace relay.
			8b. If OK, proceed to next Tests & Checks
		9. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact C2) and 47AU (DLCR Contact C3).	9a. If continuity (short circuit), remove and replace relay.
			9b. If OK, proceed to next Tests & Checks
		10. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact D2) and 47AV (DLCR Contact D3).	10a. If continuity (short circuit), remove and replace relay.
			10b. If OK, proceed to next Tests & Checks
		11. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact E2) and 47GE (DLCR Contact E3).	11a. If continuity (short circuit), remove and replace relay.
			11b. If OK, proceed to next Tests & Checks
		12. Press and hold the Door Right Close Switch. Using a multimeter, measure for discontinuity (open circuit) between wires 49AS (DLCR Contact F2) and 47GC (DLCR Contact F3).	12a. If continuity (short circuit), remove and replace relay.
			12b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, front left door (A7/A8) does not open from Front Door Control Console Switch	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 47AB (NMR2A Contact C1)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 47CB (MDRA Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 47CA (MCKSR6A Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Left Front Door Control Switch (FDCS)	5. Press and hold the Front Door Control Switch in the OPEN position. Using a multimeter, measure for 28 VDC at wire 47AY (FDCS Contact 1).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	Door Operator Fault (A7/A8)	6. Use the TOD to check for Door Faults. Check the Fault Screen.	6a. See RMSM, Section 0400 for Doors Troubleshooting.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, front right door (A1/A2) does not open from Front Door Control Console Switch.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 48AB (NMR2A Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 48CB (MDRA Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 48CA (MCKSR6A Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Right Front Door Control Switch (FDCS)	5. Press and hold the Front Door Control Switch in the OPEN position. Using a multimeter, measure for 28 VDC at wire 48AY (FDCS Contact 1).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	Door Operator Fault (A1/A2)	6. Use the TOD to check for Door Faults. Check the Fault Screen.	6a. See RMSM, Section 0400 for Doors Troubleshooting.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, front left door (B7/B8) does not open from Front Door Control Console Switch.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 48BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 48BT (MDRB Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 48BS (MCKSR6B Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Left Front Door Control Switch (FDCS)	5. Press and hold the Front Door Control Switch in the OPEN position. Using a multimeter, measure for 28 VDC at wire 48BR (FDCS Contact 1).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	Door Operator Fault (B7/B8)	6. Use the TOD to check for Door Faults. Check the Fault Screen.	6a. See RMSM, Section 0400 for Doors Troubleshooting.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, front right door (B1/B2) does not open from Front Door Control Console Switch.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 47BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 47BT (MDRB Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 47BS (MCKSR6B Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Right Front Door Control Switch (FDCS)	5. Press and hold the Front Door Control Switch in the OPEN position. Using a multimeter, measure for 28 VDC at wire 47BR (FDCS Contact 1).	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable Cause.
	Door Operator Fault (B1/B2)	6. Use the TOD to check for Door Faults. Check the Fault Screen.	6a. See RMSM, Section 0400 for Doors Troubleshooting.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Left Open Pushbutton command not OK.			
Door Left Open Pushbutton Command Missing, A-End.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 47AB (NMR2A Contact C1)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 47CB (MDRA Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 47CA (MCKSR6A Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Left Close Pushbutton (DLCPB)	5. Using a multimeter, measure for 28 VDC at DLCPB Contact 12.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Left Open Push Button (DLOPB)	6. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47AL (DLOPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47GA (DLOPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Right Open Pushbutton command not OK.			
Door Right Open Pushbutton Command Missing, A-End.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 48AB (NMR2A Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 48CB (MDRA Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 48CA (MCKSR6A Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Right Close Pushbutton (DRCPB)	5. Using a multimeter, measure for 28 VDC at DRCPB Contact 12.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Right Open Push Button (DROPB)	6. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AL (DROPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48EZ (DROPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of B-End Left Open Pushbutton command not OK.			
Door Left Open Pushbutton Command Missing, B-End.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 48BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 48BT (MDRB Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Crew Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 48BS (MCKSR6B Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Left Close Pushbutton (DLCPB)	5. Using a multimeter, measure for 28 VDC at DLCPB Contact 12.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Left Open Push Button (DLOPB)	6. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 48BL (DLOPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 48FW (DLOPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of B-End Right Open Pushbutton command not OK.			
Door Right Open Pushbutton Command Missing, B-End.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 47BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 47BT (MDRB Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Crew Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 47BS (MCKSR6B Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Right Close Pushbutton (DRCPB)	5. Using a multimeter, measure for 28 VDC at DRCPB Contact 12.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Right Open Push Button (DROPB)	6. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47BL (DROPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47FX (DROPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Left Release Pushbutton command not OK.			
Door Left Release Pushbutton Command Missing, A-End.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 47AB (NMR2A Contact C1)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 47CB (MDRA Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 47CA (MCKSR6A Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Left Close Pushbutton (DLCPB)	5. Using a multimeter, measure for 28 VDC at DLCPB Contact 22.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Left Release Push Button (DLRPB)	6. Press and hold the Door Left Release Switch. Using a multimeter, measure for 28 VDC at 47AM (DLRPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 47GA (DLRPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Right Release Pushbutton command not OK.			
Door Right Release Pushbutton Command Missing, A-End.	No Motion Relay 2A (NMR2A)	1. Using a multimeter, measure for 28 VDC at wire 48AB (NMR2A Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay A (MDRA)	2. Using a multimeter, measure for 28 VDC at wire 48CB (MDRA Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRA is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 6A (MCKSR6A)	3. Using a multimeter, measure for 28 VDC at wire 48CA (MCKSR6A Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR6A Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Right Close Pushbutton (DRCPB)	5. Using a multimeter, measure for 28 VDC at DRCPB Contact 22.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Right Release Push Button (DRRPB)	6. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48AM (DRRPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 48EZ (DRRPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of B-End Left Release Pushbutton command not OK.			
Door Left Release Pushbutton Command Missing, B-End.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 48BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 48BT (MDRB Contact F2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Crew Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 48BS (MCKSR6B Contact F1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Left Close Pushbutton (DLCPB)	5. Using a multimeter, measure for 28 VDC at DLCPB Contact 22.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Left Release Push Button (DLRPB)	6. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 48BM (DLRPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Left Open Switch. Using a multimeter, measure for 28 VDC at 48FW (DLRPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of B-End Right Release Pushbutton command not OK.			
Door Right Release Pushbutton Command Missing, B-End.	No Motion Relay 2B (NMR2B)	1. Using a multimeter, measure for 28 VDC at wire 47BB (NMR2B Contact C2)	1a. If missing, refer to Table 5-4g for No Motion Circuit Interface.
			1b. If OK, proceed to next probable cause.
	Manual Door Relay B (MDRB)	2. Using a multimeter, measure for 28 VDC at wire 47BT (MDRB Contact E2).	2a. If missing, remove and replace relay. (NOTE: the circuit energizing MDRB is OK, otherwise Right and Left Doors Inoperative from A and B car.)
			2b. If OK, proceed to next Probable Cause.
	Master Crew Key Switch Relay 6B (MCKSR6B)	3. Using a multimeter, measure for 28 VDC at wire 47BS (MCKSR6B Contact E1)	3a. If missing, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR6B Terminal X1)	4a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257). Also see Table 5-4a.
			4b. If OK, remove and replace relay.
	Door Right Close Pushbutton (DRCPB)	5. Using a multimeter, measure for 28 VDC at DRCPB Contact 12.	5a. If missing, remove and replace switch.
			5b. If OK, proceed to next Probable cause.
	Door Right Release Push Button (DRRPB)	6. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47BM (DRRPB Contact 13).	6a. If missing, remove and replace switch.
			6b. If OK, proceed to next Test & Check.
		7. Press and hold the Door Right Open Switch. Using a multimeter, measure for 28 VDC at 47FX (DRRPB Contact 23).	7a. If missing, remove and replace switch.
			7b. Perform operational test before returning LRV

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Left / B-End Right pushbutton command OK, but doors do not open.			
Door Left Open Control Signal Missing.	Door Left Open Diode 1 (DLOD1)	1. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure for 28 VDC at wire 47AR.	1a. If missing, remove and replace diode.
			1b. If OK, proceed to next Probable Cause.
	Door Left Open Relay (DLOR)	2. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47AR (DLOR Contact A1) and 47AS (DLOR Contact A2).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Tests & Checks.
		3. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47AW (DLOR Contact B1) and 47AU (DLOR Contact B2).	3a. If missing, remove and replace relay.
			3b. If OK, proceed to next Probable Cause.
	Door Left Close Relay (DLCR)	4. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47AS (DLCR Contact A3) and 49AS (DLCR Contact A2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Tests & Checks.
		5. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47AU (DLCR Contact C3) and 49AS (DLCR Contact C2).	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Door Left Open Diode 2 (DLOD2)	6. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure for 28 VDC at wire 47AJ.	6a. If missing, remove and replace diode.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Right / B-End Left pushbutton command OK, but doors do not open.			
Door Right Open Control Signal Missing.	Door Right Open Diode 1 (DROD1)	1. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure for 28 VDC at wire 48AN.	1a. If missing, remove and replace diode.
			1b. If OK, proceed to next Probable Cause.
	Door Right Open Relay (DROR)	2. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48AN (DROR Contact A1) and 48AS (DROR Contact A2).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Tests & Checks.
		3. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48AW (DROR Contact B1) and 48AU (DROR Contact B2).	3a. If missing, remove and replace relay.
			3b. If OK, proceed to next Probable Cause.
	Door Right Close Relay (DRCR)	4. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48AS (DRCR Contact A3) and 49AS (DRCR Contact A2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Tests & Checks.
		5. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48AU (DRCR Contact C3) and 49AS (DRCR Contact C2).	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Door Right Open Diode 2 (DROD2)	6. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure for 28 VDC at wire 48AJ.	6a. If missing, remove and replace diode.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Left / B-End Right pushbutton command OK, but doors do not release.			
Door Left Release Control Signal Missing.	Door Left Release Diode 1 (DLED1)	1. Press and hold A-End DLRPB or B-End DRRPB. Using a multimeter, measure for 28 VDC at wire 47AP.	1a. If missing, remove and replace diode.
			1b. If OK, proceed to next Probable Cause.
	Door Left Release Relay (DLER)	2. Press and hold A-End DLRPB or B-End DRRPB. Using a multimeter, measure continuity between wires 47AP (DLER Contact A1) and 47AT (DLER Contact A2).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Tests & Checks.
		3. Press and hold A-End DLRPB or B-End DRRPB. Using a multimeter, measure continuity between wires 47AX (DLER Contact B1) and 47AV (DLER Contact B2).	3a. If missing, remove and replace relay.
			3b. If OK, proceed to next Probable Cause.
	Door Left Close Relay (DLCR)	4. Press and hold A-End DLRPB or B-End DRRPB. Using a multimeter, measure continuity between wires 47AT (DLCR Contact B3) and 49AS (DLCR Contact B2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Tests & Checks.
		5. Press and hold A-End DLRPB or B-End DRRPB. Using a multimeter, measure continuity between wires 47AV (DLCR Contact D3) and 49AS (DLCR Contact D2).	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Door Left Release Diode 2 (DLED2)	6. Press and hold A-End DLRPB or B-End DRRPB. Using a multimeter, measure for 28 VDC at wire 47AH.	6a. If missing, remove and replace diode.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Right / B-End Left pushbutton command OK, but doors do not release.			
Door Right Release Control Signal Missing.	Door Right Release Diode 1 (DRED1)	1. Press and hold A-End DRRPB or B-End DLRPB. Using a multimeter, measure for 28 VDC at wire 48AP.	1a. If missing, remove and replace diode.
			1b. If OK, proceed to next Probable Cause.
	Door Right Release Relay (DRER)	2. Press and hold A-End DRRPB or B-End DLRPB. Using a multimeter, measure continuity between wires 48AP (DRER Contact A1) and 48AT (DRER Contact A2).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Tests & Checks.
		3. Press and hold A-End DRRPB or B-End DLRPB. Using a multimeter, measure continuity between wires 48AX (DRER Contact B1) and 48AV (DRER Contact B2).	3a. If missing, remove and replace relay.
			3b. If OK, proceed to next Probable Cause.
	Door Right Close Relay (DRCR)	4. Press and hold A-End DRRPB or B-End DLRPB. Using a multimeter, measure continuity between wires 48AT (DRCR Contact B3) and 49AS (DRCR Contact B2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Tests & Checks.
		5. Press and hold A-End DRRPB or B-End DLRPB. Using a multimeter, measure continuity between wires 48AV (DRCR Contact D3) and 49AS (DRCR Contact D2).	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Door Right Release Diode 2 (DRED2)	6. Press and hold A-End DRRPB or B-End DLRPB. Using a multimeter, measure for 28 VDC at wire 48AH.	6a. If missing, remove and replace diode.
			6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Left / B-End Right pushbutton command OK, but doors do not open / release.			
Door Left Locked Control Signal Missing.	Door Left Unlocked Diode (DLUD)	1. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure for 28 VDC at wire 47GB.	1a. If missing, remove and replace diode. 1b. If OK, proceed to next Probable Cause.
	Door Left Limp Home Relay (DLLHR)	2. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47GB (DLLHR Contact C1) and 47GC (DLLHR Contact C2).	2a. If missing, remove and replace relay. 2b. If OK, proceed to next Tests & Checks.
		3. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47GD (DLLHR Contact A1) and 47GE (DLLHR Contact A2).	3a. If missing, remove and replace relay. 3b. If OK, proceed to next Probable Cause.
	Door Left Close Relay (DLCR)	4. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47GC (DLCR Contact F3) and 49AS (DLCR Contact F2).	4a. If missing, remove and replace relay. 4b. If OK, proceed to next Tests & Checks.
		5. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure continuity between wires 47GE (DLCR Contact E3) and 49AA (DLCR Contact E2).	5a. If missing, remove and replace relay. 5b. If OK, proceed to next Probable Cause.
	Door Left Locked Diode (DLLD)	6. Press and hold A-End DLOPB or B-End DROPB. Using a multimeter, measure for 28 VDC at wire 47AG.	6a. If missing, remove and replace diode. 6b. Perform operational test before returning LRV to service.

Table 5-6a. Door Controls (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
NOTE: This symptom is a result of A-End Right / B-End Left pushbutton command OK, but doors do not open / release.			
Door Right Locked Control Signal Missing.	Door Right Unlocked Diode (DRUD)	1. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure for 28 VDC at wire 48GA.	1a. If missing, remove and replace diode.
			1b. If OK, proceed to next Probable Cause.
	Door Right Limp Home Relay (DRLHR)	2. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48GA (DRLHR Contact C1) and 48GB (DRLHR Contact C2).	2a. If missing, remove and replace relay.
			2b. If OK, proceed to next Tests & Checks.
		3. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48GC (DRLHR Contact A1) and 48GD (DRLHR Contact A2).	3a. If missing, remove and replace relay.
			3b. If OK, proceed to next Probable Cause.
	Door Right Close Relay (DRCR)	4. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48GB (DRCR Contact F3) and 49AS (DRCR Contact F2).	4a. If missing, remove and replace relay.
			4b. If OK, proceed to next Tests & Checks.
		5. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure continuity between wires 48GD (DRCR Contact E3) and 49AS (DRCR Contact E2).	5a. If missing, remove and replace relay.
			5b. If OK, proceed to next Probable Cause.
	Door Right Locked Diode (DRLD)	6. Press and hold A-End DROPB or B-End DLOPB. Using a multimeter, measure for 28 VDC at wire 48AG.	6a. If missing, remove and replace diode.
			6b. Perform operational test before returning LRV to service.

Table 5-6b. Crew Key Switches

NOTE: The following SYMPTOMS assume that the LRV doors can be opened, closed, and released when the LRV is turned on.

Symptom	Probable Cause	Tests & Checks	Corrective Action
The upper and lower exterior crew key switches at all four lead car doors are inoperative.	Low Voltage Control Circuit Breaker	1. Using multimeter, measure for 28 VDC at location 25AA on the A-end or 25BA on the B-End	1a. If missing, remove and replace the low voltage control circuit breaker
			1b. Perform operational test before returning LRV to service.
Setting the A car door (UPPER) A7/A8 crew key switch to OPEN does not open A car door A7/A8.	Upper Exterior Crew Switch / Door Control Unit A7/A8 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the A car door (LOWER) A7/A8 crew key switch to OPEN does not open A car door A7/A8.	Lower Exterior Crew Switch / Door Control Unit A7/A8 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Lower Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the A car door (UPPER) A7/A8 crew key switch to CLOSE does not close the LRV doors.	Upper Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch.
			1b. If OK, proceed to next Probable Cause.
	Crew Switch Diode 1 Left (CSD1L)	2. Using multimeter, measure for 28 VDC at wire 47AK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 1 Right (CSD1R)	3. Using multimeter, measure for 28 VDC at wire 48AK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.
Setting the A car door (LOWER) A7/A8 crew key switch to CLOSE does not close the LRV doors.	Lower Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 1 Left (CSD1L)	2. Using multimeter, measure for 28 VDC at wire 47AK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 1 Right (CSD1R)	3. Using multimeter, measure for 28 VDC at wire 48AK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.

Table 5-6b. Crew Key Switches (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Setting the A car door (UPPER) A1/A2 crew key switch to OPEN does not open A car door A1/A2.	Upper Exterior Crew Switch / Door Control Unit A1/A2 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the A car door (LOWER) A1/A2 crew key switch to OPEN does not open A car door A1/A2.	Lower Exterior Crew Switch / Door Control Unit A1/A2 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Lower Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the A car door (UPPER) A1/A2 crew key switch to CLOSE does not close the LRV doors.	Upper Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 2 Left (CSD2L)	2. Using multimeter, measure for 28 VDC at wire 47AK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 2 Right (CSD2R)	3. Using multimeter, measure for 28 VDC at wire 48AK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.
Setting the A car door (LOWER) A1/A2 crew key switch to CLOSE does not close the LRV doors.	Lower Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 2 Left (CSD2L)	2. Using multimeter, measure for 28 VDC at wire 47AK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 2 Right (CSD2R)	3. Using multimeter, measure for 28 VDC at wire 48AK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.

Table 5-6b. Crew Key Switches (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Setting the B car door (UPPER) B7/B8 crew key switch to OPEN does not open A car door B7/B8.	Upper Exterior Crew Switch / Door Control Unit B7/B8 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the B car door (LOWER) B7/B8 crew key switch to OPEN does not open A car door B7/B8.	Lower Exterior Crew Switch / Door Control Unit B7/B8 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Lower Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the B car door (UPPER) B7/B8 crew key switch to CLOSE does not close the LRV doors.	Upper Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 8 Left (CSD8L)	2. Using multimeter, measure for 28 VDC at wire 47BK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 8 Right (CSD8R)	3. Using multimeter, measure for 28 VDC at wire 48BK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.
Setting the B car door (LOWER) B7/B8 crew key switch to CLOSE does not close the LRV doors.	Lower Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 8 Left (CSD8L)	2. Using multimeter, measure for 28 VDC at wire 47BK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 8 Right (CSD8R)	3. Using multimeter, measure for 28 VDC at wire 48BK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.

Table 5-6b. Crew Key Switches (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Setting the B car door (UPPER) B1/B2 crew key switch to OPEN does not open A car door B1/B2.	Upper Exterior Crew Switch / Door Control Unit B1/B2 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the B car door (LOWER) B1/B2 crew key switch to OPEN does not open A car door B1/B2.	Lower Exterior Crew Switch / Door Control Unit B1/B2 (DCU)	1. Using multimeter, measure for 28 VDC at contact 13 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Lower Exterior Crew Switch
			1b. If OK, remove and replace DCU.
Setting the B car door (UPPER) B1/B2 crew key switch to CLOSE does not close the LRV doors.	Upper Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Upper Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 7 Left (CSD7L)	2. Using multimeter, measure for 28 VDC at wire 47BK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 7 Right (CSD7R)	3. Using multimeter, measure for 28 VDC at wire 48BK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.
Setting the B car door (LOWER) B1/B2 crew key switch to CLOSE does not close the LRV doors.	Lower Exterior Crew Switch	1. Using multimeter, measure for 28 VDC at contact 18 of the Lower Exterior Crew Switch	1a. If missing, remove and replace the Upper Exterior Crew Switch
			1b. Perform operational test before returning LRV to service.
	Crew Switch Diode 7 Left (CSD7L)	2. Using multimeter, measure for 28 VDC at wire 47BK	2a. If missing, remove and replace diode.
			2b. If OK, proceed to next probable cause.
	Crew Switch Diode 7 Right (CSD7R)	3. Using multimeter, measure for 28 VDC at wire 48BK	3a. If missing, remove and replace diode.
			3b. Perform operational test before returning LRV to service.

Table 5-6c. Door Summary Circuit

Symptom	Probable Cause	Tests & Checks	Corrective Action
Door Left Closed Signal Relay Does Not Energize When all Doors on the Left Side are Closed. NOTE: Train Propulsion Inhibit Relay will be de-energized. Train will not move or Invalid PBED (valid range 16.5% - 91.5%) will occur.	Door Signal Circuit Breaker (DSCB)	1. Using a multimeter, measure for 28 VDC at wire 49BA	1a. If missing, remove and replace the circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Door B1/B2 Drive Unit	2. Using a multimeter, measure for 28 VDC at wire 49BB	2a. If missing, continue to troubleshoot the Door Drive Unit.
			2b. If OK, proceed to next Probable Cause.
	Door B3/B4 Drive Unit	3. Using a multimeter, measure for 28 VDC at wire 49BC	3a. If missing, continue to troubleshoot the Door Drive Unit.
			3b. If OK, proceed to next Probable Cause.
	Door A5/A6 Drive Unit	4. Using a multimeter, measure for 28 VDC at wire 49AC	4a. If missing, continue to troubleshoot the Door Drive Unit.
			4b. If OK, proceed to next Probable Cause.
	Door A7/A8 Drive Unit / Door Left Closed Signal Relay (DLCSR)	5. Using a multimeter, measure for 28 VDC at wire 49AD	5a. If missing, continue to troubleshoot the Door Drive Unit.
			5b. If OK, remove and replace relay.

Table 5-6c. Door Summary Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Door Right Closed Signal Relay Does Not Energize When all Doors on the Right Side are Closed. NOTE: Train Propulsion Inhibit Relay will be de-energized. Train will not move or Invalid PBED (valid range 16.5% - 91.5%) will occur.	Door Signal Circuit Breaker (DSCB)	1. Using a multimeter, measure for 28 VDC at 49BA in the cab junction board	1a. If missing, remove and replace the circuit breaker
			1b. Perform operational test before returning LRV to service.
	Door B7/B8 Drive Unit	2. Using a multimeter, measure for 28 VDC at wire 49BD	2a. If missing, continue to troubleshoot the Door Drive Unit.
			2b. If OK, proceed to next Probable Cause.
	Door B5/B6 Drive Unit	3. Using a multimeter, measure for 28 VDC at wire 49BE	3a. If missing, continue to troubleshoot the Door Drive Unit.
			3b. If OK, proceed to next Probable Cause.
	Door A3/A4 Drive Unit	4. Using a multimeter, measure for 28 VDC at wire 49AF	4a. If missing, continue to troubleshoot the Door Drive Unit.
			4b. If OK, proceed to next Probable Cause.
	Door A1/A2 Drive Unit / Door Right Closed Signal Relay (DRCSR)	5. Using a multimeter, measure for 28 VDC at wire 49AG	5a. If missing, continue to troubleshoot the Door Drive Unit.
			5b. If OK, remove and replace relay.

Table 5-6c. Door Summary Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A End Leading, Door Indication Relay A Does Not Energize When all Doors are Closed. (Assumes A-End active, forward direction selected.) NOTE: Cab Propulsion Inhibit Relay will be de-energized after exiting brake position on the Master Controller. Train will not move or Invalid PBED (valid range 16.5% - 91.5%) will occur.	Door Signal Circuit Breaker (DSCB)	1. Using multimeter, measure for 28 VDC at 49BA in the cab junction board	1a. If missing, remove and replace the circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Tail End Relay 2B (TER2B)	2. Using multimeter, measure for 28 VDC at wire 49BH (TER2B Contact D1)	2a. If missing, proceed to Tests & Checks Step 4.
			2b. If OK, proceed to next Tests & Checks.
		3. Using multimeter, measure for 28 VDC at wire 49BJ (TER2B Contact E1)	3a. If missing, proceed to Tests & Checks Step 4.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 31BE (TER2B Contact X1)	4a. If missing, continue to troubleshoot Head and Tail End Control Circuit (ref. sheet 251).
			4b. If OK, remove and replace relay.
	Door Left Closed Signal Relay (DLCSR)	5. Using multimeter, measure for 28 VDC at 49AL (DLCSR Contact C1)	5a. If missing, proceed to next Tests & Checks.
			5b. If OK, proceed to next Probable Cause.
		6. Using multimeter, measure for 28 VDC at 49AD (DLCSR Contact Y)	6a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			6b. If OK, remove and replace relay.
	Door Right Closed Signal Relay (DRCSR)	7. Using multimeter, measure for 28 VDC at 49AN (DRCSR Contact C1)	7a. If missing, proceed to next Tests & Checks.
			7b. If OK, proceed to next Probable Cause.
		8. Using multimeter, measure for 28 VDC at 49AG (DRCSR Contact Y)	8a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			8b. If OK, remove and replace relay.

Table 5-6c. Door Summary Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A End Leading, Door Indication Relay A Does Not Energize When all Doors are Closed (cont'd.) (Assumes A-End active, forward direction selected.) NOTE: Cab Propulsion Inhibit Relay will be de-energized after exiting brake position on the Master Controller. Train will not move or Invalid PBED (valid range 16.5% - 91.5%) will occur.	Master Key Switch Relay 4A (MCKSR4A)	9. Using multimeter, measure for 28 VDC at wire 49AP (MCKSR4A Contact B1)	9a. If missing, proceed to Tests & Checks Step 11.
			9b. If OK, proceed to next Tests & Checks.
		10. Using multimeter, measure for 28 VDC at wire 49AR (MCKSR4A Contact A1)	10a. If missing, proceed to Tests & Checks Step 11.
			10b. If OK, proceed to next Probable Cause.
		11. Using multimeter, measure for 28 VDC at wire 25AP (MCKSR4A Contact X1)	11a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257).
			11b. If OK, remove and replace relay.
	Door Left Close Relay A (DLCRA)	12. Using multimeter, measure for 28 VDC at 49AH (DLCRA Contact B1)	12a. If missing, remove and replace relay.
			12b. If OK, proceed to next Probable Cause.
	Door Right Close Relay A (DRCRA) / Door Indication Relay A (DIRA)	13. Using multimeter, measure for 28 VDC at 49AJ (DLCRA Contact B1)	13a. If missing, remove and replace DRCRA relay.
			13b. If OK, remove and replace DIRA relay.

Table 5-6c. Door Summary Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B End Leading, Door Indication Relay B Does Not Energize When all Doors are Closed. (Assumes B-End active, forward direction selected.) NOTE: Cab Propulsion Inhibit Relay will be de-energized after exiting brake position on the Master Controller. Train will not move or Invalid PBED (valid range 16.5% - 91.5%) will occur.	Door Signal Circuit Breaker (DSCB)	1. Using multimeter, measure for 28 VDC at 49AA in the cab junction board	1a. If missing, remove and replace the Door Signal Circuit Breaker
			1b. If OK, proceed to next Probable Cause.
	Tail End Relay 2A (TER2A)	2. Using multimeter, measure for 28 VDC at 49AL (TER2A Contact D1)	2a. If missing, proceed to Tests & Checks Step 4.
			2b. If OK, proceed to next Tests & Checks.
		3. Using multimeter, measure for 28 VDC at 49AN (TER2A Contact E1)	3a. If missing, proceed to Tests & Checks Step 4.
			3b. If OK, proceed to next Probable Cause.
		4. Using multimeter, measure for 28 VDC at wire 31AE (TER2A Contact X1)	4a. If missing, continue to troubleshoot Head and Tail End Control Circuit (ref. sheet 251).
			4b. If OK, remove and replace relay.
	Door Left Closed Signal Relay (DLCSR)	5. Using multimeter, measure for 28 VDC at 49BH (DLCSR Contact C1)	5a. If missing, proceed to next Tests & Checks.
			5b. If OK, proceed to next Probable Cause.
		6. Using multimeter, measure for 28 VDC at 49AD (DLCSR Contact Y)	6a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			6b. If OK, remove and replace relay.
	Door Right Closed Signal Relay (DRCSR)	7. Using multimeter, measure for 28 VDC at 49BJ (DRCSR Contact C1)	7a. If missing, proceed to next Tests & Checks.
			7b. If OK, proceed to next Probable Cause.
		8. Using multimeter, measure for 28 VDC at 49AG (DRCSR Contact Y)	8a. If missing, continue to troubleshoot Door Close Summary Circuit (ref. sheet 528).
			8b. If OK, remove and replace relay.

Table 5-6c. Door Summary Circuit (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B End Leading, Door Indication Relay B Does Not Energize When all Doors are Closed (cont'd.) (Assumes B-End active, forward direction selected.) NOTE: Cab Propulsion Inhibit Relay will be de-energized after exiting brake position on the Master Controller. Train will not move or Invalid PBED (valid range 16.5% - 91.5%) will occur.	Master Key Switch Relay 4B (MCKSR4B)	9. Using multimeter, measure for 28 VDC at wire 49BL (MCKSR4A Contact B1)	9a. If missing, proceed to Tests & Checks Step 11.
			9b. If OK, proceed to next Tests & Checks.
		10. Using multimeter, measure for 28 VDC at wire 49BK (MCKSR4A Contact A1)	10a. If missing, proceed to Tests & Checks Step 11.
			10b. If OK, proceed to next Probable Cause.
		11. Using multimeter, measure for 28 VDC at wire 25DD (MCKSR4A Contact X1)	11a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257).
			11b. If OK, remove and replace relay.
	Door Left Close Relay B (DLCRB)	12. Using multimeter, measure for 28 VDC at 49BF (DLCRB Contact B1)	12a. If missing, remove and replace relay.
			12b. If OK, proceed to next Probable Cause.
	Door Right Close Relay B (DRCRB) / Door Indication Relay B (DIRB)	13. Using multimeter, measure for 28 VDC at 49BG (DLCRB Contact B1)	13a. If missing, remove and replace DRCRB relay.
			13b. If OK, remove and replace DIRB relay.

5.8.7 Lighting

The troubleshooting procedures for the lighting circuits are provided in Table 5-7a through 5-7l. For user convenience, this table is sub-divided as follows:

Table 5-7a	Head Lights
Table 5-7b	Front / Rear Marker Lights
Table 5-7c	Roof Light
Table 5-7d	Tail Lights
Table 5-7e	Stop Lights
Table 5-7f	Silent Alarm Lights
Table 5-7g	Bypass Activated Lights
Table 5-7h	Turn Signals / Side Marker Lights
Table 5-7i	Emergency Interior Lights
Table 5-7j	Main Interior Lights
Table 5-7k	Cab Lights
Table 5-7l	12 VDC Others (Windshield Wiper and Power Mirrors)

WARNING

THE FOLLOWING TABLE INCLUDES INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY.

Table 5-7a. Head Lights

NOTE: The lighting circuits that contain Automotive Power 12 VDC are as follows:

- Head Lights
- Windshield Wiper (see Table 5-7l)
- Power Mirror (see Table 5-7l)

Symptom	Probable Cause	Tests & Checks	Corrective Action
All the A-End circuits supplied by the 12 VDC Power Supply Feed 80AA are inoperative.	Circuit Breaker HLWWMPCBA / 12 VDC Power Supply	1. Using a multimeter, measure for 28 VDC Power at TB1-7 at the 12 Volt Power Supply Panel.	1a. If missing, remove and replace CB
			1b. If OK, remove and replace the 12 VDC Power Supply
A car Head Lights Low Beam inoperative. Assumptions: A-End active, forward direction selected, and headlight switch set to LOW.	Circuit Breaker HLCBA	1. Using a multimeter, measure for 12 VDC at wire 82AA.	1a. If missing, remove and replace HLCBA
			1b. If OK, proceed to the next Probable Cause.
	Forward Control Relay 1A (FCR1A)	2. Use a multimeter to measure for 28VDC at wire 31GJ.	2a. If missing, proceed to the next Tests & Checks.
			2b. If OK, proceed to the next Probable Cause.
		3. Use a multimeter to measure for 28VDC at wire 31AH.	3a. If missing, continue to troubleshoot Front and Rear Control Circuit (ref. sheet 252)
			3b. If OK, remove and replace relay
	Headlight Switch (HLS)	4. Use a multimeter to measure for 28 VDC at wire 31GK.	4a. If missing, remove and replace HLS.
			4b. If OK, proceed to the next Probable Cause.
	Headlight Low Relay (HLLR)	5. Use a multimeter to measure for 12 VDC at wire 82AC	5a. If missing, replace relay.
			5b. If OK, proceed to the next Tests & Checks.
		6. Use a multimeter to measure for 12 VDC at wire 82AE	6a. If missing, replace relay.
			6b. If OK, proceed to the next Probable Cause.
	Head Light Bulbs	7. Inspect for damage	7a. Remove and replace bulb.
			7b. Perform operational test before returning LRV to service.

Table 5-7a. Head Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car Head Lights High Beam inoperative. Assumptions: A-End active, forward direction selected, and headlight switch set to HIGH.	Circuit Breaker HLCBA	1. Using a multimeter, measure for 12 VDC at wire 82AA.	1a. If missing, remove and replace HLCBA
			1b. If OK, proceed to the next Probable Cause.
	Forward Control Relay 1A (FCR1A)	2. Use a multimeter to measure for 28 VDC at wire 31GJ.	2a. If missing, proceed to the next Tests & Checks.
			2b. If OK, proceed to the next Probable Cause.
		3. Use a multimeter to measure for 28 VDC at wire 31AH.	3a. If missing, continue to troubleshoot Front and Rear Control Circuit (ref. sheet 252)
			3b. If OK, remove and replace relay
	Headlight Switch (HLS)	4. Use a multimeter to measure for 28 VDC at wire 31GL.	4a. If missing, remove and replace HLS.
			4b. If OK, proceed to the next Probable Cause.
	Head Light Flasher Relay (HLFR)	5. Use a multimeter to measure for 12 VDC at wire 82AM.	5a. If missing, proceed to the next Tests & Checks.
			5b. If OK, proceed to the next Probable Cause.
		6. Use a multimeter to measure for 0 VDC at wire 31GM.	6a. If voltage present, continue to troubleshoot Horn/Gong Circuit (ref. sheet 829)
			6b. If OK, proceed to the next Probable Cause.
	Headlight High Relay (HLHR)	7. Use a multimeter to measure for 12 VDC at wire 82AN.	7a. If not energized, replace relay
			7b. If OK, proceed to the next Probable Cause.
	Headlight Flasher (HLF)	8. Use a multimeter to measure for 12 VDC at wire 82AD.	8a. If missing, replace HLF.
			8b. If OK, proceed to the next Tests & Checks.
		9. Use a multimeter to measure for 12 VDC at wire 82AF.	9a. If missing, replace HLF.
			9b. If OK, proceed to the next Probable Cause.
	Head Light Bulbs	10. Inspect for damage	10a. Remove and replace bulb.
			10b. Perform operational test before returning LRV to service.

Table 5-7a. Head Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
All the B-End circuits supplied by the 12 VDC Power Supply Feed 80BA are inoperative.	28 VDC Circuit breaker HLWWMPCBB / 12 VDC Power Supply	1. Using a multimeter, measure for 28 VDC Power at TB1-7 at the 12 Volt Power Supply Panel.	1a. If missing, remove and replace CB
			1b. If OK, remove and replace the 12 VDC Power Supply
B car Head Lights Low Beam inoperative. Assumptions: B-End active, forward direction selected, and headlight switch set to LOW.	Circuit Breaker HLCBB	1. Using a multimeter, measure for 12 VDC at wire 82BA.	1a. If missing, remove and replace HLCBB
			1b. If OK, proceed to the next Probable Cause.
	Forward Control Relay 1B (FCR1B)	2. Use a multimeter to measure for 28 VDC at wire 31HN.	2a. If missing, proceed to the next Tests & Checks.
			2b. If OK, proceed to the next Probable Cause.
		3. Use a multimeter to measure for 28VDC at wire 31BH.	3a. If missing, continue to troubleshoot Front and Rear Control Circuit (ref. sheet 252)
			3b. If OK, remove and replace relay
	Headlight Switch (HLS)	4. Use a multimeter to measure for 28 VDC at wire 31HP.	4a. If missing, remove and replace HLS.
			4b. If OK, proceed to the next Probable Cause.
	Headlight Low Relay (HLLR)	5. Use a multimeter to measure for 12 VDC at wire 82BC	5a. If missing, replace relay.
			5b. If OK, proceed to the next Tests & Checks.
		6. Use a multimeter to measure for 12 VDC at wire 82BE	6a. If missing, replace relay.
			6b. If OK, proceed to the next Probable Cause.
	Head Light Bulbs	7. Inspect for damage	7a. Remove and replace bulb.
			7b. Perform operational test before returning LRV to service.

Table 5-7a. Head Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car Head Lights High Beam inoperative. <u>Assumptions:</u> B-End active, forward direction selected, and headlight switch set to HIGH.	Circuit Breaker HLCBB	1. Using a multimeter, measure for 12 VDC at wire 82BA.	1a. If missing, remove and replace HLCBB
			1b. If OK, proceed to the next Probable Cause.
	Forward Control Relay 1B (FCR1B)	2. Use a multimeter to measure for 28 VDC at wire 31HN.	2a. If missing, proceed to the next Tests & Checks.
			2b. If OK, proceed to the next Probable Cause.
		3. Use a multimeter to measure for 28 VDC at wire 31BH.	3a. If missing, continue to troubleshoot Front and Rear Control Circuit (ref. sheet 252)
			3b. If OK, remove and replace relay
	Headlight Switch (HLS)	4. Use a multimeter to measure for 28 VDC at wire 31HR.	4a. If missing, remove and replace HLS.
			4b. If OK, proceed to the next Probable Cause.
	Head Light Flasher Relay (HLFR)	5. Use a multimeter to measure for 12 VDC at wire 82BM.	5a. If missing, proceed to the next Tests & Checks.
			5b. If OK, proceed to the next Probable Cause.
		6. Use a multimeter to measure for 0 VDC at wire 31HS.	6a. If voltage present, continue to troubleshoot Horn/Gong Circuit (ref. sheet 829)
			6b. If OK, proceed to the next Probable Cause.
	Headlight High Relay (HLHR)	7. Use a multimeter to measure for 12 VDC at wire 82BN.	7a. If not energized, replace relay
			7b. If OK, proceed to the next Probable Cause.
	Headlight Flasher (HLF)	8. Use a multimeter to measure for 12 VDC at wire 82BD.	8a. If missing, replace HLF.
			8b. If OK, proceed to the next Tests & Checks.
		9. Use a multimeter to measure for 12 VDC at wire 82BF.	9a. If missing, replace HLF.
			9b. If OK, proceed to the next Probable Cause.
	Head Light Bulbs	10. Inspect for damage	10a. Remove and replace bulb.
			10b. Perform operational test before returning LRV to service.

Table 5-7b. Front / Rear Marker Lights

NOTE: The marker lights are located on the front of the car as shown on the graphic at the bottom of the circuit sheet. Each marker light consists of two lights, an "amber" marker light and a "red" marker light. The marker lights are used to indicate the direction of the train as determined from the outside of the train. The "amber" marker lights are energized by the normally open C1-D1 contacts of the direction control front relay 2 (DCFR2, sheet 254). This designates the front of the vehicle. The "red" marker lights are energized by the normally closed C3-D3 contacts of the DCFR2 (sheet 254). This designates the rear of the vehicle. When a direction has not been selected (neutral), the DCFR2 relays are de-energized and the red maker lights are illuminated on both ends.

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car active, front amber marker lights inoperative on A-end. Assumptions: A-End active and forward direction selected.	Exterior Light Circuit Breaker A End (ELCBA)	1. Using a multimeter, measure for 28 VDC at wire 50AA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Direction Control Forward Relay 2A (DCFR2A) / Amber Marker Lights (ML)	2. Using a multimeter, measure for 28 VDC at wire 50AH	2a. If missing, proceed to the next Tests & Checks
			2b. If OK, remove and replace marker light.
		3. Using a multimeter, measure for 28 VDC at wire 35AD.	3a. If present, remove and replace relay.
			3b. If missing, continue to troubleshoot the Direction Control TL Circuit (ref sheet 254)
A car active, rear red marker lights inoperative on B-end. A-End active and forward direction selected.	Exterior Light Circuit Breaker B End (ELCBB)	1. Using a multimeter, measure for 28 VDC at wire 50BA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Direction Control Forward Relay 2B (DCFR2B) / Red Marker Lights (ML)	2. Using a multimeter, measure for 28 VDC at wire 50BG	2a. If missing, proceed to the next Tests & Checks
			2b. If OK, remove and replace marker light.
		3. Using a multimeter, measure for 28 VDC at wire 35BE.	3a. If missing, remove and replace relay.
			3b. If present, continue to troubleshoot the Direction Control TL Circuit (ref sheet 254)

Table 5-7b. Front / Rear Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car active, front amber marker lights inoperative on B-end. Assumptions: B-End active and forward direction selected.	Exterior Light Circuit Breaker B End (ELCBB)	1. Using a multimeter, measure for 28 VDC at wire 50BA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Direction Control Forward Relay 2B (DCFR2B) / Amber Marker Lights (ML)	2. Using a multimeter, measure for 28 VDC at wire 50BH	2a. If missing, proceed to the next Tests & Checks
			2b. If OK, remove and replace marker light.
		3. Using a multimeter, measure for 28 VDC at wire 35BE.	3a. If present, remove and replace relay.
			3b. If missing, continue to troubleshoot the Direction Control TL Circuit (ref sheet 254)
B car active, rear red marker lights inoperative on A-end. Assumptions: B-End active and forward direction selected.	Exterior Light Circuit Breaker A End (ELCBA)	1. Using a multimeter, measure for 28 VDC at wire 50AA.	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Direction Control Forward Relay 2A (DCFR2A) / Red Marker Lights (ML)	2. Using a multimeter, measure for 28 VDC at wire 50AG	2a. If missing, proceed to the next Tests & Checks
			2b. If OK, remove and replace marker light.
		3. Using a multimeter, measure for 28 VDC at wire 35AD.	3a. If missing, remove and replace relay.
			3b. If present, continue to troubleshoot the Direction Control TL Circuit (ref sheet 254)

Table 5-7c. Roof Light

Symptom	Probable Cause	Tests & Checks	Corrective Action
A Car Roof Headlight High Beam Inoperative. <u>Assumptions:</u> A-end active, forward direction selected, and Head Light Switch set to HIGH position.	Roof Headlight Circuit Breaker A (RHLCBA)	1. Using a multimeter, measure for 28 VDC at wire 40AA (pin 14 of the roof headlight high relay)	1a. If missing, remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Roof Headlight High Relay (RHLHR)	2. Using a multimeter, measure for 28 VDC at wire 40AB (pin 13 of RHLHR)	2a. If missing, proceed to next Tests & Checks
			2b. If OK, proceed to next Probable Cause.
		3. Using a multimeter, measure for 28 VDC at wire 31GL (pin A1 of RHLHR)	3a. If missing, continue to troubleshoot the Headlight Control Circuit (ref. sheet 601).
			3b. If OK, remove and replace relay.
	Roof headlight Low Relay (RHLLR) / Roof Headlight Bulb	4. Using a multimeter, measure 28 VDC at wire 40AC (pin 21~~2~~ of the RHLLR)	4a. If missing, proceed to next Tests & Checks
			4b. If OK, remove and replace bulb.
		5. Using a multimeter, measure for 0 VDC at wire 31GK (pin A1 of RHLLR)	5a. If voltage present, continue to troubleshoot the Headlight Control Circuit (ref. sheet 601).
			5b. If OK, remove and replace relay.
A Car Roof Headlight Low Beam Inoperative. <u>Assumptions:</u> A-end active, forward direction selected, and Head Light Switch set to LOW position.	Roof Headlight Circuit Breaker A (RHLCBA)	1. Using a multimeter, measure for 28 VDC at wire 40AA (terminal 1 of the roof headlight power supply)	1a. If missing, remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Roof Headlight Power Supply	2. Using a multimeter, measure for 12 VDC between wires 40AD and 40AE (terminal 1 and 2 of the roof headlight power supply (RED WIRE (+), BLACK WIRE (-))	2a. If missing, remove and replace power supply
			2b. If OK, proceed to next Probable Cause.
	Roof headlight Low Relay (RHLLR) / Roof Headlight Bulb	3. Using multimeter, measure 12 VDC between wires 40AC and 40LVGA (contacts 13 and 33 of RHLLR)	3a. If missing, remove and replace relay
			3b. If OK, remove and replace bulb.

Table 5-7c. Roof Light (cont'.d)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B Car Roof Headlight High Beam Inoperative. Assumptions: B-end active, forward direction selected, and Head Light Switch set to HIGH position.	Roof Headlight Circuit Breaker B (RHLCBB)	1. Using a multimeter, measure for 28 VDC at wire 40BA (pin 14 of the roof headlight high relay)	1a. If missing, remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Roof Headlight High Relay (RHLHR)	2. Using a multimeter, measure for 28 VDC at wire 40BB (pin 13 of RHLHR)	2a. If missing, proceed to next Tests & Checks
			2b. If OK, proceed to next Probable Cause.
		3. Using a multimeter, measure for 28 VDC at wire 31HR (pin A1 of RHLHR)	3a. If missing, continue to troubleshoot the Headlight Control Circuit (ref. sheet 601).
			3b. If OK, remove and replace relay.
	Roof headlight Low Relay (RHLLR) / Roof Headlight Bulb	4. Using a multimeter, measure 28 VDC at wire 40BC (pin 21 of the RHLLR)	4a. If missing, proceed to next Tests & Checks
			4b. If OK, remove and replace bulb.
		5. Using a multimeter, measure for 0 VDC at wire 31HP (pin A1 of RHLLR)	5a. If voltage present, continue to troubleshoot the Headlight Control Circuit (ref. sheet 601).
			5b. If OK, remove and replace relay.
B Car Roof Headlight Low Beam Inoperative. Assumptions: B-end active, forward direction selected, and Head Light Switch set to LOW position.	Roof Headlight Circuit Breaker B (RHLCBB)	1. Using a multimeter, measure for 28 VDC at wire 40BA (terminal 1 of the roof headlight power supply)	1a. If missing, remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Roof Headlight Power Supply	2. Using a multimeter, measure for 12 VDC between wires 40BD and 40BE (terminal 1 and 2 of the roof headlight power supply (RED WIRE (+), BLACK WIRE (-))	2a. If missing, remove and replace power supply
			2b. If OK, proceed to next Probable Cause.
	Roof headlight Low Relay (RHLLR) / Roof Headlight Bulb	3. Using multimeter, measure 12 VDC between wires 40BC and 40LVGB (contacts 13 and 33 of RHLLR)	3a. If missing, remove and replace relay
			3b. If OK, remove and replace bulb.

Table 5-7d. Tail Lights

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, B car rear red tail lights inoperative. Assumptions: A-end active and forward direction selected.	Tail Stop Light Circuit Breaker B End (TSLCBB)	1. Measure 28 VDC at wire 52BA	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Rear Control Relay 1B (RCR1B) / Tail Light Bulb(s)	2. Use multimeter to measure for 28 VDC at wires 52BH and 52BK.	2a. If either is missing, proceed to next Tests & Checks.
			2b. If OK, replace bulbs.
		3. Use multimeter to measure for 28 VDC at wire 31BG.	3a. If missing, continue to troubleshoot Front & Rear Control Circuit (ref. sheet 252)
			3b. If OK, remove and replace relay.
B car leading, A car rear red tail lights inoperative. (Assumes B-end active, forward direction selected)	Tail Stop Light Circuit Breaker A End (TSLCBA)	1. Measure 28 VDC at wire 52AA	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Rear Control Relay 1A (RCR1A) / Tail Light Bulb(s)	2. Use multimeter to measure for 28 VDC at wires 52AH and 52AK.	2a. If either is missing, proceed to next Tests & Checks.
			2b. If OK, replace bulbs.
		3. Use multimeter to measure for 28 VDC at wire 31AG.	3a. If missing, continue to troubleshoot Front & Rear Control Circuit (ref. sheet 252)
			3b. If OK, remove and replace relay.

Table 5-7e. Stop Lights

NOTE: In order to illuminate the stoplights the Train Run relay (TRR, sheet 257) must be energized and the stoplight relay (SLR, sheet 606) must be de-energized. The stoplight relay is de-energized when the CM trainline is de-energized, which occurs when the train is in COAST or any BRAKE position. The stoplight relay is energized in all MOTOR positions.

The stop lights are only illuminated on the rear end of the train controlled by the normally open contacts A1-A2 (left side) B1-B2 (right side) of the rear control relay (RCR1, sheet 252.) Voltage at 28.5 VDC is provided through the normally closed contacts D3-C3 (left side) and the F3-E3 (right side) of the stop light relay (SLR, sheet 606). Voltage at 28.5 VDC is provided through the normally open contacts A1-A2 (left side) and the B1-B2 right side) of the Train Run relay (TRR, sheet 257) to energize the left and right side stop lights.

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, B car rear red stop light inoperative when in braking. (Assumes A-end active, forward direction selected, Master Controller in brake position)	Tail Stop Light Circuit Breaker B End (TSLCBB)	1. Measure 28 VDC at wire 52BA	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller, A-End	2. Use multimeter to measure for 0 VDC at wire 35BX.	2a. If voltage present, continue to troubleshoot Power & Brake TL (ref. sheets 259 & 260).
			2b. If OK, proceed to next Probable Cause
	Rear Control Relay 2B (RCR2B)	3. Use multimeter to check for continuity between wire 35BX and 35HM.	3a. If not OK, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Use multimeter to measure for 28 VDC at wire 31BG.	4a. If missing, continue to troubleshoot Front & Rear Control Circuit (ref. sheet 252)
			4b. If OK, remove and replace relay.

Table 5-7e. Stop Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car leading, B car rear red stop light inoperative when in braking (cont'd.) (Assumes A-end active, forward direction selected, Master Controller in brake position)	Rear Control Relay 1B (RCR1B)	5. Use multimeter to measure for 28 VDC at wires 52BH and 52BK.	5a. If either is missing, remove and replace relay. NOTE: Circuit that energizes RCR1B was confirmed in Step 4.
			5b. If OK, proceed to the next Probable Cause.
	Stoplight Relay B (SLRB)	6. Use multimeter to measure for 28 VDC at wires 52BJ and 52BL.	6a. If either is missing, remove and replace the relay. NOTE: Circuit that energizes SLRB was confirmed in Step 3.
			6b. If OK, proceed to next Probable Cause.
	Train Run Relay B (TRRB) / Stop Light Bulb(s)	7. Use multimeter to measure for 28 VDC at wires 52BM and 52BN.	7a. If either is missing, proceed to the next Tests & Checks.
			7b. If OK, replace bulbs.
		8. Use a multimeter to measure for 28 VDC at wire 25DF.	8a. If missing, continue to troubleshoot Train On & Run TLs (ref. sheet 257).
			8b. If OK, remove and replace relay.

Table 5-7e. Stop Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, A car rear red stop light inoperative when in braking. (Assumes B-end active, forward direction selected, Master Controller in brake position)	Tail Stop Light Circuit Breaker A End (TSLCBA)	1. Measure 28 VDC at wire 52AA	1a. If missing, remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Master Controller, B-End	2. Use multimeter to measure for 0 VDC at wire 35AT.	2a. If voltage present, continue to troubleshoot Power & Brake TL (ref. sheets 259 & 260).
			2b. If OK, proceed to next Probable Cause
	Rear Control Relay 2A (RCR2A)	3. Use multimeter to check for continuity between wire 35AT and 35EY.	3a. If not OK, proceed to next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Use multimeter to measure for 28 VDC at wire 31AG.	4a. If missing, continue to troubleshoot Front & Rear Control Circuit (ref. sheet 252)
			4b. If OK, remove and replace relay.

Table 5-7e. Stop Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car leading, A car rear red stop light inoperative when in braking (cont'd.) (Assumes B-end active, forward direction selected, Master Controller in brake position)	Rear Control Relay 1A (RCR1A)	5. Use multimeter to measure for 28 VDC at wires 52AH and 52AK.	5a. If either is missing, remove and replace relay. NOTE: Circuit that energizes RCR1A was confirmed in Step 4.
			5b. If OK, proceed to the next Probable Cause.
	Stoplight Relay A (SLRA)	6. Use multimeter to measure for 28 VDC at wires 52AJ and 52AL.	6a. If either is missing, remove and replace the relay. NOTE: Circuit that energizes SLRA was confirmed in Step 3.
			6b. If OK, proceed to next Probable Cause.
	Train Run Relay A (TRRA) / Stop Light Bulb(s)	7. Use multimeter to measure for 28 VDC at wires 52AM and 52AN.	7a. If either is missing, proceed to the next Tests & Checks.
			7b. If OK, replace bulbs.
		8. Use a multimeter to measure for 28 VDC at wire 25AS.	8a. If missing, continue to troubleshoot Train On & Run TLs (ref. sheet 257).
			8b. If OK, remove and replace relay.

Table 5-7f. Silent Alarm Lights

NOTE: The Silent alarm circuit is powered by the 12 VDC output of the 12 VDC Power Supply (sheet 602). When the latching Silent Alarm Pushbutton (SAPB) is depressed +12 VDC and ground will be provided to the Silent Alarm on the roof at that end. The Silent Alarm will be illuminated and remain illuminated until the SAPB is pushed again to unlatch the circuit. In addition an input will be provided directly to the radio (sheet 821) to allow the appropriate message to be transmitted.

Symptom	Probable Cause	Tests & Checks	Corrective Action
A End Silent Alarm light inoperative.	Circuit breaker Roof headlight Circuit Breaker A (RHLCBA)	1. Using multimeter, measure 28 vdc at terminal 1 of the 12 VDC Power supply for the roof headlight and silent alarm light	1a. If missing, remove and replace RHLCBA
			1b. If OK, proceed to next Probable Cause.
	12 volt power supply for the roof headlight and silent alarm light	2. Using multimeter, measure 12 vdc between terminals and 2 (RED AND BLACK WIRES) of the 12 VDC Power supply for the roof headlight and silent alarm light	2a. If missing, remove and replace 12V power supply.
			2b. If OK, proceed to next Probable Cause.
	Silent Alarm Push Button	3. Press the silent alarm switch and confirm that 12 VDC is at contact 13 of the silent alarm push button	3a. If missing, remove and replace the silent alarm switch
			3b. If OK, proceed to next Probable Cause.
	Silent Alarm Light	4. Press the silent alarm switch and confirm that 12 VDC is between pins 2 and 1 of the silent alarm light	4a. If missing, remove and replace the silent alarm light
			4b. Perform operational test before returning LRV to service.
B End Silent Alarm light inoperative.	Circuit breaker Roof headlight Circuit Breaker B (RHLCBB)	1. Using multimeter, measure 28 vdc at terminal 1 of the 12 VDC Power supply for the roof headlight and silent alarm light	1a. If missing, remove and replace RHLCBA
			1b. If OK, proceed to next Probable Cause.
	12 volt power supply for the roof headlight and silent alarm light	2. Using multimeter, measure 12 vdc between terminals and 2 (RED AND BLACK WIRES) of the 12 VDC Power supply for the roof headlight and silent alarm light	2a. If missing, remove and replace 12V power supply.
			2b. If OK, proceed to next Probable Cause.
	Silent Alarm Push Button	3. Press the silent alarm switch and confirm that 12 VDC is at contact 13 of the silent alarm push button	3a. If missing, remove and replace the silent alarm switch
			3b. If OK, proceed to next Probable Cause.

Table 5-7f. Silent Alarm Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B End SILENT ALARM light inoperative. (cont'd.)	Silent Alarm Light	4. Press the silent alarm switch and confirm that 12 VDC is between pins 2 and 1 of the silent alarm light	4a. If missing, remove and replace the silent alarm light
			4b. Perform operational test before returning LRV to service.

Table 5-7g. Bypass Activated Lights

Symptom	Probable Cause	Tests & Checks	Corrective Action
BYPASS ACTIVATED lights inoperative A-End.	Exterior Light Circuit Breaker A End (ELCBA)	1. Using multimeter, measure for 28 VDC at Bypass Summary Relay Contact C1	1a. If missing, remove and replace the Exterior Light Circuit Breaker A End (ELCBA).
			1b. If OK, proceed to next Probable Cause.
	Console Indication Circuit Breaker A-End (CICBB)	2. Using multimeter, measure for 28 VDC at Bypass Summary Relay Contact A1	2a. If missing, remove and replace the Console Indication Circuit Breaker A-End (CICBB)
			2b. If OK, proceed to next Probable Cause.
	Bypass Summary Relay (BPSR)	3. With a bypass or cutout active, use a multimeter to measure for 28 VDC at Contact D1 of the Bypass Summary Relay	3a. If missing, proceed to next Tests & Checks
			3b. If OK, proceed to next Probable Cause.
		4. With a bypass or cutout active, use a multimeter to measure for 28 VDC at Coil X1 of the Bypass Summary Relay	4a. If present, remove and replace relay
			4b. If missing, continue to troubleshoot the Bypass & Cutout Summary TL Circuit (ref sheet 266)
	Cutout Activated Light A (CALA) End Bulb	5. Using multimeter, measure for 28 VDC between pin 1 and pin 2 of the bypass light	5a. If OK, and light not illuminated replace the bypass summary light on the A End.
			5b. Perform operational test before returning LRV to service.

Table 5-7g. Bypass Activated Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
BYPASS ACTIVATED lights inoperative B-End.	Exterior Light Circuit Breaker A End (ELCBA)	1. Using multimeter, measure for 28 VDC at Bypass Summary Relay Contact C1	1a. If missing, remove and replace the Exterior Light Circuit Breaker A End (ELCBA).
			1b. If OK, proceed to next Probable Cause.
	Console Indication Circuit Breaker B-End (CICBB)	2. Using multimeter, measure for 28 VDC at wire 37BA	2a. If missing, remove and replace the Console Indication Circuit Breaker B-End (CICBB)
			2b. If OK, proceed to next Probable Cause.
	Bypass Summary Relay (BPSR)	3. With a bypass or cutout active, use a multimeter to measure for 28 VDC at Contact D1 of the Bypass Summary Relay	3a. If missing, proceed to next Tests & Checks
			3b. If OK, proceed to next Probable Cause.
		4. With a bypass or cutout active, use a multimeter to measure for 28 VDC at Coil X1 of the Bypass Summary Relay	4a. If present, remove and replace relay
			4b. If missing, continue to troubleshoot the Bypass & Cutout Summary TL Circuit (ref sheet 266)
	Cutout Activated Light B (CALB) End Bulb	5. Using multimeter, measure for 28 VDC between pin 1 and pin 2 of the bypass light	5a. If OK, and light not illuminated replace the bypass summary light on the B End.
			5b. Perform operational test before returning LRV to service.

Table 5-7h. Turn Signals / Side Marker Lights

NOTE: The turn signal and flashers circuit is energized from the local bus through the exterior lighting circuit breaker (ELCB).

Turn Signals

The turn signals are energized by the turn signal switch (TSS) and are only energized from the lead car (HER2 energized, sheet 251). The emergency flashers are always enabled if the car has been “Localed on”.

If operating from the B-end:

When TSS is switched to the "RIGHT" (R) position, the Turn Signal Flasher Relay B (TSFRB) will be energized at a fixed rate of 75 flashes per minute. The normally open contacts of TSFRB when closed energize the TURN SIGNAL LEFT trainline, which energizes the turn signal left relays (TSLRA and TSLRB) on each car at a fixed rate of 75 flashes per minute. This flashes the side maker lights on the left side of the train (sheet 605) and the side turn signal lights on the left side of the train (sheet 606). Contacts of TSLRA illuminate the LEFT turn signal indicator light on the cab console indicating to the operator that the RIGHT turn signals are energized (sheet 271).

When TSS is switched to the "LEFT" (L) position, the Turn Signal Flasher Relay B (TSFRB) will be energized for an interval determined by the flasher (approximately one-second). The normally open contacts of TSFRB when closed energize the TURN SIGNAL RIGHT trainline, which energizes the turn signal right relays (TSRRA and TSRRB) on each car for at a fixed rate of 75 flashes per minute. This flashes the side maker lights on the right side of the train (sheet 605) and the side turn signal lights on the right side of the train (sheet 606). Contacts of TSRRB illuminate the RIGHT turn signal indicator light on the cab console indicating to the operator that the LEFT turn signals are energized (sheet 271).

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car and B car left and right turn and hazard signals inoperative from A-End. (Assumes A-end active, forward direction selected, and Hazard Warning Pushbutton Depressed.)	Exterior Lighting Circuit Breaker A (ELCBA)	1. Using multimeter, measure for 28 VDC at the contact D2 of Head End Relay 2 A (HER2A)	1a. If not present, remove and replace the circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Hazard Warning Push Button (HWPB)	2. Use a multimeter to measure for 28 VDC at wire 50AL and 50AM	2a. If not present, remove and replace the push button.
			2b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car and B car left and right turn and hazard signals inoperative from A-End. (cont'd.) (Assumes A-End active, forward direction selected, and Hazard Warning Pushbutton Depressed.)	Turn Signal Diodes, A-End (TSRDA / TSLDA)	3. Using a multimeter, measure for 28 VDC at wire 50AD.	3a. If not present, remove and replace both diodes.
			3b. If OK, then at least one diode is OK and the Hazard Signals circuit will continue to function. Further symptoms would arise when using the individual Left / Right turn signals. Diodes can be individually checked at the point or checked when troubleshooting the turn signals. Proceed to next Probable Cause.
	A End Flasher NOTE: The Flasher will cycle at a rate of 75 cycles per minute with an on/off duty percentage of about 50%.	4. Use a multimeter to confirm proper operation at wire 50AC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	4a. If not present, remove and replace the flasher.
			4b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car and B car left and right turn and hazard signals inoperative from A-End. (cont'd.) (Assumes A-End active, forward direction selected, and Hazard Warning Pushbutton Depressed.)	Turn Signal Flash Relay A (TSFRA)	5. Use a multimeter to confirm proper operation at wire 50AE. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	5a. If not present, remove and replace the relay.
			5b. If OK, proceed to next Tests & Checks.
		6. Use a multimeter to confirm proper operation at wire 50AF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	6a. If not present, remove and replace the relay.
			6b. Perform operational test before returning LRV to service.
A car and B car left and right turn and hazard signals inoperative from B-End. (Assumes B-End active, forward direction selected, and Hazard Warning Pushbutton Depressed.)	Exterior Lighting Circuit Breaker B (ELCBB)	1. Using multimeter, measure for 28 VDC at the contact D2 of Head End Relay 2 B (HER2B)	1a. If not present, remove and replace the circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Hazard Warning Push Button (HWPB)	2. Use a multimeter to measure for 28 VDC at wire 50BL and 50BM	2a. If not present, remove and replace the pushbutton.
			2b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car and B car left and right turn and hazard signals inoperative from B-End. (cont'd.) (Assumes B-End active, forward direction selected, and Hazard Warning Pushbutton Depressed.)	Turn Signal Diodes, B-End (TSRDB / TSLDB)	3. Using a multimeter, measure for 28 VDC at wire 50BD.	3a. If not present, remove and replace both diodes.
			3b. If OK, then at least one diode is OK and the Hazard Signals circuit will continue to function. Further symptoms would arise when using the individual Left / Right turn signals. Diodes can be individually checked at the point or checked when troubleshooting the turn signals. Proceed to next Probable Cause.
	B End Flasher NOTE: The Flasher will cycle at a rate of 75 cycles per minute with an on/off duty percentage of about 50%.	4. Use a multimeter to confirm proper operation at wire 50BC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	4a. If not present, remove and replace the flasher.
			4b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car and B car left and right turn and hazard signals inoperative from B-End. (cont'd.) (Assumes B-End active, forward direction selected, and Hazard Warning Pushbutton Depressed.)	Turn Signal Flash Relay B (TSFRB)	5. Use a multimeter to confirm proper operation at wire 50BE. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	5a. If not present, remove and replace the relay. 5b. If OK, proceed to next Tests & Checks.
		6. Use a multimeter to confirm proper operation at wire 50BF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	6a. If not present, remove and replace the relay. 6b. Perform operational test before returning LRV to service.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

<table>
<tr><th>Symptom</th><th>Probable Cause</th><th>Tests & Checks</th><th>Corrective Action</th></tr>
<tr><td rowspan="11">Right Side Turn Signal Inoperative from A-End.

(Assumes A-End active, forward direction selected, and Turn Signal Switch turned to the right.)</td><td rowspan="2">Exterior Lighting Circuit Breaker A (ELCBA)</td><td rowspan="2">1. Using multimeter, measure for 28 VDC at the contact D2 of Head End Relay 2 A (HER2A)</td><td>1a. If not present, remove and replace the circuit breaker.</td></tr>
<tr><td>1b. If OK, proceed to next Probable Cause.</td></tr>
<tr><td rowspan="4">Head End Relay 2A (HER2A)</td><td rowspan="2">2. Using multimeter, measure for 28 VDC at the contact D1 of Head End Relay 2 A (HER2A)</td><td>2a. If not present, proceed to the next Tests & Checks.</td></tr>
<tr><td>2b. If OK, proceed to next Probable Cause.</td></tr>
<tr><td rowspan="2">3. Using multimeter, measure for 28 VDC at the Coil X1 of Head End Relay 2 A (HER2A)</td><td>3a. If not present, continue to troubleshoot the Head and Tail End Control Circuit (ref sheet 251).</td></tr>
<tr><td>3b. If OK, remove and replace relay.</td></tr>
<tr><td rowspan="2">Turn Signal Switch (TSS)</td><td rowspan="2">4. Using multimeter, measure for 28 VDC at the contact 24 of the turn signal switch</td><td>4a. If not present, remove and replace the switch.</td></tr>
<tr><td>4b. If OK, proceed to next Probable Cause.</td></tr>
<tr><td rowspan="2">Turn Signal Right Diode, A-End
(TSRDA)</td><td rowspan="2">5. Using a multimeter, measure for 28 VDC at wire 50AD.</td><td>5a. If not present, remove and replace diode.</td></tr>
<tr><td>5b. If OK, proceed to next Probable Cause.</td></tr>
<tr><td>A End Flasher

NOTE: The Flasher will cycle at a rate of 75 cycles per minute with an on/off duty percentage of about 50%.</td><td>6. Use a multimeter to confirm proper operation at wire 50AC.
- Use the MIN function to check for 0 VDC.
- Use the MAX function to check for 28 VDC.
- Use the HZ function to check for 1.25 Hz.</td><td>6a. If not present, remove and replace the flasher.
6b. If OK, proceed to next Probable Cause.</td></tr>
</table>

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Right Side Turn Signal Inoperative from A-End (cont'd.) (Assumes A-End active, forward direction selected, and Turn Signal Switch turned to the right.)	Turn Signal Flash Relay A (TSFRA)	7. Use a multimeter to confirm proper operation at wire 50AF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	7a. If not present, remove and replace the relay. 7b. Perform operational test before returning LRV to service.
	Troubleshooting for the following: **TSML Right, A-End** Turn Signal Marker Light Right Side, A-End / Turn Signal Right Relay A (TSRRA)	8. Use a multimeter to confirm proper operation at wire 50AK. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	8a. If not present, remove and replace the relay. 8b. If present, remove and replace the TSML. 8c. Continue to next Probable Cause for additional troubleshooting of the circuit.
	Troubleshooting for the following: **TSML Left, B-End** Turn Signal Marker Light Left Side, B-End / Turn Signal Right Relay B (TSRRB)	9. Use a multimeter to confirm proper operation at wire 50BK. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	9a. If not present, remove and replace the relay. 9b. If present, remove and replace the TSML. 9c. Continue to next Probable Cause for additional troubleshooting of the circuit.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Right Side Turn Signal Inoperative from A-End (cont'd.) (Assumes A-End active, forward direction selected, and Turn Signal Switch turned to the right.)	**Troubleshooting for the following:** **Turn Signal Front Right, A-End** Turn Signal Right Relay A (TSRRA)	10. Use a multimeter to confirm proper operation at wire 52AC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	10a. If not present, remove and replace the relay. 10b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Front Right, A-End (cont'd.)** Front Control Relay 1A (FCR1A) / Turn Signal Front Right Side, A-End Bulb	11. Use a multimeter to confirm proper operation at wire 52AG. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	11a. If not present, proceed to the next Tests & Checks. 11b. If OK, remove and replace the bulb.
		12. Use a multimeter to check for 28 VDC at 31AH	12a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252) 12b. If OK, remove and replace the relay
	Troubleshooting for the following: **Turn Signal Rear Left, B-End** Turn Signal Right Relay B (TSRRB)	13. Use a multimeter to confirm proper operation at wire 52BE. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	13a. If not present, remove and replace the relay. 13b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Rear Left, B-End (cont'd.)** Rear Control Relay 1B (RCR1B) / Turn Signal Rear Left Side, B-End Bulb	14. Use a multimeter to confirm proper operation at wire 52BG. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	14a. If not present, proceed to the next Tests & Checks. 14b. If OK, remove and replace the bulb.
		15. Use a multimeter to check for 28 VDC at 31BG	15a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252) 15b. If OK, remove and replace the relay

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Left Side Turn Signal Inoperative from A-End. (Assumes A-End active, forward direction selected, and Turn Signal Switch turned to the left.)	Exterior Lighting Circuit Breaker A (ELCBA)	1. Using multimeter, measure for 28 VDC at the contact D2 of Head End Relay 2 A (HER2A)	1a. If not present, remove and replace the circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Head End Relay 2A (HER2A)	2. Using a multimeter, measure for 28 VDC at the contact D1 of Head End Relay 2 A (HER2A)	2a. If not present, proceed to the next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using a multimeter, measure for 28 VDC at the Coil X1 of Head End Relay 2 A (HER2A)	3a. If not present, continue to troubleshoot the Head and Tail End Control Circuit (ref sheet 251).
			3b. If OK, remove and replace relay.
	Turn Signal Switch (TSS)	4. Using a multimeter, measure for 28 VDC at the contact 14 of the turn signal switch	4a. If not present, remove and replace the switch.
			4b. If OK, proceed to next Probable Cause.
	Turn Signal Left Diode, A-End (TSLDA)	5. Using a multimeter, measure for 28 VDC at wire 50AD.	5a. If not present, remove and replace diode.
			5b. If OK, proceed to next Probable Cause.
	A End Flasher NOTE: The Flasher will cycle at a rate of 75 cycles per minute with an on/off duty percentage of about 50%.	6. Use a multimeter to confirm proper operation at wire 50AC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	6a. If not present, remove and replace the flasher.
			6b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Left Side Turn Signal Inoperative from A-End (cont'd.) (Assumes A-End active, forward direction selected, and Turn Signal Switch turned to the left.)	Turn Signal Flash Relay A (TSFRA)	7. Use a multimeter to confirm proper operation at wire 50AE. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	7a. If not present, remove and replace the relay. 7b. Perform operational test before returning LRV to service.
	Troubleshooting for the following: **TSML Left, A-End** Turn Signal Marker Light Left Side, A-End / Turn Signal Left Relay A (TSLRA)	8. Use a multimeter to confirm proper operation at wire 50AJ. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	8a. If not present, remove and replace the relay. 8b. If present, remove and replace the TSML. 8c. Continue to next Probable Cause for additional troubleshooting of the circuit.
	Troubleshooting for the following: **TSML Right, B-End** Turn Signal Marker Light Right Side, B-End / Turn Signal Left Relay B (TSLRB)	9. Use a multimeter to confirm proper operation at wire 50BJ. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	9a. If not present, remove and replace the relay. 9b. If present, remove and replace the TSML. 9c. Continue to next Probable Cause for additional troubleshooting of the circuit.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Left Side Turn Signal Inoperative from A-End (cont'd.) (Assumes A-End active, forward direction selected, and Turn Signal Switch turned to the left.)	**Troubleshooting for the following:** **Turn Signal Front Left, A-End** Turn Signal Left Relay A (TSLRA)	10. Use a multimeter to confirm proper operation at wire 52AB. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	10a. If not present, remove and replace the relay.
			10b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Front Left, A-End (cont'd.)** Front Control Relay 1A (FCR1A) / Turn Signal Front Left Side, A-End Bulb	11. Use a multimeter to confirm proper operation at wire 52AF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	11a. If not present, proceed to the next Tests & Checks.
			11b. If OK, remove and replace the bulb.
		12. Use a multimeter to check for 28 VDC at 31AH	12a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252)
			12b. If OK, remove and replace the relay
	Troubleshooting for the following: **Turn Signal Rear Right, B-End** Turn Signal Left Relay B (TSLRB)	13. Use a multimeter to confirm proper operation at wire 52BD. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	13a. If not present, remove and replace the relay.
			13b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Rear Right, B-End (cont'd.)** Rear Control Relay 1B (RCR1B) / Turn Signal Rear Right Side, B-end Bulb	14. Use a multimeter to confirm proper operation at wire 52BF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	14a. If not present, proceed to the next Tests & Checks.
			14b. If OK, remove and replace the bulb.
		15. Use a multimeter to check for 28 VDC at 31BG	15a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252)
			15b. If OK, remove and replace the relay

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Right Side Turn Signal Inoperative from B-End. (Assumes B-End active, forward direction selected, and Turn Signal Switch turned to the right.)	Exterior Lighting Circuit Breaker B (ELCBB)	1. Using multimeter, measure for 28 VDC at the contact D2 of Head End Relay 2 B (HER2B)	1a. If not present, remove and replace the circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Head End Relay 2B (HER2B)	2. Using multimeter, measure for 28 VDC at the contact D1 of Head End Relay 2 B (HER2B)	2a. If not present, proceed to the next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at the Coil X1 of Head End Relay 2 B (HER2B)	3a. If not present, continue to troubleshoot the Head and Tail End Control Circuit (ref sheet 251).
			3b. If OK, remove and replace relay.
	Turn Signal Switch (TSS)	4. Using multimeter, measure for 28 VDC at the contact 24 of the turn signal switch	4a. If not present, remove and replace the switch.
			4b. If OK, proceed to next Probable Cause.
	Turn Signal Left Diode, B-End (TSLDB)	5. Using a multimeter, measure for 28 VDC at wire 50BD.	5a. If not present, remove and replace diode.
			5b. If OK, proceed to next Probable Cause.
	B End Flasher NOTE: The Flasher will cycle at a rate of 75 cycles per minute with an on/off duty percentage of about 50%.	6. Use a multimeter to confirm proper operation at wire 50BC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	6a. If not present, remove and replace the flasher.
			6b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Right Side Turn Signal Inoperative from B-End (cont'd.) (Assumes B-End active, forward direction selected, and Turn Signal Switch turned to the right.)	Turn Signal Flash Relay B (TSFRB)	7. Use a multimeter to confirm proper operation at wire 50BE. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	7a. If not present, remove and replace the relay. 7b. Perform operational test before returning LRV to service.
	Troubleshooting for the following: **TSML Right, B-End** Turn Signal Marker Light Right Side, B-End / Turn Signal Left Relay B (TSLRB)	8. Use a multimeter to confirm proper operation at wire 50BJ. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	8a. If not present, remove and replace the relay. 8b. If present, remove and replace the TSML. 8c. Continue to next Probable Cause for additional troubleshooting of the circuit.
	Troubleshooting for the following: **TSML Left, A-End** Turn Signal Marker Light Left Side, A-End / Turn Signal Left Relay A (TSLRA)	9. Use a multimeter to confirm proper operation at wire 50AJ. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	9a. If not present, remove and replace the relay. 9b. If present, remove and replace the TSML. 9c. Continue to next Probable Cause for additional troubleshooting of the circuit.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Right Side Turn Signal Inoperative from B-End (cont'd.) (Assumes B-End active, forward direction selected, and Turn Signal Switch turned to the right.)	**Troubleshooting for the following:** **Turn Signal Front Right, B-End** Turn Signal Left Relay B (TSLRB)	10. Use a multimeter to confirm proper operation at wire 52BB. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	10a. If not present, remove and replace the relay.
			10b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Front Right, B-End (cont'd.)** Front Control Relay 1B (FCR1B) / Turn Signal Front Right Side, B-End Bulb	11. Use a multimeter to confirm proper operation at wire 52BF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	11a. If not present, proceed to the next Tests & Checks.
			11b. If OK, remove and replace the bulb.
		12. Use a multimeter to check for 28 VDC at 31BH	12a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252)
			12b. If OK, remove and replace the relay
	Troubleshooting for the following: **Turn Signal Rear Left, A-End** Turn Signal Left Relay A (TSLRA)	13. Use a multimeter to confirm proper operation at wire 52AD. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	13a. If not present, remove and replace the relay.
			13b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Rear Left, A-End (cont'd.)** Rear Control Relay 1A (RCR1A) / Turn Signal Rear Left Side, A-End Bulb	14. Use a multimeter to confirm proper operation at wire 52AG. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	14a. If not present, proceed to the next Tests & Checks.
			14b. If OK, remove and replace the bulb.
		15. Use a multimeter to check for 28 VDC at 31AG	15a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252)
			15b. If OK, remove and replace the relay

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Left Side Turn Signal Inoperative from B-End. (Assumes B-End active, forward direction selected, and Turn Signal Switch turned to the left.)	Exterior Lighting Circuit Breaker B (ELCBB)	1. Using multimeter, measure for 28 VDC at the contact D2 of Head End Relay 2 B (HER2B)	1a. If not present, remove and replace the circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	Head End Relay 2B (HER2B)	2. Using multimeter, measure for 28 VDC at the contact D1 of Head End Relay 2 B (HER2B)	2a. If not present, proceed to the next Tests & Checks.
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at the Coil X1 of Head End Relay 2 B (HER2B)	3a. If not present, continue to troubleshoot the Head and Tail End Control Circuit (ref sheet 251).
			3b. If OK, remove and replace relay.
	Turn Signal Switch (TSS)	4. Using multimeter, measure for 28 VDC at the contact 14 of the turn signal switch	4a. If not present, remove and replace the switch.
			4b. If OK, proceed to next Probable Cause.
	Turn Signal Right Diode, B-End (TSRDB)	5. Using a multimeter, measure for 28 VDC at wire 50BD.	5a. If not present, remove and replace diode.
			5b. If OK, proceed to next Probable Cause.
	B End Flasher NOTE: The Flasher will cycle at a rate of 75 cycles per minute with an on/off duty percentage of about 50%.	6. Use a multimeter to confirm proper operation at wire 50BC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	6a. If not present, remove and replace the flasher.
			6b. If OK, proceed to next Probable Cause.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Left Side Turn Signal Inoperative from B-End (cont'd.) (Assumes B-End active, forward direction selected, and Turn Signal Switch turned to the left.)	Turn Signal Flash Relay B (TSFRB)	7. Use a multimeter to confirm proper operation at wire 50BF. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	7a. If not present, remove and replace the relay. 7b. Perform operational test before returning LRV to service.
	Troubleshooting for the following: **TSML Left, B-End** Turn Signal Marker Light Left Side, B-End / Turn Signal Right Relay B (TSRRB)	8. Use a multimeter to confirm proper operation at wire 50BK. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	8a. If not present, remove and replace the relay. 8b. If present, remove and replace the TSML. 8c. Continue to next Probable Cause for additional troubleshooting of the circuit.
	Troubleshooting for the following: **TSML Right, A-End** Turn Signal Marker Light Right Side, A-End / Turn Signal Right Relay A (TSRRA)	9. Use a multimeter to confirm proper operation at wire 50AK. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	9a. If not present, remove and replace the relay. 9b. If present, remove and replace the TSML. 9c. Continue to next Probable Cause for additional troubleshooting of the circuit.

Table 5-7h. Turn Signals / Side Marker Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Left Side Turn Signal Inoperative from B-End (cont'd.) (Assumes B-End active, forward direction selected, and Turn Signal Switch turned to the left.)	**Troubleshooting for the following:** **Turn Signal Front Left, B-End** Turn Signal Right Relay B (TSRRB)	10. Use a multimeter to confirm proper operation at wire 52BC. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	10a. If not present, remove and replace the relay. 10b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Front Left, B-End (cont'd.)** Front Control Relay 1B (FCR1B) / Turn Signal Front Left Side, B-End Bulb	11. Use a multimeter to confirm proper operation at wire 52BG. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	11a. If not present, proceed to the next Tests & Checks. 11b. If OK, remove and replace the bulb.
		12. Use a multimeter to check for 28 VDC at 31BH	12a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252) 12b. If OK, remove and replace the relay
	Troubleshooting for the following: **Turn Signal Rear Right, A-End** Turn Signal Right Relay A (TSTRA)	13. Use a multimeter to confirm proper operation at wire 52AE. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	13a. If not present, remove and replace the relay. 13b. If OK, proceed to the next Probable Cause.
	Troubleshooting for the following: **Turn Signal Rear Right, A-End (cont'd.)** Rear Control Relay 1A (RCR1A) / Turn Signal Rear Right Side, A-End Bulb	14. Use a multimeter to confirm proper operation at wire 52AG. - Use the MIN function to check for 0 VDC. - Use the MAX function to check for 28 VDC. - Use the HZ function to check for 1.25 Hz.	14a. If not present, proceed to the next Tests & Checks. 14b. If OK, remove and replace the bulb.
		15. Use a multimeter to check for 28 VDC at 31AG	15a. If not present, continue troubleshooting the Front and Rear Control Circuit (ref. sheet 252) 15b. If OK, remove and replace the relay

Table 5-7i. Emergency Lights

NOTE: The emergency lights are powered by the essential bus from the emergency lighting circuit breaker (EMLCB), and are controlled by the emergency lighting contactor (ELC, sheet 621).

Each car end has eight emergency lights positioned above and near the passenger doors (sheet 153). There are two emergency lights located at the articulation section (one on the A-end and one on the B-end. Each emergency light fixture uses one LED tube for illumination. The frame of each fixture is grounded to the carbody for safety.

Symptom	Probable Cause	Tests & Checks	Corrective Action
Emergency Lights Inoperative.	Emergency Light Circuit Breaker (EMLCB)	1. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at the contact E2 of the Local Time Delay Relay	1a. If 28 VDC is not present at contact E2 of the Local Time Delay Relay, remove and replace the Emergency Light Circuit Breaker (EMLCB)
			1b. If OK, proceed to next Probable Cause.
	Local Delay Timer (LDT)	2. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at the contact D2 of the Local Delay Timer	2a. If 28 VDC is not present at contact D2 of the Local Delay Timer, remove and replace the Local Delay Timer (LDT).
			2b. If OK, proceed to next Probable Cause.
	Emergency Lighting Diode A (ELDA)	3. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at the Cathode Side of the Emergency Lighting Diode A (ELDA)	3a. If 28 VDC is not present at the Cathode Side of the Diode, remove and replace the Emergency Lighting Diode A (ELDA)
			3b. If OK, proceed to next Probable Cause.
	Emergency Lighting Contactor (ELC)	4. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at C1 of the Emergency Lighting Contactor (ELC).	4a. if 28 VDC is not present at C1 of the Emergency Lighting Contactor (ELC), remove and replace the Emergency Lighting Contactor (ELC).
			4b. Perform operational test before returning LRV to service.

Table 5-7i. Emergency Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A-End Emergency Lights Inoperative.	Emergency Lighting Contactor (ELC)	1. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at C1 of the Emergency Lighting Contactor (ELC).	1a. if 28 VDC is not present at C1 of the Emergency Lighting Contactor (ELC), remove and replace the Emergency Lighting Contactor (ELC).
			1b. Perform operational test before returning LRV to service.
B-End Emergency Lights Inoperative.	Emergency Lighting Contactor (ELC)	1. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at B1 of the Emergency Lighting Contactor (ELC).	1a. if 28 VDC is not present at B1 of the Emergency Lighting Contactor (ELC), remove and replace the Emergency Lighting Contactor (ELC).
			1b. Perform operational test before returning LRV to service.

Table 5-7j. Main Interior Lights

When the vehicle is off the LTDR relay (sheet 218) is de-energized. When the car is keyed up or is put in LOCAL mode the Local Time Delay relay (LTDR) is energized. Contacts A2-A1 of LTDR will close to provide 28.5 VDC to energize the main lighting contactor (MLC) if the contacts of APSFLRA (sheet 208) are de-energized.

Similarly contacts E2-E1 of LTDR will close to provide 28.5 VDC at Local Delay Timer (LDT) timer pin D1. Once LDT is energized then the Emergency Lighting Contactor (ELC) will be energized. This will illuminate the emergency lights (sheet 622) which are only in front of each set of passenger doors and in the articulation section. The (LDT) will remain energized for 16 minutes after the LRV is localed off or when the (LTDR) has de-energized.

The MLC illuminates the main lights on the A-Unit (sheet 623) and the B-Unit (sheet 624).

In the event of an APS fault the APS Fault relay A (APSFLRA, sheet 208) will be energized which will serve to disable the main lighting circuits in this “load-shed” mode. The emergency lighting will still be illuminated. In the event of a loss of 750 VDC all passenger lights remain illuminated.

When the operator keys down the car the Local Bus Timer (LBT sheet 218) times out. Then the LTDR (sheet 218) will be de-energized which will de-energize the main lighting contactor (MLC), and the main lighting circuits will go off. However, the emergency lighting contactor (ELC) will remain enabled for 16 minutes by the Local Delay Timer (LDT). The 16 minute time delay is set by the jumper between the pins B3 and C2. This will keep the emergency lighting on for that period. After that time the ELC will be de-energized and the emergency lighting will turn off.

Symptom	Probable Cause	Tests & Checks	Corrective Action
Main Interior Lights Inoperative.	Low Voltage Control Circuit Breaker (LVCCB)	1. Using multimeter, measure for 28 VDC at contact A2 of the Local Time Delay Relay	1a. If missing, remove and replace the Low Voltage Control Circuit Breaker (LVCCB)
			1b. If OK, proceed to next Probable Cause.
	Local Time Delay Relay (LTDR)	2. Using multimeter, measure for 28 VDC at contact A1 of the Local Time Delay Relay (LTDR)	2a. If missing, proceed to next Tests & Checks
			2b. If OK, proceed to next Probable Cause.
		3. Using multimeter, measure for 28 VDC at contact X1 of the Local Time Delay Relay (LTDR)	3a. If missing, troubleshoot the Local Control Bus Trainline circuit further (ref sheet 218)
			3b. If OK, remove and replace the Local Time Delay Relay (LTDR)

Table 5-7j. Main Interior Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
Main Interior Lights Inoperative (cont'd.)	Aux Power Supply Fault Relay A (APSFLRA)	4. Using multimeter, measure for 28 VDC at contact NC2 of the Aux Power Supply Fault Relay A (APSFLRA)	4a. If missing, proceed to next Tests & Checks
			4b. If OK, Perform operational test before returning LRV to service.
		5. Using a multimeter, measure for 28 VDC at wire 26AD (NO contact of APS relay K2)	5a. If missing, troubleshoot the Aux Power Supply (ref Section 5.8.3)
			5b. If OK, remove and replace the Aux Power Supply Fault Relay A (APSFLRA)
Main Interior Lights Inoperative A-End.	Interior Lighting Circuit Breaker A (ILCBA)	1. Using multimeter, measure for 28 VDC at the Main Lighting Contactor A contact A2.	1a. If missing, remove and replace the Interior Lighting Circuit Breaker A (ILCBA)
			1b. If OK, proceed to next Probable Cause.
	Main Lighting Contactor A (MLCA)	2. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at the Main Lighting Contactor A contact A1.	2a. If not energized remove and replace the Main Lighting Contactor A (MLCA)
			2b. Perform operational test before returning LRV to service.
Main Interior Lights Inoperative B-End.	Interior Lighting Circuit Breaker A (ILCBB)	1. Using multimeter, measure for 28 VDC at the Main Lighting Contactor B contact A2.	1a. If missing, remove and replace the Interior Lighting Circuit Breaker B (ILCBB)
			1b. If OK, proceed to next Probable Cause.
	Main Lighting Contactor B (MLCB)	2. With the A-End as the active cab select the forward direction. Using multimeter, measure for 28 VDC at the Main Lighting Contactor B contact A1.	2a. If not energized remove and replace the Main Lighting Contactor B (MLCB)
			2b. Perform operational test before returning LRV to service.

Table 5-7k. Cab Lights

The cab lights are powered by the emergency lighting circuit breaker, EMLCB, (sheet 210). The cab light switch (CBLS), which is located on the cab console, controls whether the cab lights are “ON” or “OFF” in the leading cab (MCKSR5A/B, sheet 257). Each cab light fixture consists of two LED tubes for illumination.

Symptom	Probable Cause	Tests & Checks	Corrective Action
A car cab light inoperative.	Emergency Lighting Circuit Breaker (EMLCB)	1. Using multimeter, measure for 28 VDC at Cab Light Switch Contact 13	1a. If missing, remove and replace the Emergency Lighting Circuit Breaker (EMLCB)
			1b. If OK, proceed to next Probable Cause.
	Cab Light switch	2. With the A-End as the active cab select the forward direction and turn the cab light switch to ON. Using multimeter, measure for 28 VDC at contact 14 of the cab light switch	2a. If 28 VDC is not at contact 14 of the cab light switch, remove and replace the cab light switch.
			2b. If OK, proceed to next Probable Cause.
	Master Key Switch Relay 5 A End (MKSR5A)	3. Using multimeter, measure for 28 VDC at contact A1 of the Master Key Switch Relay 5 A End (wire 24AD)	3a. If not present, proceed to the next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using a multimeter, measure for 28 VDC at wire 25AP	4a. If OK, remove and replace relay
			4b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
	Cab Light Bulb	5. With the A-End as the active cab select the forward direction and turn the cab light on. Using multimeter, measure for 28 VDC between pin 1 and pin 2 of the cab light assembly connector	5a. If 28 VDC is between pins 1 and pin 2 of the cab light assembly connector, remove and replace the cab light assembly
			5b. Perform operational test before returning LRV to service.

Table 5-7k. Cab Lights (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B car cab light inoperative.	Emergency Lighting Circuit Breaker (EMLCB)	1. Using multimeter, measure for 28 VDC at Cab Light Switch Contact 13	1a. If missing, remove and replace the Emergency Lighting Circuit Breaker (EMLCB)
			1b. If OK, proceed to next Probable Cause.
	Cab Light switch	2. With the B-End as the active cab select the forward direction and turn the cab light switch to ON. Using multimeter, measure for 28 VDC at contact 14 of the cab light switch	2a. If 28 VDC is not at contact 14 of the cab light switch, remove and replace the cab light switch.
			2b. If OK, proceed to next Probable Cause.
	Master Key Switch Relay 5 B End (MKSR5B)	3. Using multimeter, measure for 28 VDC at contact A1 of the Master Key Switch Relay 5 B End (wire 24BD)	3a. If not present, proceed to the next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using a multimeter, measure for 28 VDC at wire 25DD	4a. If OK, remove and replace relay
			4b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
	Cab Light Bulb	5. With the B-End as the active cab select the forward direction and turn the cab light on. Using multimeter, measure for 28 VDC between pin 1 and pin 2 of the cab light assembly connector	5a. If 28 VDC is between pins 1 and pin 2 of the cab light assembly connector, remove and replace the cab light assembly
			5b. Perform operational test before returning LRV to service.

Table 5-7l. 12 VDC Others (Windshield Wiper and Power Mirrors)

NOTE: The lighting circuits that contain Automotive Power 12 VDC are as follows:

- Head Lights (see table 5-7a)
- Windshield Wiper
- Power Mirror

Symptom	Probable Cause	Tests & Checks	Corrective Action
All the A-End circuits supplied by the 12 VDC Power Supply Feed 80AA are inoperative.	Circuit Breaker HLWWMPCBA / 12 VDC Power Supply	1. Using a multimeter, measure for 28 VDC Power at TB1-7 at the 12 Volt Power Supply Panel.	1a. If missing, remove and replace CB
			1b. If OK, remove and replace the 12 VDC Power Supply
A car mirror control and windshield wiper inoperative.	Circuit breaker WWCBA	1. Using a multimeter, measure for 12 VDC at wire 81AA	1a. Remove and replace WWCBA
			1b. Perform operational test before returning LRV to service.
A Car windshield wiper inoperative. (Assumes A-End active, forward direction selected)	MCKSR4A Relay	1. Confirm that the relay MCKSR4A is energized	1a. If not energized, proceed to the next Tests & Checks
			1b. If OK, proceed to the next Probable Cause.
		2. Use a multimeter to measure for 28 VDC at wire 25AP.	2a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257)
			2b. If OK, remove and replace relay.
	WPRA Relay	3. Confirm that the relay WPRA is energized.	3a. If not energized replace WPRA Relay
			3b. If OK, proceed to the next Probable Cause.
	Wiper Switch	4. Confirm the wiper delay switch red wire (81AB) has 12 VDC. Set the wiper switch to high position and confirm the white wire (81AC) has 12 VDC Power.	4a. If 81AB has 12 VDC and 81AC does not have 12 VDC replace Wiper Switch
			4b. If OK, proceed to the next Probable Cause.
	Wiper Motor	5. Confirm the wiper delay switch red wire (81AB) has 12 VDC. Set the wiper switch to high position and confirm the white wire (81AC) has 12 VDC Power.	5a. If 81AB has 12 VDC and 81AC has 12 VDC replace Wiper Motor
			5b. Perform operational test before returning LRV to service.

Table 5-7l. 12 VDC Others (Windshield Wiper and Power Mirrors) (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A-end, Left Mirror Inoperative (Unable to Tilt to the Left). (Assumes the mirror switch set to the left mirror, move the switch to the mirror left position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (5) 81AL and negative lead at position (7) 81AN. Measure for +12 VDC.	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (3-BLK) 81AL and negative lead at position (1-RED) 81AN. Measure for +12 VDC.	2a. If present, remove and replace the Left Side Mirror Assembly
			2b. Perform operational test before returning LRV to service.
A-end, Left Mirror Inoperative (Unable to Tilt to the Right). (Assumes the mirror switch set to the left mirror, move the switch to the mirror right position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (5) 81AL and negative lead at position (7) 81AN. Measure for -12 VDC.	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (3-BLK) and negative lead at position (1-RED) 81AN. Measure for -12 VDC.	2a. If present, remove and replace the Left Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
A-end, Left Mirror Inoperative (Unable to Tilt Up). (Assumes the mirror switch set to the left mirror, move the switch to the mirror up position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (3) 81AM and negative lead at position (7) 81AN. Measure for +12 VDC.	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81AM and negative lead at position (1-RED) 81AN. Measure for +12 VDC.	2a. If present, remove and replace the Left Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
A-end, Left Mirror Inoperative (Unable to Tilt Down). (Assumes the mirror switch set to the left mirror, move the switch to the mirror down position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (3) 81AM and negative lead at position (7) 81AN. Measure for -12 VDC.	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81AM and negative lead at position (1-RED) 81AN. Measure for -12 VDC.	2a. If present, remove and replace the Left Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.

Table 5-7I. 12 VDC Others (Windshield Wiper and Power Mirrors) (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
A-end, Right Mirror Inoperative (Unable to Tilt to the Left). (Assumes the mirror switch set to the right mirror, move the switch to the mirror left position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (6) 81AH and negative lead at position (8) 81AK. Measure for +12 VDC	1a. If missing, remove and replace the mirror control switch. 1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at right motor wire position (3-BLK) 81AH and negative lead at position (1-RED) 81AK. Measure for +12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly. 2b. Perform operational test before returning LRV to service.
A-end, Right Mirror Inoperative (Unable to Tilt to the Right). (Assumes the mirror switch set to the right mirror, move the switch to the mirror right position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (6) 81AH and negative lead at position (8) 81AK Measure for -12 VDC.	1a. If missing, remove and replace the mirror control switch. 1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at right motor wire position (3-BLK) 81AH and negative lead at position (1-RED) 81AK. Measure for -12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly. 2b. Perform operational test before returning LRV to service.
A-end, Right Mirror Inoperative (Unable to Tilt Up). (Assumes the mirror switch set to the right mirror, move the switch to the mirror up position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (4) 81AJ and negative lead at position (8) 81AK. Measure for +12 VDC	1a. If missing, remove and replace the mirror control switch. 1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81AJ and negative lead at position (1-RED) 81AK. Measure for +12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly. 2b. Perform operational test before returning LRV to service.
A-end, Right Mirror Inoperative (Unable to Tilt Down). (Assumes the mirror switch set to the right mirror, move the switch to the mirror down position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (4) 81AJ and negative lead at position (8) 81AK. Measure for -12 VDC	1a. If missing, remove and replace the mirror control switch. 1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81AJ and negative lead at position (1-RED) 81AK. Measure for -12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly. 2b. Perform operational test before returning LRV to service.

Table 5-7I. 12 VDC Others (Windshield Wiper and Power Mirrors) (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
All the B-End circuits supplied by the 12 VDC Power Supply Feed 80BA are inoperative.	28 VDC Circuit breaker HLWWMPCBB / 12 VDC Power Supply	1. Using a multimeter, measure for 28 VDC Power at TB1-7 at the 12 Volt Power Supply Panel.	1a. If missing, remove and replace CB
			1b. If OK, remove and replace the 12 VDC Power Supply
B car mirror control and windshield wiper inoperative.	Circuit breaker WWCBB	1. Using a multimeter, measure for 12 VDC at wire 81BA	1a. Remove and replace WWCBB
			1b. Perform operational test before returning LRV to service.
B Car windshield wiper inoperative. (Assumes B-End active, forward direction selected)	MCKSR4B Relay	1. Confirm that the relay MCKSR4B is energized	1a. If not energized, proceed to the next Tests & Checks
			1b. If OK, proceed to the next Probable Cause.
		2. Use a multimeter to measure for 28 VDC at wire 25DD.	2a. If missing, continue to troubleshoot Train On and Run TLs (ref. sheet 257)
			2b. If OK, remove and replace relay.
	WPRB Relay	3. Confirm that the relay WPRB is energized.	3a. If not energized replace WPRB Relay
			3b. If OK, proceed to the next Probable Cause.
	Wiper Switch	4. Confirm the wiper delay switch red wire (81BB) has 12 VDC. Set the wiper switch to high position and confirm the white wire (81BC) has 12 VDC Power.	4a. If 81BB has 12 VDC and 81BC does not have 12 VDC replace Wiper Switch
			4b. If OK, proceed to the next Probable Cause.
	Wiper Motor	5. Confirm the wiper delay switch red wire (81BB) has 12 VDC. Set the wiper switch to high position and confirm the white wire (81BC) has 12 VDC Power.	5a. If 81BB has 12 VDC and 81BC has 12 VDC replace Wiper Motor
			5b. Perform operational test before returning LRV to service.

Table 5-7I. 12 VDC Others (Windshield Wiper and Power Mirrors) (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B-end, Left Mirror Inoperative (Unable to Tilt to the Left). (Assumes the mirror switch set to the left mirror, move the switch to the mirror left position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (5) 81BL and negative lead at position (7) 81BN. Measure for +12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (3-BLK) 81BL and negative lead at position (1-RED) 81BN. Measure for +12 VDC	2a. If present, remove and replace the Left Side Mirror Assembly
			2b. Perform operational test before returning LRV to service.
B-end, Left Mirror Inoperative (Unable to Tilt to the Right). (Assumes the mirror switch set to the left mirror, move the switch to the mirror right position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (5) 81BL and negative lead at position (7) 81BN. Measure for -12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (3-BLK) 81BL and negative lead at position (1-RED) 81BN. Measure for -12 VDC	2a. If present, remove and replace the Left Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
B-end, Left Mirror Inoperative (Unable to Tilt Up). (Assumes the mirror switch set to the left mirror, move the switch to the mirror up position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (3) 81BM and negative lead at position (7) 81BN. Measure for +12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81BM and negative lead at position (1-RED) 81BN. Measure for +12 VDC	2a. If present, remove and replace the Left Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
B-end, Left Mirror Inoperative (Unable to Tilt Down). (Assumes the mirror switch set to the left mirror, move the switch to the mirror down position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (3) 81BM and negative lead at position (7) 81BN. Measure for -12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Use a multimeter to measure at left motor wire position (2-WHT) 81BM and negative lead at (1-RED) 81BN. Measure for -12 VDC	2a. If present, remove and replace the Left Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.

Table 5-7I. 12 VDC Others (Windshield Wiper and Power Mirrors) (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
B-end, Right Mirror Inoperative (Unable to Tilt to the Left). (Assumes the mirror switch set to the right mirror, move the switch to the mirror left position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (6) 81BH and negative lead at position (8) 81BK. Measure for +12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at right motor wire position (3-BLK) 81BH and negative lead at position (1-RED) 81BK. Measure for +12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
B-end, Right Mirror Inoperative (Unable to Tilt to the Right). (Assumes the mirror switch set to the right mirror, move the switch to the mirror right position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (6) 81BH and negative lead at position (8) 81BK. Measure for -12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at right motor wire position (3-BLK) 81BH and negative lead at position (1-RED) 81BK. Measure for -12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
B-end, Right Mirror Inoperative (Unable to Tilt Up). (Assumes the mirror switch set to the right mirror, move the switch to the mirror up position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (4) 81BJ and negative lead at position (8) 81BK. Measure for +12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81BJ and negative lead at position (1-RED) 81BK. Measure for +12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.
B-end, Right Mirror Inoperative (Unable to Tilt Down). (Assumes the mirror switch set to the right mirror, move the switch to the mirror down position)	Mirror Switch	1. Using a multimeter, place the positive lead at mirror switch wire position (4) 81BJ and negative lead at position (8) 81BK. Measure for -12 VDC	1a. If missing, remove and replace the mirror control switch.
			1b. If OK, proceed to the next Probable Cause.
	Mirror Motor	2. Using a multimeter, place the positive lead at left motor wire position (2-WHT) 81BJ and negative lead at position (1-RED) 81BK. Measure for -12 VDC	2a. If present, remove and replace the Right Side Mirror Assembly.
			2b. Perform operational test before returning LRV to service.

5.8.8 Communications

The troubleshooting procedures for Communications are provided in Table 5-8. Detailed information can be found in the respective RMSM sections:

- Section 0200: Car Body
- Section 1400: Communications
- Section 1700: Data Comm (TCN)
- Section 1800: Train Controls and Diagnostics
- Section 1900: CCTV

WARNING

THE FOLLOWING TABLES INCLUDE INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY OR DEATH.

Table 5-8. Vehicle Communications

Symptom	Probable Cause	Tests & Checks	Corrective Action
Multiple Ethernet devices not connected.	VMS Circuit Breakers, DVR Circuit Breaker	1. Confirm 28 VDC at wire 63AA/BA and 27BA	1a. If not present remove and replace respective circuit breaker.
			1b. See RMSM, Section 1700 for Ethernet Network Troubleshooting.
No trainline indication after coupling or incorrect vehicles displayed on TOD.	Active Cab	1. Confirm there is an active cab in the consist after coupling.	1a. If not preset, key up a cab
			1b. If OK, proceed to next Probable Cause.
	EEI Modules	2. Check TLIM Status on the TOD on **all vehicles** to ensure they are connected	2a. See RMSM, Section 1700 for EEIM Troubleshooting.
			2b. Perform operational test before returning LRV to service.

Table 5-8. Vehicle Communications (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
APC not counting passengers.	VMS Circuit Breaker	1. Confirm 28 VDC at wire 63BA	1a. If not present remove and replace circuit breaker.
			1b. If OK, proceed to next Probable Cause.
	CoPilot PC, Analyzers, Sensors	2. Check for faults on the TOD.	2. See RMSM, Section 0200 for APC Troubleshooting.
Train Radio does not power on.	Master Key Switch Relay 5A/5B (assumes active cab)	1. If radio does not turn on automatically, try turning on manually. Press the power button on the radio control head.	1a. If powers on manually, proceed to the next Tests & Checks.
			1b. If does not power on manually, proceed to the next Probable Cause.
		2. Using a multimeter, measure for 12 VDC at the Master Key Switch Relay 5A/5B Contact C1	2a. If missing, proceed to the next Tests & Checks
			2b. If OK, proceed to next Probable Cause.
		3. Using a multimeter, measure for 28 VDC at wire 25AP / 25DD	3a. If OK, remove and replace relay
			3b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
	Radio Power Supply Circuit Breaker	4. Confirm 28 VDC at wire 55AA/BA	4a. If not present remove and replace circuit breaker.
			4b. If OK, proceed to next Probable Cause.
	Radio Power Supply	5. Confirm 12 VDC at wire 55AB/BB	5a. If not present remove and replace power supply.
			5b. If OK, proceed to next Probable Cause.
	Radio Power Supply 12V Circuit Breaker	6. Confirm 12 VDC at wire 84AA/BA	6a. If not present remove and replace circuit breaker.
			6b. If OK, proceed to next Probable Cause.
	Radio Unit	7. (see Corrective Action)	7. Notify RailComm.
Train Radio is not audible.	Cab Speaker	1. Disconnect Cab Speaker from Radio Equipment Panel. Measure for 8 ohm resistance between speaker terminals.	1a. If not 8 ohm, remove and replace cab speaker.
			1b. If OK, proceed to next Probable Cause.
	Radio Unit	2. (see Corrective Action)	2. Notify RailComm.

5.8.9 Coupler Control

The troubleshooting procedures for the coupler control follows.

WARNING

THE FOLLOWING TABLES INCLUDE INSTRUCTIONS FOR TROUBLESHOOTING LIVE CIRCUITS. FOLLOW ALL LACMTA SAFETY PROCEDURES FOR WORKING ON OR AROUND A LIVE VEHICLE. FAILURE TO COMPLY CAN RESULT IN SERIOUS INJURY OR DEATH.

Table 5-9. Coupler Control

NOTE: Coupling and uncoupling may be performed automatically or manually. Vehicles are coupled automatically when one vehicle moves and fully engages the coupler hook of the stationary vehicle. Vehicles are coupled manually when the Upper Control Panel Electric Coupler Switch (ECS) is set to NORMAL. Vehicles are uncoupled automatically when the ECS is moved to ISOLATE. Vehicles are uncoupled manually by setting the Coupler Loop Switch (CLS) to the uncoupled position and following the prescribed steps to retract the electric couplers. Setting the ECS coupler switch to ISOLATE closes the trainline loops, effectively forming an end-of-train, while disconnecting most of the trainlines from the electric coupler connector interface.

Symptom	Probable Cause	Tests & Checks	Corrective Action
After mechanically coupling the Electric Couplers are not extended (Active Cab car). Assumptions: The mating couplers are properly mechanically coupled.	Coupler Control circuit breaker	1. Confirm 28 VDC at wire 43AA/BA at circuit breaker	1a. If not present remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Low Voltage Control circuit breaker	2. Confirm 28 VDC at wire 25AA/BA at circuit breaker	2a. If not present remove and replace circuit breaker
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 4A/B	3. Confirm MCKSR4A/B is energized on CRP4A/B	3a. If not energized, proceed to the next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using a multimeter, measure for 28 VDC at wire 25AP / 25DD	4a. If OK, remove and replace relay
			4b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)

Table 5-9. Coupler Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
After mechanically coupling the Electric Couplers are not extended (Active Cab car) (cont'd.)	Coupler Diode 3A/B	5. When ECS is moved to Normal confirm 28 VDC at wire 43AB/BB at CRP4A/B	5a. If not present remove and replace CD3A/B
			5b. If OK, proceed to next Probable Cause.
	Isolate Time Delay Relay (ITDR) / Isolate Time Delay (ITD) Timer	6. Confirm 28 VDC at wire 43AE/BE at cab terminal block 4	6a. If not present, proceed to the next Tests & Checks
			6b. If OK, proceed to next Probable Cause.
		7. Verify ITDA/ITDB L-terminal is de-energized. Measure for 0 VDC at wire 43AT/BT.	7a. If not OK, wait for ITD Timer to extinguish.
			7b. If OK, proceed to next Probable Cause.
	Coupler Proximity Switch	8. Confirm 28 VDC at wire 43AK/BK at Coupler Loop Switch (CLS)	8a. If not present, remove and replace the Coupler Proximity Switch (S8).
			8b. If OK, proceed to next Probable Cause.
	Coupler Loop Switch (CLS)	9. Confirm CLS is in Uncouple position	9a. If not AUX OFF BOTH CARs and move to Uncouple position and AUX ON BOTH CARs.
			9b. If OK, proceed to next Tests & Checks.
		10. Confirm 28 VDC at wire 43AU/BU	10a. If not present, remove and replace CLS
			10b. If OK, proceed to next Probable Cause.
	Hook Switch Relay A/B	11. Confirm HSRA/B is energized.	11a. If not energized, remove and replace the relay
			11b. If OK, proceed to next Tests & Checks.
		12. Verify HSRA/B contacts A1-B1 close. Confirm 28 VDC at wire 43AW/BW.	12a. If not present remove and replace the relay.
			12b. If OK, proceed to next Probable Cause.

Table 5-9. Coupler Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
After mechanically coupling the Electric Couplers are not extended (Active Cab car) (cont'd.)	Coupler Diode 2A/B / Coupler Diode 4A/B	13. Confirm 28 VDC at wire 43AL/BL at CRP7A/B	13a. In not present, continue to next Tests & Checks.
			13b. If OK, proceed to next Probable Cause.
		14. Individually test CD2A/B and CD4A/B for the failure	14a. Replace the failed diode(s).
	Extend Magnet Valve	15. Confirm 28 VDC at terminal 9 in Coupler Terminal box	15a. If not present check coupler wiring and ground wiring.
			15b. If voltage present and Electric Coupler is not extended remove and replace Extend Magnet Valve. Check coupler ground wiring.
After mechanically coupling the Electric Couplers are not extended (Inactive Cab car). <u>Assumptions:</u> The mating couplers are properly mechanically coupled.	Low Voltage Control circuit breaker	1. Confirm 28 VDC at wire 25AA/BA at circuit breaker	1a. If not present remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
	Train Run Relay	2. Confirm 28 VDC at wire 25CT/DT at CRP7A/B	2a. If not present, proceed to the next Tests & Checks
			2b. If OK, proceed to next Probable Cause.
		3. Verify TRRA/B is de-energized. Measure for 0 VDC at wire 25AS/DF.	3a. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
			3b. If OK, remove and replace TRRA/B.
	Isolate Time Delay Relay (ITDR) / Isolate Time Delay (ITD) Timer	4. Confirm 28 VDC at wire 43AE/BE at cab terminal block 4	4a. If not present, proceed to the next Tests & Checks
			4b. If OK, proceed to next Probable Cause.
		5. Verify ITDA/ITDB L-terminal is de-energized. Measure for 0 VDC at wire 43AT/BT.	5a. If not OK, wait for ITD Timer to extinguish.
			5b. If OK, proceed to next Probable Cause.

Table 5-9. Coupler Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
After mechanically coupling the Electric Couplers are not extended (Inactive Cab car) (cont'd.)	Coupler Proximity Switch	6. Confirm 28 VDC at wire 43AK/BK at Coupler Loop Switch (CLS)	6a. If not present, remove and replace the Coupler Proximity Switch (S8).
			6b. If OK, proceed to next Probable Cause.
	Coupler Loop Switch (CLS)	7. Confirm CLS is in Uncouple position	7a. If not AUX OFF BOTH CARs and move to Uncouple position and AUX ON BOTH CARs.
			7b. If OK, proceed to next Tests & Checks.
		8. Confirm 28 VDC at wire 43AU/BU	8a. If not present, remove and replace CLS
			8b. If OK, proceed to next Probable Cause.
	Hook Switch Relay A/B	9. Confirm HSRA/B is energized.	9a. If not energized, remove and replace the relay
			9b. If OK, proceed to next Tests & Checks.
		10. Verify HSRA/B contacts A1-B1 close. Confirm 28 VDC at wire 43AW/BW.	10a. If not present remove and replace the relay.
			10b. If OK, proceed to next Probable Cause.
	Coupler Diode 2A/B / Coupler Diode 4A/B	11. Confirm 28 VDC at wire 43AL/BL at CRP7A/B	11a. In not present, continue to next Tests & Checks.
			11b. If OK, proceed to next Probable Cause.
		12. Individually test CD2A/B and CD4A/B for the failure	12a. Replace the failed diode(s).
	Extend Magnet Valve	13. Confirm 28 VDC at terminal 9 in Coupler Terminal box	13a. If not present check coupler wiring and ground wiring.
			13b. If voltage present and Electric Coupler is not extended remove and replace Extend Magnet Valve. Check coupler ground wiring.

Table 5-9. Coupler Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
After mechanically coupling Electric Couplers are extended but Coupler Loop switches remain in UNCOUPLE position.	Electrical Couplers on the other car	1. Confirm the electric couplers are extended on the other car	1a. If not extended, extend heads before proceeding.
			1b. If OK, proceed to next Probable Cause.
	Coupler Loop Switch	2. With the transfer switch in the Neutral position. confirm 28 VDC at wire 43AP/BP at CLS	2a. If not present, check coupler pins and car wiring
			2b. If OK but CLS does not energize and rotate to COUPLE position remove and replace CLS.
When automatically uncoupling the electric couplers do not retract.	Coupler Control circuit breaker	1. Confirm 28 VDC at wire 43AA/BA at circuit breaker	1a. If not present remove and replace circuit breaker
			1b. If OK, proceed to next Probable Cause.
(Assumes the ECS was used to Isolate)	Low Voltage Control circuit breaker	2. Confirm 28 VDC at wire 25AA/BA at circuit breaker	2a. If not present remove and replace circuit breaker
			2b. If OK, proceed to next Probable Cause.
	Master Controller Key Switch Relay 4A/B	3. Confirm MCKSR4A/B is energized on CRP4A/B	3a. If not energized, proceed to the next Tests & Checks.
			3b. If OK, proceed to next Probable Cause.
		4. Using a multimeter, measure for 28 VDC at wire 25AP / 25DD	4a. If OK, remove and replace relay
			4b. If not OK, troubleshoot the Train ON and RUN circuit further starting with Cab Front and Rear Interlock Relays (ref sheet 257)
	Coupler Diode 3A/B	5. Confirm 28 VDC at wire 43AB/BB at CRP4A/B	5a. If not present remove and replace CD3A/B
			5b. If OK, proceed to next Probable Cause.
	No Motion relay 2A / 1B	6. Confirm NMR2A / 1B is energized on CRP1A/B	6a. If indicator on relay is green check operation per Table 5-2.
			6b. If indicator on relay is red, proceed to next Probable Cause.

Table 5-9. Coupler Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
When automatically uncoupling the electric couplers do not retract (cont'd.)	Electric Coupler Switch (ECS)	7. When ECS is moved to Isolate, confirm 28 VDC at contact 24 (wire 43AR/BR)	7a. If not OK, remove and replace ECS
			7b. If OK, proceed to next Probable Cause.
	Retract Magnet Valve	8. When ECS is moved to Isolate confirm 28 VDC at terminal 11 in Coupler Terminal box	8a. If not present check coupler wiring and ground wiring.
			8b. If voltage present and Electric Coupler is not retracted remove and replace Retract Magnet Valve. Check coupler ground wiring.
When automatically uncoupling the electric couplers retract but Coupler Loop switches remain in Couple position after moving ECS to Isolate position.	Coupler Loop Switch	1. When ECS is moved to Isolate confirm 28 VDC at wire 43AR/BR at CLS	1a. If not present check car wiring.
			1b. If OK but CLS does not energize and rotate to UNCOUPLE position remove and replace CLS.

Table 5-9. Coupler Control (cont'd.)

Symptom	Probable Cause	Tests & Checks	Corrective Action
When automatically uncoupling the electric couplers retract and CLS rotates to UNCOUPLE but unable to mechanically uncouple.	Uncouple Push Button (UCPB)	1. When UCPB is depressed, confirm 28 VDC at contact 14 (wire 43AH/BH)	1a. If not OK, remove and replace UCPB
			1b. If OK, proceed to next Probable Cause.
	Uncouple Time Delay (UTD) Timer	2. When UCPB is depressed, confirm 28 VDC at wire 43AS/BS	2a. If not OK, remove and replace UTDA/B Timer.
			2b. If OK, proceed to next Probable Cause.
	Uncouple Time Delay Relay (UTDR) (Part 1 of 2)	3. When UCPB is depressed, Confirm 28 VDC at wire 43AF/BF (relay contact D1)	3a. If not OK, remove and replace UTDR.
			3b. If OK, proceed to next Tests & Checks.
	Coupler Loop Switch	4. When UCPB is depressed, confirm 28 VDC at wire 43AM/BM at CLS	4a. If not present, remove and replace CLS.
			4b. If OK, proceed to next Probable Cause.
	Electric Coupler Retract Switches 3.2	5. When UCPB is depressed, confirm 28 VDC at terminals 1 and 4 in Coupler Terminal box	5a. If not present, remove and replace S3.2.
			5b. If OK, proceed to next Probable Cause.
	Electric Coupler Retract Switches 3.1	6. When UCPB is depressed, confirm 28 VDC at terminals 3 in Coupler Terminal box	6a. If not present, remove and replace S3.1.
			6b. If OK, proceed to next Probable Cause.
	Uncouple Time Delay Relay (UTDR) (Part 2 of 2)	7. When UCPB is depressed, Confirm 28 VDC at wire 43AJ/BJ (relay contact D3)	7a. If not OK, remove and replace UTDR.
			7b. If OK, proceed to next Tests & Checks.
	Uncouple Magnet Valve	8. When UCPB is moved to Uncouple confirm 28 VDC at terminal 7 in Coupler Terminal box	8a. If not present check coupler wiring and ground wiring.
			8b. If voltage present and Coupler is not uncoupled remove and replace Uncouple Magnet Valve. Check coupler ground wiring.

5.8.10 Start-Up Conditions

The table below lists potential faults that may occur on the P3010 during the course of vehicle start-up, including coupling or uncoupling. These faults should clear on their own in a few moments or after an active cab is selected. If these faults do not clear, further action may be necessary.

NOTE: See RMSM Section 1800 for a complete list of P3010 faults on the TOD.

Table 5-10: Start-Up Condition Faults

Subsystem	Fault	Symptoms	Possible Cause	Corrective Action
Friction Brakes (Air Supply Unit)	Main Reservoir Pressure Low	ECUC reports main reservoir pressure low on the TOD and/or the main reservoir indicator on the TOD is displaying a value below 90 psi.	1. Air stored in the main reservoir was exhausted below 90 psi since the vehicle was last on.	1a. Confirm both MR cutout cocks are closed, wait for the air compressor to turn on and pumps the Main Reservoirs.
				1b. If the Main Reservoir Pressure does not increase after a few minutes, refer to 1300 RMM for detailed troubleshooting steps.
Friction Brakes	Control Volume Deviation	ECU reports control volume deviation on the TOD.	1. There is a discrepancy between the commanded control volume pressure and actual control volume pressure	1a. Confirm the main reservoir compressor has been allowed adequate time to fill the reservoirs and system with air pressure.
				1b. If the fault does not clear automatically after a few minutes, refer to 1300 RMM for detailed troubleshooting steps.

Table 5-10: Start-Up Condition Faults (cont'd.)

Subsystem	Fault	Symptoms	Possible Cause	Corrective Action
NVR	All Cameras Offline	All cameras on the vehicle are reporting offline within the first (5) minutes of the vehicle powering on.	1. The vehicle may have recently been reset. When this occurs, the NVR system may still be performing or booting from the graceful shutdown courtesy of the NVR Shutdown Timer.	1a. Wait approximately (5) minutes for the NVR and Ethernet cameras to boot-up and begin recording. Confirm there is a reset event for all cameras and that no active camera fault persists.
				1b. If all camera faults do not clear automatically, refer to 1900 RMM for detailed troubleshooting steps.
Communications (TOA)	The Master ACP cannot determine the order of TrainID.	TOA reporting TrainID fault on the TOD.	1. If the train consist configuration has recently changed, either adding or subtracting cars, the combination of Head End and Tail End Relays may have changed to an "invalid" state momentarily, triggering this fault.	1a. Key up one end of the train consist, ensuring no other cab is keyed up, and wait.
				1b. If the fault does not clear automatically, refer to 1402 RMM for detailed troubleshooting steps.
Communications (TOA)	Error with RIO A/B connection.	TOA reporting RIO connection error on the TOD.	1. If the Ethernet RIO does not respond back to the Interface Unit (IFU) in the allotted time, this fault will be triggered.	1a. Wait approximately (15) seconds for the IFU to send another request to the RIO.
				1b. If the fault does not clear automatically, refer to 1402 RMM for detailed troubleshooting steps.

Table 5-10: Start-Up Condition Faults (cont'd.)

Subsystem	Fault	Symptoms	Possible Cause	Corrective Action
Communications (TOA)	Error with all Signs and both PID Controllers.	TOA reporting FSD1, FDS2, SDS2, SDS2, PID Controller 1 and PID Controller 2 error	1. The APS is in a load shed condition.	1a. Use the TOD to check for low Line Voltage (below 550 VDC). TOD can be used to confirm load shed via the MVB 0100 port information. Wait for Line Voltage to rise.
				1b. If the APS is not in a load shed condition, refer to 1402 RMM for detailed troubleshooting steps.
Propulsion	Friction Brake Not Released (when rollback occurs in the train consist)	Propulsion unit reports Friction Brakes Not Released, typically on the coupled cars in a consist that did not detect rollback.	1. Rollback detected by one (or more) propulsion units in the consist, causing friction brakes to apply.	1a. Put the vehicle into a Full-Service Brake (FSB), wait for no motion, and confirm the FB Release TL is Low to reset the Rollback. (The FB Not Released fault will also reset.)
				1b. If the Friction Brake Not Released fault persists or rollback is not being detected in the consist, further troubleshooting of the Friction Brake Release TL is required.

Subsystem	Fault	Symptoms	Possible Cause	Corrective Action
ATC (CSRD)	CSRD Module Fail, CSRD Link Down, (others)	The ATC reports CSRD Fault	1. CSRD module fail, CSRD link down, and other CSRD faults may occur at startup. This is normal and is due to one half of the CSRD receiving a reset command before the other.	1a. If these faults are seen at startup with CSRD Self-Test passed event, no further investigation is necessary.
				1b. If these faults occurred along with ATP CSRD Link Down event, further troubleshooting may be required. Refer to 1500 RMM for detailed troubleshooting steps.
ATC (TWC)	TWC Link Down	The ATC reports TWC Link Down	1. The vehicle is positioned above a TWC loop, but the vehicle did not receive a response from the Wayside TWC. The Wayside TWC loop may not be operative at that moment.	1a. Move the vehicle above different TWC loops and see if the error re-occurs.
				1b. If the fault continues, refer to 1500 RMM for detailed troubleshooting steps.
ATC (ADU)	ADU Hardware Error	The ADU reports a HW error on the TOD	1. If ADU buttons are pressed multiple times in quick succession.	1a. Provide a pause between ADU button presses.
				1b. If the fault continues, refer to 1500 RMM for detailed troubleshooting steps.

5.8.11 LRV Vibration

There are multiple systems that can contribute to LRV Vibrations. These conditions can stem from wheel flats, LRV leveling, and excessive debris in the traction motor rotor holes. The following table is in the order of operations of the first corrective action to the last correction action. The cleaning of the traction motor rotor holes should be the last corrective action

Table 5-11: LRV Vibration

Subsystem	Fault	Symptoms	Possible Cause	Corrective Action
Trucks	Wheel Flats	LRV Vibrations	Wheel flats	See RMSM, Section 1200 Trucks, Section 4.4.2 for corrective maintenance
Trucks	Lateral and Radial Runout	LRV Vibrations	Lateral and Radial Runout out of tolerance	See HRMM, Section 1200 Trucks, Section 3.4.1.2.5 for corrective maintenance

Table 5-11: LRV Vibration (cont'd.)

Subsystem	Fault	Symptoms	Possible Cause	Corrective Action
Trucks	LRV out of Level	LRV Vibrations	LRV out of Level requiring shimming or adjustments	See RMSM, Section 1200 Trucks, Section 4.2 for corrective maintenance
Trucks	Excessive Debris	LRV Vibrations	Excessive Debris trapped in the traction motor rotor holes	See RMSM, Section 0700 Propulsion, Section 4.8 Preventative Maintenance

5.8.12 Traction Motor Exhaustive Cleaning Procedure

The following cleaning procedure is developed and described in that the traction motors are mounted to the gearboxes on the truck. To perform this procedure, after the first step of cleaning the LRV must be moved forward or backward about 44 inches to allow the rotor of traction motor to rotate by 180 degrees. Moving the LRV is required to perform the cleaning in accordance with this procedure.

1. Remove the two (M10) traction motor inspection cover mounting bolts below from Figure 5-7 in the graphic below.

2. Compressor air must be blown with a blow gun into the rotor cooling holes one at a time. Each hole must have compressor air blown into the traction motor for (30) seconds per hole per traction motor rotor cooling hole. Please see view from Figure 5-8 in the graphic below.

3. After cleaning all four (4) traction motors on the LRV, the LRV must be moved forward or backward about 44 inches to allow the rotor of traction motor to rotate by 180 degrees.

4. When the LRV is repositioned to allow for the traction rotor of traction motor to be rotated by 180 degrees. Repeat step number 2

5. After cleaning, all speed sensor cover mounting bolts must be reinstalled and tightened. The torque shall be 39 Nm.

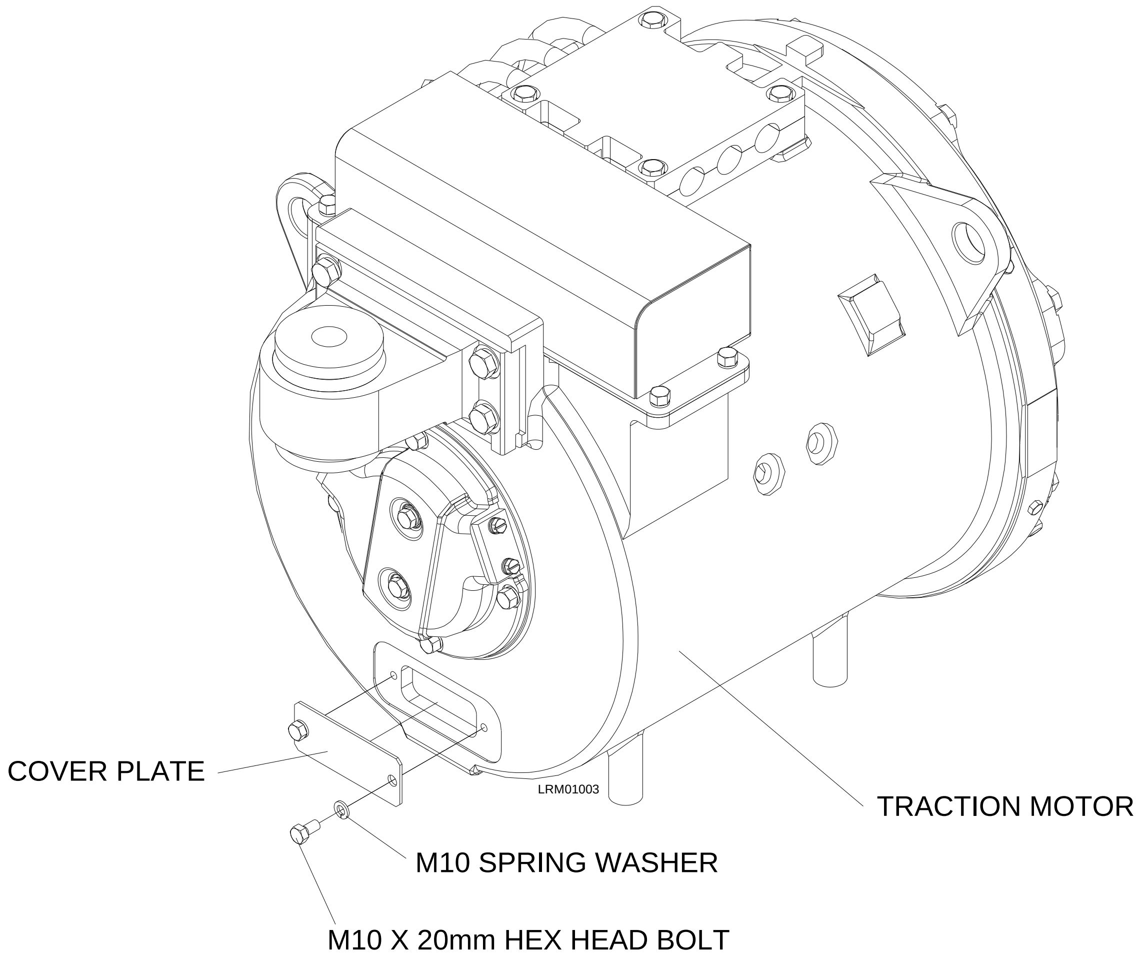


Figure 5-7: Traction Motor

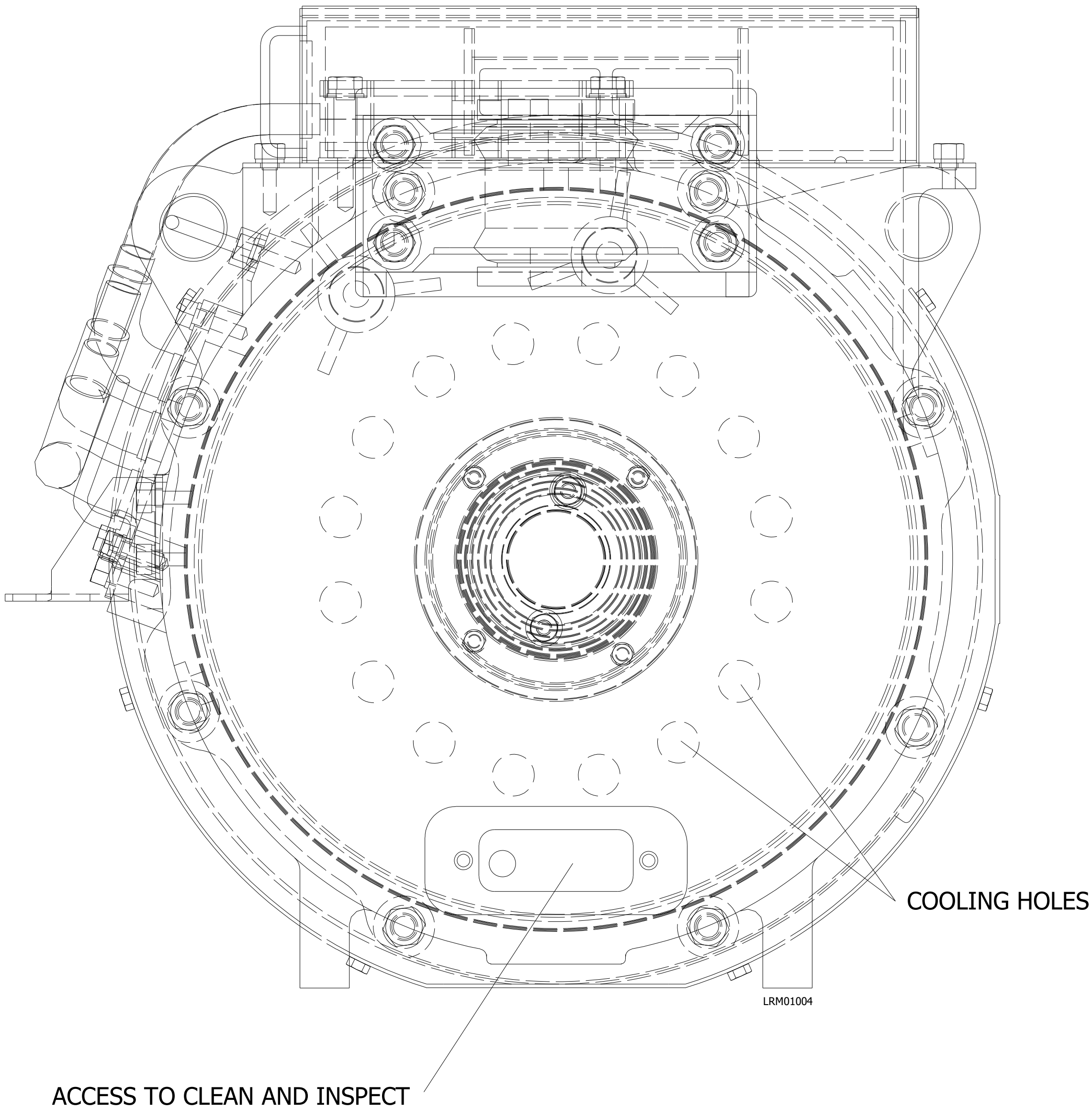


Figure 5-8: Rotor Cooling Holes

5.9 Reference Documents

The following individual documents listed below are helpful in troubleshooting P3010 vehicle systems. All of these documents can be found compiled into the ***Schematic and Narrative Manual***.

- P3010 Circuits Diagram (CDRL 128)
- P3010 Tabulations (CDRL 128)
- UER0677, Vehicle Circuits Descriptions (CDRL 130, 131, 508)
- KSJ Wiring Diagrams (see list in Table 5-12a)
- Relay Panel Schematics (see list in Table 5-12b)
- Cab Console Schematics (see list in Table 5-12c)
- Additional Vehicle System Schematics (see list in Table 5-12d)

Table 5-12a: List of KSJ Wiring Diagrams

KSJ WIRING DIAGRAMS	
NO.	DESCRIPTION
UB07956	WIRING DIAGRAM FOR HIGH TENSION CIRCUIT A-END
UB07957	WIRING DIAGRAM FOR HIGH TENSION CIRCUIT B-END
UB07958	ROOF WIRING DIAGRAM A-UNIT
UB07959	ROOF WIRING DIAGRAM B-UNIT
UB07960	UNDERFLOOR WIRING DIAGRAM A-UNIT
UB07961	UNDERFLOOR WIRING DIAGRAM B-UNIT
UB07962	CAB WIRING DIAGRAM A-UNIT
UB07963	CAB WIRING DIAGRAM B-UNIT
UB07964	INTERIOR WIRING DIAGRAM A-UNIT
UB07965	INTERIOR WIRING DIAGRAM B-UNIT
UB07966	ARTICULATION LOCKER WIRING DIAGRAM A-UNIT
UB07967	ARTICULATION LOCKER WIRING DIAGRAM B-UNIT
UB07968	INTERNAL WIRING DIAGRAM OF BATTERY
UB07981	TERMINAL ASSIGNMENT OF CAB JUNCTION BOARD A-UNIT
UB07982	TERMINAL ASSIGNMENT OF CAB JUNCTION BOARD B-UNIT
UB07983	TERMINAL ASSIGN. OF ARTIC. END JUNCTION BOARD A-UNIT
UB07984	TERMINAL ASSIGN. OF ARTIC. END JUNCTION BOARD B-UNIT
UB07985	PIN ASSIGNMENT OF ARTICULATION JUMPER
UB07986	PIN ASSIGNMENT OF ROOF EQUIPMENT
UB07987	PIN ASSIGNMENT OF UNDERFLOOR EQUIPMENT
UB07988	TERMINAL ASSIGNMENT OF INTERIOR EQUIPMENT
UB07989	PIN ASSIGNMENT OF INTERIOR EQUIPMENT
UB07990	PIN ASSIGNMENT OF INTERIOR LIGHT
UB07991	TERMINAL & PIN ASSIGNMENT OF DOOR EQUIPMENT
UB07992	PIN ASSIGNMENT OF ECU
UB07993	PIN ASSIGNMENT OF CAB EQUIPMENT
UB07994	TERMINAL ASSIGNMENT OF CAB EQUIPMENT
UB07995	PIN ASSIGNMENT OF CAB CONSOLE
UB07996	PIN ASSIGNMENT OF ATP EQUIPMENT
UB07997	TERMINAL & PIN ASSIGNMENT OF RELAY PANEL A-UNIT
UB07998	TERMINAL & PIN ASSIGNMENT OF RELAY PANEL B-UNIT
UB07999	PIN ASSIGNMENT OF TCN EQUIPMENT
UB08000	TERMINAL ASSIGNMENT OF DC BREAKER PANEL
UB08001	TERMINAL ASSIGNMENT OF AC BREAKER PANEL
UB08002	PIN ASSIGNMENT OF COUPLER

Table 5-12b: List of Relay Panel Schematics

RELAY PANEL SCHEMATICS	
NO.	DESCRIPTION
RTC2282	CRP1A SCHEMATIC
RTC2281	CRP2A SCHEMATIC
RTC2278	CRP3A SCHEMATIC
RTC2377	CRP4A SCHEMATIC
RTC2280	CRP5A SCHEMATIC
RTC2286	CRP6A SCHEMATIC
RTC2289	CRP7A SCHEMATIC
RTC2290	CRP8A SCHEMATIC
RTC2283	ARP1B SCHEMATIC
RTC2329	CRP1B SCHEMATIC
RTC2330	CRP2B SCHEMATIC
RTC2374	CRP3B SCHEMATIC
RTC2378	CRP4B SCHEMATIC
RTC2399	CRP5B SCHEMATIC
RTC2287	CRP6B SCHEMATIC
RTC2326	CRP7B SCHEMATIC

Table 5-12c: List of Cab Console Schematics

CAB CONSOLE SCHEMATICS	
NO.	DESCRIPTION
RTC2381	CAB CONSOLE SCHEMATIC
RTC2408	CAB PANEL 1 SCHEMATIC
RTC2380	CAB PANEL 2 SCHEMATIC
RTC2382	CAB PANEL 3 SCHEMATIC
RTC2409	CAB PANEL 4 SCHEMATIC

Table 5-12d: List of Additional Vehicle System Schematics

ADDITIONAL VEHICLE SYSTEM SCHEMATICS	
NO.	DESCRIPTION
RTC2292	RADIO POWER SUPPLY WIRING DIAGRAM
RTC2284	COUPLER PIN ASSIGNMENT
RTC2482	HORN CONTROLLER PANEL WIRING DIAGRAM
RTC2388	TRACK BRAKE A/B SCHEMATIC
RTC2389	TRACK BRAKE C SCHEMATIC
RTC2373	UPPER CONTROL PANEL SCHEMATIC
RTC2379	BYPASS PANEL SCHEMATIC
RTC2293	12VDC POWER SUPPLY WIRING DIAGRAM
RTC2387	HEATER/DEFROSTER PANEL SCHEMATIC
RTC2323	HOURMETER/ODOMETER PANEL WIRING DIAGRAM

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