LOS ANGELES COUNTY

METROPOLITAN TRANSPORTATION AUTHORITY

LIGHT RAIL VEHICLE

P2550

RUNNING MAINTENANCE AND SERVICE MANUAL

SECTION 07 PROPULSION

LOS ANGELES COUNTY

METROPOLITAN TRANSPORTATION AUTHORITY

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RUNNING MAINTENANCE AND SERVICE MANUAL

VOLUME M-01
PART I
THEORY OF OPERATION
SECTION 07 - PROPULSION

SECTION 07

PROPULSION

PART I

THEORY OF OPERATION

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SECTION 07

PROPULSION SYSTEM

07-I-01 INTRODUCTION

This Section of the Running Maintenance and Service Manual is divided into three Parts:

- Part I: Theory of Operation
- Part II: Troubleshooting
- Part III: Maintenance

Each Paragraph is numbered accordingly, to avoid that paragraphs of the same Section, pertaining to a different Part, have the same number.

Part I - Theory of Operation

Part I gives a thorough overview of the System structure and operation, by means of descriptions, figures, photos, schematics, block diagrams and flow charts, together with references to other documents or Sections when needed.

Part II - Troubleshooting

It gives the Maintenance Technicians a path to troubleshoot the System in every condition by means of the available tools:

- The PTU, equipped with the specific SW program
- The IDU
- The Fault Isolation Table.

Part III - Maintenance consists of:

- Preventive Maintenance
- Corrective Maintenance
- Consumable Materials
- Test Equipment, Tools, & Special Tools

07-I-01.a LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

The Abbreviations, Acronyms and Symbols commonly used throughout this manual are given below with their related meaning.

Abbreviation	Meaning
AC	Alternate Current
APS	Auxiliary Power Supply
ATP	Automatic Train Protection
BCU	Brake Control Unit
BI	Board Inside
C/L	Centerline
CCF	Charging Filter Contactor
CEMIPS	Conductive EMI Protection System
CMF	Inverter Fan Contactor
COAST	Coast Mode
CP	Propulsion Contactor
DC	Direct Current
DCU	Door Control Unit
DSP	Digital Signal Processor
EB	Emergency Brake
ECU	(Brake) Electronic Control Unit
EDU	EMI Detector Unit
EMI	Electromagnetic Interferences
FCF	Fuse Charging Filter
FM	Function Module
FPGA	Field Programmable Gate Array
FSB	Full Service Brake Mode
FWD	Forward
GTW	Gateway
HRSB	High Rate Service Brake
HSCB	High Speed Circuit Breaker
HV	High Voltage
HVAC	Heating Ventilation & Air Conditioning
HW	Hardware
IDU	Integrated Diagnostic Unit
IDU_A	Integrated Diagnostic Unit of the ‘A’ body section
IDU_B	Integrated Diagnostic Unit of the ‘B’ body section

Abbreviation	Meaning
IGBT	Insulated Gate Bipolar Transistor
LH	Left-Hand Side
LON	Local Operative Network
LRV	Light Rail Vehicle
LV	Low Voltage
LVDS	Low Voltage Distribution System
LVPS	Low Voltage Power Supply
M	Power (Motor) Mode
MBL	Metro Blue Line
MC	Master Controller
MDS	Monitor and Diagnostic System
ME	Motor truck total Effort
MoT	Master Of Train
MoV	Master Of Vehicle
MTBF	Mean Time Between Failure
MVB	Multifunction Vehicle Bus
MVDS	Medium Voltage Distribution System
NVRAM	Non Volatile Random Access Memory
OCS	Overhead Catenary System
PGL	Pasadena Gold Line
PTU	Portable Test Unit
PWM	Pulse Width Modulation
RAM	Random Access Memory
RCF	Filter Charging Resistor
REB	Emergency Brake Relay
REV	Reverse
RH	Right-Hand Side
RMF	Inverter Fan Supply Contactor
RMS	Root Mean Square
ROM	Read Only Memory
RSCEB	Slide Controlled Emergency Brake Relay
RTC	Real Time Clock
SCEB	Slide Controlled Emergency Brake
SW	Software
TA	Current Transducer (from “A” Module to “A” Motors phase)
TAL1	Positive Current Transducer
TAL2	Negative Current Transducer
TB	Current Transducer (from“B” Module to “B” Motors phase)
TBS	To Be Supplied

Abbreviation	Meaning
TC	Current Transducer(from “C” Module to “C” Motors phase)
TCH	Current Transducer(from “Chopper” Module to Braking Resistor
TCMS	Train Control and Monitor and System
TCN	Train Communication Network
TCU	Traction Control Unit
TCU_A	Traction Control Unit of the ‘A’ body section
TCU_B	Traction Control Unit of the ‘B’ body section
TE	Trailer (center) truck Effort
TLE	Trailer (center) truck Limited Effort
TVF	Transducer Voltage Filter
TWC	Train-to-Wayside Communication
VVVF	Variable Voltage Variable Frequency
WTB	Wired Train Bus

07-I-01.b LIST OF DEFINITIONS

The Definitions commonly used throughout this manual are given below with their related meaning.

Definition	Meaning
'A' body section	The section of an articulated vehicle containing the pantograph
'B' body section	The section of an articulated vehicle not containing the pantograph
AW0	Empty car operating weight
AW1	Full seated load plus AW0
AW2	Standees at 4 persons per square meter plus AW1
AW3	Standees at 6 persons per square meter plus AW1
AW4	Standees at 8 persons per square meter plus AW1
Front door	The door close to the Operator's Cab
Rear door	The door close to the Articulation Section
MC Handle	Master Controller Handle
"A" Cab (or Cab A)	Operator Cab in the A body section
"B" Cab (or Cab B)	Operator Cab in the B body section

07-I-01.c LIST OF MEASUREMENT UNITS AND SYMBOLS

The Measurement Units commonly used throughout this manual are given below with their related meaning.

Definition	Meaning
ft	Foot (Length)
gal........	Gallon (Volume)
in.........	Inch (Length)
kg.........	Kilogram - approx 2.205 pounds (Weight)
km.........	Kilometer - approx 0.621 miles (Length)
lb.........	Pound (Weight)
lb-ft	Pound force (Force)
m	Meter - approx 3.28 feet (Length)
mm	Millimeter - approx 0.0394 inches (Length)
mph	Miles per hour (Velocity)
Km/h	Kilometers per hour (Velocity)
s.........	Seconds (Time)
V	Volt (Tension)
Vdc	Direct Voltage (Tension)
Vac	Alternate Voltage (Tension)
kVA........	Kilo-Volt-Ampere (Power)
kW	Kilo-Watt (Power)
W	Watt (Power)
F	Farad (Capacity)
H.........	Henry (Inductance)
Ω	Ohm (Resistance)
°F........	Fahrenheit (Temperature)
°C	Celsius (Temperature)
A	Ampere (Current)
Hz	Herz (Frequency)
rpm	Revolution per Minute (Frequency)
N.........	Newton (Force)
Nm........	Newton-Meter (Torque)
mphps........	Mile Per Hour Per Second (Acceleration)

07-I-02 THEORY OF OPERATION

07-I-02.01 General Description of the System

[redacted]

Figure 07-I-02.1 Propulsion System Block Diagram

The P2550 LRV is made up of a married pair of semi-permanently coupled ‘A’ and ‘B’ Body Sections.

A motorized Truck is connected to each A and B body section.

The Center (unmotorized) Truck is located under the articulation joint.

Each LRV can operate independently, by means of its own Propulsion System. Multiple vehicles (up to 4) may be coupled together to form a Train Consist.

The LRV Propulsion System is made up of two separate, identical Propulsion Subsystems, made up of the following components (refer to Figure 07-I-02.1):

- Propulsion Inverter, supplying the two AC motors mounted on the relevant Motor Truck, each one of them coupled with the relevant Gear Unit to transform the electric power into mechanical power for the axles
- Line Reactor, to prevent damage to the Inverter solid-state equipment from very high voltage transients, likely to be present on the line
- Brake Resistor, to dissipate the energy generated by the motors during dynamic braking, when the Catenary Line is not receptive
- Master Controller/Encoder, which translates the position of the MC Handle into current signals to be interpreted by the Traction Control Unit (TCU)

The two Propulsion sub-systems and the relevant components are totally interchangeable.

The Propulsion Inverter is the heart of the Propulsion System and controls the power that goes to the traction motors during acceleration and braking operations.

The Propulsion Inverter converts the nominal 750 Vdc of the Catenary Line (which travels through the Pantograph (refer to Section 08 - Pantograph), the HSCB and the Knife Switch (refer to Section 09 - HV Distribution System)) into a Variable Voltage Variable Frequency (VVVF) three-phase Alternate Current (AC) to power the relevant AC Motors.

Each Propulsion Inverter is contained in an enclosed housing which prevents water and dirt from entering and contacting the electronic components.

Each Inverter is made up of five watertight Modules (refer to Figure 07-I-02.5):

- Three Phase Modules (Phase A, phase B and phase C)
- One Braking Chopper Module (Phase CH)
- One Inverter Control Module (Which contains various relays, contactors, fuse, resistors, sensors/transducers as well as the TCU - Traction Control Unit)
- One Inverter Fan which cools all of the modules (Phase A, B, C, and CH)
- The hierarchical tree structure of the Propulsion System, with all subsystems and the relevant components connected together in a parent-children relationship, is shown in Figure 07-I-02.4

The three Phase Modules and the Chopper Module are identical, even if their function is different: each Phase Module generates one phase current for the relevant AC motors, while the Braking Chopper Module returns the current generated by the motors during non-regenerative dynamic braking to the Braking Resistors if the Catenary Line is not receptive at all; or, only partially receptive in the case of blended regenerative/non-regenerative braking. The Chopper Module is also used to connect the roof resistors to the Catenary (via the TMs) during motoring; if the Line Voltage is getting too high.

The Inverter Control Module contains the TCU (Traction Control Unit) together with all contactors, voltage and current transducers, filter charge switches, etc. needed to control the Inverter operations.

The Propulsion system operates in response to the train line signals supplied to the propulsion logic by the Master Controller.

The management of traction and braking is assured by the Traction Control Unit (TCU), one per car section (inside the Inverter Control Module of the relevant Propulsion Inverter).

The TCU is an electronic rack (containing several electronic boards) which provides an output signal (to the phase modules) that reflects the demands required by the operator. The Master Controller Handle, along with the Encoder, will generate the proper input signal for the TCU which will inform the TCU exactly what the Operators demands are with regards to propulsion or braking.

Each Traction Control Unit (TCU) controls the Propulsion System and drives the Propulsion Inverter to obtain the requested torque value from the motors.

Above all, the requested torque value depends on the position of the Master Controller Handle (MC Handle), but can be modified by the TCU if an incorrect condition is detected (for example, the TCU automatically reduces the motor torque when a spin condition is detected, or forces a FSB if an overspeed condition is detected (refer to paragraph 07-I-03.01 for details about the TCU functions).

The following systems are connected with the TCU and can modify the motor torque request:

- The Emergency Brake (EB)
- The Automatic Train Protection (ATP)
- The Doors Status
- Diagnostic Signal from the Vehicle

The TCU “reads” the motor temperature through two Thermal Sensors per motor.

Each TCU “reads” the vehicle speed through three Speed Sensors (one per motor and one on one of the axles of the Center truck - axle 3 for TCU_A and axle 4 for TCU_B).

At start-up, TCU_A (the TCU in the A Car Section) becomes, by default, the Master of Vehicle (MoV) TCU.

If the vehicle is not coupled with any other vehicles then the MoV TCU is also the Master of Train (MoT) TCU. In a train consist the MoT TCU is the MoV TCU located in the vehicle with the active cab.

The MoT TCU generates all train commands, while the MoV TCU generates the commands for the local vehicle and the Slave TCU. (The B-end TCU is typically the Slave TCU for a MoV TCU). A slave TCU will generate commands for the propulsion inverter on the same end of the vehicle as the slave TCU itself

TCUs communicate one to each other by means of the MVB bus, on the same vehicle, and the WTB bus between coupled vehicles (refer to Section 18).

When two (or more, up to four) vehicles are coupled together in a Train consist, the exchange of Propulsion signals between vehicles is guaranteed by means of Trainlines for the MC Handle and EB status, and by means of MVB and WTB buses for MoV and MoT TCU commands.

Through the TCUs, the Propulsion System exchanges signals with the other systems, like the Friction Braking, the Automatic Train Protection (ATP), the Doors, the Train Control and Monitoring System (TCMS) and the Communication systems.

The MoT TCU sends signals to the three Brake Electronic Control Units (ECUs) of the Friction Braking system and collects feedback signals from the ECUs; this allows for the correct data processing with regards to the requested braking rate.

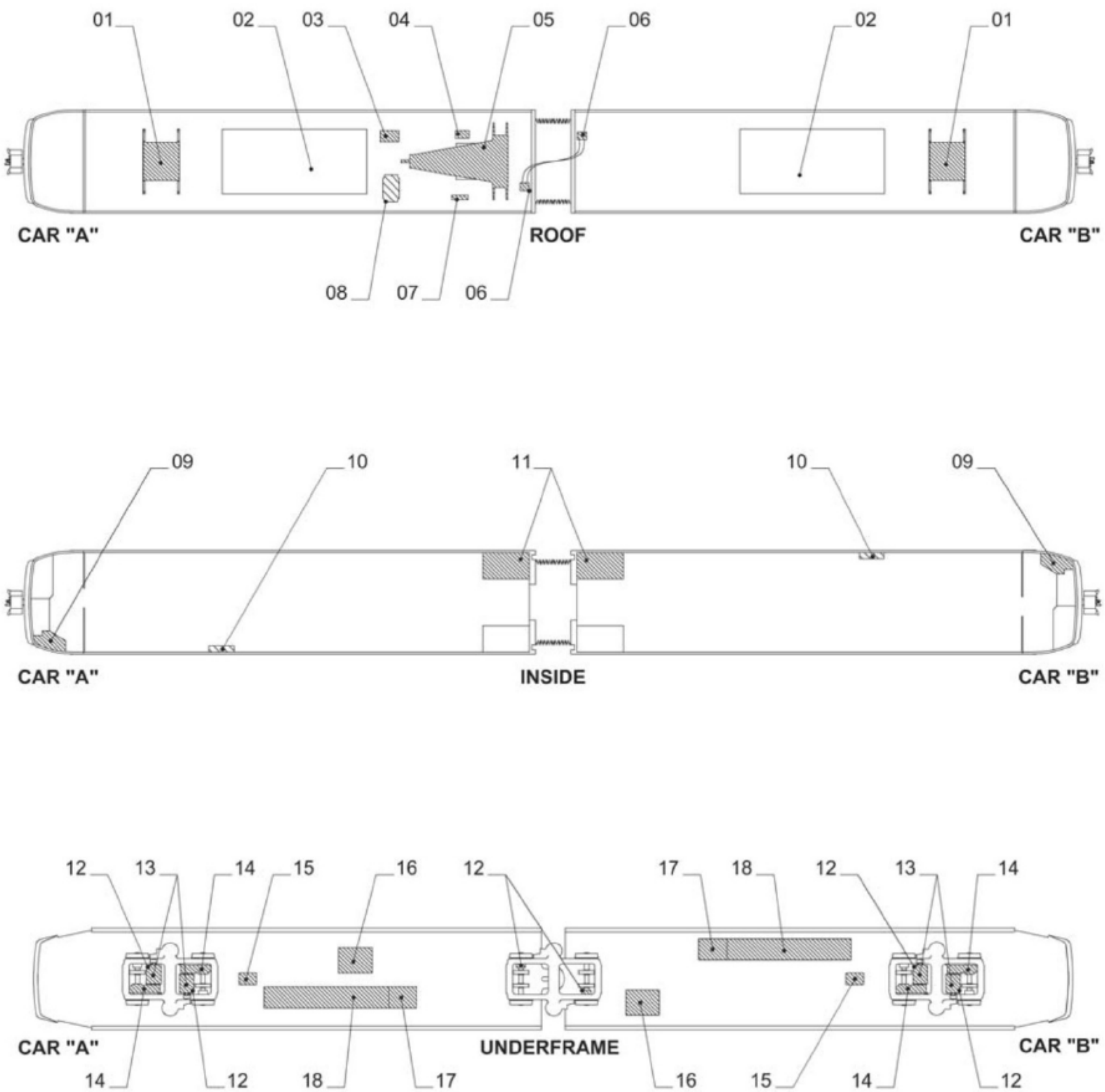
The ATP system may request a FSB application, or even an emergency braking intervention, from the MoT TCU during an overspeed condition.

If all Doors are not Closed and Locked, the Door system does not generate the signal required by the TCU to let the train move.

The TCMS buses (refer to Section 18) are used for transferring both command and diagnostic signals, thus contributing to the safe and correct management of the vehicle motion. Through the IDU, the operator can monitor all vehicle systems and, in case of failure, display all information needed for troubleshooting.

The location of the Propulsion System components is shown in Figure 07-I-02.2:

The Propulsion System components will be described in details in the following paragraphs.



01. BRAKING RESISTOR
02. HVAC UNIT
03. HCT BOX
04. LIGHTNING ARRESTOR
05. PANTOGRAPH
06. JUNCTION BOX
07. FUSE BOX
08. HSCB
09. MASTER CONTROLLER
10. BRAKE RES. CABLE PSGW
11. ELECTRONIC CABINET
12. SPEED SENSOR
13. TRACTION MOTOR
14. GEAR UNIT
15. DISCONNECT BOX
16. LINE REACTOR
17. TCU
18. TRACTION INVERTER

Figure 07-I-02.2 Location of the Propulsion System Components

i. System-Vehicle Relationship

[redacted]

Figure 07-I-02.3 Propulsion System - Vehicle Relationship

The Propulsion System is the main system of the P2550 LRV and is connected to all other systems of the vehicle:

- On one side it receives electric power from the catenary line, through the Pantograph (refer to Section 08) and the HV Distribution System (refer to Section 09) and transforms it into power for the motors (refer to Figure 07-I-02.3 bold line)
- On the other side, through the TCU, it exchanges information and sends commands to the other systems of the vehicle/consist for managing propulsion and braking, in all conditions, and assuring the required level of safety to the whole vehicle (refer to Figure 07-I-02.3, thin line)

The TCU takes into consideration the indications coming from the other systems and, depending on their conditions, can override the Master Controller commands.

The cases in which the TCU overrides the MC Commands are:

- EMERGENCY BRAKING, forced by the ATP System or by the EB pushbutton
- FULL SERVICE BRAKE, forced by the DOOR System, the ATP System, or the Dead man circuit
- POWER REDUCTION, forced by the EMI Detector Unit
- SPEED LIMITATION, determined by the ATP System, the CarWash Pushbutton, and by cut-outs/By-Pass Switches, and/or TCU or ECU faults

The connection between the Propulsion System and all other systems is realized by means of:

- LON (Local Operating Network): LONWork Bus (refer to Section 18)
- TCN (Train Communication Network): made up by the MVB and WTB Buses (refer to Section 18)
- LVDS, through the Relay Logic (refer to Section 10)

ii. System-Equipment Relationship

[redacted]

iii. System Characteristics and Performances

Table 07-I-02.1 Parameters

PARAMETER	VALUE	NOTES
LINE		
Line voltage	950 Volts (max) 750 Volts (nom) 525 Volts (min)	
ENVIRONMENT		
Ambient air temperature	19.4°F (-7 °C) (min) 114.8°F (46 °C) (max)	
VEHICLE		
Battery voltage	42 Volts (max) 37.5 Volts (nom) 25 Volts (min)	
Wheel diameter	27.99in (711) mm (new) 25.98in (660 mm) (full worn)	
Number of Vehicles per Train Consist	minimum = 1 maximum = 4	
Total Translatory Mass	AW0 = 103,265 lbs (46,840 Kg) AW1 = 114,993lbs (52,160 Kg) AW2 = 129,499lbs (58,740 Kg) AW3 = 136,752lbs (62,030 Kg) AW4 = 136,752lbs (65,320 Kg)	
Total Mass including rotative Mass	AW0 = 113,590lbs (51,524 Kg) AW1 = 125,319lbs (56,844 Kg) AW2 = 139,826lbs (63,424 Kg) AW3 = 147,079lbs (66,714 Kg) AW4 = 154,332lbs (70,004 Kg)	Rotative mass = 10% AW0
MOTOR		
Nominal Voltage	585 Vac	
Supply Frequency Range	0 - 140 Hz	
Max Service Speed	4,200 rpm = 65.24 mph	(worn wheel)
Max Traction Output Power	145 kW	
Max Braking Output Power	200 kW	

07-I-02.02 Main Propulsion System Components

07-I-02.02.01 The Propulsion Inverter

The Propulsion Inverter carries out two important functions:

- During Motoring: it converts the Catenary Voltage coming from the HV System (refer to Section 9) into a 3-phase current for the relevant AC Motors
- During Braking: it returns the current generated by the AC Motors to the Catenary or to the relevant Braking Resistor if the catenary line is not receptive.

The Propulsion Inverter is made up of three Inverter Phase (IGBT: Insulated Gate Bipolar Transistor) Modules, a Braking Chopper Module, an Inverter Fan, an Air Duct and an Inverter Control Module, containing the TCU (Traction Control Unit) which controls the entire Propulsion System.

The two Propulsion Inverters are identical (and the four IGBT modules are identical) and interchangeable. They are used to create the three phase inverter output during Motoring or for returning current to the line when the line is receptive during Dynamic Braking (Phase Modules); or for sending current to the Braking Resistors when the line is not receptive during Dynamic Braking (Braking Chopper).

The main characteristics of the Propulsion Inverter and of the Braking Chopper are listed below:

Inverter Main Characteristics:

Rated input voltage	750 Vdc Max input voltage (protection) 1000 Vdc
Rated Power	500 kVA
Maximum traction power	700 kVA
Efficiency	> 0.97

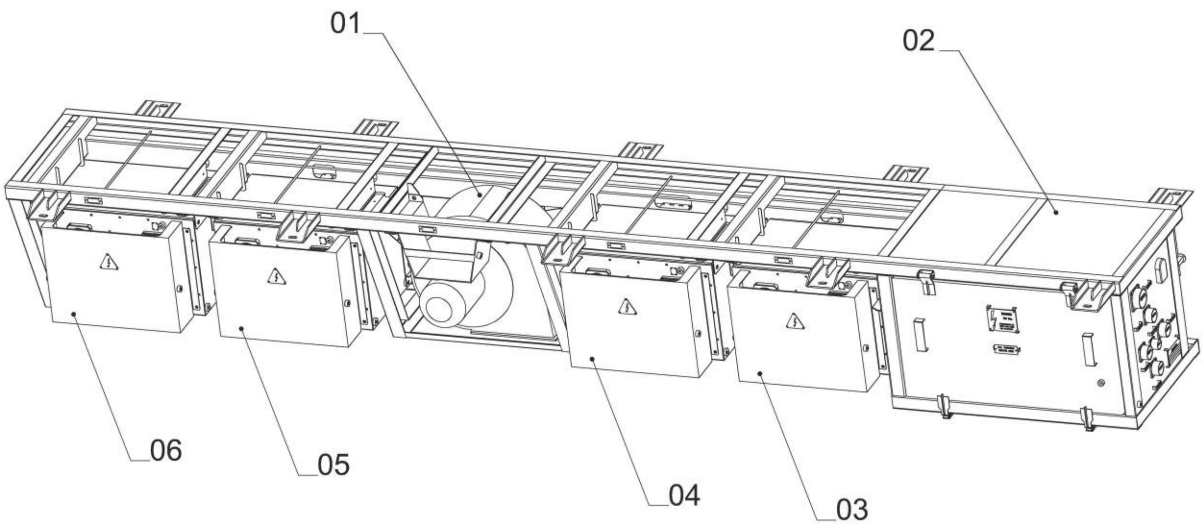
Braking Chopper Main Characteristics:

Operating voltage range	780 - 860 Vdc
Maximum power	750 kW

The propulsion inverter is cooled by forced ventilation, provided by an Inverter fan located between the “B” and “C” Phase Modules.

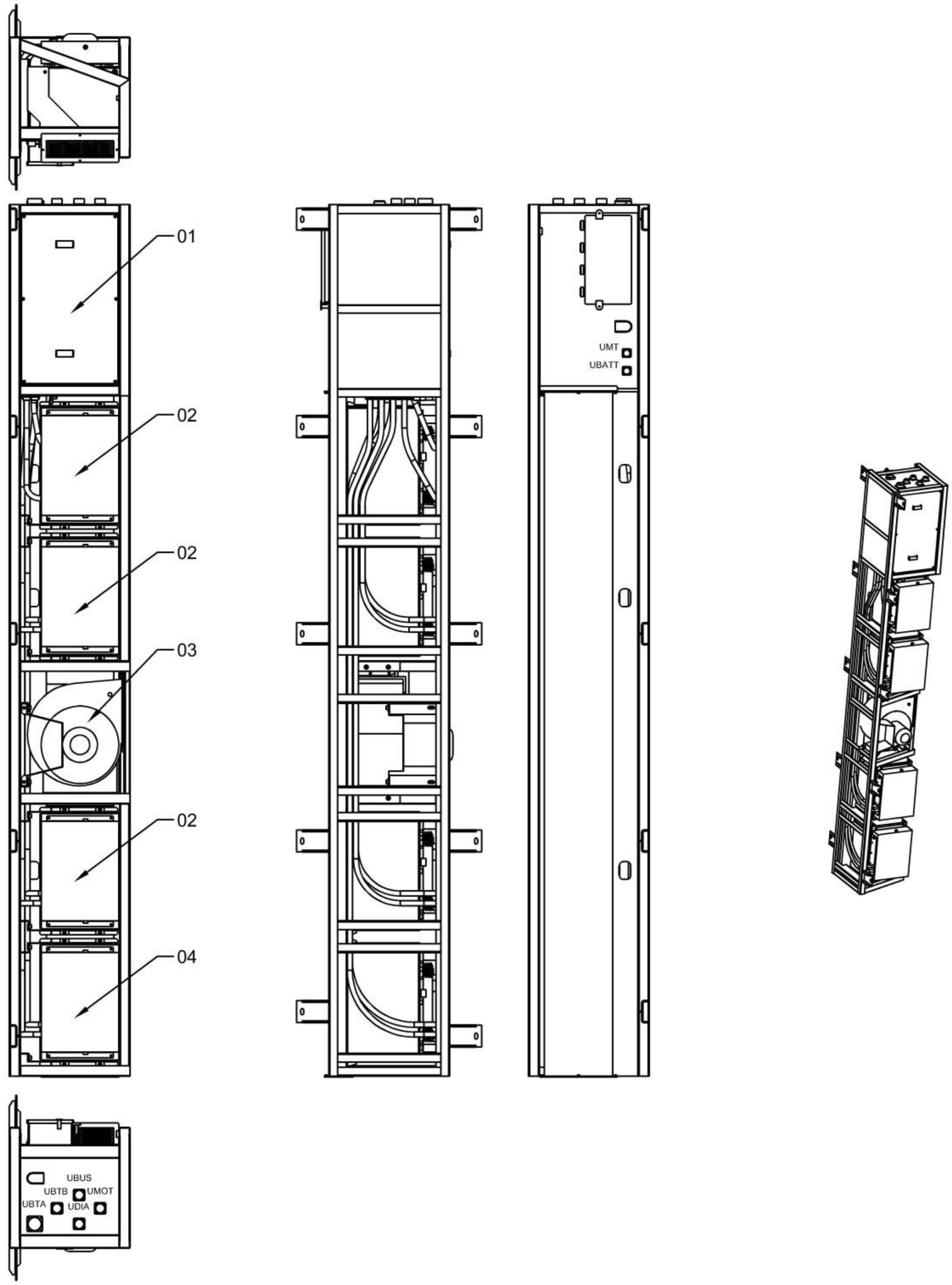
The IGBT module is completely sealed (IP65) (refer to paragraph 07-I-03.05 “IP Code”).

The Inverter Control Module is a water proof enclosure that contains the Traction Control Unit (TCU), the high voltage switches and transducers.



01. INVERTER FAN
03. PHASE MODULE A
05. PHASE MODULE C
02. CONTROL MODULE
04. PHASE MODULE B
06. BRAKING CHOPPER

Figure 07-I-02.5 Propulsion Inverter and Control Modules



01. CONTROL MODULE
02. INVERTER MODULE
03. INVERTER FAN
04. CHOPPER MODULE

Figure 07-I-02.6 Mechanical Lay-out

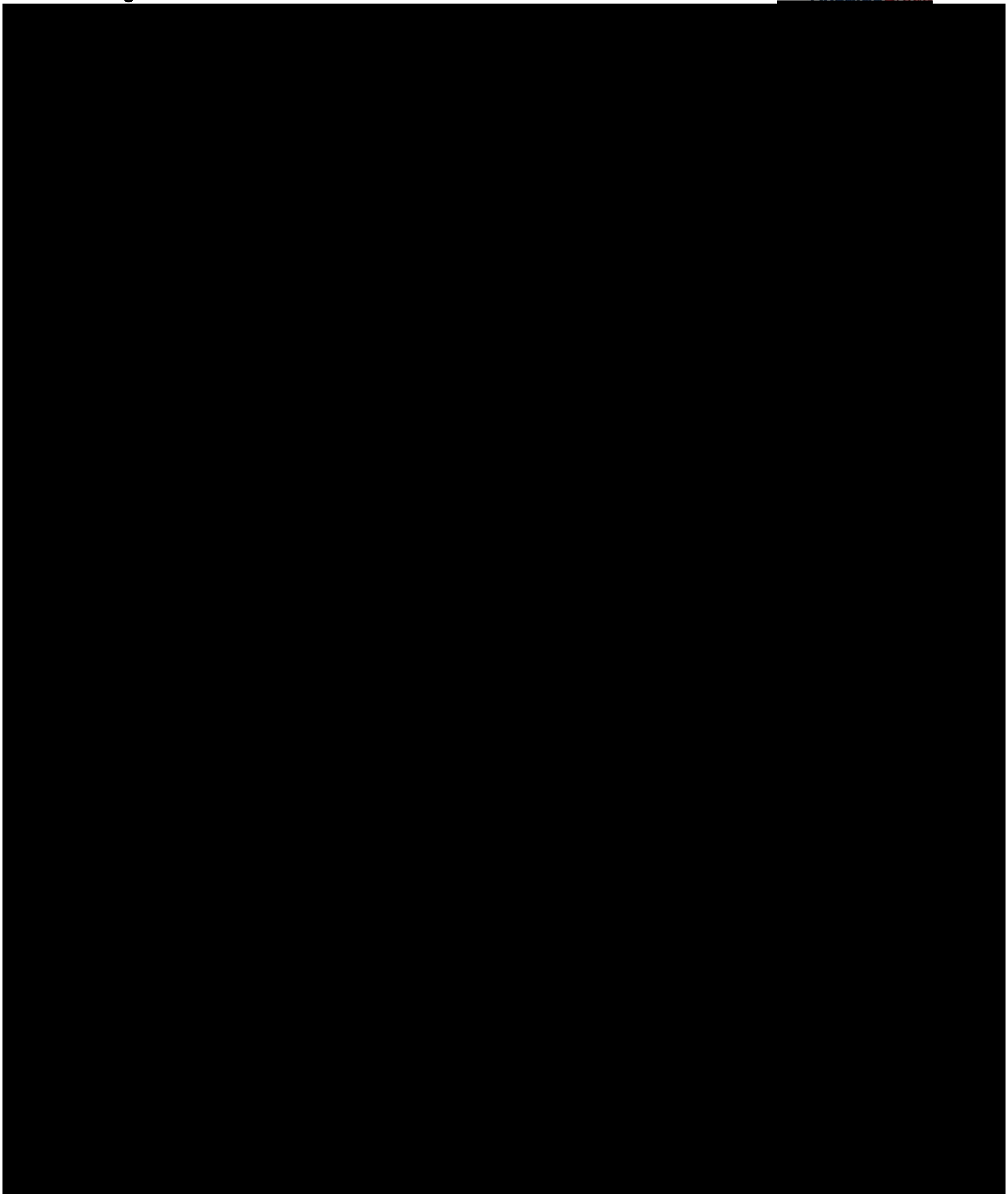


Figure 07-I-02.7 Propulsion Inverter HV Electrical Schematic

07-I-02.02.01.01 Inverter Phase Modules and Braking Chopper

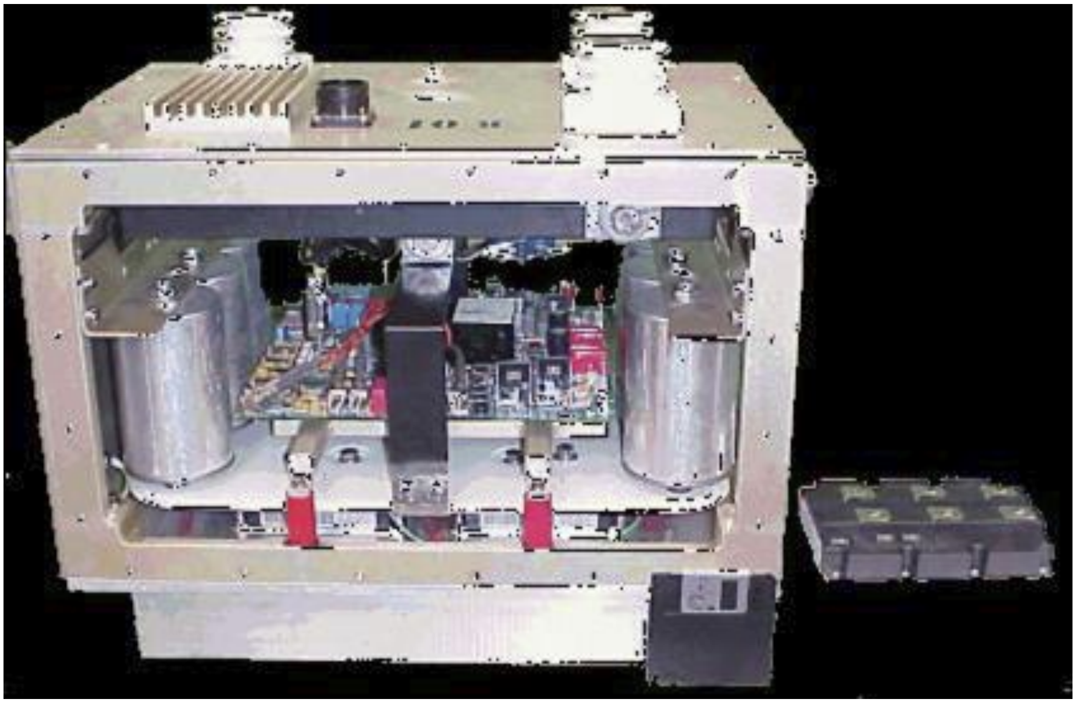


Figure 07-I-02.8 Inverter Phase Module

The module type used for the Braking Chopper is the same as the Inverter Phase Modules.

The Inverter Phase Modules drive the Motors, the Braking Chopper discharges the excess current to the Braking Resistor (refer to paragraph 07-I-02.02.03).

Each Inverter Phase Module consists of the power semi-conductor IGBT assembly and the relevant circuits and drive electronics.

The IGBTs are connected in half bridge configuration and the diode is included in the same IGBT case (refer to Figure 07-I-02.9).

The Phase Modules can be easily removed and replaced without removal of the entire converter unit, significantly improving maintainability and increasing vehicle availability.

The weight of each sealed module is less than 110lbs and the overall Module dimensions are very little: 20.8 x17.8 x14.2inches (530 x 455 x 360 mm), so that it can be replaced very quickly by two technicians. No special tool is needed for the Module replacement.

During the manufacturing stage, each module is separately tested to provide improved availability, reliability and ease of maintenance, then the whole converter assembly undergoes a combined testing at the final production stage. This extensive testing process is geared towards reducing the commissioning time for the vehicle.

Each inverter module includes (refer to Figure 07-I-02.9 and/or Figure 07-I-02.8):

- 2 IGBT Module 1700V/1800A
- 1 Driver board (EPI)
- 6 Filter capacitors 1100V/220mF
- 1 Low inductance bus bar
- 1 Current transducer
- 1 Thermal switch
- 1 Aluminum heat sink
- 1 LV connector
- 3 HV Bushings
- 1 Aluminum box
- 2 Filter discharge resistors 6.8 kΩ

The Output current is measured with an active Current Transducer (Hall Effect[1]).

A Thermal Switch monitors the module temperature.

The thermal threshold is 221°F and in case of overtemperature on one of the switches, the relative digital signal becomes low.

The IGBT driver board EPI (included in the module) has the following functions:

- Driver (turns the IGBTs on and off)
- Sequence control (between the two half phases)
- Diagnostics and protections
- Power supply and galvanic isolation. Galvanic isolation is provided by means of high frequency transformers (power supply circuit) and by opto-couplers (input/output signal)

The Filter capacitors are located very close to the IGBT devices, with a low inductance power bus-bar, in order to reduce the over-voltage on the IGBT due to the commutations.

For the Capacitor discharge, two discharge resistors are connected in parallel to the filter capacitors.

The TCU checks the line voltage during the discharge and, if necessary, fires the Braking Chopper to discharge the filter faster (10s), (refer to paragraph 07-I-03.02.19). The IGBTs and the other components that need to dissipate any heat are mounted in close thermal contact with an aluminum heat sink. The outer face of the power module is at ground potential. All electronic devices of the Inverter Module are assembled inside an aluminum waterproof box, suitable for “under frame” mounting and for the exposed environment in that location.

[1] The Hall Effect refers to the potential difference (Hall voltage) on the opposite sides of an electrical conductor through which an electric current is flowing, created by a magnetic field applied perpendicular to the current. The transducer voltage depends on the current.

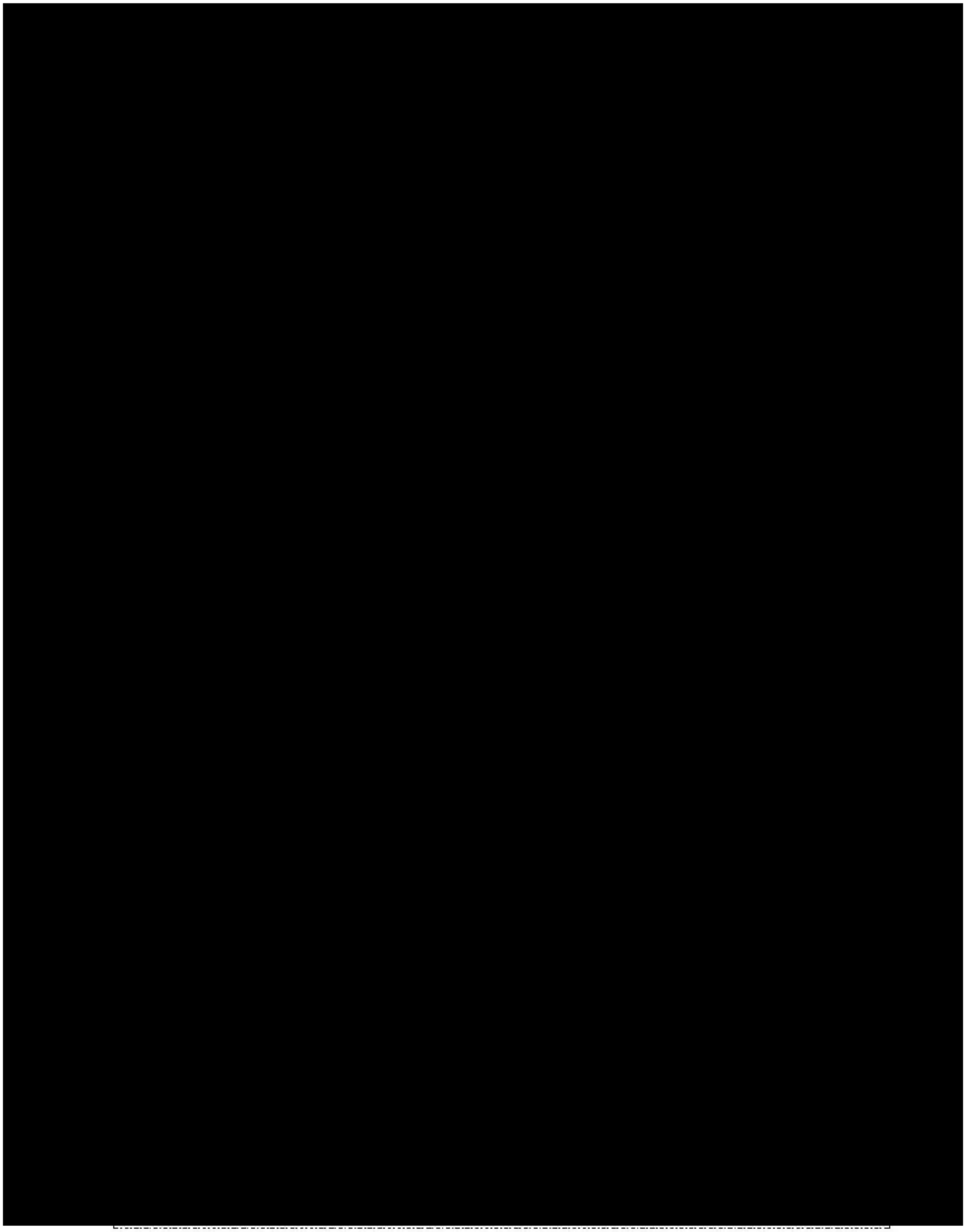


Figure 07-I-02.9 Inverter Phase Module Electrical Schematic

NOTE:

For the EPI board Functional Schematic refer to document 237EE07879C in the AnsaldoBreda Database.

For the EPID board Functional Schematic refer to document 237EE40229C in the AnsaldoBreda Database.

For the EPIM board Functional Schematic refer to document 237EE40230C in the AnsaldoBreda Database.

For the EPIC board Functional Schematic refer to document 237EE40231C in the AnsaldoBreda Database.

For the EPID board Component location refer to document 232EE40229B in the AnsaldoBreda Database.

For the EPIM board Component location refer to document 232EE40230D in the AnsaldoBreda Database.

For the EPIC board Component location refer to document 232EE40231B in the AnsaldoBreda Database.

Refer to Section 00 of this Manual on “How to use the AB Database”.

Each Phase Module is connected to the outside through HV (P, N, F) and LV (U) connectors. The F connector of the Braking Chopper is connected to the Braking Resistor.

Table 07-I-02.2 lists the HV Phase Outputs.

Table 07-I-02.2 HV Phase Output Pins

Motor interface	
Connector	**Description**
PHASE A - F	Motor Phase A
PHASE B - F	Motor Phase B
PHASE C - F	Motor Phase C

Table 07-I-02.3 lists the connectors to the Braking Resistor that are placed on the front side of the Braking Chopper IGBT Module.

Table 07-I-02.3 HV Chopper Output Pins

Braking resistor interface	
Connector	**Description**
BRAKING CHOPPER - F	Braking Resistor Positive
BRAKING CHOPPER - N	Braking Resistor Negative

Table 07-I-02.4 lists the Inverter Phase Module and Braking Resistor HV Input connectors:

Table 07-I-02.4 HV Input Connectors

Connector	Description
P	Positive connection
N	Negative connection

Three pass through insulators are used for the high-voltage connections P, N, and F.

The external connector (U) is a LV power connection.

Through this connector the Inverter Phase Modules are connected to the TCU which (refer to paragraph 07-I-02.02.01.01) drives the IGBTs to obtain the requested motor torque and receives signals from the Thermal Switch (ST) and the Current Transducer (TA).

The (U) connector is also used for LV power supply and for diagnostics from the Inverter Phase Module to the TCU.

Table 07-I-02.5 IGBT (U) Connectors

Connector	Type	Description
UA	VEAM 19 pin flying female	Phase A IGBT inverter module
UB	VEAM 19 pin flying female	Phase B IGBT inverter module
UC	VEAM 19 pin flying female	Phase C IGBT inverter module
UCH	VEAM 19 pin flying female	Braking Chopper IGBT module

Table 07-I-02.6 "A" Inverter Phase Module (UA Connector)

PIN	Signal	Description
E	P15TA	Phase current transducer power supply - positive
F	N15TA	Phase current transducer power supply - negative
R	TA	Phase current transducer measurement
P	SCHTA	Phase current transducer shield
G	CFAA	Phase command
H	DIAA	Module fault Indication
J	ABIA	Phase Enable Command
K	P15A	Command/Enable/Fault positive reference
L	GNA	Command/Enable/Fault ground reference
T	SCHA	Module commands shield
B	IN5A-SWTA	Thermo Switch (low = overheat)
C	PBAT	Battery power supply - positive
U	NBAT	Battery power supply - negative
V	PBAT	Battery power supply - positive
A	Not Connected	
D	Not Connected	
M	Not Connected	
N	Not Connected	
S	Not Connected	

Table 07-I-02.7 "B" Inverter Phase Module (UB Connector)

PIN	Signal	Description
E	P15TB	Phase current transducer power supply - positive
F	N15TB	Phase current transducer power supply - negative
R	TB	Phase current transducer measurement
P	SCHTB	Phase current transducer shield
G	CFAB	Phase command
H	DIAB	Module fault Indication
J	ABIB	Phase Enable Command
K	P15B	Command/Enable/Fault positive reference
L	GNB	Command/Enable/Fault ground reference
T	SCHB	Module commands shield
B	IN5A-SWTB	Thermo Switch (low = overheat)
C	PBAT	Battery power supply - positive
U	NBAT	Battery power supply - negative
V	PBAT	Battery power supply - positive
A	Not Connected	
D	Not Connected	
M	Not Connected	
N	Not Connected	
S	Not Connected	

Table 07-I-02.8 “C” Inverter Phase Module (UC Connector)

PIN	Signal	Description
E	P15TC	Phase current transducer power supply - positive
F	N15TC	Phase current transducer power supply - negative
R	TC	Phase current transducer measurement
P	SCHTC	Phase current transducer shield
G	CFAC	Phase command
H	DIAC	Module fault Indication
J	ABIC	Phase Enable Command
K	P15C	Command/Enable/Fault positive reference
L	GNC	Command/Enable/Fault ground reference
T	SCHC	Module commands shield
B	IN5A-SWTC	Thermo Switch (low = overheat)
C	PBAT	Battery power supply - positive
U	NBAT	Battery power supply - negative
V	PBAT	Battery power supply - positive
A	Not Connected	
D	Not Connected	
M	Not Connected	
N	Not Connected	
S	Not Connected	

Table 07-I-02.9 Braking Chopper Inverter Phase Module (UCH Connector)

PIN	Signal	Description
E	P15TCH1	Phase current transducer power supply - positive
F	N15TCH1	Phase current transducer power supply - negative
R	TCH1	Phase current transducer measurement
P	SCHTCH1	Phase current transducer shield
G	CFACH1	Phase command
H	DIACH1	Module fault Indication
J	ABICH1	Phase Enable Command
K	P15CH1	Command/Enable/Fault positive reference
L	GNCH1	Command/Enable/Fault ground reference
T	SCHCH1	Module commands shield
B	IN5A-SWTCH1	Thermo Switch (low = overheat)
C	PBAT	Battery power supply - positive
U	NBAT	Battery power supply - negative
V	PBAT	Battery power supply - positive
A	Not Connected	
D	Not Connected	
M	Not Connected	
N	Not Connected	
S	Not Connected	

07-I-02.02.01.02 Inverter Control Module

The Control Module (refer to Figure 07-I-02.10) is located at the same end of the Inverter frame (the frame which holds all of the Phase and Chopper modules) as the "A" Phase Module.

The Inverter Control Module contains electromechanical and high-voltage devices, such as line switches, filter charge switches, voltage and current transducers and the low-voltage Traction Control Unit (TCU - refer to paragraph 07-I-02.02.06) that controls the entire Propulsion System.

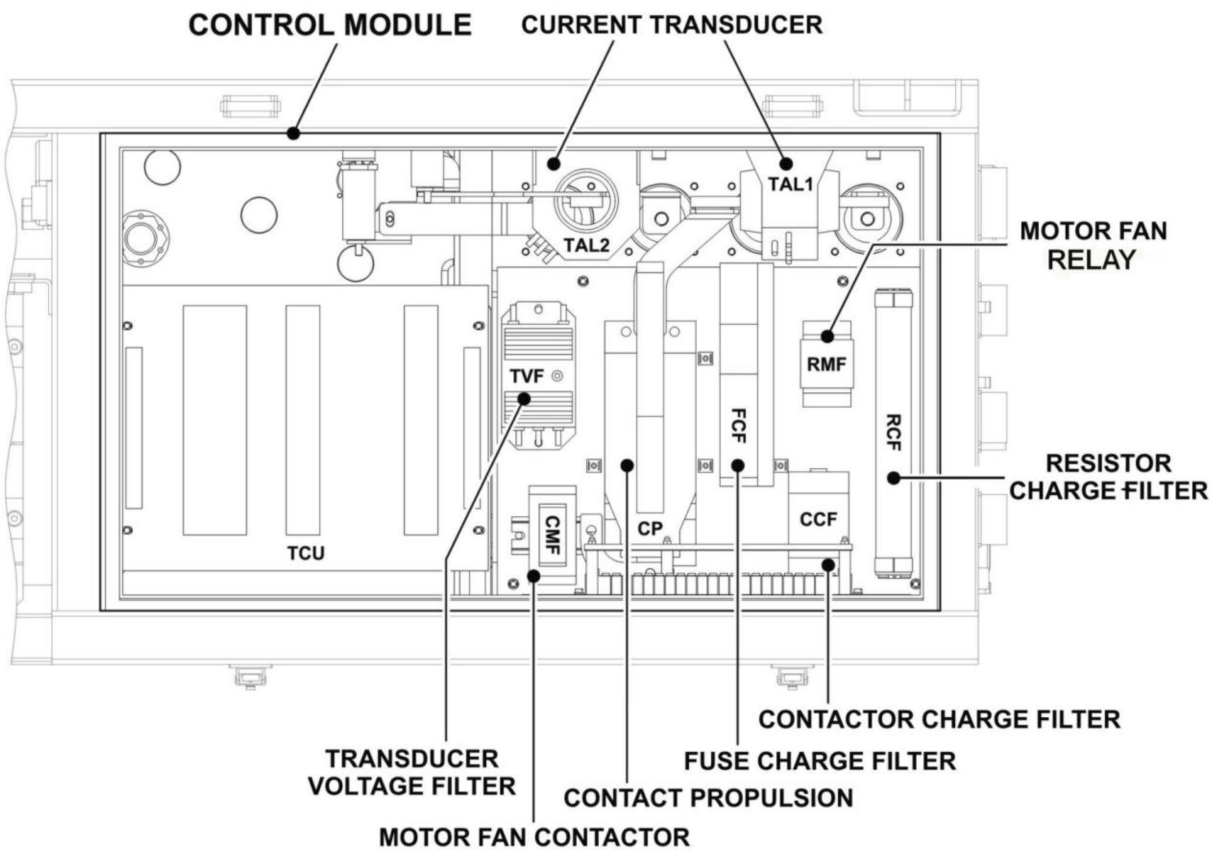


Figure 07-I-02.10 Inverter Control Module

The electrical and electro-mechanical components contained in the Inverter Control Module and their relevant functions are listed below (refer to Figure 07-I-02.7 and Figure 07- I-02.10)

- CCF (Charging Filter Contactor): single pole contactor for charging the filter capacitors.
- CMF (Inverter Fan Contactor): Tripolar contactor used for supplying 208 VAC to the Inverter Fan Motor.
- RMF (Inverter Fan Supply Contactor): The RMF contactor communicates to the TCU whether the Inverter Fan 208 VAC Supply is present or not.
- CP (Propulsion Contactor): single pole contactor which is the normal mode for connecting the 750 VDC Power from the catenary to the Propulsion circuitry.
- FCF (Fuse Charging Filter): Fuse that protects the filter charging circuit during the initial charging of the Phase Module capacitors.
- RCF (Filter Charging Resistor): Resistor which will limit the in rush of current during the initial charging of the filter capacitors.
- TVF (Transducer Voltage Filter): Line Voltage Transducer, used by the TCU to measure the catenary voltage.
- TAL1 (Positive Line Current Transducer): Used by the TCU to measure the positive line current.
- TAL2 (Negative Line Current Transducer): used by the TCU to measure the negative line current.
- REB (Emergency Brake Relay): when it is de-energized, the Emergency Brake mode is applied (refer to paragraph 07-I-02.03.03.05).
- RSCEB (Slide Controlled Emergency Brake Relay): when it is de-energized, a Slide Controlled Emergency Brake is applied (refer to paragraph 07-I-02.03.03.04)

Figure 07-I-02.7 shows the Propulsion Inverter Electrical Schematic.

The Catenary line current enters the Inverter Control Module through the (P) connector then passes through a line current transducer (TAL1). At this point it can either pass through the CP contact (in normal conditions) or it can go through fuse FCF, contactor CCF and resistance RCF (during the pre-charge phase)

The line current exits the Propulsion Inverter and passes through the Line Reactor and then re-enters the Inverter Control Module to be checked by a Voltage transducer (TVF) before it goes to the Inverter Phase Modules and the Braking Chopper.

Figure 07-I-02.11 shows the connection between the Inverter Control Module Components and the TCU.

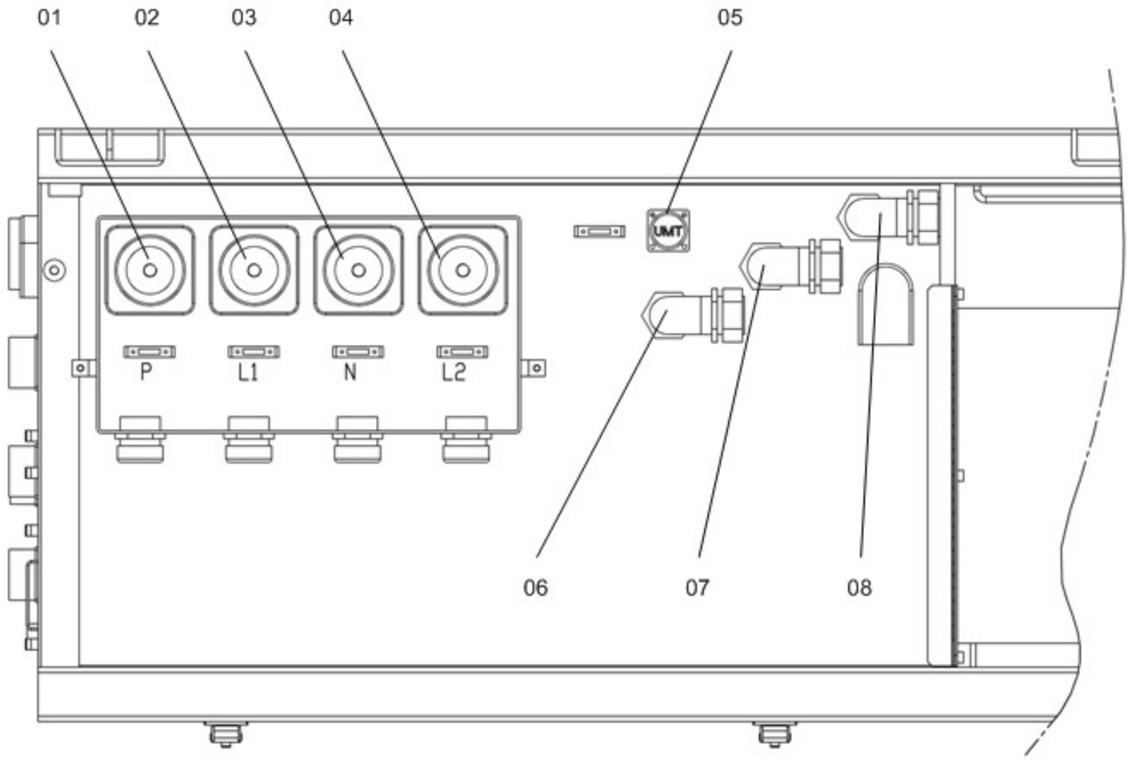
[redacted]

Figure 07-I-02.11 Connections between Components and TCU

a) Inverter Control Module HV Connectors

The TCU High-voltage connections (refer to Figure 07-I-02.12) are made up of high voltage through-hole insulators.

The connectors to the power line and to the line reactor are located on the back of the Inverter Control Module, protected by a water tight cover.



01. (P) HV Positive IN – Knife Switch
02. (L1) HV Positive OUT – Line Reactor
03. (N) HV Negative OUT – Modules
04. (L2) HV Positive IN – Line Reactor
05. (UMT) MV – Inverter Fan Connector
06. LV Fairlead to UB Connector
07. LV Fairlead to UC Connector
08. LV Fairlead to UCH Connector

Figure 07-I-02.12 HV Connectors (Back-side of the Inverter Control Module)

Table 07-I-02.10 lists the HV Connectors placed on the back side of the Inverter Control Module. Refer to Figure 07-I-02.7 and Figure 07-I-02.12.

Table 07-I-02.10 HV Input Connectors

Line interface	
Connector	**Description**
P	Power Positive
N	Power Return
L1	Line Reactor Positive
L2	Line Reactor Return

The HV cables from the Inverter Control Module to the Inverter Phase Modules and the Braking Chopper pass inside the Inverter.

b) Inverter Control Module LV Connectors

The VEAM type connectors are used to interface the Propulsion System TCU with the vehicle logic, the vehicle diagnostic signals, the vehicle buses and trainlines, the sensors and the LVPS System.

They are located on the outside of the Inverter Control Module and are listed in Table 07-I-02.11.

Table 07-I-02.11 LV Connectors

Connector name	Type	Description
UBATT	VEAM 7 pins	37.5 Vdc - LVPS
UBTA	VEAM 70 pins	Vehicle Logic / Trainlines
UBTB	VEAM 37 pins	Diagnostic inputs
UBUS	VEAM 37 pins	Vehicle buses
UMOT	VEAM 37 pins	Speed / Thermal sensors
UDIA	VEAM 37 pins	Diagnostic / Chart Record

The Figures and Tables that follow, list the connectors' pins.

The Figures also show the connections with the TCU.

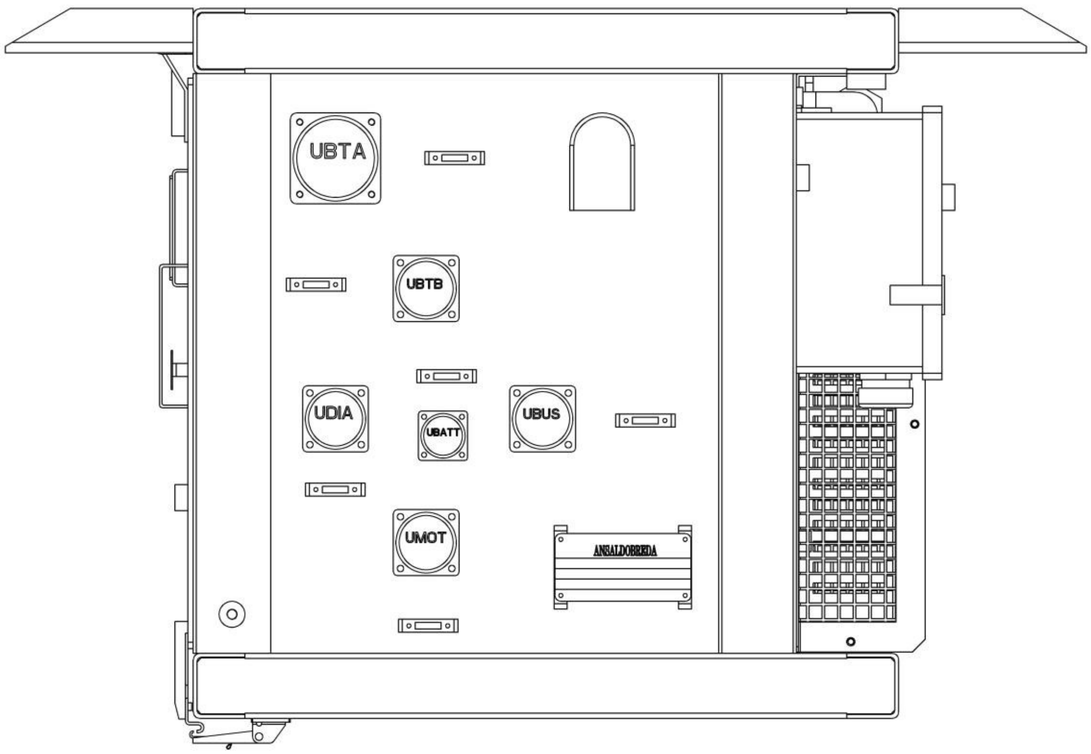


Figure 07-I-02.13 Inverter Control Module - Connectors LV side

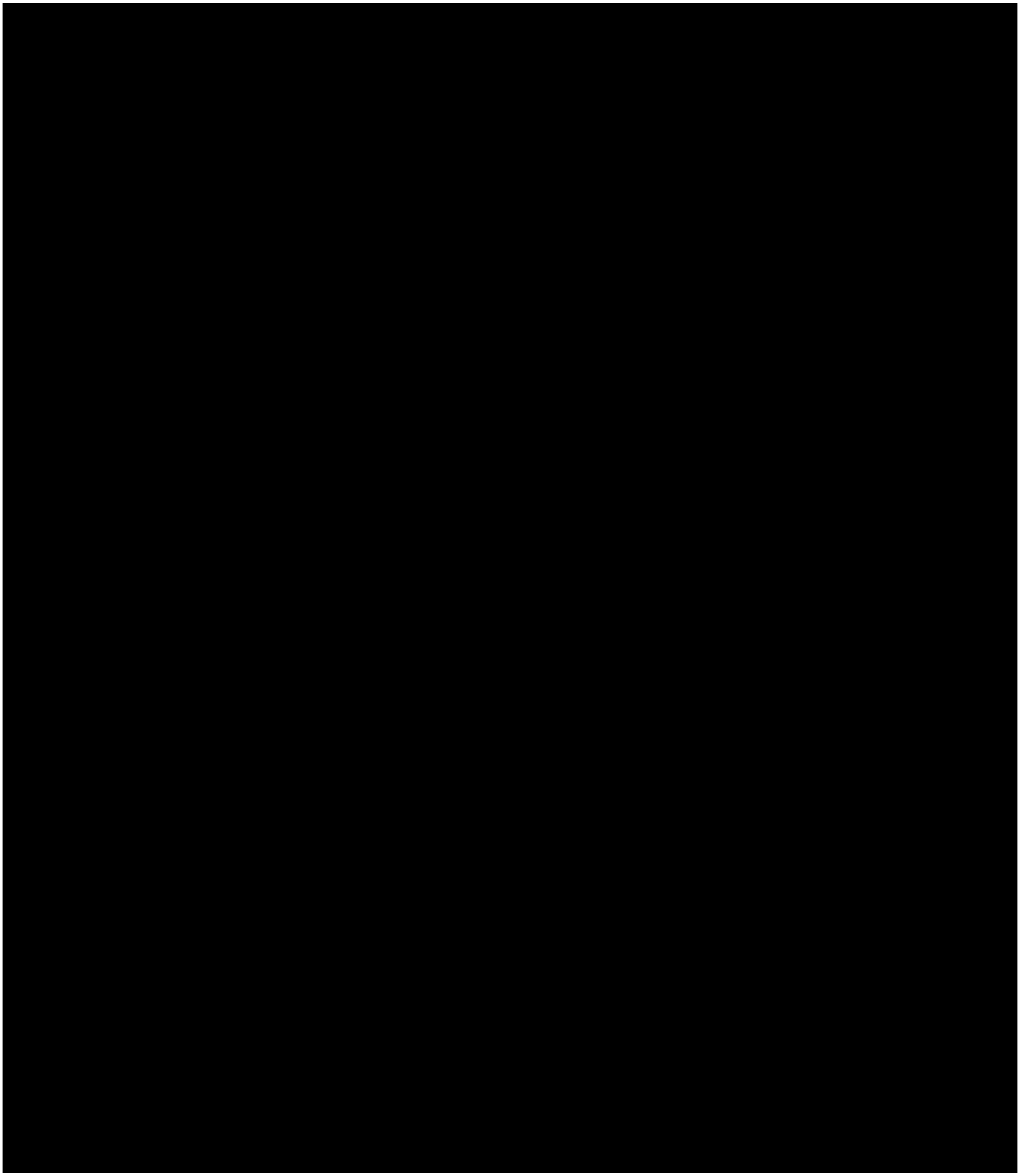


Figure 07-I-02.14 UBTA, UBTB and UBAT Connectors

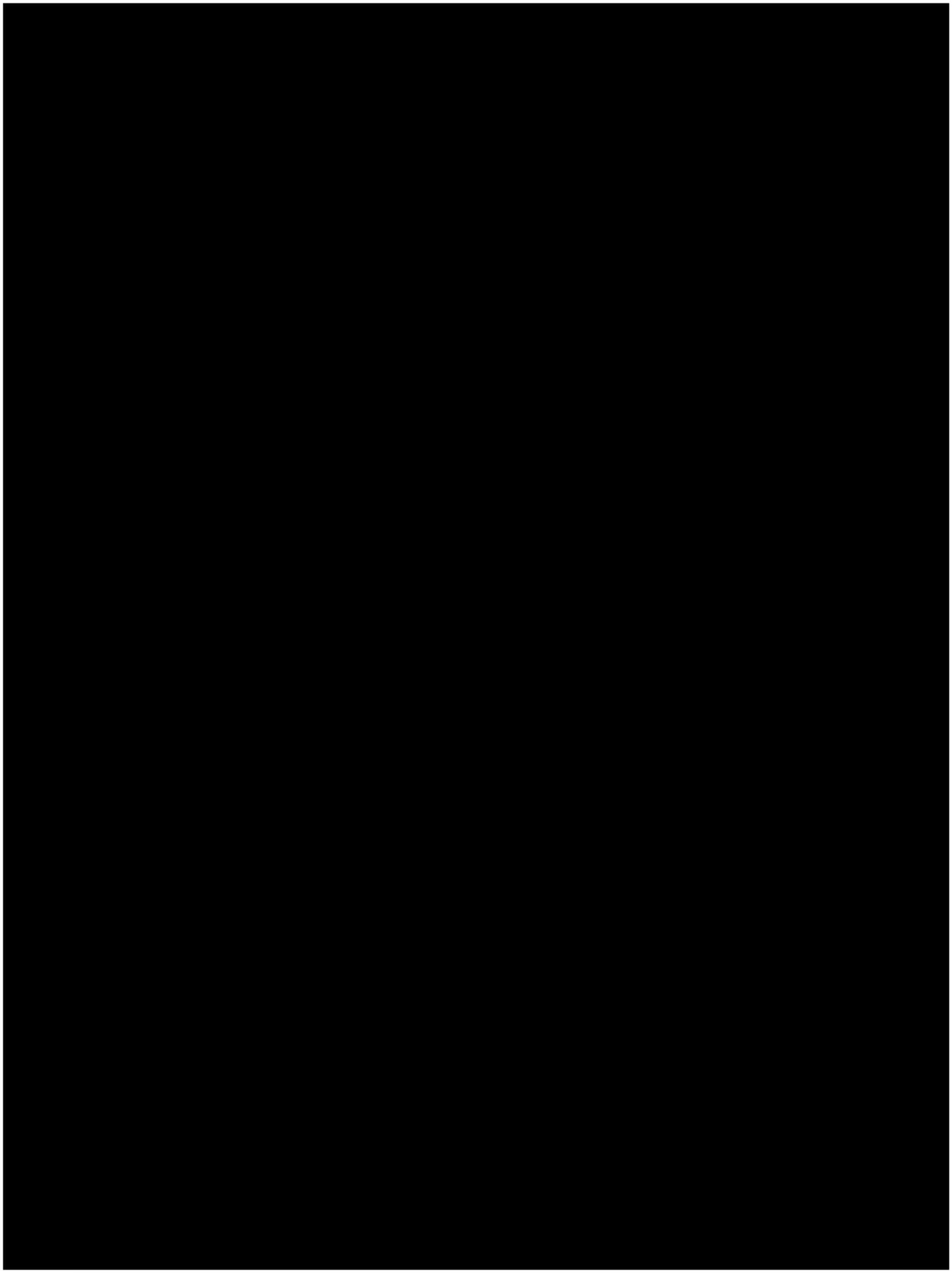


Figure 07-I-02.15 UBUS Connector

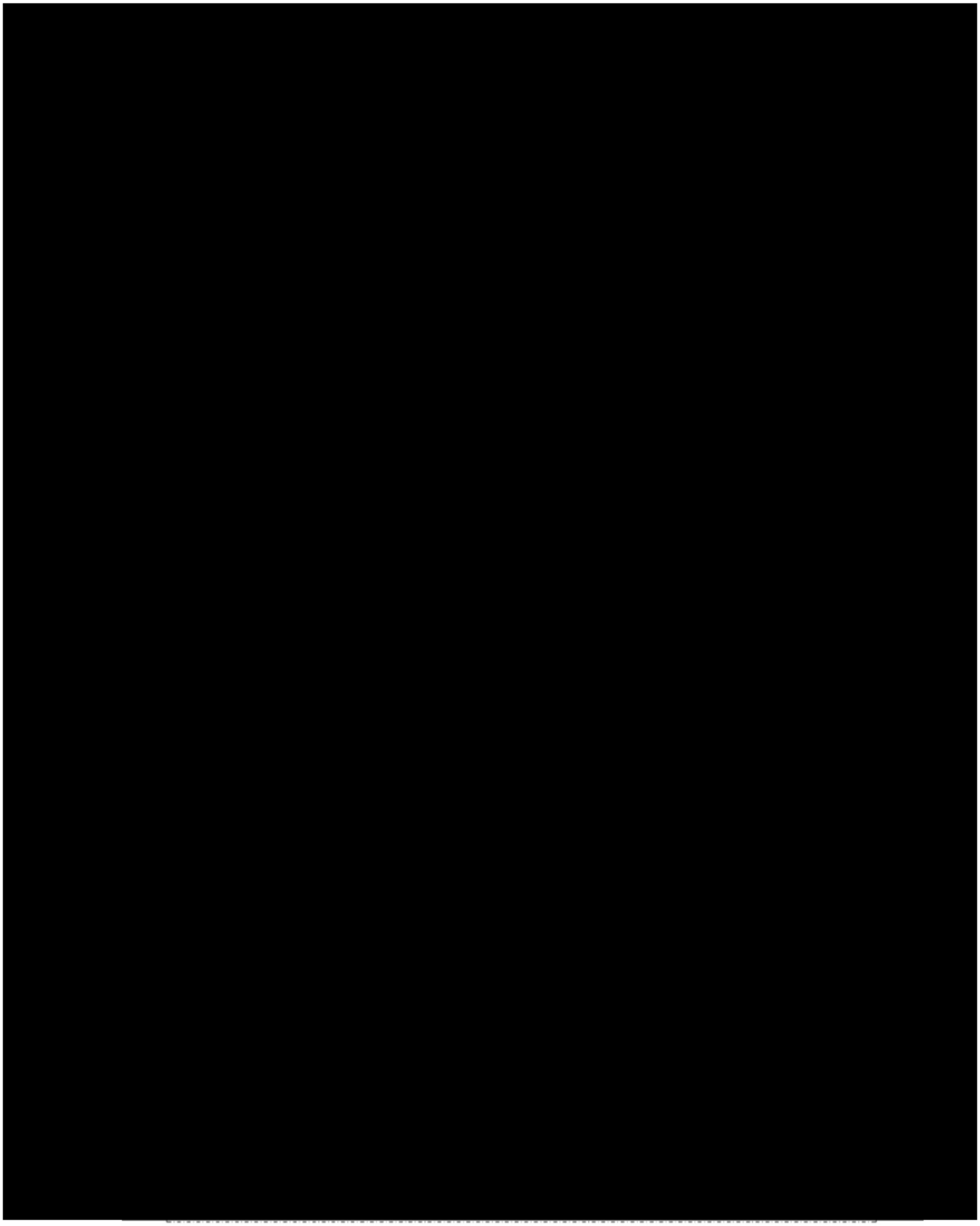


Figure 07-I-02.16 UMOT and UDIA Connectors

Table 07-I-02.12 Low Voltage Power Supply (UBATT Connector)

PIN	Signal	Description
B	PBATT	37.5vdc Battery power supply positive
E	NBATT	0Vdc Battery power supply negative

Table 07-I-02.13 Vehicle Logic/Trainlines (UBTA Connector)

PIN	Signal	Description
1	C2 - SPARE	Spare low side output
2	C3 - SPARE	Spare low side output
3	C8 - SPARE	Spare low side output
4	C10 - SPARE	Spare low side output
5	C14 - SAND	Sand request output
6	NM-1A	No Motion relay - contact 1 - terminal A Output
8	Not Connected	
9	Not Connected	
10	Not Connected	
11	Not Connected	
12	Not Connected	
13	Not Connected	
14	Not Connected	
15	Not Connected	
16	Not Connected	
17	EBN	Emergency Brake Negative
18	IN30A-TOWING	Towing Mode Input
19	IN27A-CW	Car Wash mode Input
20	IN21A-RES	Propulsion Reset Input
21	IN12A-FSB	Full Service Brake Trainline Input
22	SCEBP	Slide Controlled Emergency Brake Positive T/L Input
23	IN1A-NMCC	No Motion Cross Check Input
24	C13-STOP	Stopping output
25	C9-SPARE	Spare low side output
26	C4-SPARE	Spare low side output
27	C1-SPARE	Spare low side output
28	C6-SPARE	Spare low side output
29	C7-SPARE	Spare low side output
30	Not Connected	
31	OUT2-SPARE	Spare high side output
34	Not Connected	
35	Not Connected	
36	Not Connected	
37	Not Connected	
38	Not Connected	
39	Not Connected	

Table 07-I-02.13 Vehicle Logic/Trainlines (UBTA Connector) (cont'd)

PIN	Signal	Description
40	IN31A-PBR	Friction /Park Brake Applied Trainline input
41	IN28A-TB	Track Brake Applied input
42	IN20A-ID	TCU is A
43	IN13A-MOT	Power mode Trainline input
44	Not connected	
45	IN2A-PBCO	Park Brake Cut-Out
46	C11-SPARE	Spare low side output
47	C5-SPARE	Spare low side output
48	C16-HSCB	HSCB open request output
49	OUT1-ODOM	Odometer pulses output
50	NM-1B	No Motion relay - contact 1 - terminal B
53	SCEBN	Slide Controlled EB Negative Trainline Input
54	IN9A-REV	Reverse Trainline input
55	IN23A-DC	Doors Closed
56	IN29A-MRL	Main Reservoir Low input
57	IN26A-SL	Speed Limit Trainline input
58	IN17A-HSC	HSCB closed status Input
59	IN11A-HRS	High Rate Service Brake Trainline input
60	IN3A-ED	Emergency Doors Input
61	C17-TCUOK	Propulsion Fault output
62	NM-2A	No Motion relay - contact 2 - terminal A
63	NM-2B	No Motion relay - contact 2 - terminal B
65	IN24A-CB	Cab B enabled input
66	EBP	Emergency Brake Positive Trainline Input
67	IN22A-CA	Cab A enabled input
68	IN14A-COA	COAST mode Trainline input
69	IN4A-PRCO	Propulsion Cut Out Input
70	IN16A-FWD	Forward Direction Trainline input
64	CLAP	4-20mA - A Cab - MC Rate reference - Positive
52	CLAN	4-20mA - A Cab - MC Rate reference - Negative
51	SCHA	4-20mA Current Loop A Shield
33	CLBP	4-20mA - B Cab - MC Rate reference - Positive
7	CLBN	4-20mA - B Cab - MC Rate ref. - Negative Input
32	SCHB	4-20mA Current Loop B Shield

Table 07-I-02.14 Diagnostic Imputs (UBTB Connector)

Channel #	NDI X3 Connector Pin	Connected to	Description
IN1	4d	UBTA - 23 - NMCC	No Motion Cross Check
IN2	6d	UBTA - 45 - PBCO	Park Brake Cut Out
IN3	8d	UBTA - 60 - ED	Emergency Door
IN4	10d	UBTA - 63 - PROPCO	Propulsion Cut Out
IN5	12d	SWTA	IGBT Phase A Thermic Alarm
IN6	14d	SWTB	IGBT Phase B Thermic Alarm
IN7	18d	SWTC	IGBT Phase C Thermic Alarm
IN8	20d	SWTCH1	IGBT Braking Chopper Thermic Alarm
IN9	22d	UBTA - 54 - REV	Reverse Trainline Status
IN10	24d	RSCEB	SCEB Relay Status
IN11	26d	UBTA - 59 - HRSB	High Rate Service Brake Trainline Status
IN12	28d	UBTA - 21 - FSB	Full Service Brake Trainline Status
IN13	30d	UBTA - 43 - MOTOR	Motor Trainline Status
IN14	4b	UBTA - 68 - COAST	Coast Trainline Status
IN15	6b	CMF	Motor Blower Contactor Status
IN16	8b	UBTA - 70 - FWD	Forward Trainline Status
IN17	10b	UBTA - 58 - HSCB/C	HSCB Status
IN18	12b	CP	CP Contactor Status
IN19	14b	CCF	CCF Contactor Status
IN20	18b	UBTA - 42 - TCU_A	TCU is A
IN21	20b	UBTA - 20 - RESET	Propulsion Reset
IN22	22b	UBTA - 67 - CABA	Cab A is enabled
IN23	24b	UBTA - 55 - DC	Door Closed
IN24	26b	UBTA - 65 - CABB	Cab B is enabled
IN25	28b	REB	Emergency Brake Relay Status
IN26	30b	UBTA - 57 - SL	Speed Limit Trainline Status
IN27	4z	UBTA - 19 - CW	Car Wash console Command
IN28	6z	UBTA - 41 - TB	Track Brake Status
IN29	8z	UBTA - 56 - MRL	Main Reservoir Low
IN30	10z	UBTA - 18 - TOWING	Towing Console Command
IN31	12z	UBTA - 40 - FBPA	Friction or Park Brake Applied Trainline Status

Table 07-I-02.15 Diagnostic/Chart recorder (UDIA Connector)

PIN	Signal	Description
K	STRX	STB RS232 RX
L	STBTX	STB RS232 TX
E	STBGND	STB RS232 GND
A	SCH1	STB RS232 shield
r	PCARX	PCA RS232 RX
j	PCATX	PCA RS232 TX
s	PCAGND	PCA RS232 GND
C	DAC2	Not Used
F	IR	Phase A current
G	SCH2	Shield
H	IS	Phase B current
M	IT	Phase C current
N	VF	Line Filter Voltage
B	COM	Common reference
k	SCH7	Shield
T	VL	Not Used
U	IL	Line Current
V	DAC1	Not Used
a	ICH1	Brake Resistor Current
b	ICH2	Return line Current
c	IVOK	Inverter Active
S	SCH3	Shield
P	DG1	Not Used
R	DG2	Not Used
J	CHOK	Braking Chopper Active
D	SCH4	Shield
m	DA1	Digital to Analog Converter output 1
W	DA2	Digital to Analog Converter output 2
X	DA4	Digital to Analog Converter output 4
d	DA7	Digital to Analog Converter output 7
e	DA5	Digital to Analog Converter output 5
f	DAGND	DAC reference
Z	SCH5	Shield
g	DA3	Digital to Analog Converter output 3
n	DA6	Digital to Analog Converter output 6
p	DA8	Digital to Analog Converter output 8
h	SCH6	Shield

Table 07-I-02.16 Vehicle Buses (UBUS Connector)

PIN	Signal	Description
R	LONA1	LON bus - A signal - terminal 1
Z	LONB1	LON bus - B signal - terminal 1
S	LONA2	LON bus - A signal - terminal 2
a	LONB2	LON bus - B signal - terminal 1
C	XP	RS485 TX/RX - positive
D	XN	RS485 TX/RX - negative
H	SCH485	shield
A	B1DATAN	MVB bus - channel B - negative
B	B1DATAP	MVB bus - channel B - positive
E	A1DATAN	MVB bus - channel A - negative
F	A1DATAP	MVB bus - channel A - positive
G	SCHMVB1	shield
T	A2TERMN	MVB bus channel A negative
U	A2TERMP	MVB bus channel A positive
K	B2TERMN	MVB bus - channel B - termination - negative
L	B2TERMP	MVB bus - channel B - termination - positive
M	SCHMVBT	shield
P	B2DATAN	MVB bus - channel B - negative
V	B2DATAP	MVB bus - channel B - positive
W	A2DATAN	MVB bus - channel A - negative
X	A2DATAP	MVB bus - channel A - positive
N	SCHMVB2	shield
J	Not Connected	
b	Not Connected	
c	Not Connected	
d	Not Connected	
e	Not Connected	
f	Not Connected	
g	Not Connected	
h	Not Connected	
j	Not Connected	
k	Not Connected	
m	Not Connected	
n	Not Connected	
p	Not Connected	
r	Not Connected	
s	Not Connected	

c) Inverter Control Module Bus Connector (UBUS)

The Inverter Control Module UBUS Connector allows the Propulsion System to be connected with the Vehicle and Train Networks.

The Vehicle and Train Networks are:

- LON (Local Operating Network, based on the “LonTalk” protocol)
- TCN (Train Communication Network, made up of the MVB and the WTB buses)

Figure 07-I-02.17 and Figure 07-I-02.18 show how the above mentioned networks and how the systems can exchange data.

The Communication System is connected to the TCU by means of the UBUS Connector and a half duplex RS485 bus.

All systems connected to the LONWorks bus transmit their diagnostic and status data collected in packages (datasets).

The TCU uses the LON Works bus connection to acquire data from the ATP System, the APS/LVPS and the EMI Detector Unit.

Through the LONWorks Bus, the TCU sends its status to the IDUs for troubleshooting purposes.

The TCU is connected to the MVB bus to exchange data with the Brake Electronic Control Units (ECUs), with the remote TCU, the HVACs, the Event Recorder Unit and the IDUs.

The GTW (Gateway) interconnects the MVB and the WTB buses, thus allowing data exchange between the systems of coupled vehicles and determines the timing of the exchange.

Refer to Section 18 for detailed information on Vehicle and Train Networks.

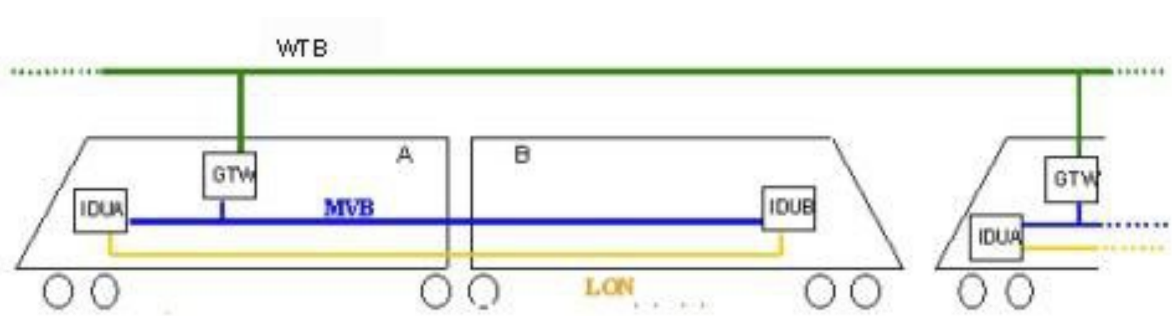


Figure 07-I-02.17 TCMS Train Network

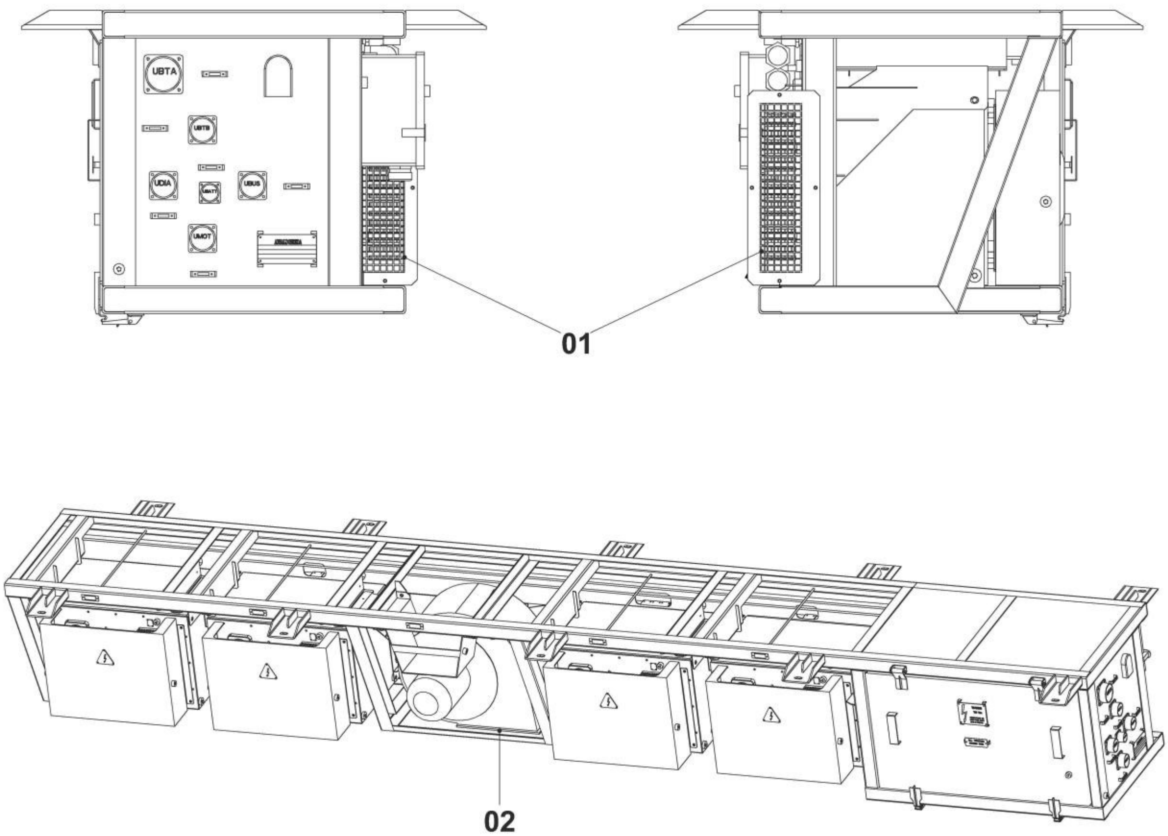
Figure 07-I-02.18 TCMS Vehicle Network

07-I-02.02.01.03 Inverter Fan

The Inverter fan is mounted within the Inverter frame, between the B and C Phase Modules.

Fresh air is sucked from the two ends of the cooling duct which runs on the back side of the four Inverter Phase Modules.

It removes heat from the heat sinks of the modules and then exhausts the heated air down, towards the ballast.



01. AIR INLET 02. AIR OUTLET

Figure 07-I-02.19 Inverter Fan and Air Duct

The Inverter Fan complies with rolling stock applications.

The Inverter Fan Motor turns on automatically (CMF contactor - refer to Figure 07-I-02.13) when one of the following conditions is met:

- The Propulsion Inverter is activated; (CP contactor closed)
- The Vehicle speed is above 6.2 mph (10 km/h)

The Inverter Fan Motor is powered down 2 minutes after one of the following conditions is met:

- The Propulsion Inverter is deactivated; (CP contactor open)
- The vehicle speed is below 5 mph (8 km/h)

Features of the Centrifugal Inverter Fan for rolling stock application:

Nominal working point	
Airflow	550 l/s
Static pressure	55 mm H2O
Ventilation efficiency (with static pressure)	
@ Nominal working point	50 %

Table 07-I-02.17 Inverter Fan Specifications

Type	Three-phase sinusoidal voltage
Phase to phase nominal voltage	208 Vac ± 5%
Frequency	60 Hz ± 1%
Number of poles	2
Input current	3.4 A
Absorbed electrical power	1.58 kW
Shaft Power	1.1 kW
Rotation Speed	3.490 rpm
Insulation class[2]	H
Environmental conditions	19.40°F -131°F (-7°C +55 °C)
Acoustic pressure level	< 78 dB (A)
Axial thrust in opposite direction of air flux	0.04 N
MTBF @ nominal working conditions	250,000 hrs
MTBF - Bearing	30,000 hrs

[2] Refer to Appendix 07-I-03.06 for Insulation Class description.

[redacted]

a) Inverter Fan MV Connector (UMT)

Medium Voltage is required for the Inverter Fan motor.

The three-phase 208V 60Hz power supply, coming from the APS/LVPS System, must be connected to the UMT connector located on the back of the Inverter Control Module (refer to Figure 07-I-02.12 and Figure 07-I-02.13).

The UMT connector is a 7 pin VEAM type connector.

Table 07-I-02.18 UMT Connector Pins

Medium Voltage Interface - UMT connector	
Terminal Name	**Description**
A	A phase
B	Not connected
C	C phase
D	Not connected
E	B phase
F	Not connected
G	Not connected

07-I-02.02.02 Line Reactor

An external Line Reactor is an Inductor used to form a single cell L-C input filter. The Line Reactor is connected to the Propulsion Inverter through the (L1) and (L2) HV insulated connectors (refer to paragraph 07-I-02.02.01.02a) and Figure 07-I-02.12).

The input filter capacity is obtained through the Input capacitors of each Inverter Phase Module (refer to paragraph 07-I-02.02.01.01).

The input filter prevents damage to solid-state equipment from very large voltage transients, likely to be present on the line due to causes such as a lightning strike or an interruption of line current caused by vehicles and by wayside breakers.

The line filter has the following parameters:

L = 4 mH and C = 5.8 mF.

The line reactor is the air core type, cooled by natural air ventilation, and is class H insulated.

The Line Reactor winding impregnation technology provides complete insulation of the live parts from the environment.

A pre-charging circuit, located inside the Inverter Control Module, receives the Line Current before the Input Filter and limits the in-rushing current when line voltage is applied and filter capacitors are either discharged or at a low-voltage level.

This circuit consists of a resistor (RCF) which is used to limit the in-rush of current during the initial charging of the filter capacitors; a fuse (FCF) which is used to protect against excessive currents; and a contactor (CCF) that will route the incoming 750 VDC through the pre-charging circuit during the initial charging of the filter capacitors.

After the filter capacitors are charged up then the contactor CP will close to bypass the pre-charging circuit and the CCF contactor will open. The CP and CCF contactors are both controlled by the TCU, as well. All of these components are mounted inside of the Inverter Control Module. (Refer to paragraph 07-I-03.02.18 and Figure 07-I-02.9)

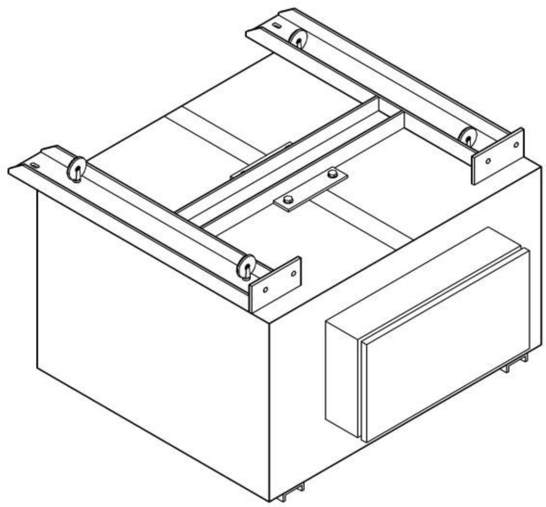


Figure 07-I-02.21 Main Inverter Line Reactor

07-I-02.02.03 Braking Resistor

The two Braking Resistors (one per Propulsion Inverter) are mounted on the car roof in a stainless steel frame. The resistors are insulated from their support frame, and the support frame from the car body, with high-temperature insulators.

The Braking Resistor is sized for the specified duty cycles (up to, and including, AW3 passenger load), as if there was no regenerative braking.

During braking, the unused energy is sent back to the line: if the line is receptive, the breaker remains closed so that the energy can be returned to the catenary. If the line is non-receptive then the CP Contactor, which is housed in the inverter enclosure, will open forcing the current to flow through the Dynamic Brake Resistors (via the Chopper Module). The Braking Resistors will dissipate the energy in the form of heat. (Refer to paragraph: 07-I-02.04)

The Braking Resistor is cooled by natural ventilation resulting from the vehicle's motion and will have sufficient thermal capacity to handle all braking current.

The Braking Resistor is made up of an active material consisting of a nickelchromium steel alloy. This makes the Braking Resistor suitable for uses with square wave voltages and/or high frequencies, as well.

The maximum active element temperature under these conditions is limited to 752°F (400°C).

The Braking Chopper and the Braking Resistor also perform the function of voltage clamp in case of line overvoltage (refer to paragraph 07-I-03.02.05).

Cable connections are made outside of the heated airflow by means of terminals insulated from the frame.

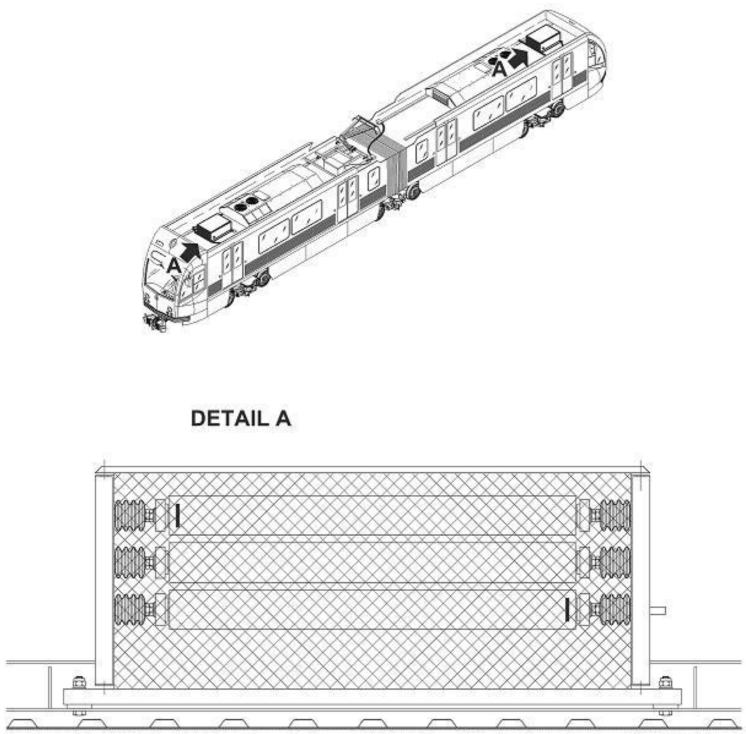


Figure 07-I-02.22 Braking Resistor

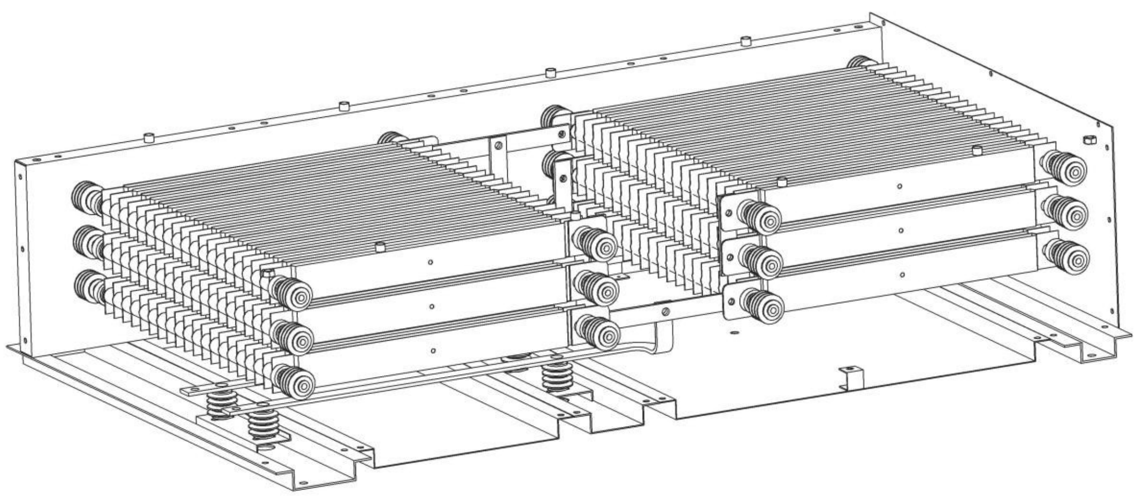


Figure 07-I-02.23 Braking Resistor Internal View

Table 07-I-02.19 Characteristics of each Braking Resistor

Maximum Voltage	950Vdc
Maximum Current	1830A
Minimum Resistance (at 19.4°F (-7°C))	0.52Ω
Maximum Resistance (at 68°F (20°C))	0.545 Ω
Maximum Resistance (at hot conditions)	0.86 Ω
Continuous Power Rating	122kW

Overall dimensions: 62.992 x 43.307 x 16.338 in (1,600 x 1,100 x 415 mm).

07-I-02.02.04 Traction System

Each Motor Truck is equipped with one Traction System.

Each Traction System is made up of the following main components:

- Two AC Traction Motors
- Two Gear Units
- Two Couplings

07-I-02.02.04.01 MTA-F4 145V Traction Motor

Each Propulsion Inverter (refer to paragraph 07-I-02.02.01) supplies two parallel connected induction motors, one per Motor Truck Axle.

The MTA-F4 145V traction motor is designed for the Los Angeles P2550 LRV. The main characteristics of the vehicle propulsion system are the following:

- One inverter powers two traction motors. The vehicle has two independent inverter drive units, one for each powered truck
- One motor per axle; two motors per truck for each end-truck connected to the relevant Inverter
- suspension deflection, is 90mm (3.54in)
- The nominal level of the primary power from the overhead catenary system is 750 Vdc
- The traction motor provides mechanical power to its associated axle through a gear drive
- Wheel diameter new/worn: 28.0/26.0in (711/660mm)

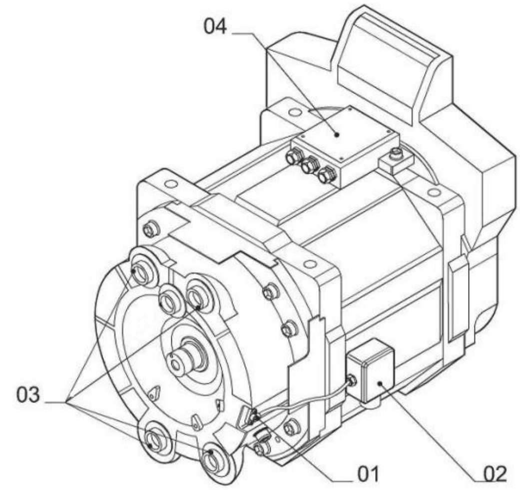
The MTA-F4 145V Traction Motor main characteristics are:

Table 07-I-02.20 Propulsion Motor Characteristics

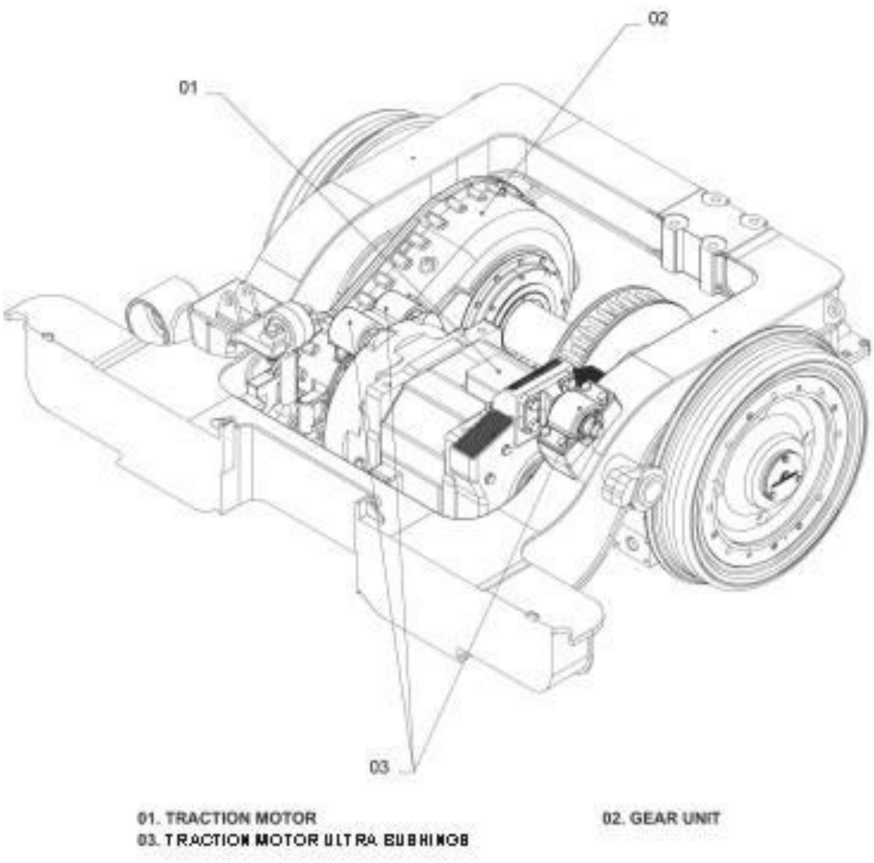
Parameter	Value
Phase Connection	STAR
Nominal Voltage (fundamental RMS)	585 Vac
Square wave frequency	64 Hz
Number of poles	4
Supply frequency range	0 - 140 Hz
Starting Torque	1,608 Nm
Max Service Speed (worn wheel)	4,200rpm = 65.24 mph (105 kmph)
Max Design Speed (worn wheel)	4,550rpm = 70.21 mph (113 kmph)
Continuous Rating	
Motor Voltage (fundamental RMS)	534 Vac
Frequency	58.7 Hz
Output Power	145 kW
Stator Phase Current (fundamental RMS)	211 A
Traction Maximum Rating	
Motor Voltage (fundamental RMS)	360 Vac
Frequency	39.6 Hz
Output Power	200 kW
Stator Phase Current (fundamental RMS)	400 A
Braking Maximum Rating	
Motor Voltage (fundamental RMS)	678 Vac
Frequency	110 Hz
Output Power	406 kW
Stator Phase Current (fundamental RMS)	410 A
Mechanical transmission Efficency	0.975
Weight	1,323 lb (600 kg)
MTBF	800,000 hrs
Ambient temperature range	20°F to 115°F (-7°C to 46°C)

Table 07-I-02.21 Traction Motor Support Torque Values

Motor Support bolts	302 ± 5% ft*lb
Motor Support Collar bolts	144 ± 5% ft*lb
Motor Support Nut	288 ± 5% ft*lb
Safety Nose Screw	144 ± 5% ft*lb



01. MOTOR SPEED SENSOR
03. TRACTION MOTOR ULTRA BUSHINGS
02. TEMPERATURE SENSOR
04. CABLE BOX



01. TRACTION MOTOR
03. TRACTION MOTOR ULTRA BUSHINGS
02. GEAR UNIT

Figure 07-I-02.24 Motor External View and Location

a) Stator

The stator casing is an all welded structure composed of a magnetic core stacked with eight steel plates.

The magnetic circuit is made with 0.5mm lamination thickness with iron losses and coating insulation.

The stator coils are made of wound copper wire, and coil ends are fastened securely in order to resist the mechanical vibration of the motor.

Conductor insulation is made of kapton type “corona resistant”.The class 200 insulated coils employ a standard system developed and guaranteed by experience.

The ground insulation consists of porous glass backed mica tape for VPI insulation and kapton.

The finish coils are Vacuum pressure impregnated with class 200 resin and cured to provide a covering oil proof, of high dielectric strength, good heat conductivity and excellent mechanical strength.

b) Rotor

High grade sheet steel is used for the rotor core.

The rotor winding is a squirrel cage type. The rotor bar and the end ring are securely brazed together with special silver alloy.

c) Bearings

The rotor is equipped with grease lubricated roller bearings.

Both bearings are insulated and packed with sealing plates, labyrinths and grease valves.

The lubrication interval is 60,000 miles

d) Speed Sensors

Each motor is equipped with a speed sensor, which provides the relevant signals to the TCU (Traction Control Unit). (Refer to paragraph 07-I-03.02.10).

e) Thermal Sensors

The motor is equipped with two thermal probes type PT100. They have a platinum resistance (Pt 100 Ohm at 32°F (0°C) used for picking up the temperature of the stator pack of the electric traction motor.

The platinum sensor is laid on a ceramic support and is encapsulated within a stainless steel cover, type X5 Cr Ni 18-10 UNI6900.

The range of temperatures that can be picked up by the active element is:

-328°F - 932°F (-200°C - 500°C).

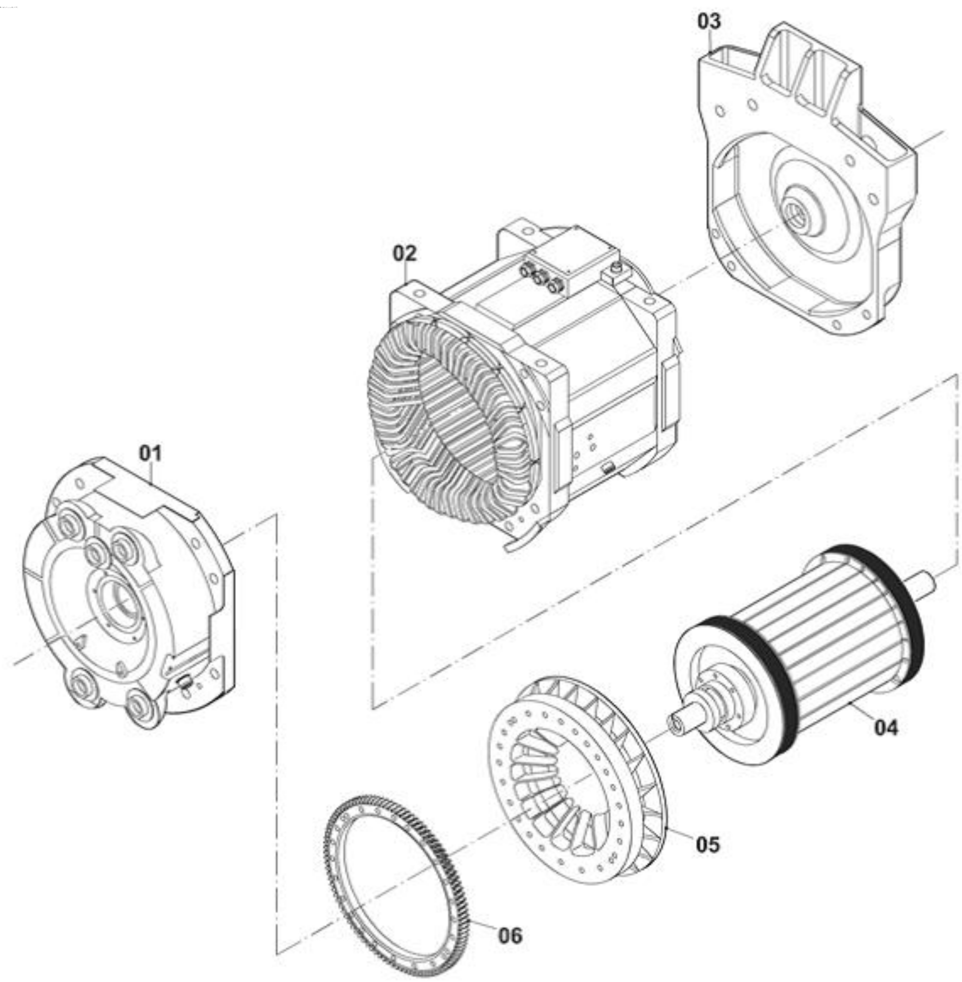
The working temperature range is:

-58°F - 392°f (-50°C - 200°C).

f) Cooling system

The rotor is self-ventilated by means of a fan which rotates together with the motor shaft. Air inlet is on coupling opposite side.

The air is taken in from the underframe. Both inlet and outlet air openings are protected by a stainless steel net.



01. ENDSHIELD
03. ENDSHIELD
05. FAN
02. STATOR ASSEMBLY
04. ROTOR ASSEMBLY
06. TOOTHED ATTACHING PARTS RING

Figure 07-I-02.25 Traction Motor - Internal Structure

g) Traction Motor Coupling

The Traction Motor is coupled to the Gear Unit from one side and sits on the Motor Truck Frame on the other side, supported by the Motor support.

The coupling with the Gear Unit is made possible by means of a toothed gear coupling made up of two coupling halves and the flange connection (refer to Figure 07-I-02.26)

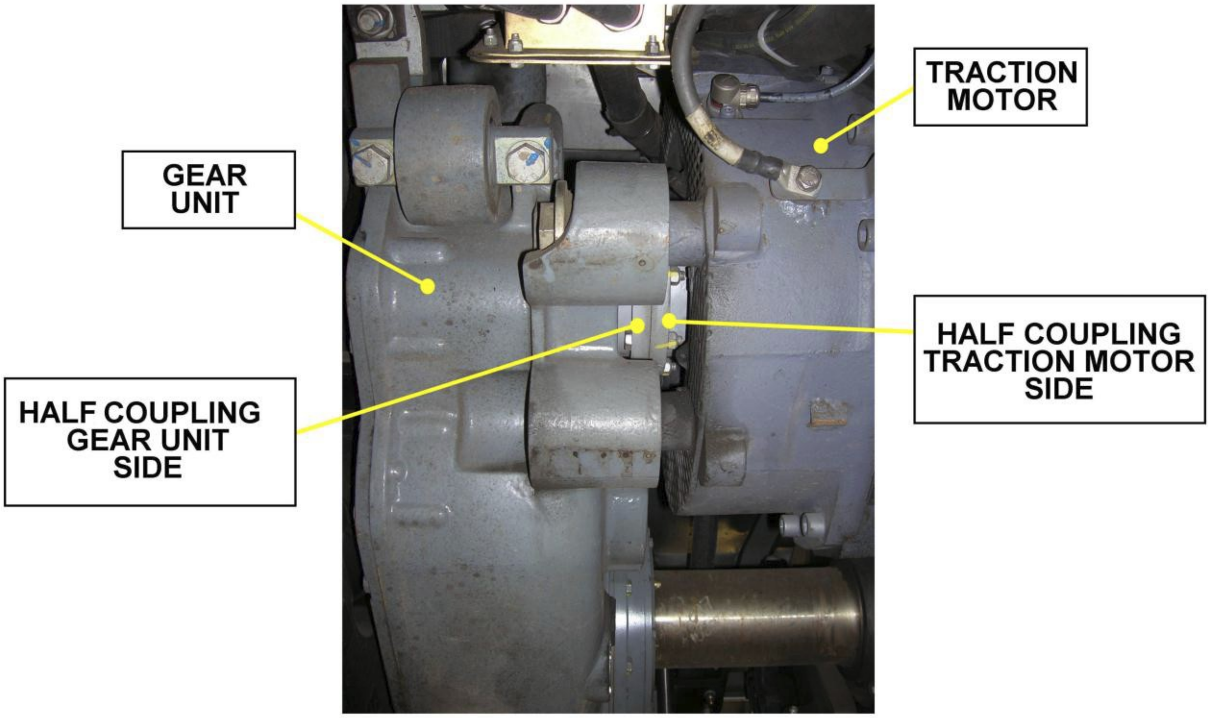


Figure 07-I-02.26 Coupling Location

h) Traction Motor Electric Connection

The two motors located in the same truck have an opposite orientation and the threephase cables are connected accordingly.

The effects of different behaviour of motor phases have been reduced by modifying the traction motor wiring; on both motor trucks the wiring are done according to the following electrical principal scheme:

Example: motor1-connector1 = motor2-connector1 = phase A, motor1-connector2 = motor2-connector3 = phase B and motor1-connector3 = motor2-connector2 = phase C.

Figure 07-I-02.27 Traction Motor Electric Connection

07-I-02.02.04.02 Gear Unit

A motor truck is equipped with two drive units.

A drive unit is made up of Traction Motor, Gear Unit, curved tooth coupling and Reaction Rod.

The Gear Unit is assembled on the wheel axle (axle hung) and fixed to the truck frame by means of the Reaction Rod.

The Reaction Rod incorporates resilient mounts, which are suitable for the dynamic and static loading of the system.

The drive torque, developed by the truck-mounted motor, is transmitted over the curved tooth coupling and the Gear Unit to the driven wheels.

Because of the different suspension points for motor and Gear Unit, there is a relative movement, in axial and radial direction, between these two components when in operation.

The curved tooth coupling absorbs this relative movement.

The motor is connected to the Gear Unit by means of four spheroelastic bearings, which are suitable for the dynamic and static loading of the system.

a) Function

The Gear Unit in normal operation transmits the drive torque (positive or negative), developed by the truck resiliently mounted traction motor, to the driven wheels.

The Function of the Gear Unit is to reduce the revolution speed of the Wheel Axle with respect the revolution speed of the Rotor Axle.

The ratio between the Axle Speed and the Rotor Speed is called Gear Ratio:the P2550 Total Gear Ratio is **1** / **4.943**.

The Reaction Rod is designed to take up the thrusts which take place during service. This includes forces due to traction and braking moments, peak torque due to electrical short circuit in the motor, vibrations and shocks to be withstood.

The purpose of the Reaction Rod is to withstand the mechanical shocks introduced into the wheel set caused by the track-wheel contact during normal operations.

If the wheel set moves in accordance to the truck frame, the mounted ultrabush in the Reaction Rod will allow the axle mounted Gear Unit to move in accordance with the displacements of the wheel axle, without interfering with other parts.

The safety catch, independent of the Reaction Rod, ensures that the Gear Unit cannot fall down on the tracks in the event of a catastrophic failure of the reaction rod or it's mounting hardware

b) Operation

Deviations from normal operation: increased power consumption, mechanical overloading, oil leakage, abnormal temperatures or vibrations, unusual noise or odorous, damaged parts etc., indicate that the Gear Unit is not working properly.

An appropriately designed control and speed monitoring system must be used to ensure that the maximum values specified in the technical data are not exceeded.

In case of malfunctioning or unusual operating conditions that could indicate mechanical overloading of the Gear Unit, the appropriate maintenance work and tests should be carried out in accordance with the regulations described in the Gear Unit and Reaction Rod “Heavy Repair Maintenance Manual”.

c) Description (Refer to Figures 07-I-02.28 through 07-I-02.32

The two-stage Gear Unit has gears with helical teeth. The teeth of the gears are made of the material 17CrNiMo6 - DIN EN 10083 T1 and T2 (Oct 91), carburized and ground quality 6 according to DIN3962 and DIN3963.

The geometry is optimized and the helical teeth have a special profile correction to minimize the total noise of the Gear Unit. These gears are calculated ‘infinite life’ according to DIN3990.

The Gear Unit housing is made of nodular graphite iron GGG40.3 and consists of a box and a large cover at the wheel side (split plane perpendicular to the wheel axle). These two parts are bolted together and the interface is sealed with a liquid sealant. An inspection cover (Fig 07-I-02.32, item 35) allows the contact pattern of the gear wheel to be checked.

The Gear Unit housing rests on the wheel axle by way of two tapered roller bearings, foreseen with a special cage.

The gear wheel (Fig 07-I-02.31, item 38) of both stages is pressure fitted to the intermediate shaft and the wheel axle, and has an oil injection hole for hydraulic removal.

By expanding the hub of the gear wheel by hydraulic pressure, the gear wheel can be removed from the wheel axle.

The pinion (Fig 07-I-02.29, item 37) is located in the housing by a fixed bearing set, composed of one cylindrical bearing type NU (7) (radial forces) combined with a four-point contact ball bearing type QJ (8) (axial forces), and a loose cylindrical bearing type NU (7).

This pinion has a taper fit for pressing on the coupling half Gear Unit side. This fit has an oil injection hole that allows the coupling hub to be hydraulically expanded for installation and removal purposes.

The gear and all bearings are oil-lubricated. During service, oil is collected in small cavities in the upper part of the housing and delivered by channels to the bearings for lubrication purposes.

Ferrous abraded material and dirt particles are collected at the magnetic oil drain and the fill cap. The oil level is checked by an oil gauge glass (Fig 07-I-02.32, item 71). Oil has to be filled by the oil fill cap (Fig 07-I-02.31, item 40, Fig 07-I-02.32, item 40).

The seals between the pinion and the Gear Unit housing and between the axle and Gear Unit housing are contact less labyrinth seals.

Each of the outermost labyrinth chambers is in the form of a separation chamber to protect against splashed water. They are also designed to prevent the entrance of dirt or other contamination and to retain the oil.

The Gear Unit housing has two machined surfaces and two tapped holes for attaching the Reaction Rod.

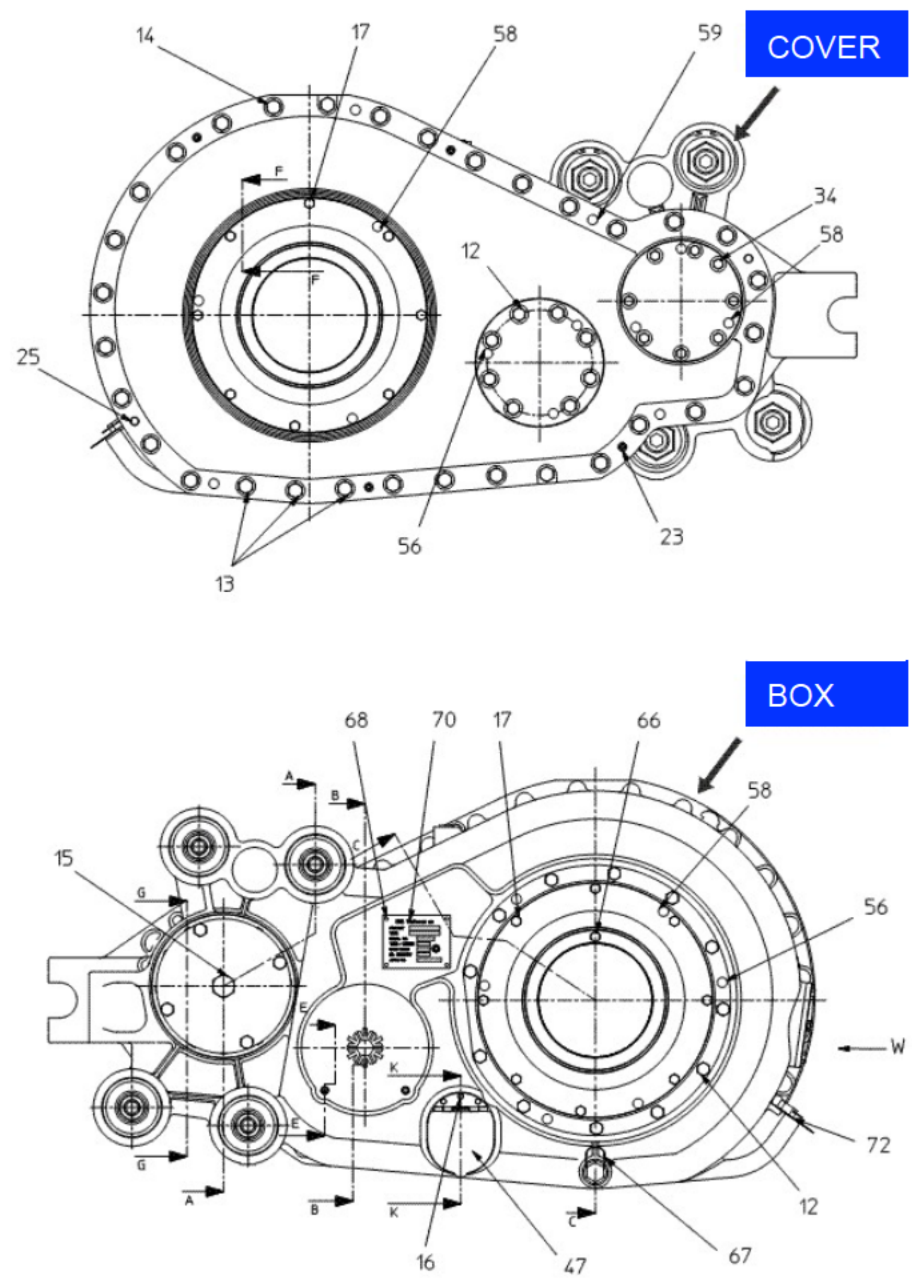


Figure 07-I-02.28 Gear Unit

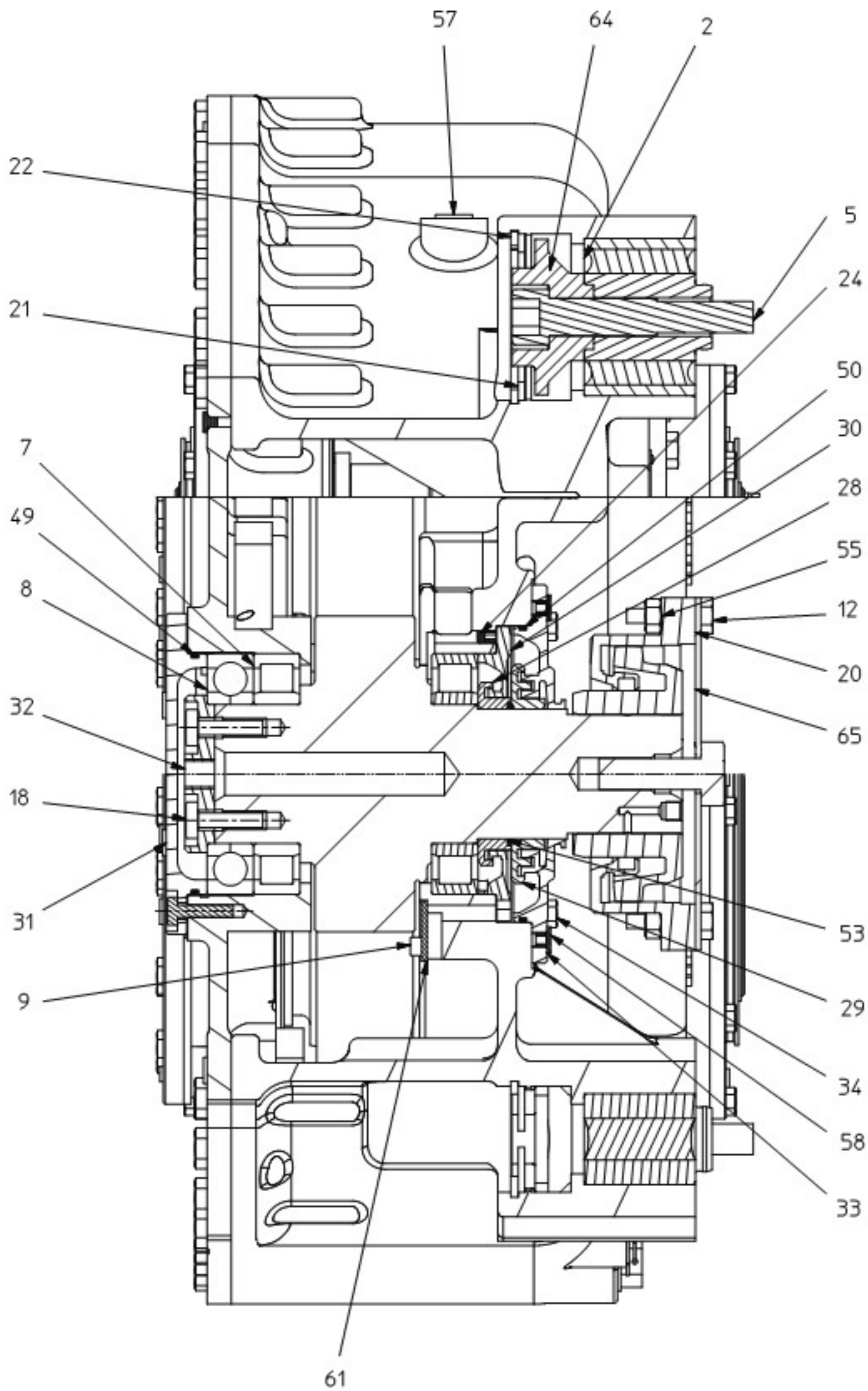


Figure 07-I-02.29 Gear Unit -A-A Section

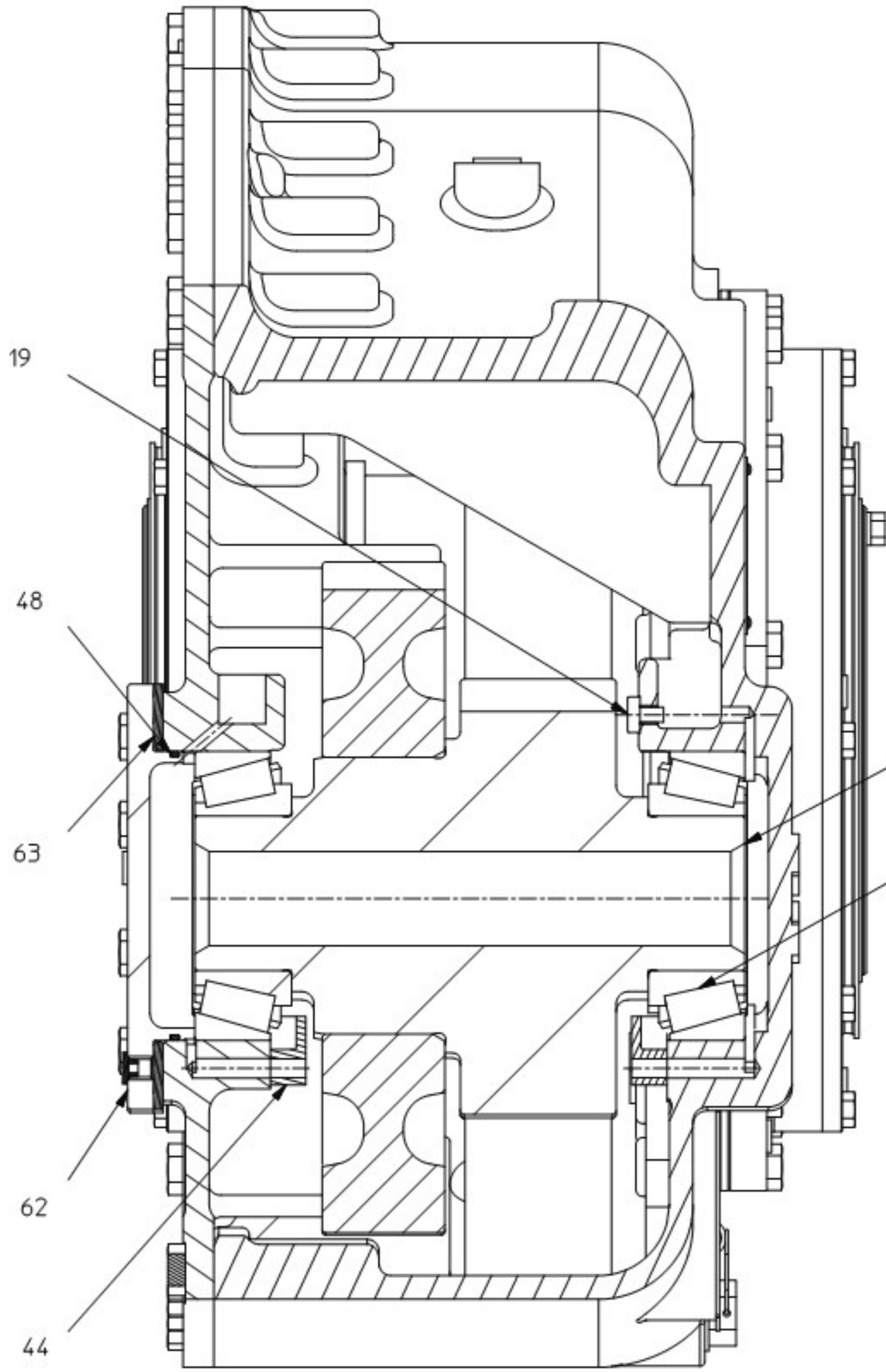


Figure 07-I-02.30 Gear Unit -B-B Section

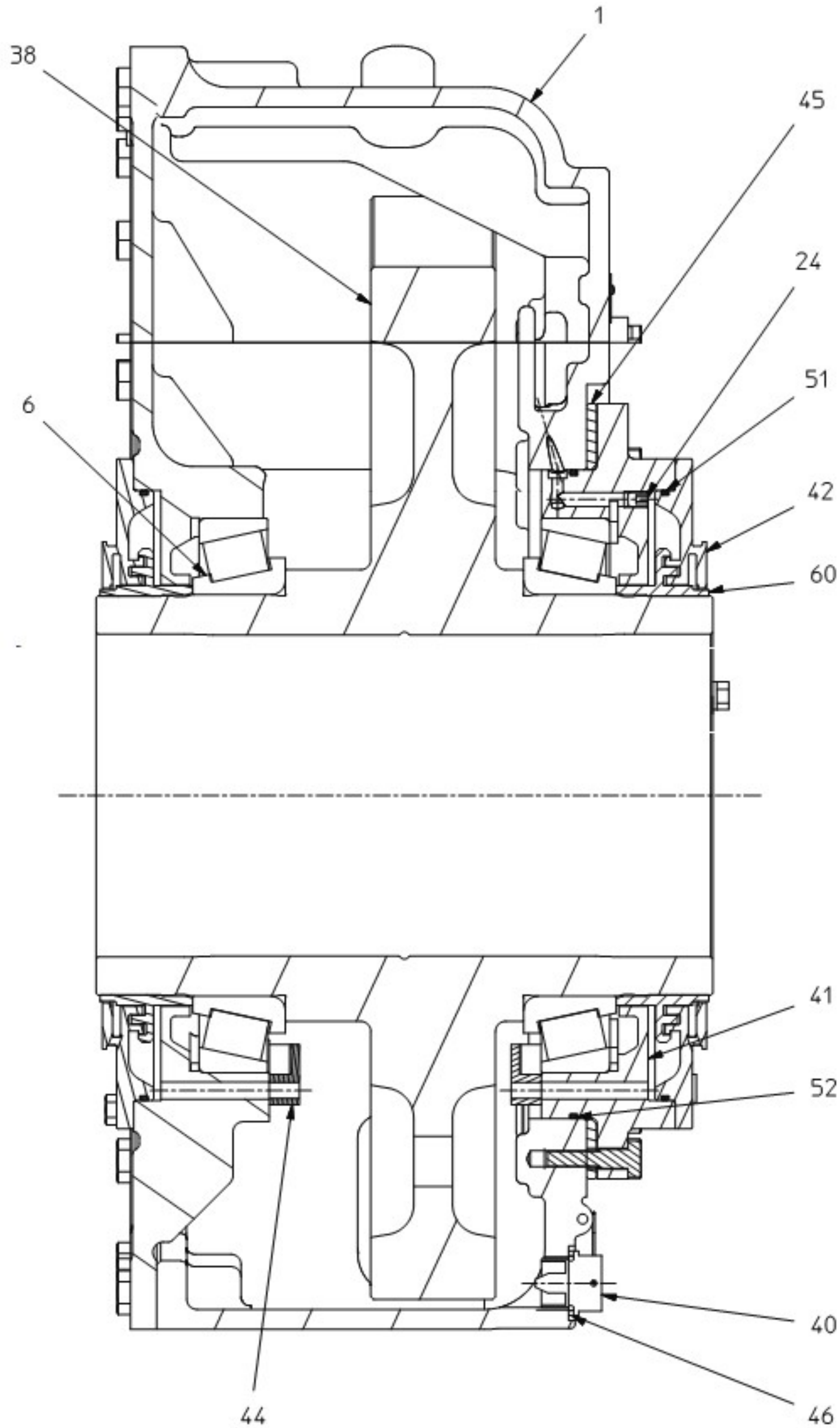


Figure 07-I-02.31 Gear Unit -C-C Section

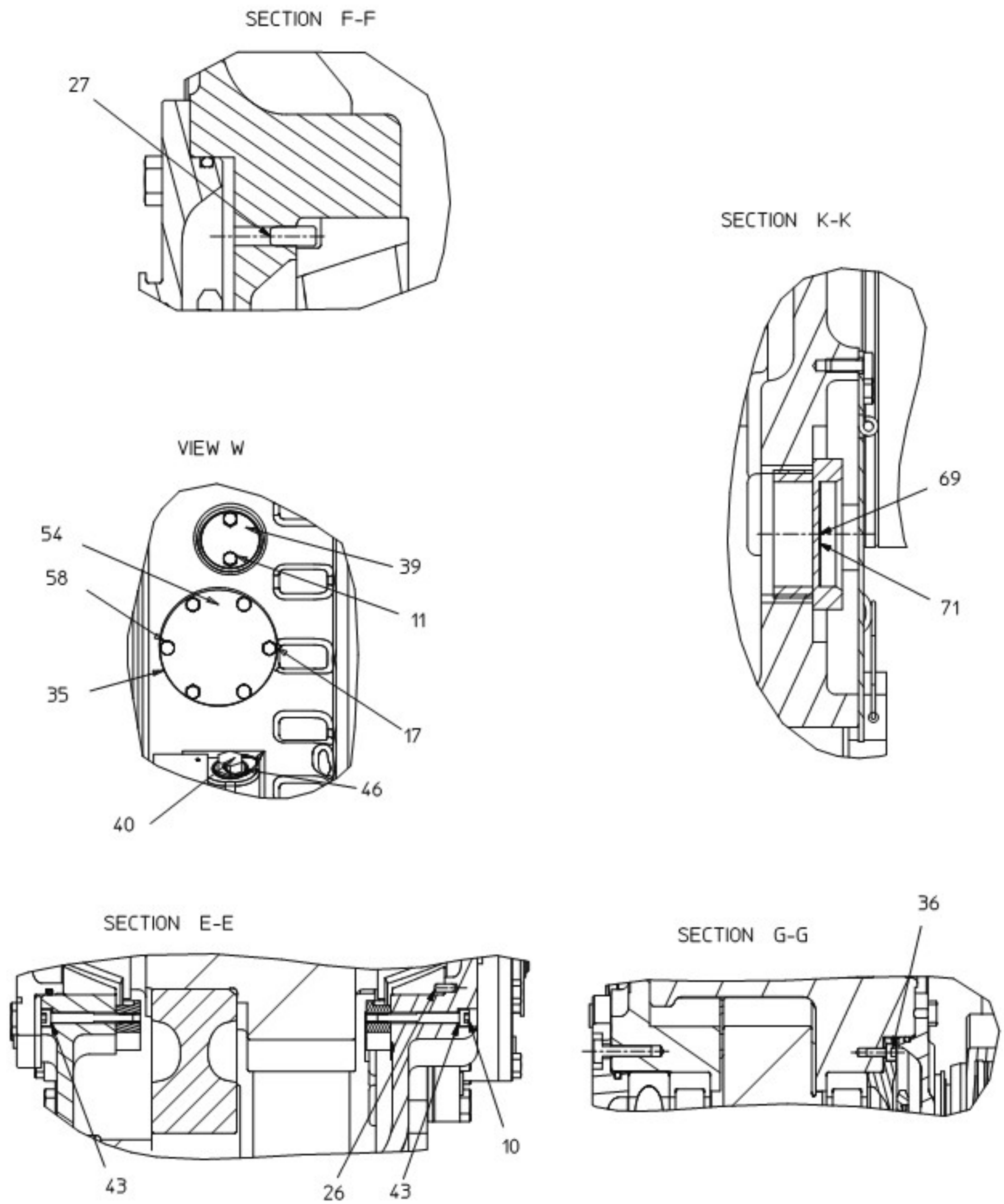


Figure 07-I-02.32 Gear Unit - Sections

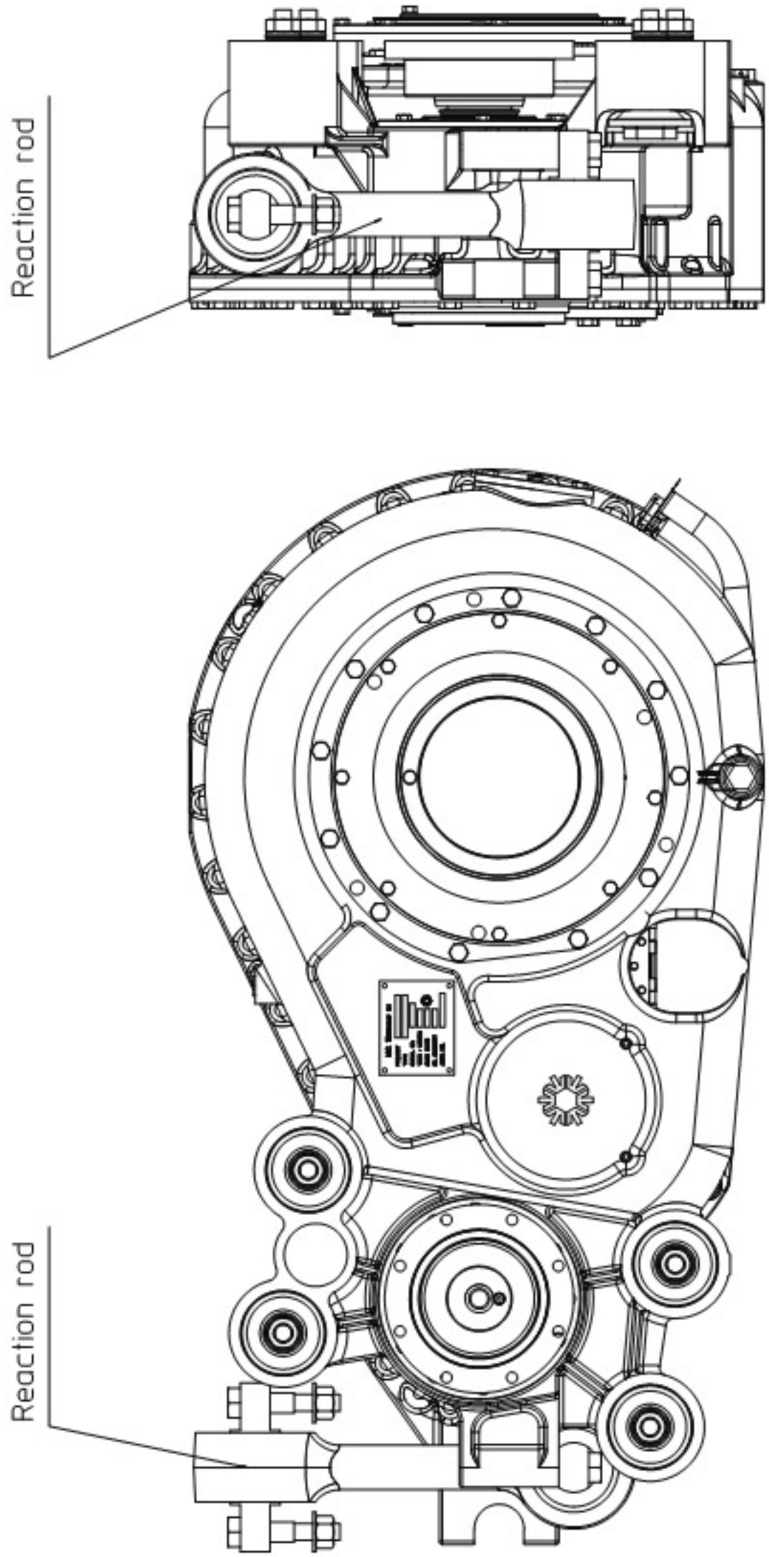


Figure 07-I-02.33 Gear Unit and Reaction Rod

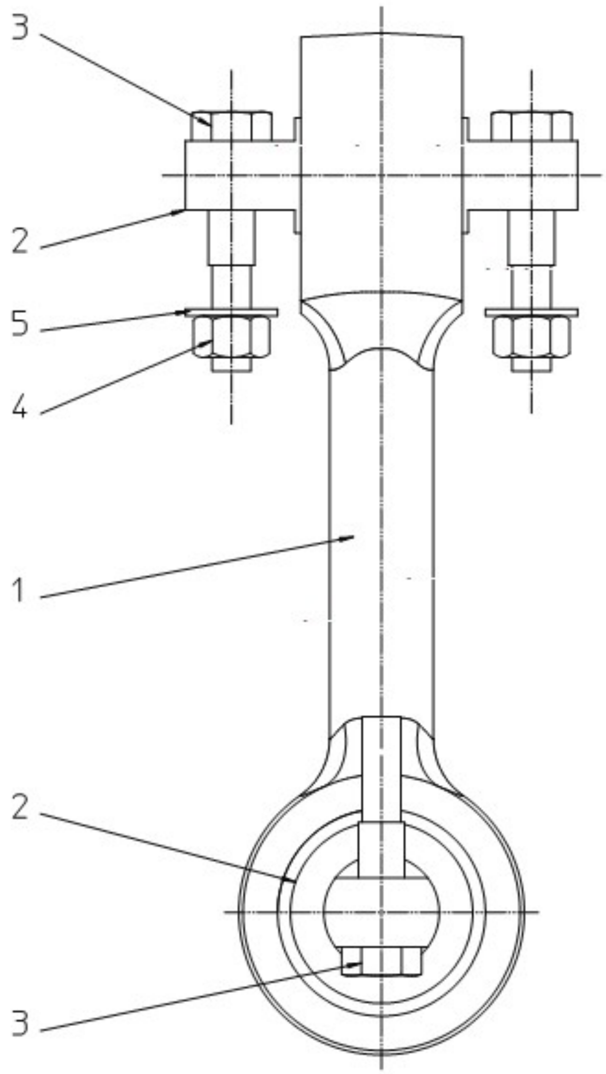


Figure 07-I-02.34 Reaction Rod

The Reaction Rod (1) is one finished part with two ultra bushes (2) on each end of the Reaction Rod (1).

The lower ultrabush (2) is bolted with two hexagon cap screws M20x100 (3) to the Gear Unit, and the upper ultrabush (2) is bolted to the truck with two hexagon cap screws M20x100 (3), two nuts M20 (4) and two washers (5).

d) Technical data

Mechanical data of the two-stage Gear Unit with helical tooth system for installation and operation in railway vehicles:

Total gear ratio:	1/4.943
Module:	1st stage: 4.5 2nd stage: 5
Helix angle:	1st stage: 17°30 2nd stage: 15°
Center distance:	1st stage: 8.58in (218 mm) 2nd stage: 13.07in (332 mm)
Maximum motor power:	219 kW
Maximum braking power:	490 kW
Maximum motor speed:	4200 rpm
Short circuit torque at pinion:	3-phase short circuit torque 6700Nm Phase to phase short circuit torque 7200 Nm
Minimum bottom clearance(worn wheels):	2.52in (64 mm)
Calc. bearing life-time L10:	> 1.6 ^{E}06 km
Reaction Rod Center to center distance ultra bushes:	12.6in (320 mm)

Weights

Gearbox complete (without motor, wheel axle, coupling, Reaction Rod):	793.66lbs (360 kg)

Bearings

Pinion:	fixed bearing:	SKF-NU215ECML/P63H
	loose bearing:	SKF-NU215ECML/P63H
	loose bearing:	SKF-NU215ECML/P63H
Intermediate shaft:	two tapered roller bearings:	SKF-33214/QVE141
Wheel axle:	two tapered roller bearings	SKF-LM214147/110/VE673

Lubrication

Oil type:	Mobilize SUC 75W90-LS
Initial oil volume:	1.45 gals (5.5 liters)
Reaction Rod total weight:	35.27lbs (16 kg)

07-I-02.02.04.03 Traction Motor-Gear Box Coupling

The Traction motor - Gearbox Coupling is made up of two coupling halves and a flange connection.

The toothed gear type coupling is not interchangeable. It is torsionally rigid and has toothing with self-centering gear teeth.

The torque transmission is positive-locking through interlocking external and internal tooth gearing with the involutes profile of the hubs or sleeves.

The coupling is supplied with complete coupling halves.

The position of the coupling halves in relation to each other and the arrangement of the flange screws can be decided at will.

The anticorrosive agent on the flange face and hub bore holes must be removed.

Before starting any installation procedure, the following must taken into consideration:

- The Gear Unit comes together with the wheel axle and the wheels towards the truck assembly
- The coupling half motor side is mounted on the motor shaft and supplied with the motor
- The coupling half Gear Unit side is mounted on the pinion and supplied with the Gear Unit
- The Reaction Rod is supplied with bolts for assembling on the Gear Unit; bolts, flat washers and two nuts for assembling on the truck, and with the parts necessary for the assembling of the two coupling halves

07-I-02.02.05 Master Controller Console

The Master Controller Console is located in each operator cab, on the left-hand side of the Console.

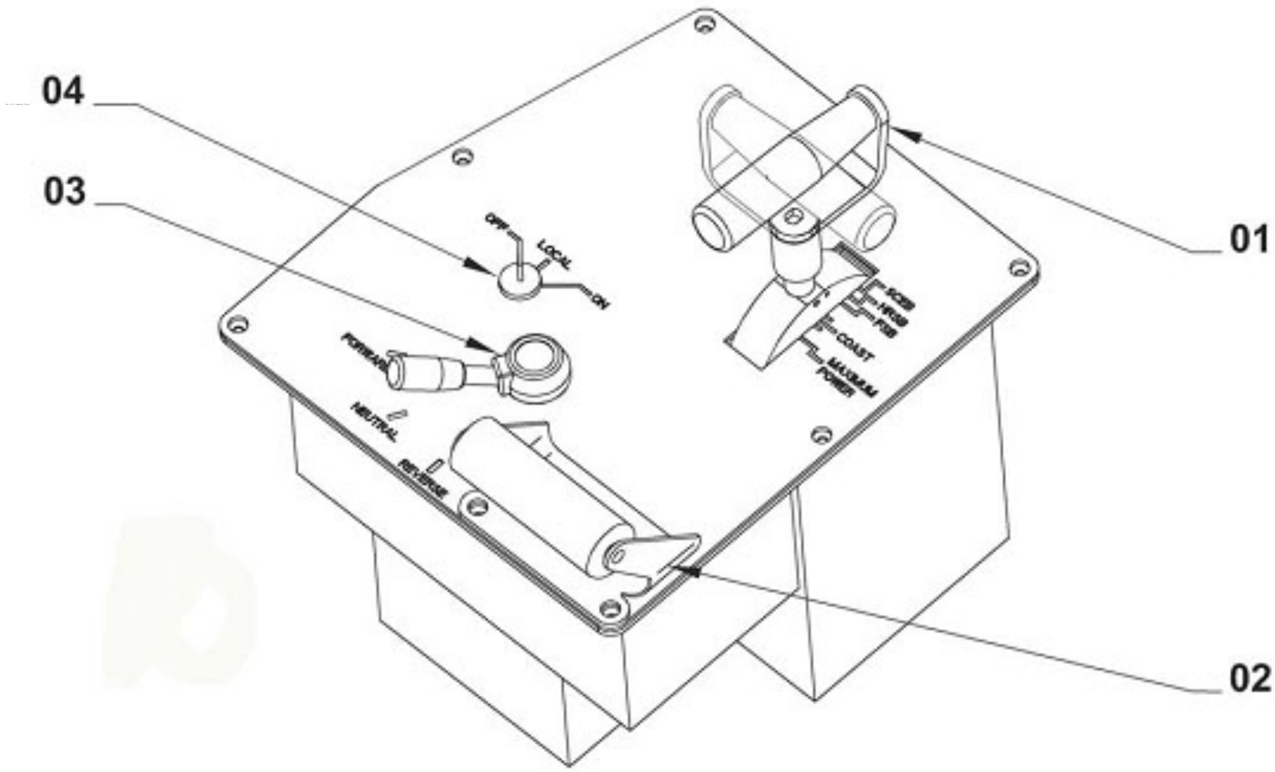
Through the Master Controller Console, the operator can select the desired Operating Mode (Power, Coast, Service Brake, Full Service Brake, High Rate Service Brake, Slide Controlled Emergency Brake), the direction of travel, the amount of tractive or braking effort.

The Operating Mode and the tractive/braking effort requests are delivered to the TCU. The TCU uses this information to drive the Inverter Phase Modules and, through the Inverter Phase Module, the AC motors.

The Master Controller Console is made up of the following main components:

- Transfer Switch (3-position)
- Reverser Switch (3-position)
- Master Controller Handle
- Encoder Interface
- Encoder Power Supply

The Master Controller Handle incorporates the Dead-man function with interlock, which provides a FSB brake application in the event that the handle slips out of the operator's hand (and is not repositioned within 2 sec).



01. MASTER CONTROLLER HANDLE
02. ARM REST SUPPORT
03. REVERSER SWITCH
04. TRANSFER SWITCH

Figure 07-I-02.35 Master Controller Console

07-I-02.02.05.01 Transfer Switch

The Transfer Switch is operated by means of the Operator key.

It has three positions: OFF, LOCAL and ON.

By rotating the switch clockwise from OFF to LOCAL, the Reverser Switch and the MC Handle are still locked.

In both OFF and LOCAL positions the operator's Key can be pulled out, only with the Reverser Switch in NEUTRAL and the Master Controller Handle in FSB.

When the Transfer Switch is switched to ON, the relative Cab becomes ACTIVE and the relevant Master Controller Handle is enabled. No other cab in the train consist can be active at the same time.

With the T.S. ON, the Reverser Switch is unlocked and both FORWARD and REVERSE directions may be selected. When the Transfer Switch is in the ON position the Key cannot be pulled out.

07-I-02.02.05.02 Reverser Switch

The Reverser Switch is used to select the direction of travel (FORWARD, REVERSE) when the Transfer Switch is switched to ON.

As soon as the Reverser Switch is set to the FWD or REV position, the Master Controller Handle can be moved freely from the FSB position while the Transfer Switch is locked to the ON position.

The Reverser Switch must be set back to the NEUTRAL position and the Transfer Switch must be placed into either LOCAL or OFF in order to be able to pull the Operator's Key out of the Transfer Switch

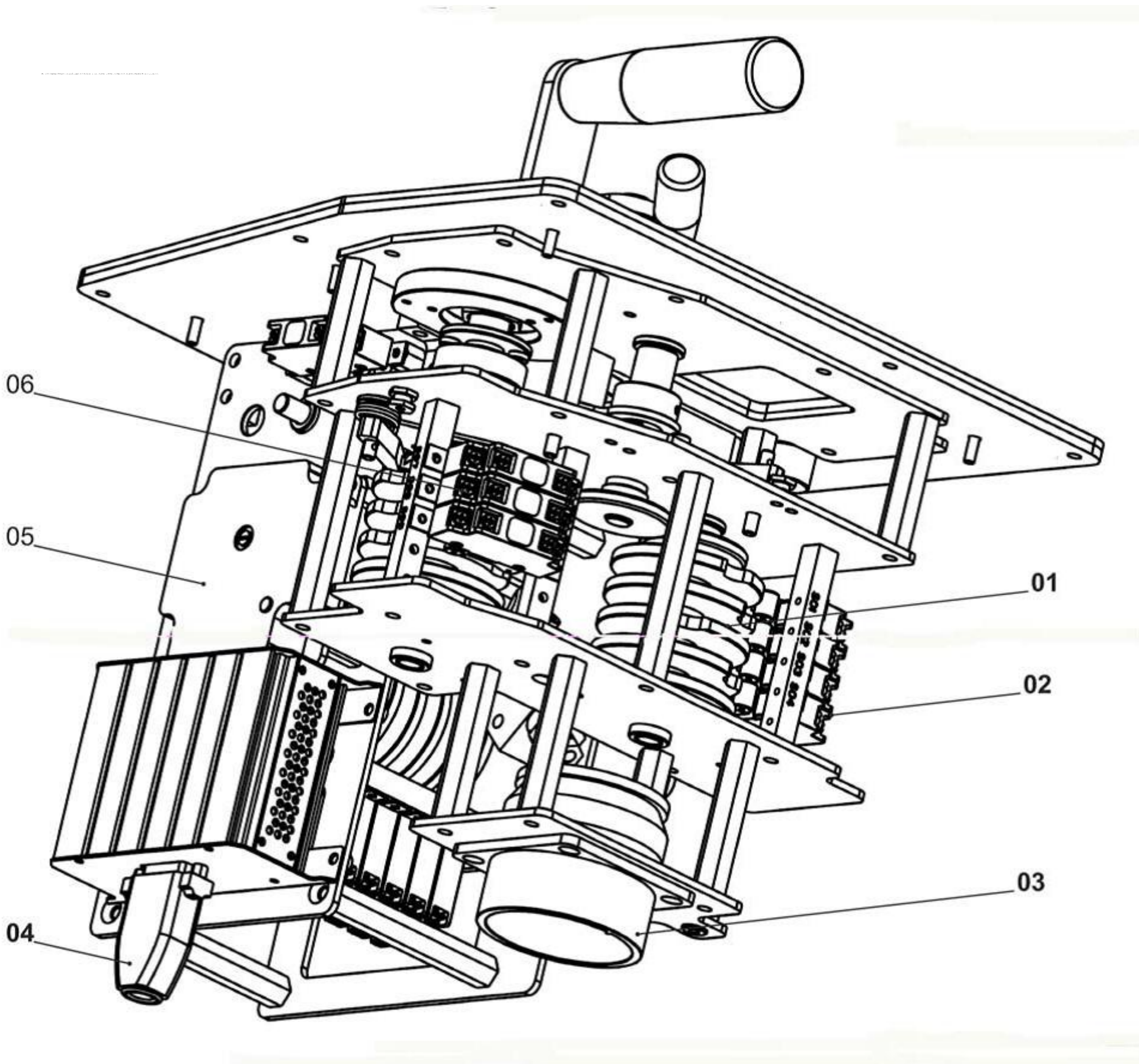
The following table shows the interrelated positions of the Transfer Switch, the Reverser Switch and the Master Controller Handle.

Table 07-I-02.22 Master Controller Interlocking Configuration

Transfer Switch Position	Reverser Switch Position	Master Controller Handle
OFF	[NEUTRAL]	[FSB]
LOCAL	[NEUTRAL]	[FSB]
ON	NEUTRAL	[FSB]
[ON]	FWD/REV*	Moveable

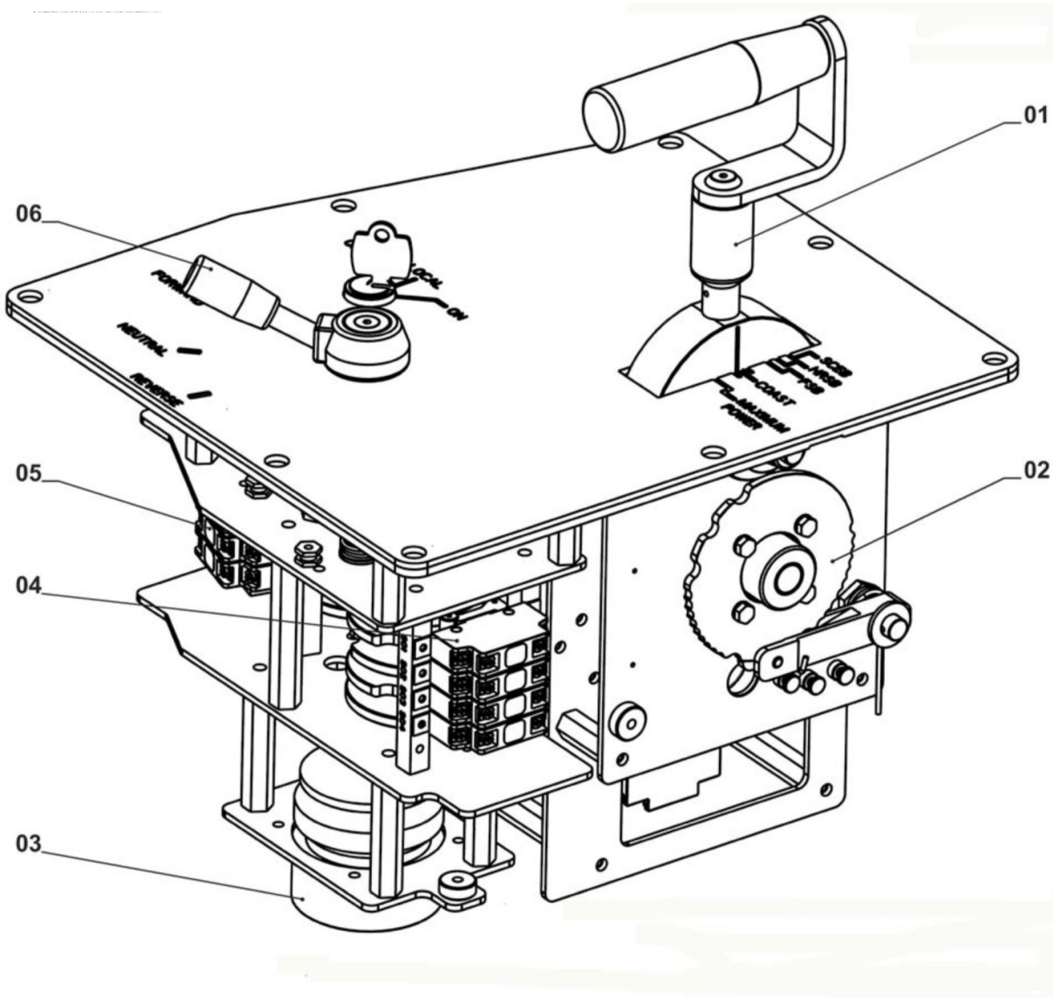
* with the Master Controller Handle out of the FSB position, the Reverser Switch is locked in the FWD or REV position until the Master Controller Handle is set back to FSB.

07-I-02.02.05.03 Master Controller



01. MC HANDLE CONTACTORS MECHANISM
02. MC HANDLE CONTACTORS
03. MC LV CONNECTOR
04. MC ENCODER CONNECTOR
05. ENCODER
06. REVERSER SWITC CONTACTORS

Figure 07-I-02.36 Master Controller Gears - Internal View (1/2)



01. MASTER CONTROLLER HANDLE	02. MC HANDLE POSITION WHEEL	03. MC LV CONNECTOR
04. MC CONTACTS	05. MC REVERSER SWITCH CONTACTORS	06. REVERSER SWITCH

Figure 07-I-02.37 Master Controller Gears - Internal View (2/2)

The Master Controller Handle has the function of managing the vehicle. It regulates and controls the amount of traction and/or braking effort to be applied.

Only The Master Controller Handle located in the Active Cab can generate operating mode commands for the Propulsion and the Friction Brake Systems.

The Master Controller of the active cab propagates the digital outputs status through the whole train by means of five trainlines:

M (Motoring),

CM (Coast),

FSB (Full Service Brake),

HRSB (High Rate Service Brake) and

SCEB (Slide Controlled Emergency Brake),

which correspond to the relevant positions of the Handle.

The Service Brake (SB) is a braking condition that involves both dynamic and friction braking.

The selected Operating Mode depends on the MC Handle position as shown in Figure 07-I-02.38. The “CLA” or “CLB” signal (CLA when the A Cab is active; CLB when the B Cab is active) is the Encoder output (refer to paragraph 07-I-02.02.05.03a).

Figure 07-I-02.38 shows the different positions the MC Handle can be set to, associated with the relevant signals generated by the Encoder.

[redacted]

The signal generated by the Encoder is sent to the two TCUs of the ACTIVE vehicle. The MoT TCU (located on the ACTIVE vehicle) will then generate the RATE REFERENCE signal which is train lined, via the MVB & WTB buses, to all propulsion and friction brake systems in the consist.

Figure 07-I-02.39 and 07-I-02.40 shown the five trainlines and the Emergency Brake pushbutton (also called Panic Brake or Mushroom) whose signal is trainlined and sent to all TUCs, ECUs and BCUs.

The Emergency Brake (EB) and the Slide Controlled Emergency Brake (SCEB) trainlines are made up of a double wire: one carries the positive and the other one carries the negative supply.

The supply is provided by a dedicated galvanically isolated power supply so that none of the wires is directly connected to the battery positive or negative lines.

When EB is requested, the REB (Emergency Brake Relay) is de-energized; when SCEB is requested, the RSCEB (Slide Controlled Emergency Brake Relay) is de-energized.

The EB trainlines are connected to the power supply through a double break switch located in the EB mushroom.

The SCEB trainlines are connected to the power supply through a double break switch located inside the Master Controller Handle.

The Master Controller Handle is also equipped with a “DEAD MAN” feature. In order to move the vehicle, the handle must be rotated 90° counterclockwise so that its position is perpendicular to the tracks.

Since it is springloaded, as soon as the handle is left free, it returns to its rest position, parallel to the railway line thus activating the auxiliary contact (S19) that leads to a FSB.

a) Encoder

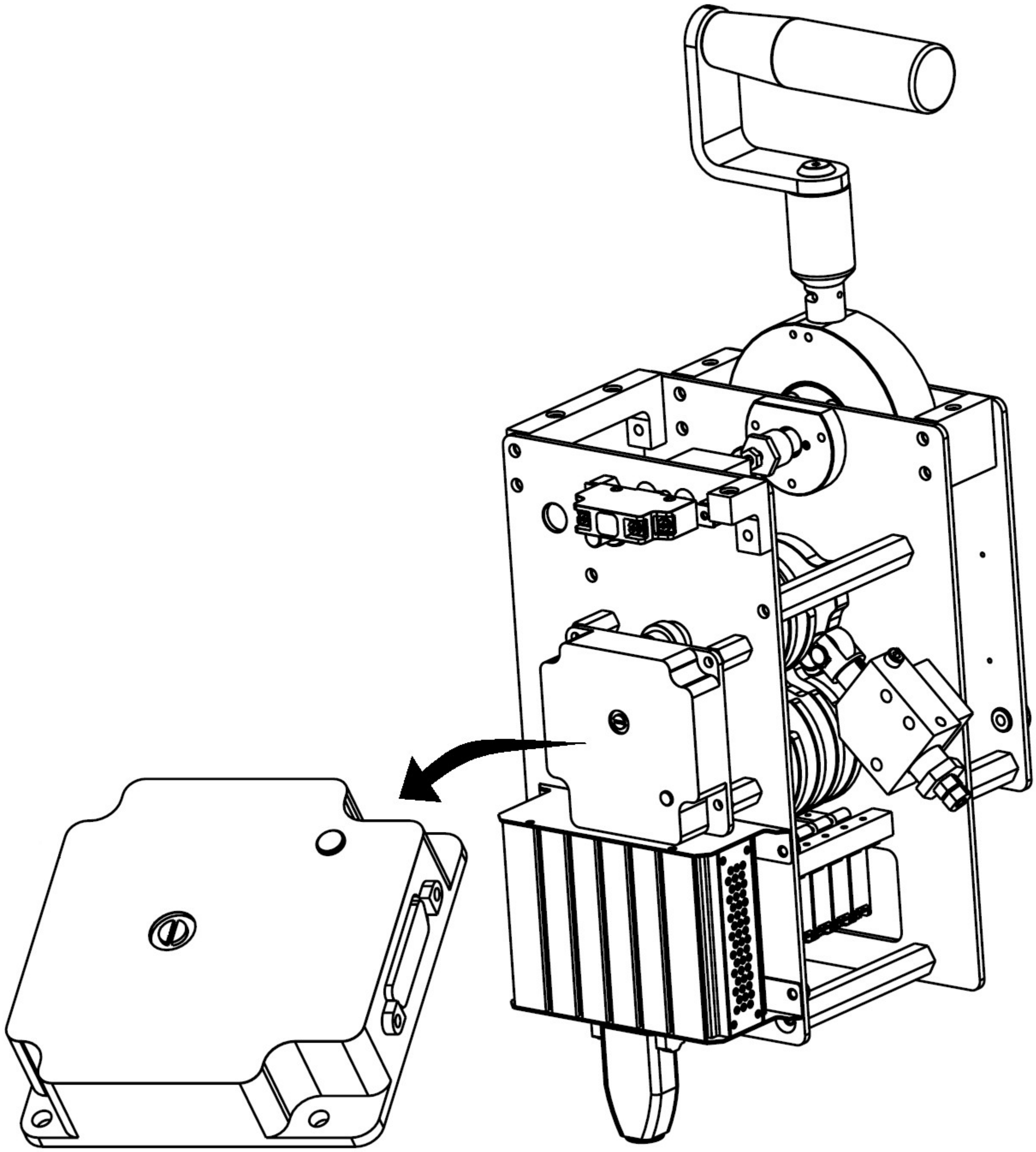


Figure 07-I-02.41 Master Controller Encoder

The Encoder is mechanically and electrically connected to the low side of the Master Controller Handle and translates the MC Handle positions into a current signal which can vary from 4mA (when the MC Handle is in FSB or a stronger braking mode position) to 20mA (when the MC Handle is in Max Power position).

Refer to Figure 07-I-02.41.

Only the Encoder in the Active Cab (the one with the Transfer Switch ON and the corresponding 3K13 relay which is energized) is active.

The current signal goes from the Encoder to the two TCUs of the same vehicle where it is located.

The two current signals are called CLA for the A Cab and CLB for the B Cab (the relevant TCU software signals are MstContrl1 and MstContr2, respectively).

Example:

The A Cab is active and the relevant MC Handle is in COAST mode;

In this situation (refer to Figure 07-I-02.39)

Trainlines: M=0, CM=1, FSB=1, HRSB=1, SCEB=1.

Where 1 (=37.5 VDC) means “High”, 0 (=0 VDC) means “Low”

CLA (MstCntrl1) = 12mA

[redacted]

The 4-20mA signal is monitored by the Event recorder.

07-I-02.02.06 TCU

The Traction Control Unit (TCU) can be considered the brain of the Propulsion System and is based on 32 bit microprocessors with associated peripherals and I/O.

The TCU controls the relevant propulsion inverter and the associated Braking Chopper.

Each vehicle is equipped with two TCUs, one per Inverter (which means one per Car Section).

The two TCUs are hierarchically arranged and each TCU manages the relevant Propulsion System

A MoT (Master of Train) TCU and, at least, a MoV (Master of Vehicle) TCU is always present in a Vehicle/Train Consist. If the Train Consist is made up of one vehicle only, the MoT corresponds to the MoV.

The MoT manages the Train propulsion commands/controls while the MoV manages the Vehicle propulsion commands/controls.

TCUs that are not MoT nor MoV are SlaveTCUs. The Slave TCUs manage all commands and controls relevant to the local Inverter and not managed by the MoT or the MoV.

The commands/controls managed specifically by the MoT are listed below:

- Car Wash Mode status
- Tow Mode status
- Overspeed Condition status
- Propulsion Reset command
- Rate Reference command
- Roll-back status

The commands managed specifically by the MoV (related to the local vehicle) are listed below:

- Friction Brake Interlock
- Linear Blending Mode
- Stopping Signal

The TCU carries out the following main functions:

- MoT TCU: handling of train commands
- MoV TCU: handling of vehicle commands
- Driving the Inverter Phase Modules and Braking Chopper IGBTs (Command Pulses)
- Assessing the status of the propulsion and the other train systems and managing the propulsion system
- Transferring diagnostic and status information to the IDU and the PTU
- Storing the diagnostic faults

Refer to paragraph 07-I-03.01 for a detailed description of the main important TCU functions.

Independent control logic units and logic power supplies are provided for each truck so that one truck can operate even if the propulsion system of the other one has failed.

The TCU is made up of standard PCB boards. All TCU PCBs can be swapped with the corresponding PCBs of another TCU without the need for any adjustments

07-I-02.02.06.01 Propulsion System Monitoring

A system parameter database in the propulsion logic software allows the authorized users to change the system behavior (limited to predefined functions) without software update.

The system is based on a parameter database predefined in the logic software and resident in the non-volatile RAM of the PCA board.

The parameters are grouped into functional sets.

A different password can be defined for each parameter set to access/change the parameters' values by means of the PTU (Portable Test Unit).

A checksum is also calculated for each parameter set. This can be useful to fast check the alignment of different vehicle parameters.

Each parameter in the database has its own default value that can be recalled by issuing a "restore default" command.

A minimum, a maximum and, if necessary, a more robust validation algorithm can be programmed for each parameter.

Propulsion system operating parameters, including tractive effort and jerk rate limit, are programmable to enable initial performance to be set and for maintenance purposes.

It is possible to implement the adjustments, by modifying the microprocessor's nonvolatile memory and safely and knowledgeably utilizing the PTU.

The adjustment for wheel wear is implemented via the IDU.

At a minimum, adjustment for wheel wear will be made in 0.0394-inch (1 millimeter) increments of wheel diameter from new to fully worn wheels.

The PTU provides an easy user interface to the parameter database. The parameter database can be browsed and changed by providing the correct password.

The upload of one or more parameter sets from a disc file to the propulsion logic can be carried out by means of the PTU.

The download of the parameters from the propulsion logic to a parameter file is possible as well, again, with the use of the PTU.

07-I-02.02.06.02 TCU Boards

The TCU contains seven boards connected to a Back Panel (motherboard) by means of X1 and X2 board connectors.

The X1 connectors link the boards through the VME bus while the X2 connectors provide for direct links between boards (wired connections).

VME (Versa Module Europa) Bus is a computer bus standard, originally developed for the Motorola 68000 line of CPUs, but later widely used for many applications and standardized by the IEC as ANSI/IEEE 1014-1987.

NOTE: In some AnsaldoBreda documents the X1 and X2 connectors of the TCU Boards are also named J1 and J2.

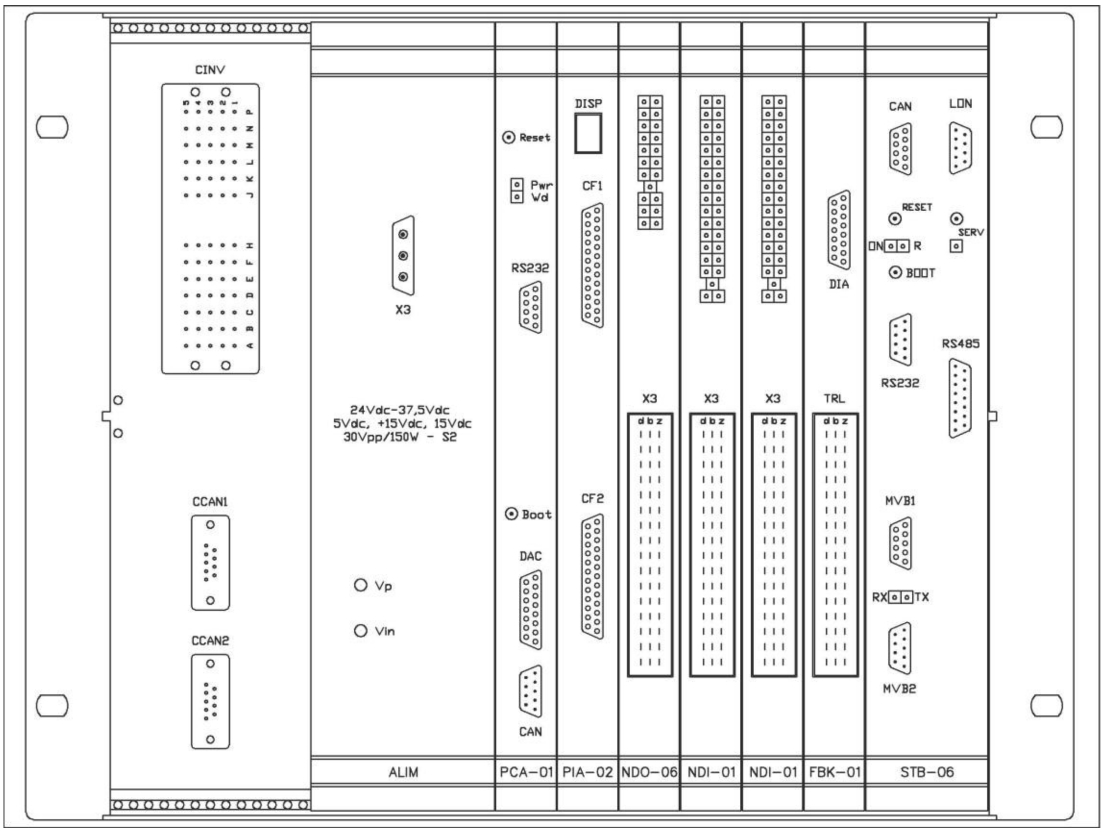


Figure 07-I-02.43 TCU front view

Table 07-I-02.23 TCU Boards

Board Name	Function
SUPPLY	Low Voltage Power Supply
PCA	Inverter Control Microprocessor board
PIA	Inverter I/O interface + Speed Sensors Interface
NDO	Battery Level Digital Output (1 input)
NDI “A”	Battery Level Digital Input
NDI “B”	Battery Level Digital Input
FBK	Master Controller Interface, No Motion relay circuit
STB	MVB bus interface, Fault Data logger

[redacted]

Figure 07-I-02.44 shows a functional schematic of the Inverter Control Module and of the TCU main components and their connections.

The Inverter Control Module main components (besides the TCU PCBs) are:

Connectors:

UMOT, UA, UB, UC, UCH, UBTB, UDIA, UBTA, UBAT, UBUS, MTCU.

Sensors:

TAL1 and TAL2 (current), TVF (voltage).

Contactors:

CMF, CCF, CP, FCF & RCF, RMF, REB (with relay), RSCEB (with relay),

a) Low Voltage Power Supply (Feeder)

Starting from the vehicle battery voltage, the LVPS unit generates the regulated DC voltages used by the TCU Boards.

All transducers are also powered by the LVPS unit, including the current transducers located inside the phase inverter modules.

The generated voltages are:

- +5V;
- +15V/-15V.

The power rating is 150W.

b) TCU Mother Board

The communication among TCU Boards is carried out by means of the TCU Motherboard (also called Backplane BKU).

The TCU Mother Board allows the communications between Boards with two methods:

- Board Communications by bus: a data bus, called VME, which connects all TCU Boards through their X1 connectors, is mounted on the TCU Mother Board
- Board Communications by means of specific wired connections: the TCU Mother Board allows exchange of data, between boards or between a board and equipment external to the TCU, by means of dedicated lines among X2 board connectors and between X2 connectors and the CINV connector. The CINV connector interfaces the TCU Mother Board with equipment exterior to the TCU (i.e.: through the CINV connector the TCU receives the Current and Voltage Transducer values)

The TCU Mother Board has also two connectors (CCAN1 and CCAN2) for CAN Bus communication (not used).

The TCU Motherboard also receives the +5Vdc and the ±15Vdc from the Low Voltage Power Supply to supply all TCU Boards.

NOTE: The 237EE40307D AnsaldoBreda document contains the Motherboard Functional Schematic (refer to the AB Database).

Refer to Section 00 of this Manual on "How to use the AB Database."

c) PCA Board

The PCA board is a high performance microprocessor board equipped with:

- One Siemens SAKC167CS (16-bit) micro-controller
- One Texas Instruments TMS320C31 (32-bit) DSP acting as a mathematical co-processor that implements control algorithms requiring high computing power
- One VME bus interface
- One Real Time Clock (RTC)
- Eight chart recorder outputs that can be programmed by the PTU.(refer to PTU User Manual)
- One Non-Volatile RAM (NVRAM) bank for control parameters and fault log
- FPGA-XILINX to interface the micro-controller with the other board system

The PCA board is definitely the most important board of the rack. By means of its DSP and micro-controller it supervises and regulates all propulsion aspects.

The main PCA board (refer to Figure 07-I-02.45) functions are: -

Generating the command pulses for the inverter modules. -

Controlling the Braking Chopper.

- Controlling the Line switches.
- Commanding the output signals (through the NDO board) to energize or deenergize relays and open or close contactors.

The major TCU functions, described in paragraph 07-I-03.01, are implemented by the PCA board.

All of the PCA Board outputs are generated by software.

NOTE: For the PCA Board Functional Schematic refer to document 237EE60405C in the AnsaldoBreda Database.

For the location of the PCA Board Components refer to document 232EE60412C of the AnsaldoBreda Database.

Refer to Section 00 on "How to use the AB Database"

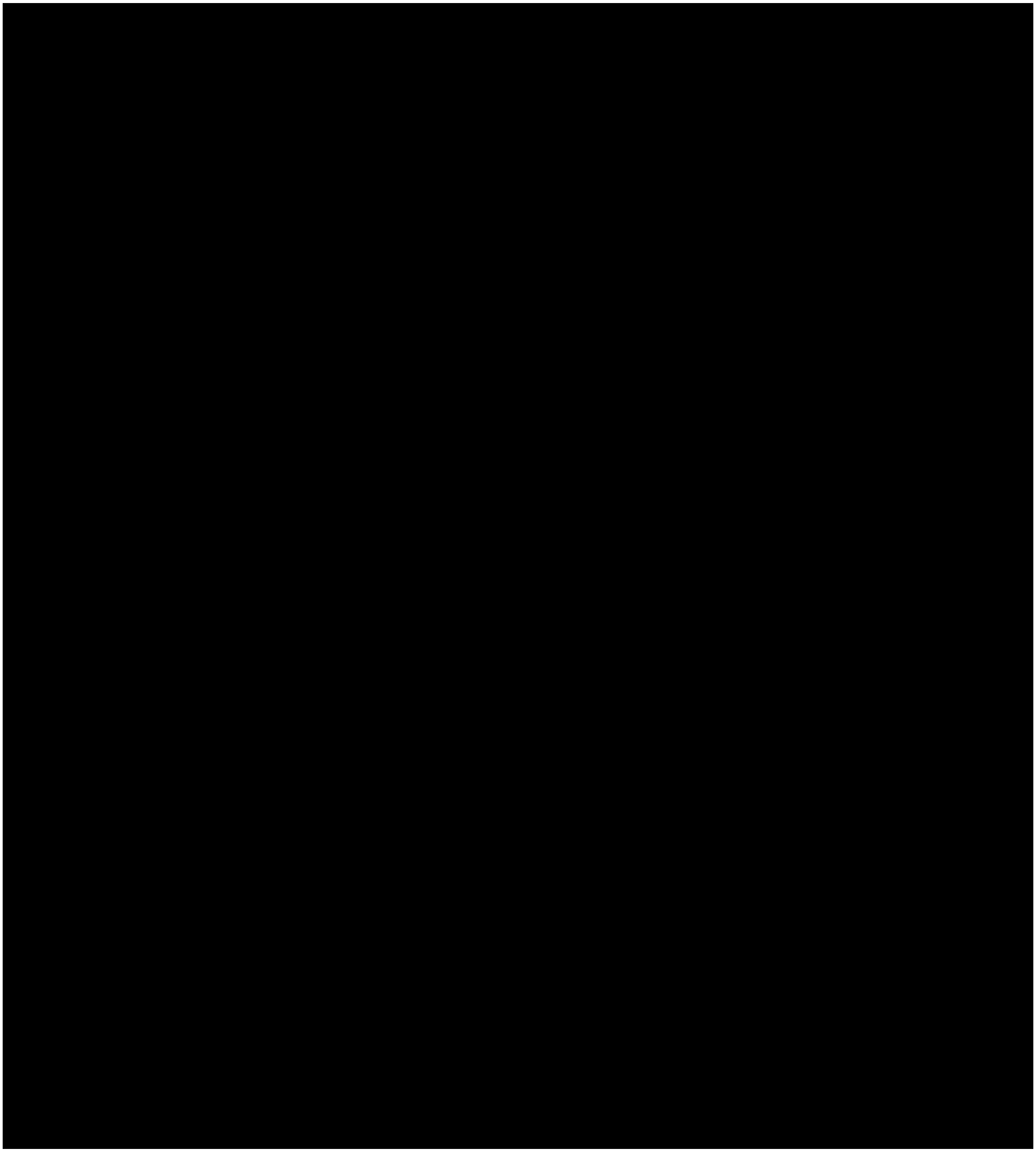


Figure 07-I-02.45 PCA Functional Diagram

d) PIA board

The PIA board interfaces the Inverter Phase Modules with the TCU (together with the PCA board).

Moreover, the PIA board acquires diagnostic signals from the motors and the HV line and uses them to implement hardware protections.

The main PIA functions are (refer to Figure 07-I-02.46):

Receiving and transmitting the pulse commands from the PCA board to the Inverters, to make them drive the motors and get the right torque. The PCA transmits the inverter commands by means of the VME bus. The PIA board receives them through the X1 connector. The commands go to the FPGA and are sent to the Inverter Phase Modules through the CF1 connector and the Command and Enable Channel circuit

- Acquiring the axle rotation frequencies of the relative body section (those values are linked to the car speed). The axle rotation frequencies (F1, F2, F3, F4, FSP) are received by the PIA board through the CF2 connector. The Pick Up Channels circuit interface the speed sensors' value with the boards; then they are sent to the X2 connector for PCA board direct acquisition and to the FPGA to pass an internal check
- Acquiring the motor thermal sensor values and, if necessary, implementing the HW protection. The motor thermal sensor signals pass through the X2 connector, then they are converted from analog into digital and are sent to the FPGA. Finally they are sent to the VME bus
- Acquiring and checking the phase currents of the Inverter Modules. The Phase Current signals pass through the X2 connector; then they are converted from analog into digital and are sent to the FPGA. Finally they are sent to the VME bus. The FPGA also checks their value
- Acquiring and checking the positive and negative Line Current. The Line Current signals pass through the X2 connector, are converted from analog into digital and sent to the FPGA. Finally they are sent to the VME bus. The FPGA also checks their value
- Acquiring and checking the filter voltage. The Filter Voltage signal passes through the X2 connector, then is converted from analog into digital and sent to FPGA. Finally it is sent to the VME bus. The FPGA also checks its value
- Acquiring and checking the diagnostic signals from the Inverter Modules. The diagnostic signals pass from the CF1 connector. They are interfaced with the board by the Diagnostic Circuit and sent to the FPGA which checks them and sends the information on the status of the Inverters to the VME bus
- Supplying the motor thermal sensors, through the X2 connector by means of a Thermal Sensor Supply Circuit.
- Supplying the motor speed sensors, through the CF2 connector using an Active Pick-up Supply Circuit. The Center Truck speed sensor is passive, so supply is not necessary

All checks are implemented by the FPGA. The FPGA may point out a dangerous condition, transmit the alert and start a hardware protection.

The PIA board has two auxiliary circuits:

- RESET Circuit: The FPGA is supplied and the command channels are enabled only when the card feed is stable (so alert commands cannot accidentally start)
- TEST Circuit: the PIA board auto-checks the proper operation of its acquisition channels.

NOTE: For the PIA board Functional Schematic refer to the 237EE60446C document in the AnsaldoBreda Database.
For the PIA board Component location refer to the 232EE60446C document in the AnsaldoBreda Database.
Refer to Section 00 on “How to use the AB Database”.

Figure 07-I-02.46 PIA Functional Diagram

e) NDO board

The NDO board is a digital input/output standard interface that communicates with the PCA and STB boards through the VME bus.

The NDO board is provided with 19 digital input/output channels.

The channels are low side (open collector) and operate at battery voltage.

Each individual channel is protected against current overloads, and channel diagnostic information is available through the VME bus.

Four channels, when used as digital outputs, can sink up to 2 amps and are used for contactor direct driving. All other channels can sink up to 500mA.

Each channel is addressable using the VME bus. The four high current channels can also be driven directly.

The PIA board drives two 2 Amps NDO channels directly, without using the VME bus. In this way critical hardware protections can open the line switches independently from the software.

Galvanic isolation is provided on the board through opto-couplers.

The main NDO functions are (refer to Figure 07-I-02.47)

- Interfacing the TCU with the Relay Logic so that the TCU (PCA board) is able to modify the relays' status. The relay commands (coming from the PCA board through the VME bus and the X1 connector) command the opening and the closing of the output channels to energize or de-energize the relative relay connected to the X3 NDO connector (refer to Figure 07-I-02.48)
- Acquiring and sending the RMF (Inverter Fan Power Supply status detector) to the PCA board (via VME bus). RMF is acquired from the X3 connector and sent to the X1 connector (on the VME bus)

The NDO board opens or closes the output channels (and the relevant relay is active or not) depending only on the PCA command the NDO board receives via VME bus (or directly via the PIA board, in case a hardware protection condition is detected).

The NDO board has no internal logic to open or close a channel.

The board supply is cut-out if an incorrect supply is detected.

NOTE:

For the NDO board Functional Schematic refer to document 237EE60441C in the AnsaldoBreda Database.

For the NDO board Components location refer to document 232EE60441C in the AnsaldoBreda Database.

Refer to Section 00 on "How to use the AB Database."

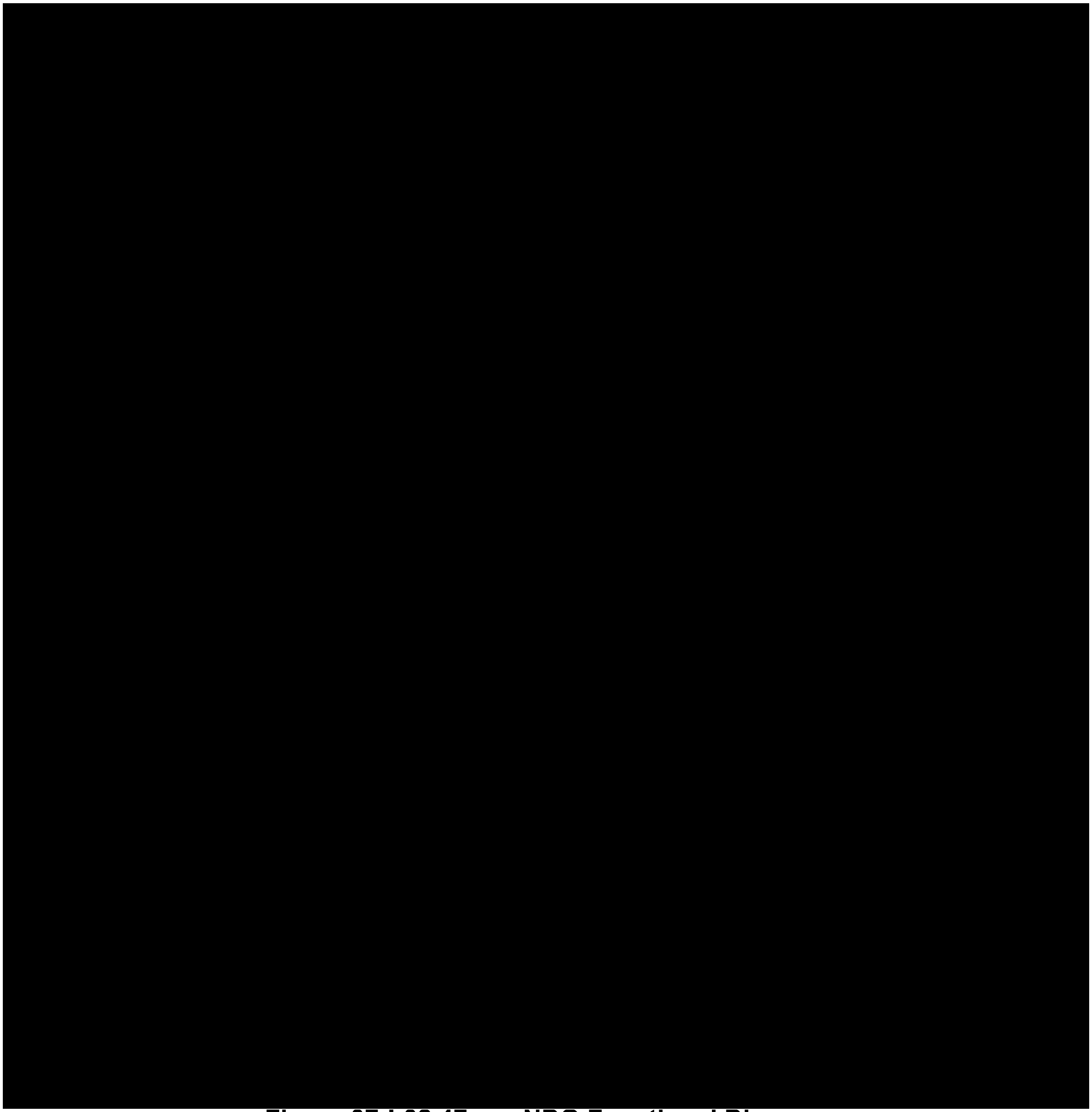


Figure 07-I-02.47 NDO Functional Diagram

Table 07-I-02.24 NDO X3 Connector Pins

Channel #	NDO X3 Connector Pin	Usage	Connected to	Description
C1	4d	OUT	UBTA-27-C1 SPARE	Not used
C2	4b	OUT	UBTA-1-C2 SPARE	Not used
C3	4z	OUT	UBTA-2-C3 SPARE	Not used
C4	8d	OUT	UBTA-26-C4 SPARE	Not used
C5	8b	OUT	UBTA-47-C5 SPARE	Not used
C6	8z	OUT	UBTA-28-C6 SPARE	Not used
C7	12d	OUT	UBTA-29-C7 SPARE	Not used
C8	12b	OUT	UBTA-3-C8 SPARE	Not used
C9	12z	OUT	UBTA-25-C9 SPARE	Not used
C10	16d	OUT	UBTA-4-C10 SPARE	Not used
C11	16b	OUT	UBTA-46-C11 SPARE	Not used
C12	16z	IN	RMF	Inverter fan Power Supply detector Status
C13	20d	OUT	UBTA-24-STOPPING	Stopping Signal to the Braking System
C14	20b	OUT	UBTA-5-SANDING	Sand Request to the sanders
C15	20z	OUT	CMF	CMF (Inverter fan Contactor) Command
C16	24d-24b	OUT	UBTA-48-HSCB	HSCB Open Request
C17	28d-28b	OUT	UBTA-61-TCUOK	Propulsion Fault signal output
C18	32d-32b	OUT	CP	CP (CP Contactor) Command
C19	26z-28z	OUT	CCF	CCF (Charging Filter Contactor) Command

Table 07-I-02.25 NDO Board Electric Characteristics

Abbreviation	Value	Description
Vbat	16.7V < Vbat < 45V	Battery Voltage
Vbat_t	14.5V < Vbat < 50V	Transitory (<100ms) Battery Voltage
In	0.5A	Nominal current standard channel
In 2A	2A	Nominal current powered channel
In 25ms	1.5In or 1.5In 2A	Max current per 25ms
In 4ms	3In or 2In 2A	Max current per 4ms
Vomax	0.5V	Max conduction voltage
I leak	1.5A	Max current in OFF mode
Fmax	10Hz	Max working frequency
tdmax	5ms	Max delay from input and output

Figure 07-I-02.48 NDO Relay Energization

f) NDI boards

The TCU is provided with two identical NDI boards that can be swapped with no problem.

Looking at the TCU rack front, the NDI board to the left is denominated NDI_A while the NDI board to the right is denominated NDI_B.

Each NDI board is provided with 31 digital battery level input channels.

The function of each NDI board (a field digital input standard) is to check the digital battery status and transfer the information to the PCA board by means of the VME bus (refer to Figure 07-I-02.49).

The NDI boards consider the battery level HIGH if the voltage is above 14.4V, while they consider the battery level LOW if the voltage is below 3V. More details are given in Table 07-I-02.26.

A yellow LED for each channel turns ON when the channel battery level is high. Otherwise it stays off.

Each channel is tested during its normal operation for proper operation.
The test is performed periodically by forcing a digital 1 (TEST1) and a digital 0 (TEST2) in the input stage of the channel.

The board supply is cut-out if an incorrect supply is detected (shut-down).

Table 07-I-02.26 NDI Board Electric Characteristic

Abbreviation	Value	Description
Vbat	16.7V < Vbat < 45V	Battery Voltage
Vbat_t	14.4V < Vbat < 50V	Transitory (<100ms) Battery Voltage
Vih	14.4V < Vbat < 50V	Voltage to acquire an high battery level (channel close)
Vil	-50V < Vbat < 3V	Voltage to acquire a low battery level (channel open)
Iih	1.25 mA	Continuative input current
Iih_f	(Vi/1.18) mA	Fritting current (to add to Iih)
f_frit	6.5Hz	Iih_f frequency
t_frit	7ms	Fritting pulse time
Fmax	10Hz	Max working frequency
tdmax	5ms	Max delay from input and output

All the signals acquired by the NDI boards are listed in paragraph 07-I-03.01.02 “Digital Input Signals Module.”

For the NDI board Functional Schematic refer to document 237EE60440C in the AnsaldoBreda Database.

NOTE: For the NDI board Component location refer to document 232EE60440C in the AnsaldoBreda Database.

Refer to Section 00 on “How to use the AB Database”.

[redacted]

Figure 07-I-02.49 NDI Functional Diagram

g) FBK Board

The FBK is a non-standard interface board (especially made for the LACMTA P2550 LRV). It interfaces both digital and analog signals.

The FBK board is equipped with the following circuits.

- 2 current input Interfaces for the 4-20 mA signals coming from the Encoder (refer to Figure 07-I-02.50)
- 1 watch dog circuitry to drive the No Motion Relay. (Refer to paragraph 07-I-03.02.25)
- 10 analog buffering circuits to connect an oscilloscope or chart recorder to the propulsion transducers
- 4 digital buffering circuits to connect an oscilloscope or chart recorder to the propulsion digital signals
- 2 auxiliary analog input channels (not used)
- 4 high-side battery voltage level isolated digital outputs. Max current 500mA each
- 1 CAN bus adapter (not used and not shown in Figure 07-I-02.50)

The Main Functions of the FBK are:

- Interfacing the two master controller Encoders with the TCU, transforming the 4-20 mA signals (CLA and CLB) into 0-4.096V signals so that the STB board can use them to generate the RateReference signal (refer to paragraph 07-I-03.01.01)
- Energizing the No Motion relays depending on the WDin (Watch Dog) signal which comes from the STB board through the X2 connector (refer to paragraph 07-I-03.02.25 and 07-I-03.01.03)
- Implementing the odometer every time a new mile is traveled. The new mile is incrementing by the STB board and sent to the FBK through the X2 connector (refer to paragraphs 07-I-03.01.03 and 07-I-03.02.27)
- Showing the diagnostic signals coming from the PIA and PCA boards, throu the DIA connector

NOTE: For the FBK board Functional Schematic refer to document 237EE60423C in the AnsaldoBreda Database. For the FBK board Components location refer to document 232EE60423C in the AnsaldoBreda Database.

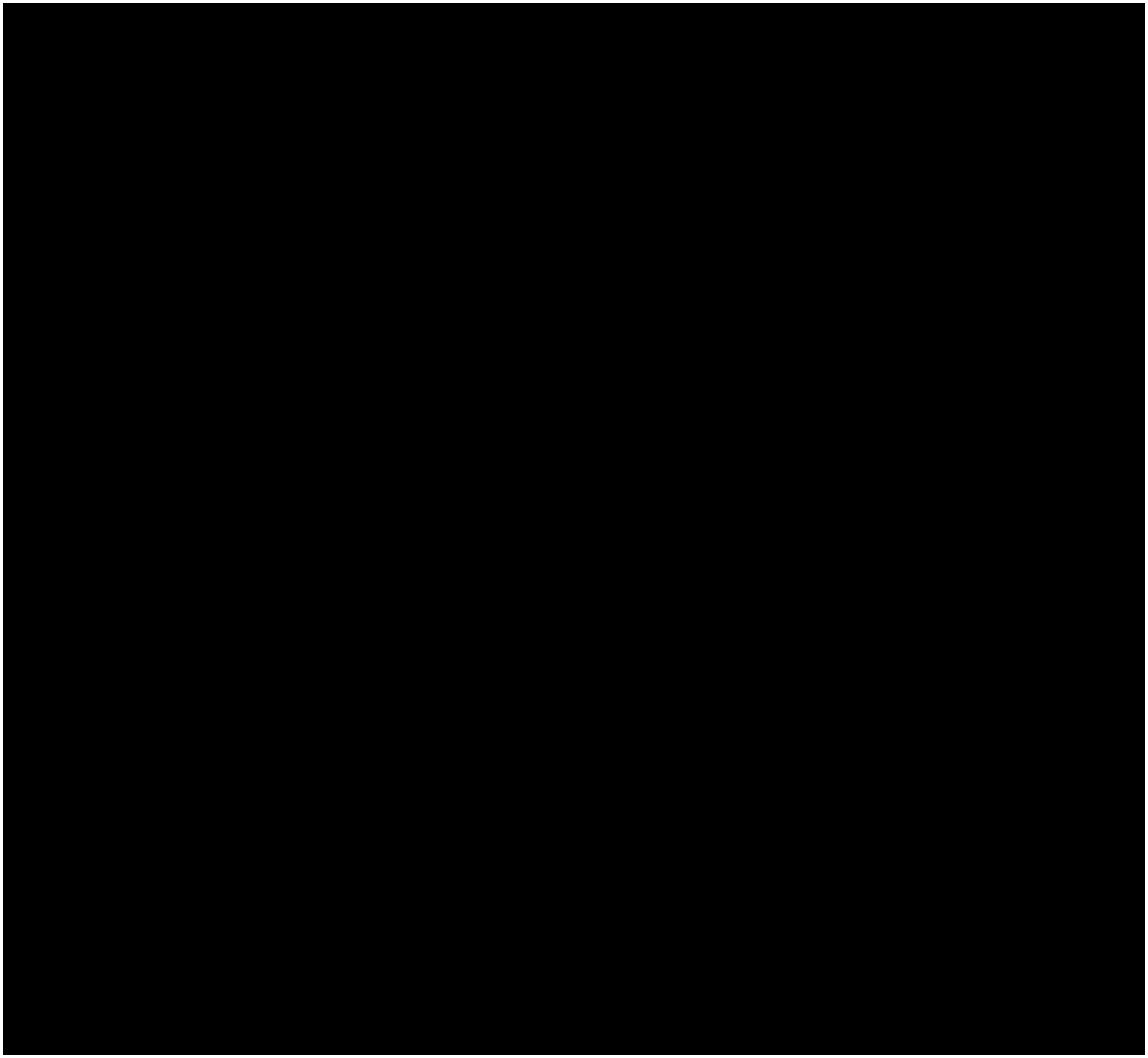


Figure 07-I-02.50 FBK Functional Diagram

h) STB board

The STB board is a microprocessor board equipped with the following components (refer to Figure 07-I-02.51):

- One Siemens SAKC167CS micro-controller One Xilinx spartan FPGA
- One Main RAM (512K x 16)
- One Supplementary RAM (512K x 16)

- FLASH memory (2M x 16)
- Dual Port RAM (2K x 16) (inside the FPGA)
- Traffic Memory (512K x 16)
- LON and MVB Interface
- VME Interface (inside the FPGA)
- Analog input Interface
- Analog - Digital converter (10bit) (inside the micro-controller C167)
- Time Counter (inside the micro-controller C167)
- Thermal Sensor (inside the FPGA)
- CAN Connector
- LONWorks Connector
- Reset Pushbutton
- SERV LON Pushbutton
- Supply LED
- Watch Dog LED
- SERV LON LED
- Boot Pushbutton
- RS232 Connector
- RS485 Connector
- MVB connector
- MVB LEDs

Like the PCA board, the STB board implements software elaborations. The main functions of the STB board are:

- Interfacing LONWorks bus communication
- Interfacing MVB communication
- Recording Fault log and data
- Managing vehicle control logics related to the Car Speed

The STB calculates the car speed, by knowing the wheel diameters, checks the speed sensors, implements the odometer and transforms the Encoder signals, coming from the FBK board, into the RateReference signal.

NOTE:	For the STB board Functional Schematic refer to document 237EE60418C in the AnsaldoBreda AB Database. For the STB board Component location refer to 232EE60422C in the AnsaldoBreda Database. Refer to Section 00 on “How to use the AB Database.”

[redacted]

07-I-02.02.06.03 TCU Main Functions (Logic Control)

Managing and monitoring all aspects of the vehicle propulsion are the main purposes of the TCU.

To achieve these goals, the TCU implements a large number of functions using both hardware and software.

In order to ease the understanding of these functions, the TCU is theoretically divided into **Modules**. Each module implements and represents the relevant function.

Table 07-I-02.27 lists the TCU main Modules.

Table 07-I-02.27 TCU Function Modules

Module Number	Module
5	Analog Input Signals Module
6	Digital Input Signals Module
7	Digital Output Signals Module
8	Master Controller Module
9	Rate Reference Module
10	Torque Reference Module
11	Jerk Limiter and Car Acceleration Module
12	Motor Torque Control Module
13	PWM Modulator Module
14	Braking Chopper Control Module
15	Non Linear and Linear Blending Module
16	Speed Sensors Acquisition Module
17	Spin Control Module
18	Slide Control Module
19	Car Speed Calculation Module
20	Wheel Diameter Calculation Module
21	Speed Sensor Failure Detection Module
22	Overspeed Management Module
23	Speed Limit Module
24	MoV MoT Determination Module
25	Towing Mode Module
26	Car Wash Mode Module
27	Filter Precharging Module
28	Filter Discharging Module
31	Cut Out Module
32	HSCB Control Module
33	Propulsion Reset Module
34	Stopping Module
35	RollBack Module
36	No Motion Module
37	Friction Brake Interlock Module
39	Odometer Module
XX	Inverter Status Module
40	MVB Bus Communication Module

The detailed description of each Module, of its inputs and outputs, and of its functions can be found in the APPENDIX at the end of this Section (refer to paragraph 07-I-03.01).

Each module implements the relevant function. Often a function output is the input for another function or other functions.

For example, a function calculates the wheel diameter and this value is then acquired by another function which calculates the car speed.

To fully explain what is implemented by the Module, two different block Diagrams have been used:

Function Module Block Diagram, to explain the function of the subject Function Module, with inputs and outputs from/to other Modules. They do not refer to the board(s) where the function is physically implemented (refer to Figure 07-I-02.52);

Board Inside Block Diagrams, indicating the board(s) and components involved in the implementation of the Module function. They do not refer to where the inputs come from or what the outputs do.

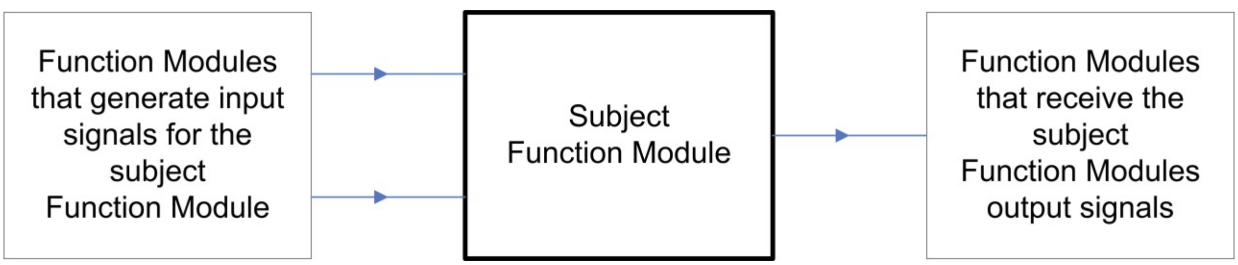


Figure 07-I-02.52 Function Module Block Diagram

07-I-02.03 Vehicle Operating Modes

Through the position of the Master Controller Handle, the operator requests a certain amount of traction or braking effort which corresponds to the Operating Mode. The Operating Modes are:

- Max power
- Minimum Power
- Coast
- Minimum Brake
- Full Service Brake
- High Rate Service Brake
- Slide Controlled Emergency Brake
- Emergency Brake (Requested via the Mushroom Switch/Panic Button and/or ATP)

The Operating Mode between FSB and Minimum Brake is called Service Brake Mode (SB - refer to Figure 07-I-02.39) and is the area in which Electric Braking and Friction Braking operate together (refer to paragraph 07-I-02.03.03.01 in this chapter).

The Operating Mode between Minimum Power and Maximum Power is called Power Mode or Motoring (M - refer to Figure 07-I-02.39)

07-I-02.03.01 Power Mode

The following chart (refer to Figure 07-I-02.53) shows the Torque versus Speed characteristic for each motor connected to the propulsion inverter, while in Power Mode.

The torque is measured at the motor axle. The two curves are related to a 100% rate reference (refer to paragraph 07-I-03.02) with a 600V and a 750V or higher line voltage.

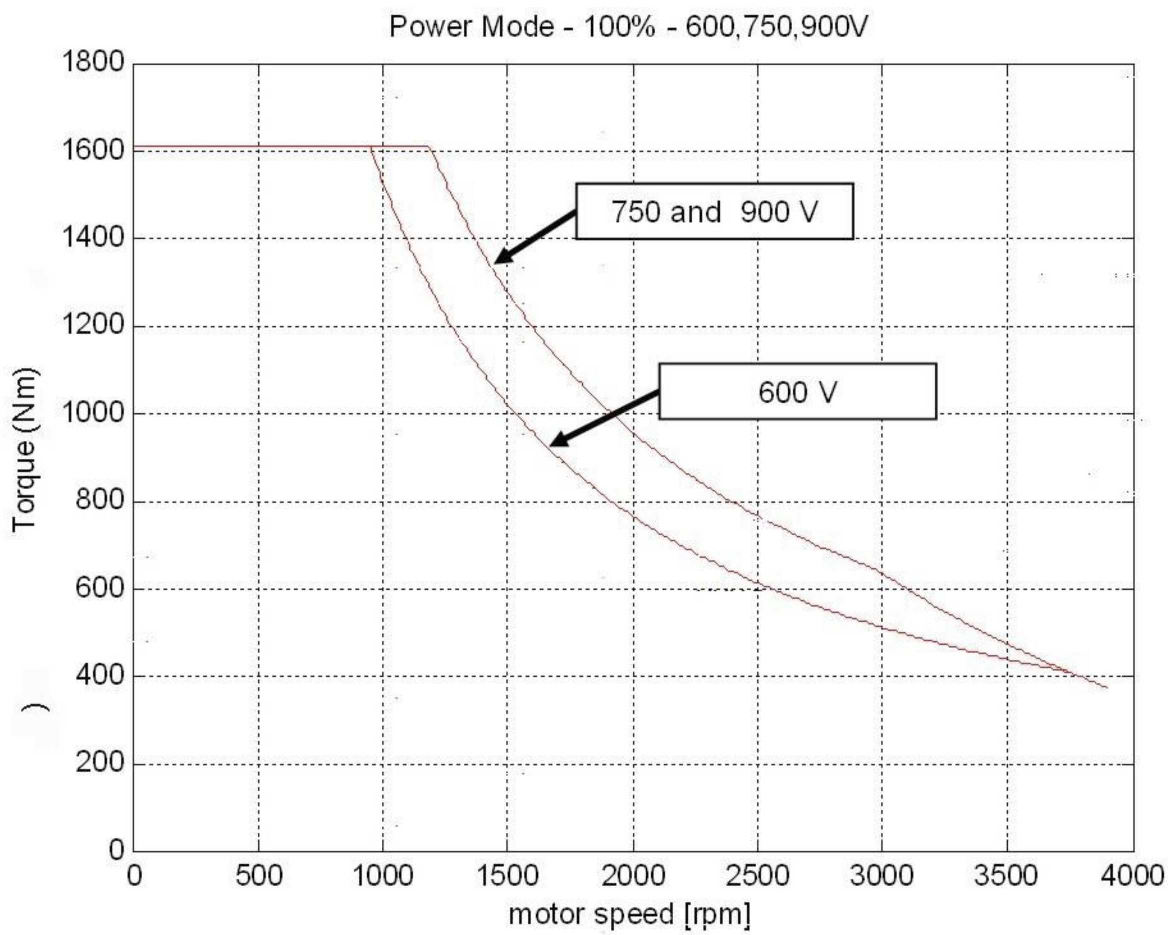


Figure 07-I-02.53 Torque vs Motor Speed

The following chart (refer to Figure 07-I-02.54) shows the input Power (dotted lines) and Line Current (continuous lines) versus Speed for a single propulsion system.

The curves are shown for a 100% rate reference and 600, 750 and 950 Vdc line voltage.

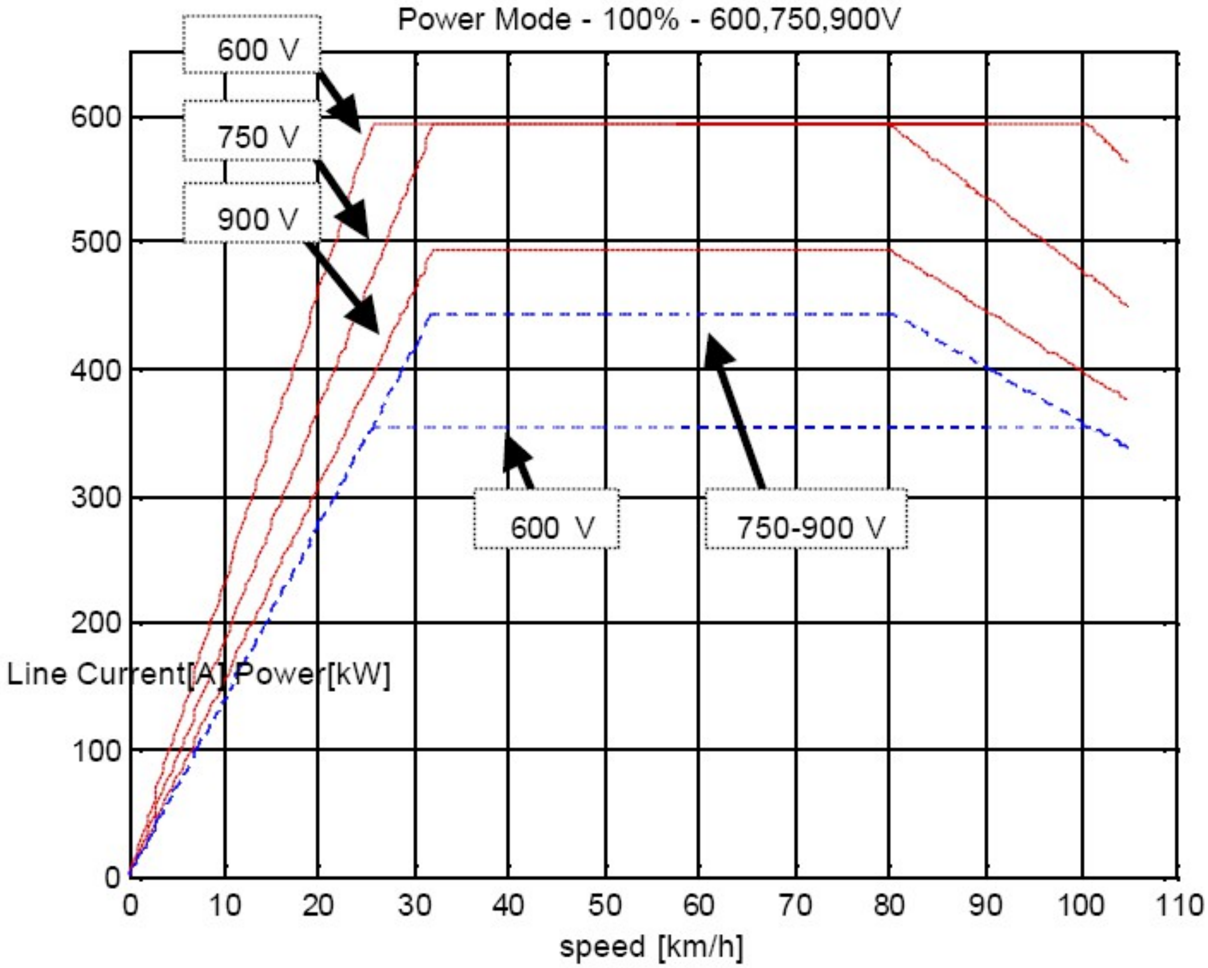


Figure 07-I-02.54 Current/Power vs Car Speed

07-I-02.03.02 Coast Mode

In coast mode no HV current goes to the motors.

07-I-02.03.03 Braking Mode

The following chart (refer to Figure 07-I-02.55) shows the Torque versus Speed characteristic for each motor connected to the propulsion inverter, while in Brake Mode.

The Torque is measured at the motor axle. The two curves are related to a -100% rate reference with a 750V and an 870V or higher line voltage.

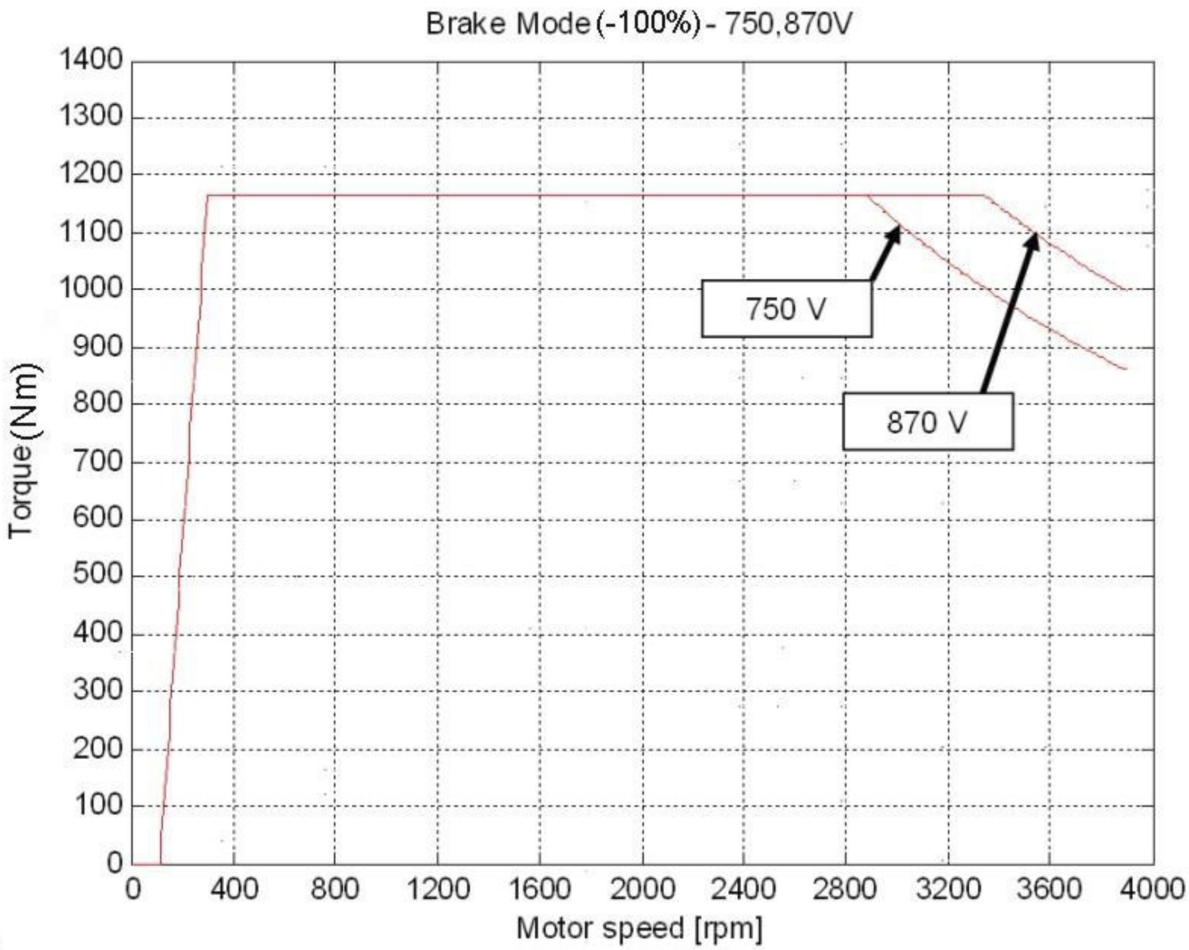


Figure 07-I-02.55 Torque vs Motor Speed

The following chart (refer to Figure 07-I-02.56) shows the input Power (dotted line) and Line Current (continuous line) versus Speed for a single propulsion system.

The curves are shown for a (-100%) rate reference and 750 and 870 Vdc line voltage. The line current is plotted in the assumption that a totally regenerative dynamic brake is performed.

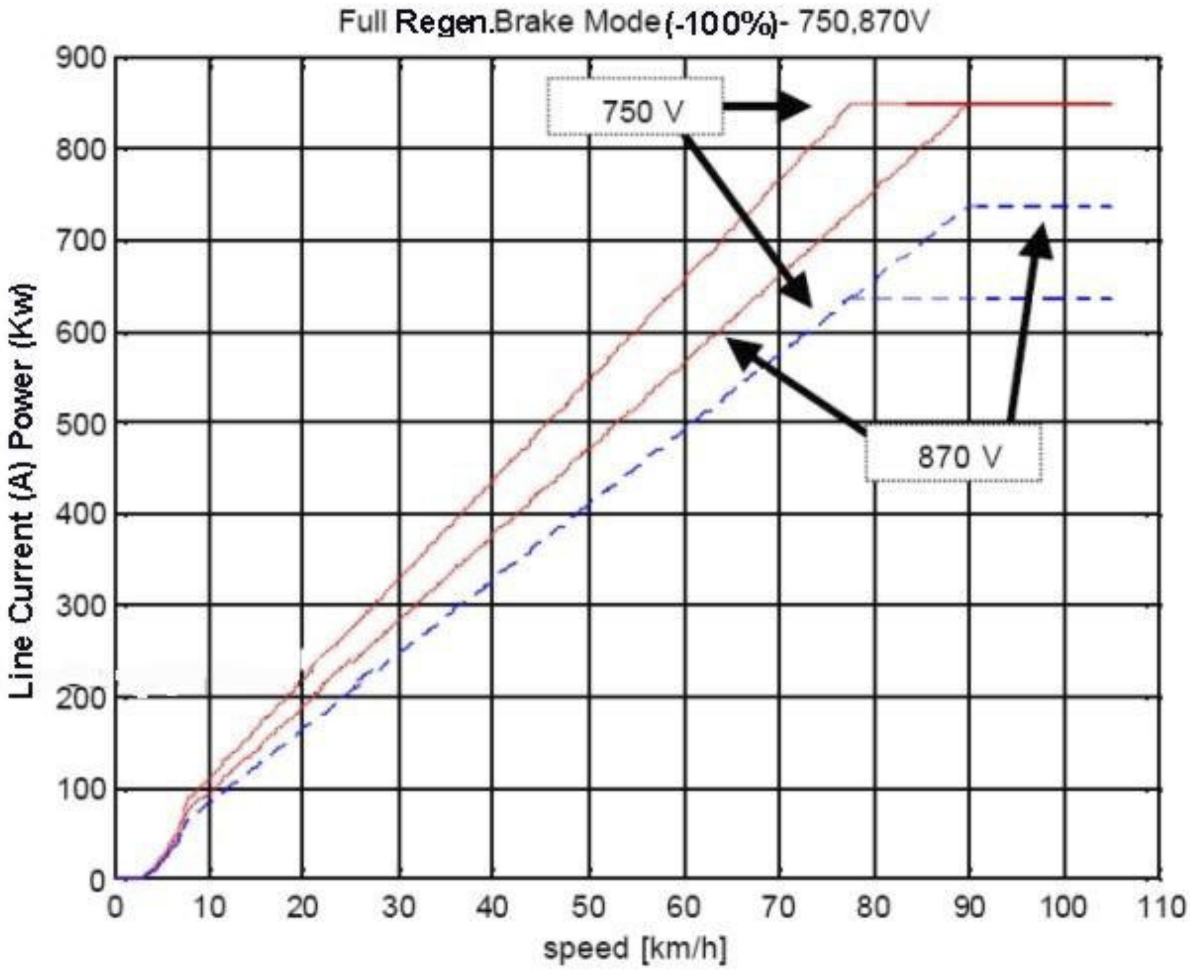


Figure 07-I-02.56 Current/Power vs Car speed

Table 07-I-02.28 shows the Braking Modes in terms of system reaction.

Table 07-I-02.28 System Reaction to Braking Modes

BRAKING MODE	ACHIEVED RATE	SLIDE CONTROL	JERK	SAND	TRACK BRAKES	HSCB	DYNAMIC BRAKE
SB	0…FSB	Y	Y	N	N	CLOSED	YES
FSB	FSB	Y	Y	N	N	CLOSED	YES
HRSB	EB	Y	Y	N	Y	CLOSED	YES
SCEB	EB	Y	N	Y	Y	OPEN	YES
EB	EB	N	N	Y	Y	OPEN	NO

For example, in case of a SCEB (Slide Controlled Emergency Brake) request, the system reacts with:

Achieved Rate = EB (Emergency Brake),

Slide Control = applied,

no Jerk limitation,

Sand = dropped,

Track Brakes = applied,

HSCB (High Speed Circuit Breaker) = open (refer to Section 9) and

Dynamic Braking = applied.

07-I-02.03.03.01 Service Brake Mode

During Service Brake (from Minimum Brake to FSB), the vehicle is decelerated at a rate ranging from 0 to 3.5 mphps, depending on the requested rate.

The requested rate is obtained with the Dynamic Brakes (power trucks) and Friction Brakes (typically center truck) blended together (refer to Figure 07-I-02.57).

Passing from Dynamics to Friction braking (with regards to the power trucks), the brake effort does not change: the Dynamic Brake effort reduction is exactly compensated by the Friction Brake effort increase.

Each TCU performs the requested rate as long as the braking effort needed stays within the propulsion system limits.

The actuated Dynamic Brake signal is delivered to the ECUs also.

If needed, the ECUs will supplement the braking effort with friction braking in order to obtain the requested rate (the master TCU is connected to the ECUs by means of the MVB and the WTB buses).

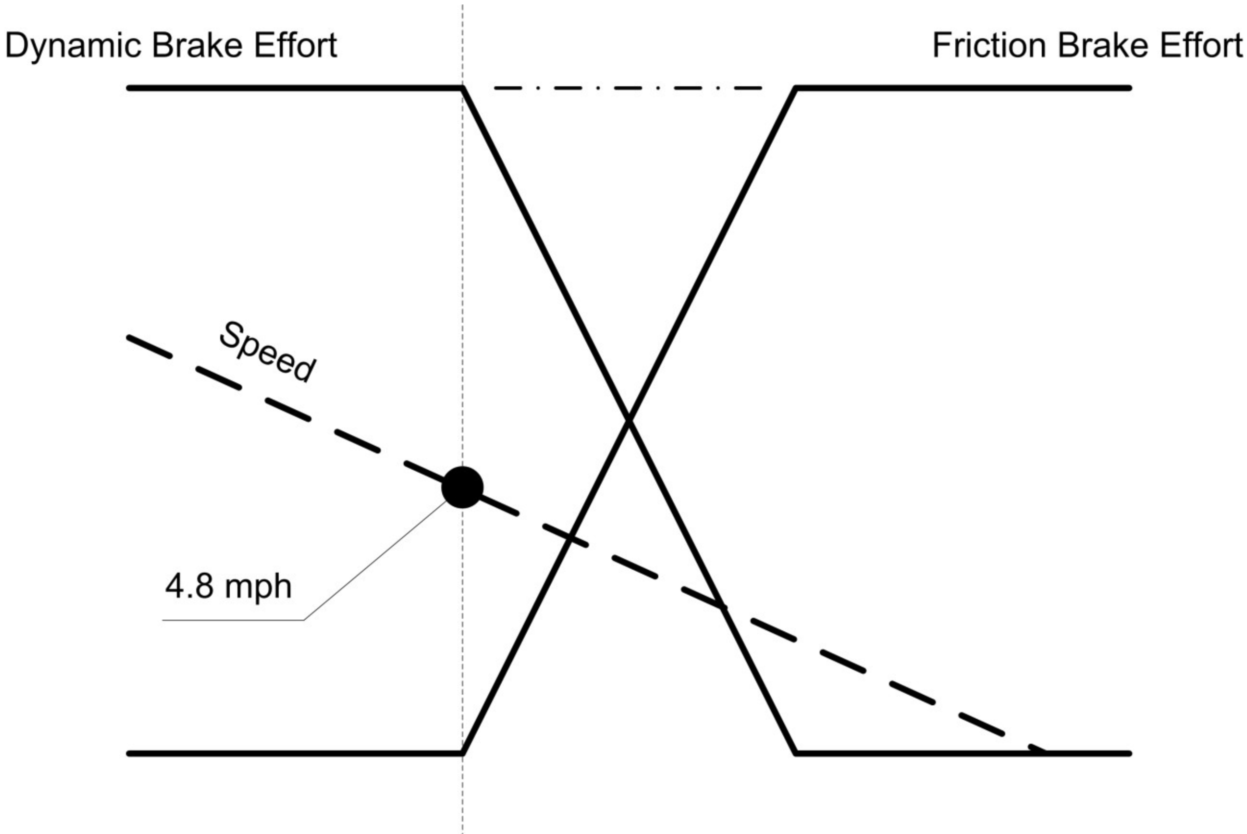


Figure 07-I-02.57 Dynamic - Friction Brake Blending
(Power Truck only at Low Speed)

07-I-02.03.03.02 FSB Mode

FSB Operating Mode is active when the FSB trainline is de-energized and HRSB, SCEB and EB trainlines are energized (refer to Figure 07-I-02.39).

In this case the TCUs and the ECUs consider the full 3.5 mphps rate.

The FSB Mode may be requested by:

- The Operator through the position of the Master Controller Handle - (FSB position)
- The ATP (refer to Section 15) or the TCU if an unsafe condition is detected (for example an Overspeed)
- The Door System (when a door is not closed and the vehicle is not in No Motion condition)
- The Dead Man feature associated with the Master Controller Handle: The handle not being rotated CCW 90 degrees

07-I-02.03.03.03 HRSB Mode

This braking mode is defined as a Full Service Brake with the addition of the Track Brakes.

The TCU communicates the achieved Dynamic Brake effort to the ECUs and then each ECU calculates the Friction Brake effort to be applied in order to achieve the requested braking rate.

When the HRSB train line signal is low (0 VDC) then the Track Brakes are activated. When the Track Brakes are applied, a digital track brake applied status signal is sent both to the TCUs and the ECUs.

- TCUs and ECUs will apply the FSB rate with jerk rate limitation and no sand.

The HRSB Mode may be requested by:

- The Operator by means of the Master Controller Handle.

07-I-02.03.03.04 SCEB Mode

The Slide Controlled Emergency Brake (SCEB) is requested through the position of the Master Controller Handle by means of a double break switch (which is located inside the Master Controller Console).

When the SCEB Mode is selected, the propulsion and friction brake systems ignore the requested rate reference and apply the FSB rate.

Furthermore:

- Track Brakes and sanding are directly applied by the SCEB trainline. A digital Track Brake Applied status signal is sent both to the TCUs and the ECUs
- The TCUs and ECUs apply the FSB rate with no jerk rate limitation

- When a TCU or an ECU receives a SCEB command, they internally latch the command so that it continues to be applied until zero speed is reached, even if the trainline command is removed. The TCU/ECU resets its latched SCEB command when a zero speed is detected
- The TCUs open the HSCB within one second from the SCEB command. This time delay is used to have the Dynamic Brake applied even if propulsion is in full power when the SCEB command is received. The time delay depends on the propulsion status at the time the SCEB command is received. The delay is small if the Propulsion System is already in braking mode. The delay must be considered for the HSCB opening only, not for the Dynamic Brake activation that takes place as soon as the SCEB command is received

The SCEB Mode may be requested by:

- The Operator by means of the Master Controller

07-I-02.03.03.05 EB Mode

The EB Mode is requested through the Emergency push-button (Mushroom) on the operator console or by the ATP system.

The Emergency push button directly de-energizes the train EB loop. When the EB loop is de-energized the following actions are directly carried out by vehicle logic relays:

- Track Brakes and sanding are directly applied by the de-energized SCEB trainline. A digital Track Brake Applied status signal is sent both to the TCUs and the ECUs
- The EMV valves located in the BCUs are de-energized
- The BCU anti-slide dump valve commands are cut
- The HSCB is opened
- The EB loop is latched open until the Zero Speed is detected

In this way the EB continues to be applied until the vehicle reaches a complete stop, even if the Emergency push button is set back to normal position.

TCUs and ECUs are not involved in an Emergency Brake.

The EB Mode may be requested by:

- The Operator by means of the Emergency push button
- The ATP

a) Slide Control Enabling in Emergency Brake

The operating principle of the EB Mode is that braking in emergency by means of the Emergency push button, or ATP, should not be assisted by slide control.

The operations listed in the following describe the hardware modifications to be carried out in order to have the Emergency Brake with slide control applied:

Update the ECU control software;

Insert a short circuit jumper between the following pins

- A1 and A2 of the 6K11/1 relay in the A section electric locker
- B1 and B2 of the 6K11/1 relay in the A section electric locker
- A1 and A2 of the 6K11/1 relay in the B section electric locker
- B1 and B2 of the 6K11/1 relay in the B section electric locker
- C1 and C2 of the 6K11/1 relay in the B section electric locker
- D1 and D2 of the 6K11/1 relay in the B section electric locker

07-I-02.04 Dynamic Brake Control

The TCU provides the Dynamic and Rheostatic braking and the input inverter overvoltage protection that controls the Braking Chopper and the CP contactor.

The TCU controls the Braking Chopper action by opening and closing the Braking Chopper IGBTs.

The Braking Chopper is activated in the Dynamic Braking Mode or in the Power Mode during transient inverter input over-voltage conditions.

The system performs Dynamic braking, using rheostatic and regenerative braking according to the line receptivity.

Dynamic braking will be both rheostatic and regenerative. (For more details refer to paragraph 07-I-03.02.05).

During Service Brake applications, Dynamic Braking (Power Trucks) and Friction braking (typically Center Truck) will be continuously blended to achieve the required braking effort. The control system, based on the achieved Dynamic brake effort, will compensate with the Friction Brake effort, if necessary, in order to achieve the required level of effort.

In case one of the two propulsion inverters fails or is cut-out, the control system will cut-out the Dynamic Brake signal of that inverter; therefore the Friction Brake only will be used for the braking on that truck.

Switching between Propulsion and Brake Mode and direction changes will be accomplished by the IGBTs. The HSCB or line breaker (CP Contactor) will not be operating during routine power-to-brake and brake-to-power transitions.

07-I-02.04.01 Full Regenerative Brake

This type of braking takes place when the line is capable of receiving the energy coming from the propulsion system with a limited line voltage increase. In this case the CP contactor is closed, the Braking Chopper is not fired and all energy generated is sent to the line (refer to Figure 07-I-02.58).

07-I-02.04.02 Blended Regenerative/Rheostatic Brake

If the line is partially receptive, a blended regenerative/rheostatic brake is performed. The CP contactor is closed and the braking chopper is fired.

The energy generated by the propulsion system is either sent back to the line (if totally receptive) or dissipated through the Braking Resistor (if not receptive), or both (if partially receptive).

The blending of the two components is done based on the line voltage in such a way that the regenerative part is maximized and reduced only when the line voltage rises.

A totally rheostatic brake is performed when the line voltage reaches 920Vdc (or less if the line current value is high) (refer to paragraph: 07-I-03.02.05).

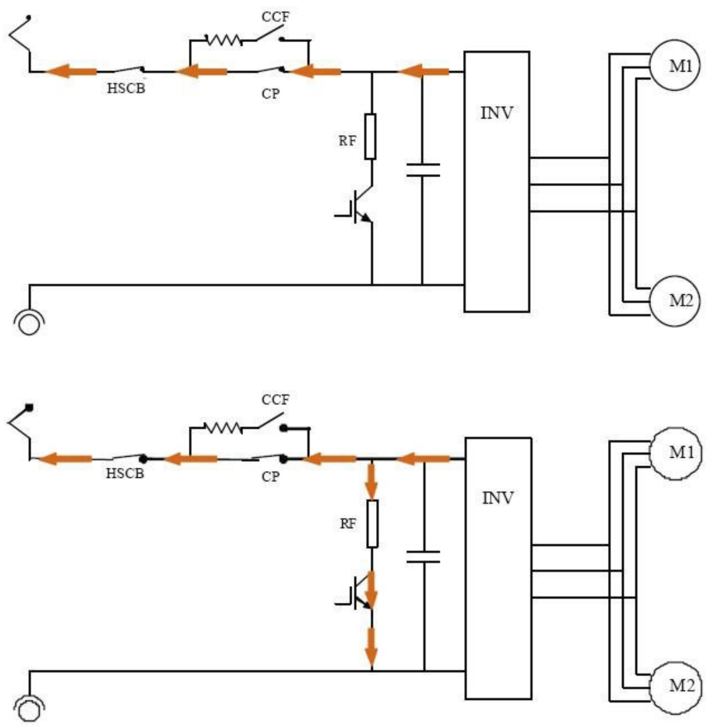


Figure 07-I-02.58 Regenerative and Rheostatic / Regenerative Brake

For more details about the Dynamic Braking condition refer to paragraph 07-I-03.04.04 "Motoring and Dynamic Braking Mode.

07-I-03 APPENDIX

07-I-03.01 TCU Module Main Functions

The functions of each Module are implemented in two types of block diagrams:

Function Module (FM) Block Diagram. The FM Block Diagram is made up of:

- The subject FM, receiving inputs and generating outputs
- The Input Function Modules, which generate the inputs for the FM
- The Input signals to the FM, generated by the Input Function Modules;
- The Output signals, generated by the FM
- The Output Function Modules, receiving the output signals from the FM

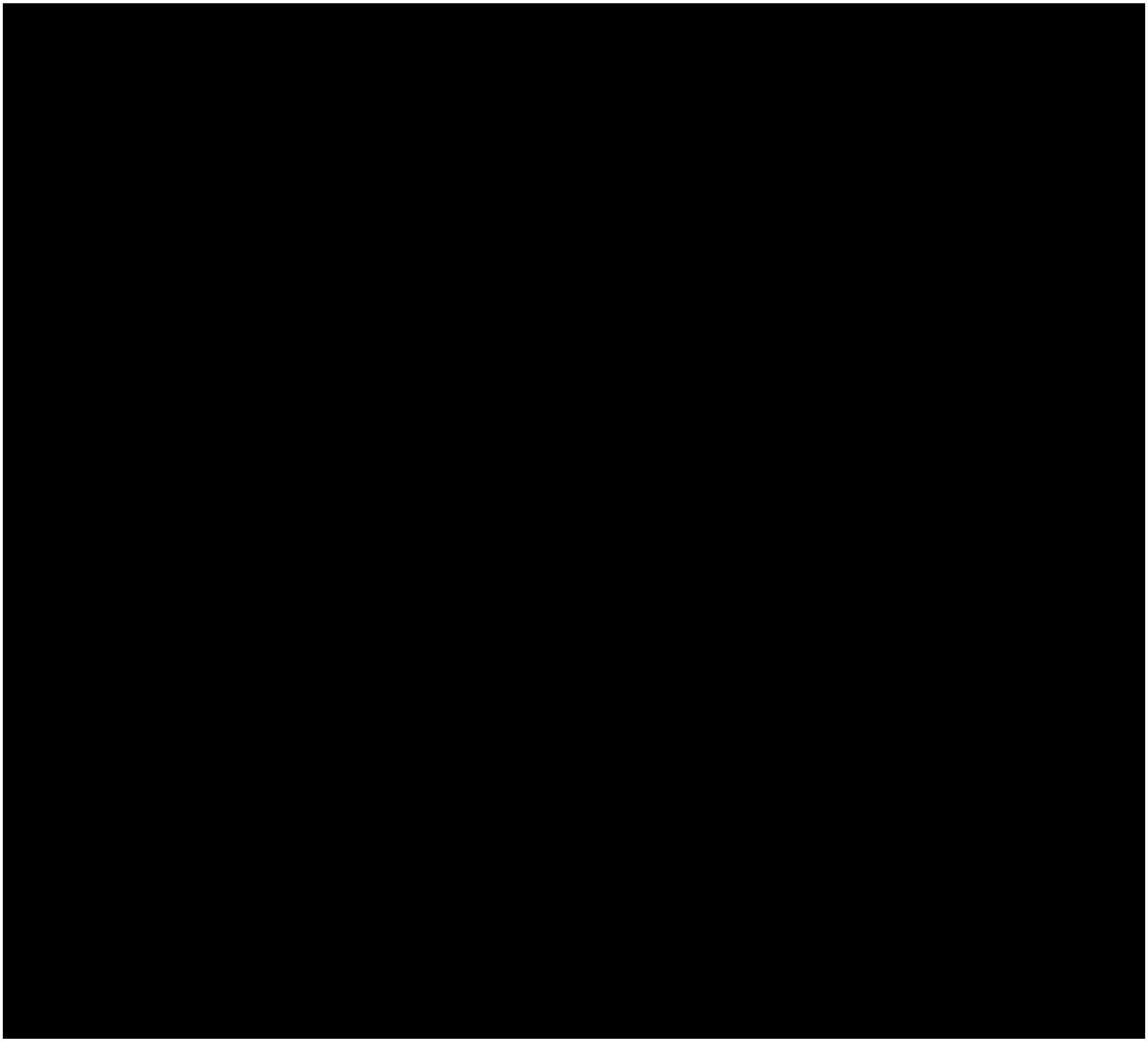
Each one of the Input and the Output Function Modules is, at its turn, the subject FM. The FM Block Diagram does not show where, physically, the function is implemented, and does not explain how the function is carried out.

Board Inside (BI) Block Diagram. This block diagram gives a detailed description of the relevant Function Module elaboration(s) and indicates which board(s), inside the TCU, this(these) elaboration(s) is(are) implemented in.

The (BI) Block Diagram does not show information related to the source and destination modules of the signals.

Table 07-I-03.1 TCU Function Modules

Module Number	Module
5	Analog Input Signals Module
6	Digital Input Signals Module
7	Digital Output Signals Module
8	Master Controller Module
9	Rate Reference Module
10	Torque Reference Module
11	Jerk Limiter and Car Acceleration Module
12	Motor Torque Control Module
13	PWM Modulator Module
14	Braking Chopper Control Module
15	Non Linear and Linear Blending Module
16	Speed Sensors Acquisition Module
17	Spin Control Module
18	Slide Control Module
19	Car Speed Calculation Module
20	Wheel Diameter Calculation Module
21	Speed Sensor Failure Detection Module
22	Overspeed Management Module
23	Speed Limit Module
24	MoV MoT Determination Module
25	Towing Mode Module
26	Car Wash Mode Module
27	Filter Precharging Module
28	Filter Discharging Module
31	Cut Out Module
32	HSCB Control Module
33	Propulsion Reset Module
34	Stopping Module
35	RollBack Module
36	No Motion Module
37	Friction Brake Interlock Module
39	Odometer Module
XX	Inverter Status Module
40	MVB Bus Communication Module



The Analog Input Signal Module considers all analog signals used by the TCU, what the sources are and the destination Modules for those signals.

[redacted]

Table 07-I-03.2 Analog Source System

SOURCE SYSTEM	DESCRIPTION
2 Speed sensors MOTOR 1	2 Speed sensors of MOTOR 1
2 Speed sensors MOTOR 2	2 Speed sensors of MOTOR 2
2 Thermal sensors MOTOR 1	2 Thermal sensors of the MOTOR 1
2 Thermal sensors MOTOR 2	2 Thermal sensors of the MOTOR 2
ENCODER Cab_A	Encoder of the master controller handle of the A Cab
ENCODER Cab_B	Encoder of the master controller handle of the B Cab
Center Truck Speed sensor	1 Speed sensor of the central truck axle
TA	Current Transducer: it measures the current from the A inverter module to the motors (A phase)
TAL1	Current Transducer: it measures the current of the positive line of the HV (the current that goes into the vehicle from the catenary)
TAL2	Current Transducer: it measures the current of the negative line of HV (the current that goes back to the running rails)
TB	Current Transducer: it measures the current from the B inverter module to the motors (B phase)
TC	Current Transducer: it measures the current from the C inverter module to the motors (C phase)
TCH	Current Transducer: it measures the current from the Chopper module to the braking resistor
TVF	Voltage Transducer: it measures the voltage between the positive catenary line and the return line/running rails (750V nominal)
F1	Motor 1 speed sensor 1 (number of teeth detected by the speed sensor)
F2	Motor 1 speed sensor 2 (number of teeth detected by the speed sensor)
F3	Motor 2 speed sensor 1 (number of teeth detected by the speed sensor)
F4	Motor 2 speed sensor 2 (number of teeth detected by the speed sensor)

Table 07-I-03.3 Analog Input Signals Module - Signals Used

Signal	Description
FSN	Center truck speed sensor negative signal (number of teeth detected by the speed sensor)
Pk3	Center truck speed sensor positive signal (number of teeth detected by the speed sensor)
iA	Inverter phase A current (value from TA)
iB	Inverter phase B current (value from TB)
iC	Inverter phase C current (value from TC)
iCH	Inverter phase CH current (value from TCH)
iLINP	Positive line current (value from TAL1)
iLINN	Negative line current (value from TAL2)
MstCntrl1	4-20 mA A-cab Encoder signal, (converted by the FBK Board into the 0-4.096 VDC signal)
MstCntrl2	4-20 mA A-cab Encoder signal, (converted by the FBK Board into the 0-4.096 VDC signal)
MstCntrl1P	Positive signal from current loop on the A cab
MstCntrl1N	Negative signal from current loop on the A cab
MstCntrl2P	Positive signal from current loop on the B cab
MstCntrl2N	Negative signal from current loop on the B cab
thMot1	Motor 1 thermal sensor 1 temperature (value from Thermal Sensors Motor 1)
thMot2	Motor 1 thermal sensor 2 temperature (value from Thermal Sensors Motor 1)
thMot3	Motor 2 thermal sensor 1 temperature (value from Thermal Sensors Motor 2)
thMot4	Motor 2 thermal sensor 2 temperature (value from Thermal Sensors Motor 2)
vFIL	Filter voltage (value from TVF)

Signals from TVF, TAL1, TAL2, TA, TB, TC, TCH, Thermal Sensors:

These signals enter the PIA board (X2 connector) through the CINV connector of the Motherboard.

The PIA board converts them from analog into digital signals using an Analog-to-Digital Converter with a sample 230 kHz frequency.

From here the signals proceed to the PCA and STB boards through the VME bus.
The FPGA controls the timing of the AD Converter and interfaces the signals with the bus.

Signals from the Speed Sensors:

Signals coming from the speed sensors enter the PIA board through the CF2 connector and proceed to the Motherboard through the X2 connector (the Pick-Up channel Circuit interfaces the speed sensors with the TCU.

FPGA monitors them with an internal circuit Test).

Signals from the Encoders:

The MC Handle signal (MstCntrl1 or MstCntrl2) is a current signal with a value ranging from 4 to 20mA (4mA = FSB, 20mA = Max Power).

These signals reach the FBK board through the TRL connector. The FBK board is equipped with two Current/Voltage converters that convert the MstCntrl1 or the MstCntrl2 signal (range:4-20mA) into a Voltage signal MstCntrl (range: 0-4.096V)."

After conversion, these signals are sent to the RATE REFERENCE FM (refer to paragraph: 07-I-03.02) through the X2 connector of the Motherboard.

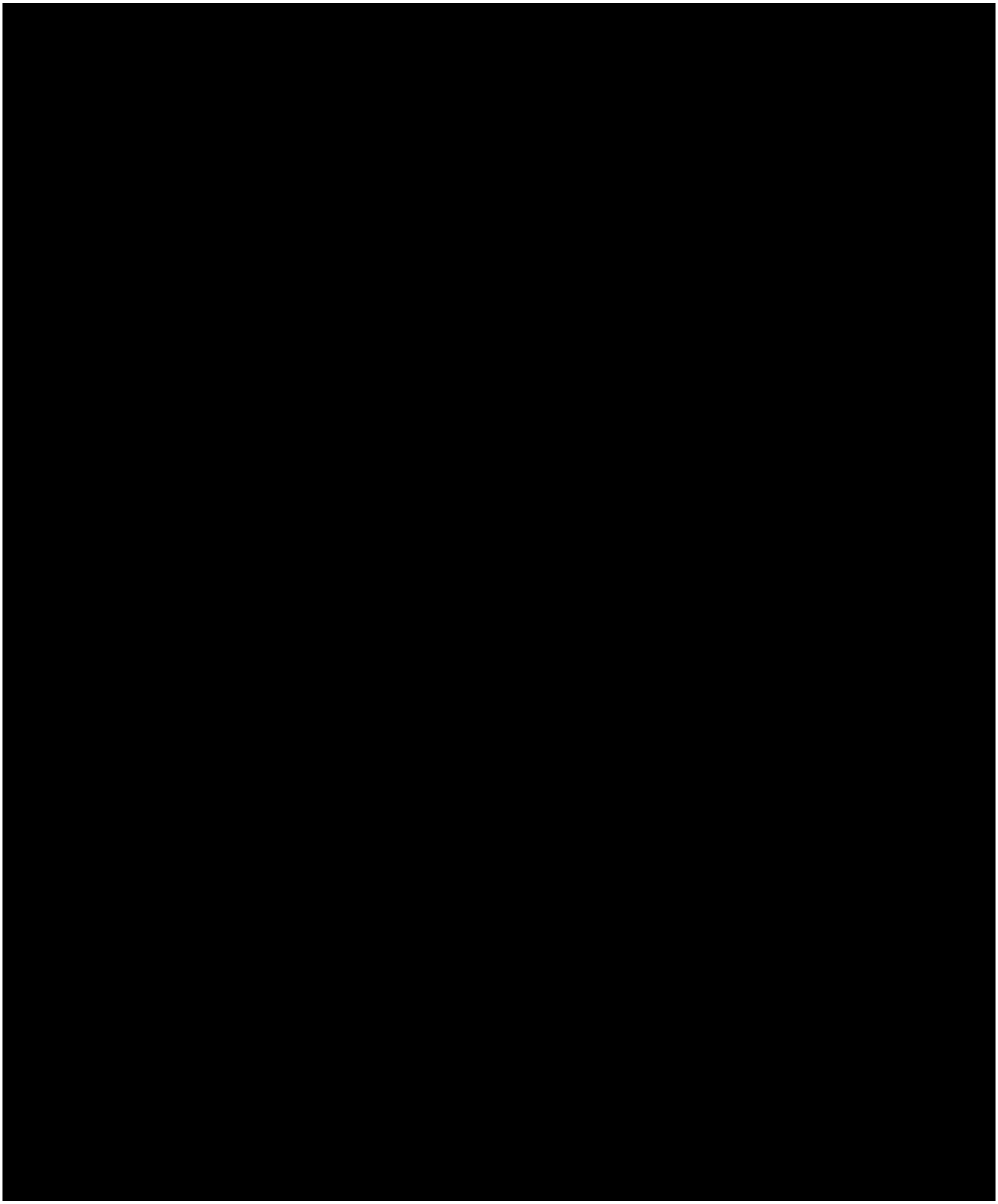


Figure 07-I-03.3 Digital Input Signals FM

[redacted]

All Digital Input Signals get to the TCU through the two NDI boards.
The only exception is the RMF signal which uses a channel of the NDO board.

Table 07-I-03.4 Digital Signal to NDI_A through UBTA Connector

Signal	Description
CAB_A	Cab A is enable
Cab_B	Cab B is enable
CW	Car Wash console command
COAST	Coast Trainline status
DC	Doors Closed
ED	Emergency Door
PBA	Friction or park brake Applied Trainline status
FSB	Full Service Brake Trainline status
FWD	Forward Trainline Status
HRSB	High Rate Service Brake Trainline status
HSCB	High Speed Circuit Breaker status
MOTOR	Motor Trainline status
MRL	Main Reservoir low
NMCC	No motion cross check
PBCO	Park Brake Cut Out
PROPCO	Propulsion Cut Out operator Request
RESET	Propulsion reset Request
REV	Reverse Trainline Status
SL	Speed limit trainline status
IDENTIF	The TCU is located in the A car body
TOWING	Towing Console Command
TB	Track Brakes status

Table 07-I-03.5 Digital Signal Directly to NDI_A

Signal	Description
CCF	CCF contactor status
CMF	Motor Blower contactor status
CP	CP contactor status
EB	Emergency Brake status
SCEB	SCEB relay status
SWTA	IGBT phase A thermal alarm
SWTB	IGBT phase B thermal alarm
SWTC	IGBT phase C thermal alarm
SWTCH	IGBT braking chopper thermal alarm

Table 07-I-03.6 Digital Signal Directly to NDO

Signal	Description
RMF	Motor Blower Power Supply detector status

NOTE: Each SCEB and EB signal has two train-lines (positive and negative) available. These signals enter the TCU through the UBTA connector and energize relays REB and RSCEB. The state of these relays is acquired by the NDI_A board.

Table 07-I-03.7 NDI Contacts for SCEB and EB Status

signal	UBTA	X3 - NDI
+SCEB	22	24d
-SCEB	53	
+EB	66	28b
-EB	17	

The signals acquired by the NDI_B are not shown in the block diagram.

These signals are related to the system status, and not all of them are acquired by both TCUs (A and B).

The signals acquired by NDI_B are listed in Table 07-I-03.8 and Table 07-I-03.9.

Table 07-I-03.8 Signals Acquired through NDI_B of TCU_A

NDI X3 Connector Pin	Connected to	Description
4d	UBTB - A	Diagnostic supply IDU-EMI monitor & air compr.
6d	UBTB - B	Diagnostic Supply GTW
8d	UBTB - C	Diagnostic console 1
10d	UBTB - D	Diagnostic speed circuit breaker com.
12d	UBTB - E	Dead man Tripped
14d	UBTB - F	Diagnostic - A-End 3F24 Circuit Breaker Status
18d	UBTB - G	Diagnostic compressor ON
20d	UBTB - H	Diagnostic MPH limit
22d	UBTB - J	Diagnostic encoder
24d	UBTB - K	Diagnostic track-brake select - A-End 3F20 Circuit Breaker Status.
26d	UBTB - L	SPARE
28d	UBTB - M	Diagnostic pantograph command
30d	UBTB - N	Diagnostic pantograph command motor
4b	UBTB - P	Diagnostic - EB Loop Power Supply 37.5 V/37.5 Vcc
6b	UBTB - R	Diagnostic Track Brakes A & C Trucks
8b	UBTB - S	SPARE

Table 07-I-03.8 Signals Acquired through NDI_B of TCU_A

NDI X3 Connector Pin	Connected to	Description
10b	UBTB - T	ECU By-pass for A & C Trucks
12b	UBTB - U	Supply Circuit Breakers for A & C Truck ECUs
14b	UBTB - V	Diagnostics - Supply Circuit Breaker for A-Truck Sanders Solenoid Valve
18b	UBTB - W	Diagnostic sanders command
20b	UBTB - X	Diagnostic - A-End Cab Lights, Headlights, & Roof Light
22b	UBTB - Z	Diagnostic - Stop lights & Turn Signal Lights
24b	UBTB - a	Diagnostic - Supply for A & C-Truck BCU and Friction Brake Cutout Relay
26b	UBTB - b	Diagnostics - Marker Lights & Exterior Bypass Light.
28b	UBTB - c	Diagnostic door control
30b	UBTB - d	Diagnostic door supply
4z	UBTB - e	Diagnostic ATP exclude
6z	UBTB - f	Diagnostic - Supply for W/S Wipers, Horn & Gong, and Ext. Mirrors
8z	UBTB - g	Diagnostic HVAC power
10z	UBTB - h	Diagnostic communication power
12z	UBTB - j	Diagnostic switch coupler

Table 07-I-03.9 Signals Acquired through NDI_B of TCU_B

NDI X3 Connector Pin	Connected to	Description
4d	UBTB - A	Diagnostic - IDU Supply
6d	UBTB - B	Diagnostic - Battery Supply for Emerg. Lighting, Commun., Crew doors, and Panto. Cmnd
8d	UBTB - C	Diagnostic - Cab Enable Circuitry
10d	UBTB - D	Diagnostic - Supply for HSCB Control Circuitry
12d	UBTB - E	Diagnostic APS power supply
14d	UBTB - F	Diagnostic - B-End 3F24 Circuit Breaker Status
18d	UBTB - G	APS fault
20d	UBTB - H	LVPS fault
22d	UBTB - J	Diagnostic encoder
24d	UBTB - K	Diagnostic track-brake select - B-End 3F20 Circuit Breaker Status.
26d	UBTB - L	Diagnostic - Battery Ckt Bkr and Low Voltage Supply Ckt Bkr Status
28d	UBTB - M	Diagnostic pantograph command
30d	UBTB - N	Diagnostic - Passenger Lighting Supply and Passenger Lighting Timer Relay Supply
4b	UBTB - P	Diagnostic - Emergency Lighting Supply Circuit Breaker
6b	UBTB - R	Supply track brakes B
8b	UBTB - S	Diagnostic hazard lights
10b	UBTB - T	ECU By-pass for B-Truck
12b	UBTB - U	Supply Circuit Breaker for B-Truck ECU

Table 07-I-03.9 Signals Acquired through NDI_B of TCU_B

NDI X3 Connector Pin	Connected to	Description
14b	UBTB - V	Diagnostic - Supply Circuit Breaker for B-Truck Sanders Solenoid Valve
18b	UBTB - W	Diagnostic sanders command
20b	UBTB - X	Diagnostic - B-End Cab Lights, Headlights, Roof Light & CB for Lighting Power Supply
22b	UBTB - Z	Diagnostic - Tail lights & Turn Signal Lights
24b	UBTB - a	Diagnostic - Supply for B-Truck BCU and Friction Brake Cutout Relay
26b	UBTB - b	Diagnostic - Supply CB for Silent Alarm Lights
28b	UBTB - c	Diagnostic door control
30b	UBTB - d	Diagnostic door supply
4z	UBTB - e	Diagnostic ATP display
6z	UBTB - f	Diagnostic - Supply for W/S Wipers, Horn & Gong, and Ext. Mirrors
8z	UBTB - g	Diagnostic HVAC power
10z	UBTB - h	Diagnostic communication power
12z	UBTB - j	Diagnostic switch coupler

These signals, when active, have a nominal voltage of 37.5V, which is too high for the TCU circuits.

For this reason, in order to make them usable by the TCU Boards (and the PCA board in particular), the NDI boards (and the NDO board for RMF) manage to send them via the VME bus.

[redacted]

Figure 07-I-03.5 Digital Output Signals FM

Table 07-I-03.10 Signals Used by the Digital Output Signals Module

Signal	Description
CCF	CCF (Charge contactor) command
CMF	Motor Blower Contactor command
CP	CP (CP Contactor) command
HSCB	HSCB Open request
ODOM	Odometer Output (1 mile signal)
SANDING	Sand Request (to the sanders)
STOPPING	Stopping Signal (to the braking system)
TCUOK	Propulsion Fault Signal output
WDin	No Motion Relays driven

All NDO output signals are used to energize the relevant relay.

For this reason the NDO hardware output circuits receive these signals from the PCA board (through VME bus) and transform them into a digital 0 or 37.5 VDC signal (refer to NDO board: paragraph 07-I-02.02.06.02e).

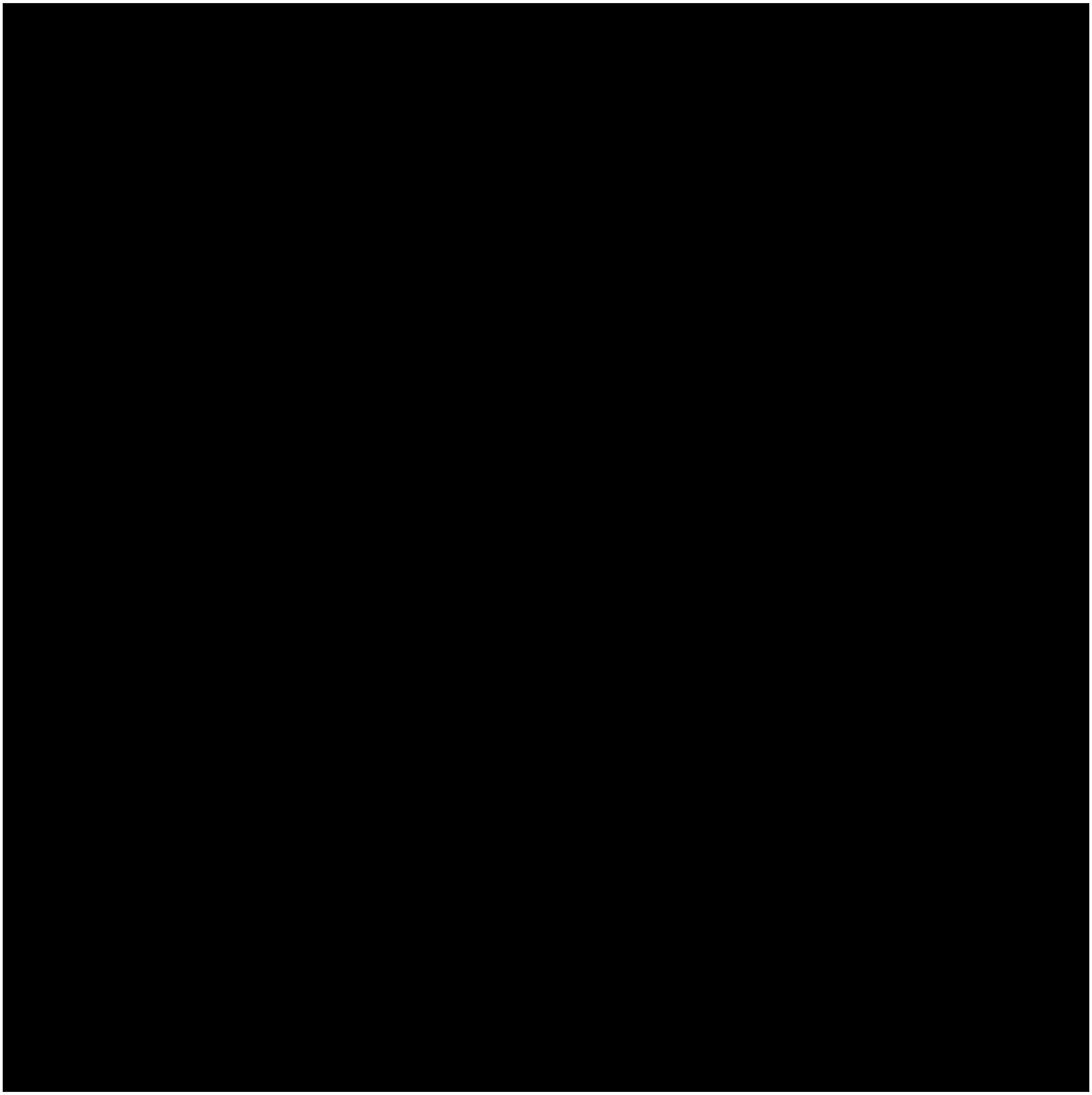


Figure 07-I-03.6 Digital Output Signals BI

[redacted]

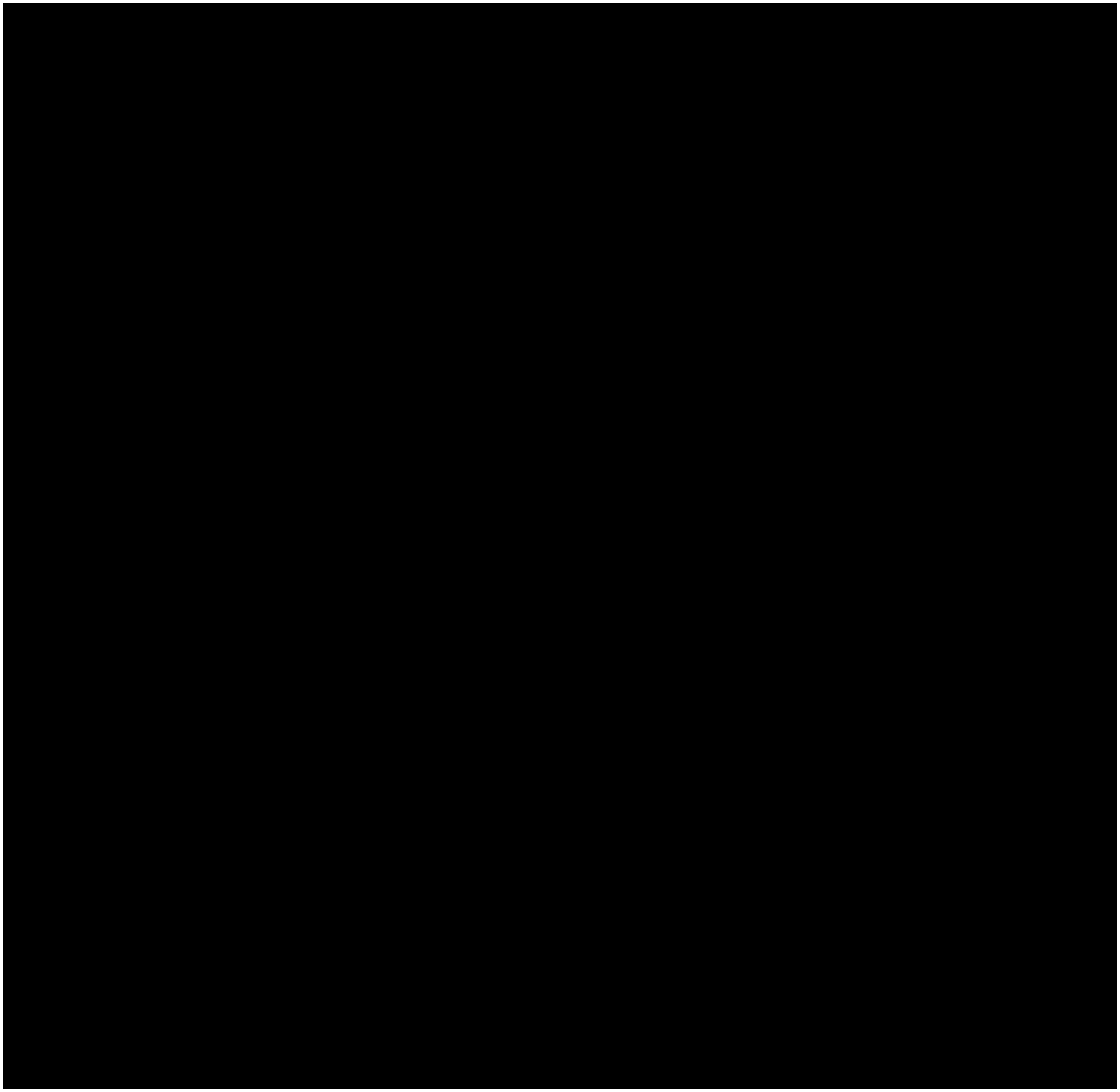
The odometer of the vehicle is located inside the B-End Electronics locker and is driven by the MoT TCU.

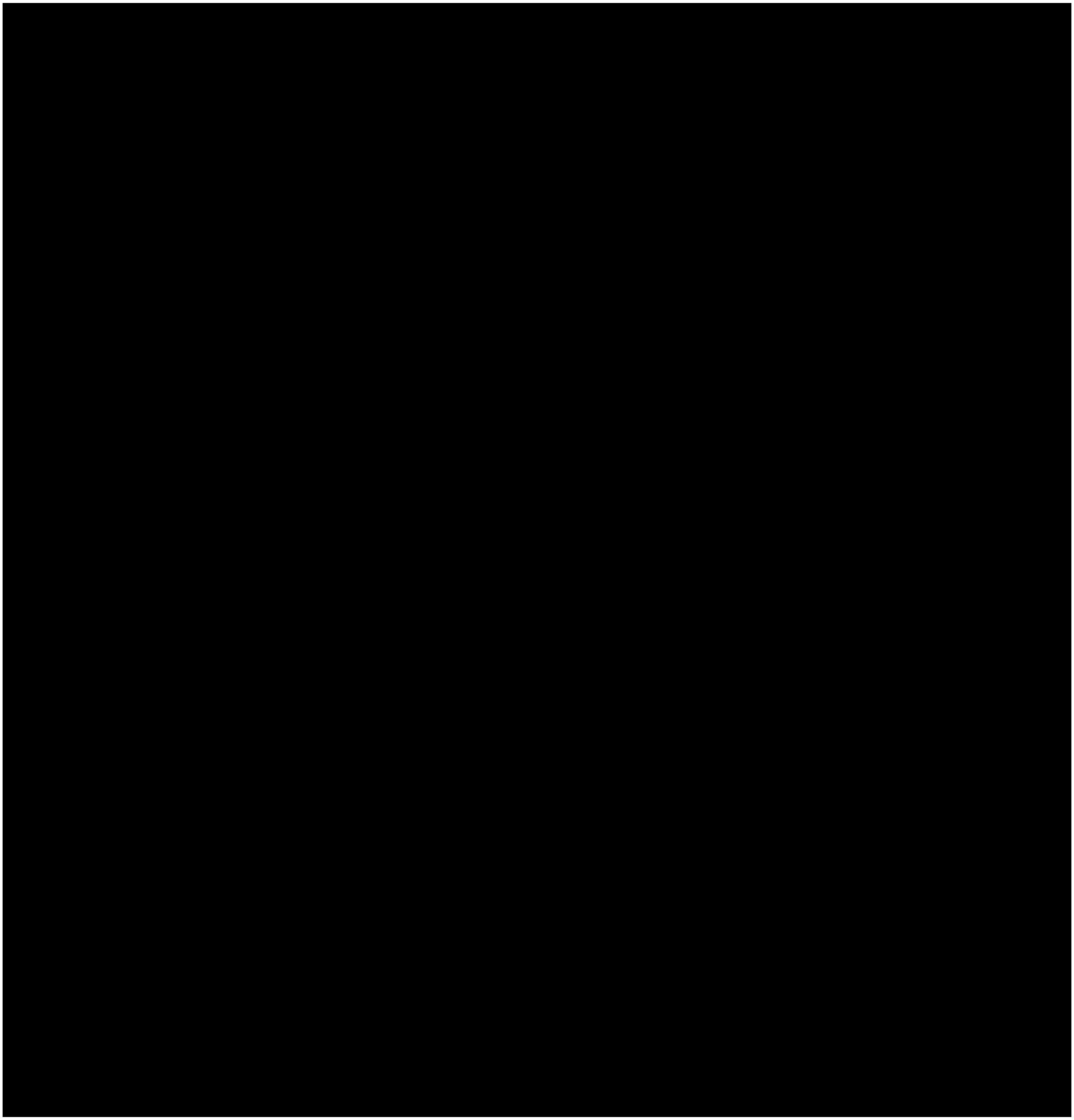
A diode protects the TCUs from the MoT TCU OdometerOut command.

As soon as a Zero Speed is detected (refer to Figure 07-I-03.9), the WDin (Watch Dog) signal starts alternating and the Watch Dog Circuit reacts by closing the two contacts in the FBK board, thus connecting 32D with 30D and 30Z with 32Z, which energizes the 3K26 relay, and, through it, the two No-motion relays (3K05/1 and 3K05/2) (refer to paragraph 07-I-03.02.25 - NO MOTION MODULE).

[redacted]

07-I-03.01.04 Master Controller Module





This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.11 Signals used by the Master Controller Module

Signal	Description
COAST	COAST Trainline status
DirCmd	Direction Request
DoorClosed	Doors status
EB	Emergency Brake status
FbInterlocked	Friction Brake Interlocked
FSB	FSB Trainline status
FWD	Forward Trainline status
HRSB	HRSB Ttrainline status
MoT	TCU is MoT
MOTOR	MOTOR Trainline status
OpMode	Operating Mode request
OverSpeed	Over Speed Condition status
RateReference	Rate Reference command
REV	Reverse Trainline status
SCEB	SCEB Trainline status

a) Determination of OpMode (Operating Mode) Signal.

— Operating Mode determination sub-block

The OpMode output is calculated by means of the following table:

Table 07-I-03.12 OpMode Determination

MODE SELECTION TRAINLINE						OPERATING MODE OpMode
M	CM	FSB	HRSB	RSCEB	REB	
1	1	1	1	1	1	Power
0	1	1	1	1	1	Coast
0	0	1	1	1	1	Service brake SB
X	X	0	1	1	1	Full service brake FSB
X	X	X	0	1	1	High rate service brake HRSB
X	X	X	X	0	1	Slide controlled emergency brake SCEB
X	X	X	X	X	0	Emergency brake EB

X = don’t care

0 = de-energized trainline

1 = energized trainline

With respect to the Braking Modes, the position of the zero farthest to the right decides the operating mode.

Example: when the MC Handle is in SB (refer to Figure 07-I-02.39) and the EB button is not pressed, the Mode Selection trainline is: M=0, CM=0, FSB=1, HRSB=1, RSCEB=1, REB=1. With this Mode Selection Trainline configuration OpMode = ServiceBrake.

- Control Logic

The RateReference, MoT, DoorClosed and FbInterlock signals are used as inputs to check the OpMode signal:

(RateReference < 0%) AND (OpMode = POWER) → OpMode = FSB

(RateReference = 0%) AND (OpMode = POWER) → OpMode = COAST

(OpMode = POWER) AND [(FbInterlock = 1) OR (MoT = 0)] → OpMode = COAST

[(OpMode = POWER) OR (OpMode = COAST)] AND (DoorClosed = 0) → OpMode = FSB

The FbInterlocked signal is generated by the FRICTION BRAKE INTERLOCK MODULE (refer to paragraph: 07-I-03.02.26).

b) Determination of "DirCmd"

The Determination of the train Direction sub-module creates the DirCmd signal starting from the FWD and REV signals:

Table 07-I-03.13 DirCmd Determination

FWD	REV	Direction
0	0	No direction
0	1	Reverse
1	0	Forward
1	1	ILLEGAL

When the FWD and REV trainlines are not energized, there is a 'No direction' condition. FWD and REV energized at the same time is a fault condition.

c) RateReference Modification

If the Overspeed signal is low, the output RateReference has the same value as the input RateReference. Vice versa, if the Overspeed signal is high, the output RateReference is forced to -100% (FSB - independently from its input value)

OverSpeed = 1 → RateReference = -100%

OverSpeed = 0 → RateReference = RateReference

For Overspeed signal activation and performance reduction refer to OVERSPEED MANAGEMENT MODULE (paragraph: 07-I-03.02.13) and SPEED LIMIT MODULE (paragraph: 07-I-03.02.14).

07-I-03.02 Rate Reference Module

[redacted]

Figure 07-I-03.13 Rate Reference BI

Table 07-I-03.14 Signals used by the Rate Reference Module

Signal	Description
MstCtrl1	Cab A Master Controller 0-4.096 VDC Analog value
MstCtrl2	Cab B Master Controller 0-4.096 VDC Analog value
Cab_A	A Cab active
Cab_B	B Cab active
RateReference	Rate Reference command

By means of the software elaboration, the Rate Reference Module turns the analog signal MstCtrl into a Signal called RateReference (with a range from (-100%) to (+100%)).

The Rate Reference value depends on the position of the Master Controller handle, as shown in Table 07-I-03.15.

Table 07-I-03.15 Rate Reference Determination

INPUT		OUTPUT
MC Handle POSITION	**Current [mA]**	**RateReference [%]**
SCEB	< 5	-100
HRSB	< 5	-100
FSB	< 5	-100
SB	< 5	-100
SB	5..9.5	Linear from -100 to -8
SB	9.5..11	-8
COAST	11..13	0
POWER	13..14.5	10
POWER	14.5..19	Linear from 10 to 100
MAX POWER	> 19	100

The MUX (multiplexer) selects only the RateReference signal coming from the active Cab.

The RateReference value is sent to all TCUs through the MVB bus.

[redacted]

[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.16 Signals Used by the Torque Reference Calculation Module

signal	description
Stopping	Stopping Signal (to the braking system)
LinearBlend	Linear Blending Mode
LoadX	Local Percentage Load (0% à AW0, 100% à AW4)
LoadC	Center Truck Percentage Load (0% à AW0, 100% à AW4)
TowingSt	The Towing Mode status
WheelDiaCalc	Wheel Diameter
RateReference	Rate Reference command
StatoInv	Actual Inverter status
Torque	Reference Torque

The TORQUE REFERENCE CALCULATION Module is responsible for calculating the reference Torque to be provided to the Inverters.

The signal will be modified if a spin or a slide is detected and will be transformed into an IGBT driver signal for the Inverter Phase Modules.

a) ABS Sub-module:

The ABS Sub-module transforms LoadX and LoadC from percentage values into weight values (refer to Table 07-I-0.16)

b) Effort Request Calculation Sub-module:

The RateReference signal determines, together with the truck loads (loadX, loadC), the actual Operating Mode (StatoInv) and, together with the type of brake application (LinearBlend), the correct effort requested (EffReq).

c) Fade Out Sub-module:

The fading algorithm is used to handle the transition between the dynamic braking and the friction braking.

With a High Stopping command (coming from the MoT TCU through the MVB bus), the EffReq, starting from 4.8mph, is linearly reduced to zero. With a Low Stopping command the EffReq does not change while passing through the FADE OUT sub-module.

All TCUs implement this module so that each vehicle in the Consist will fade dynamic and friction braking independently (refer to Figure 07-I-03.17)

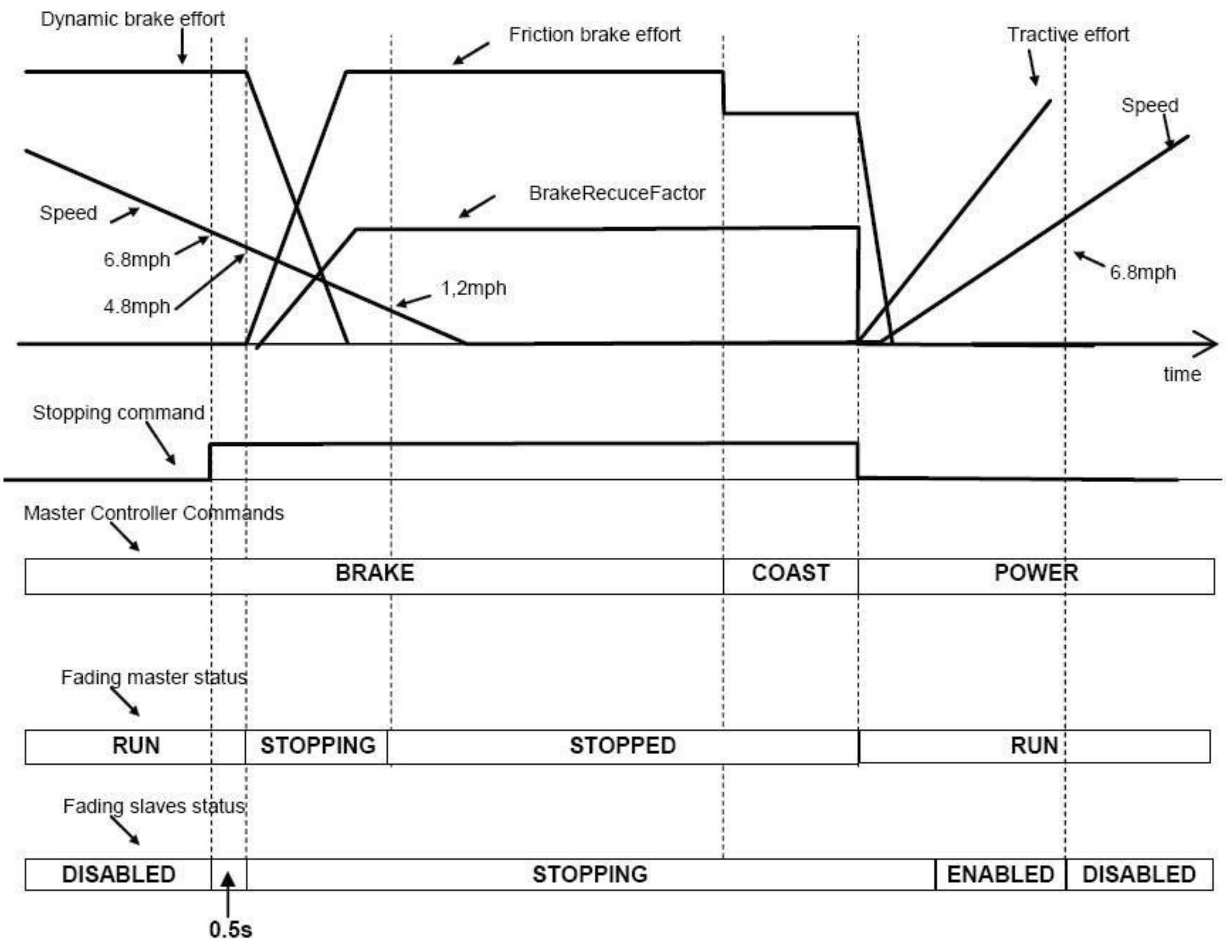


Figure 07-I-03.17 Fade Out

Figure 07-I-03.17 shows (on the right-hand side) also that during a train re-start the Friction Brake Effort is not immediately released and for this reason the train does not immediately move.

It starts to move only when Tractive effort becomes higher than the Friction Brake effort. Refer to paragraph 07-I-03.02.23 for more details about the Stopping command.

d) Torque Reference Calculation Sub-module:

The Reference Torque value can be calculated by the PCA micro-processor by knowing the effort requested (EffReq) and the wheel diameter (WheelDiaCalc).

The Reference Torque value is increased by 20% (Reference Torque = Reference Torque *1.2) through a MUX (multiplexer) if a request of Towing (TowingSt) is active.

[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.17 Signals used by the Torque Reference and Car Accel. Module

Signal	Description
CarAcceleration	Theoretical Vehicle Acceleration
LoadC	Center Truck Percentage Load (0% →AW0, 100% → AW4)
LoadX	Local Percentage Load (0% → AW0, 100% → AW4)
OpMode	Operating Mode Request
RateReference	Rate Reference command
StatoInv	Actual Inverter status

All TCUs, through the Jerk Limiter and Car Acceleration Module, modify the RateReference signal coming from the MoT TCU in order to limit the RateReference slew rate: the output RateReference is the input RateReference signal without sudden value changes.

The Jerk Rate value is calculated in order to reach the requested target acceleration according to the values in Table 07-I-03.18:

Table 07-I-03.18 Jerk rate

Operating Mode	RateReference	Jerk Rate value
POWER	100	3.0 mphpsps
POWER	66	2.0 mphpsps
POWER	33	1.0 mphpsps
SB	-33	1.15 mphpsps
SB	-66	2.3 mphpsps
FSB	-100	3.5 mphpsps

To limit the RateReference acceleration/deceleration rate, the Jerk Limiter and Car Acceleration Module considers the relevant Motor Truck load (loadX with X = A or B), the Center Truck load (loadC), the difference between the Operation Mode selected by the operator with the MC Handle (OpMode) and the Operation Mode that the inverters are carrying out at that time (StatoInv)

In the Jerk Limiter and Car Acceleration Module, the input RateReference is also used to calculate the theoretical acceleration of the train (used if all wheels are sliding):

The theoretical acceleration (CarAcceleration) is calculated considering the maximum acceleration rate according to the actual Operating Mode (StatoInv):

Table 07-I-03.19 Theoretical acceleration

StatoInv	CarAcceleration
POWER	3,0 * RateReference
COAST	0
SB or FSB	-3,5 * RateReference
HRSB or SCEB	-6.2 * RateReference

[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.20 Signals used by the Motor Torque Control Module

Signal	Description
eta	Modulation value
Fd	Desired rotor flux
fmot	Motor frequency
freal	Power supply motor frequency
fs	Slips frequency
iDrif	Direct current component
iQrif	Squaring current component
TorqueAsk	Reference torque
TorqueAskSpin	Reference torque after the spin control
TorqueAskSlide	Reference torque after the slide control
vD	Reference direct control voltage
vFIL	Filter voltage (value from TVF)
vQ	Reference quadrature voltage

The MOTOR TORQUE CONTROL Module transforms the Torque value (coming from the Spin Slide Control Module into signals that can be used to generate the Command Pulses for the Inverter Phase Modules in order to command the relative motors (refer to paragraph 07-I-03.02.04). Starting from the Reference Torque (TorqueAsk) the TCU defines the Command Pulses that command the IGBTs inside the Inverter Phase Modules. By controlling the IGBTs opening and closing, the TCU controls the supply to the Motors and, consequently, the Motor Torque (refer to paragraph 07-I-03.03).

This Module defines:

- "freal" (fundamental power supply motor frequency). This frequency is also called f_{sync} (synchronous frequency) (refer to paragraph 07-I-03.03)
- "eta" (modulation value)

From these signals the PWM Modulator Module (refer to paragraph 07-I-03.02.04) produces the Command Pulses for the Inverter Phase Module.

a) MIN Sub-module:

The Minimum Torque (absolute value) between the spin and slide control is chosen.

In case of spin: |TorqueAskSpin| < |TorqueAskSlide|,
then TorqueAsk = TorqueAskSpin

In case of slide: |TorqueAskSlide| < |TorqueAskSpin|,
then TorqueAsk = TorqueAskSlide

Neither spin nor slide condition: TorqueAsk = TorqueAskSlide = TorqueAskSpin b) IFOC (Indirect Flux Oriented Control) Sub-module:

This sub-module calculates the desired flux (Fd).

Desired flux and torque value (TorqueAsk) are used by the IFOC to calculate the direct current component (iDrif, which generates the flux) and the squaring current component (iQrif, which generates the Torque).

The IFOC also calculates the slip frequency (f_s) (>0 during an acceleration and <0 during a deceleration).

“freal” is the sum of fmot and f_s and represents the basic power supply motor frequency,

“freal” = fmot+f_s:

Acceleration is requested (f_s>0) freal > fmot ACCELERATION

Deceleration is requested (f_s<0) freal < fmot DECELERATION

fmot is the rotor frequency and follows the freal.

For this reason, when the stator is supplied with freal > fmot, the rotor reacts by incrementing its frequency and the train has an acceleration.

On the contrary, when freal < fmot the rotor reduces its frequency, thus causing a train deceleration. For a more detailed operating description refer to paragraph 07-I-03.02.04.

c) Converter I/V Sub-module:

From the direct and the squaring current components, the PCA micro-processor calculates the voltage components (vD and vQ).

d) Modulation Value Sub-module:

By knowing vFIL with vD and vQ, the software calculates the “eta” value. “eta” is used to generate the command.

[redacted]

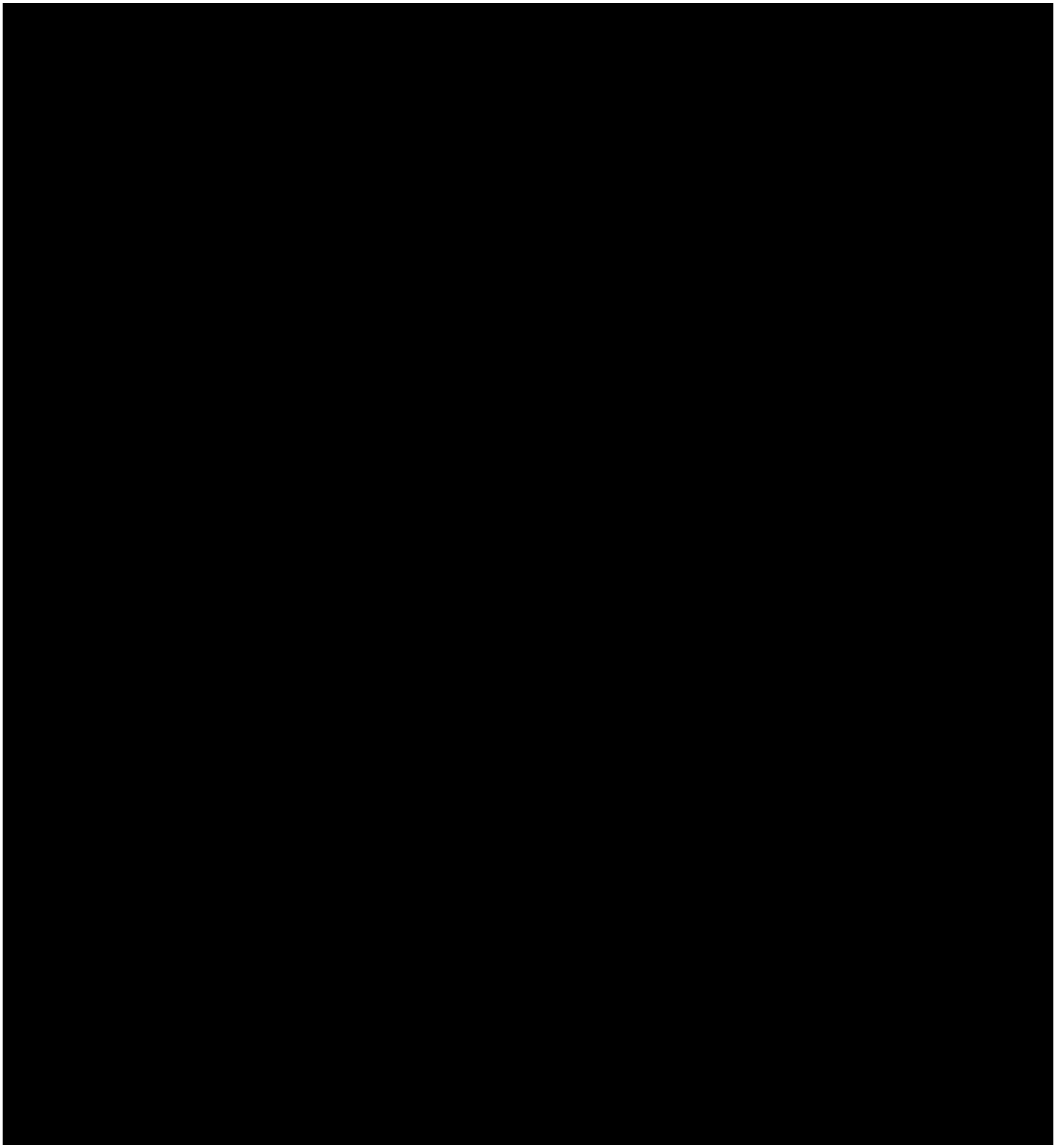


Figure 07-I-03.23 PWM Modulator BI

Both the PCA and the PIA boards implement this module.

The PCA board, through a software elaboration of its DSP, computes the three Inverter Phase Commands.

The PIA board, through a hardware elaboration, interfaces these commands with the Inverter Modules. From the PCA board, the phase command goes to the PIA board through the VME bus.

Table 07-I-03.21 Signals used in the PWM modulator

Signal	Description
freal	Power supply motor frequency
eta	Modulation value
fA	Inverter phase A command
fB	Inverter phase B command
fC	Inverter phase C command
CFAA	Command pulse (phase A)
CFAB	Command pulse (phase B)
CFAC	Command pulse (phase C)

Starting from “freal” and “eta”, this module defines the command pulses to be sent to the Inverter Modules A, B and C of the relevant Motor Truck.

With these signals the Inverter Modules can drive the motors in accordance with request of the Operator

[redacted]

Four types of PWM modulations are possible:

- Asynchronous modulation
- Synchronous modulation
- Overmodulation
- Six Step

Refer to APPENDIX 07-I-03.03.01 for PWM functioning description.

a) Comparator:

The logic evaluates which modulation is needed by monitoring “eta” and “freal”. When the Inverter Power Supply Frequency (“freal”) rises, the system passes from the Asynchronous modulation to the Six Step modulation. This is necessary in order to maximize the efficiency of the traction motors and to minimize EMI.

b) Asynchronous modulation:

“eta” defines the duty cycle (tON) of the command pulses. The switching frequency (f_{sw}: the modulation pulse frequency) of these pulses is constant (1,000Hz).
1,000Hz is the max switch frequency that the Inverter Phase Module can apply.

c) Synchronous modulation:

The switching frequency (f_{sw}) depends on “freal” (it’s a multiple of 3freal: f_{sw} = 3*n*freal where 3*n is the pulse number.). By decreasing the pulse number, step by step, it is possible to increase the freal without exceeding f_{sw} = 1,000Hz.

d) Overmodulation:

It is a hybrid condition to handle the jump in the six step mode. The fsw decreases quickly in order to obtain f_{sw} = freal.

e) Six Step:

In this mode fsw is equal to freal and the control has reached the maximum voltage value that can be applied to the motor (78% of the line voltage). In the Six Step modulation the flux starts decreasing (like 1/”freal”).

[redacted]

Figure 07-I-03.25 Inverter Switching Frequency Diagram

[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.22 Signals used by the Braking Chopper Control Module

Signal	Description
CFACH	Command Pulse (Chopper Module)
Torque	Reference Torque
DutyCH	Chopper Duty Cycle
DutyFF	Feed Forward Duty Cycle
freal	Power Supply Motor Frequency
iLINP	Input Line Current
InvPower	Input Inverter Power
ScaFil	Command to discharge the Filter with the Braking Resistor
vFIL	Line Voltage
VFREF	Line Voltage Reference

The Braking Chopper Control Module defines the command pulse for the Inverter Chopper Module.

The Chopper Module is used to perform the non-regenerative braking, the mixed braking and to prevent a filter overvoltage protection.

Unlike the command pulse for the Inverter Phase Module (refer to paragraph 07-I-03.02.04), only the duty cycle is variable while the switch frequency does not change.

During the electric brake mode the chopper duty cycle dutyCH is calculated as follows:

dutyCH = dutyFF + dutyVF

DutyFF is the "Feed Forward" value calculated starting from the input inverter power (InvPower) and the line current value (iLINP).

DutyFF represents the duty cycle that should be used in case of a complete rheostatic braking.

This means that the control starts to dissipate the power coming from the inverter to the braking resistor.

Then it tries to regenerate the power using the dutyVF parameter up to a complete regenerative braking, depending on the filter voltage level.

DutyVF is the contribution based on the filter voltage reference value VFREF. The SW calculates dutyVF using a PI regulator, which looks at the instantaneous error vF-VFREF and the actual state of the regulator.

The maximum value is 0, while the minimum is -dutyFF.

Therefore, if dutyVF is 0, the braking is completely rheostatic; if it is -dutyFF the brake is completely regenerative and if it is between the limit values, the braking mode is mixed.

In addition to this, the dutyVF value is kept at 0 until the inverter power is greater or equal to 0, which means that the actual operating mode is power or coast.

The value of the filter voltage reference value VFREF is 920.0V.

This value can be adjusted if the line is going to regenerate too much current.

For this reason the VFREF value is the output of a PI regulator which receives as input the actual line current and the maximum value of the regenerative current IRECMAX (600A).

OverVoltage Protection:

The overvoltage protection is realized in two different ways: HW and SW.

The software protection is activated when a filter voltage value higher than 960Vdc is detected. The Braking Chopper Duty Cycle is incremented and is 100% when the line voltage is higher than 1,000 Vdc.

The HW protection is activated when the FPGA on the PIA board (refer to paragraph 07-I-02.02.06.02d)) detects a filter voltage value of 1,000 Vdc.

In this case the HW automatically fires the chopper with a duty cycle of the 50% until the SW detects this HW protection, removes it and takes control by firing the chopper if necessary.

Finally, if the filter discharging command (ScaFil) is detected (refer to paragraph: 07-I-03.02.19), the Braking Chopper duty cycle is forced at 10% to reduce the discharge time.

07-I-03.02.06 Non Linear and Linear Blending Module

[redacted]

Table 07-I-03.23 Signals used by the Non Linear and Linear Blending Module

Signal	Description
LinearBlend	Linear Blending Mode
OpMode	Operating Mode Request
Sliding	The Sliding status

Figure 07-I-03.29 Non Linear and Linear Blending Bl

This software elaboration is carried out by the PCA controller (C167).

This Module selects one of the two blending schemes (Linear or Non-Linear). Normally the Non-Linear Mode is implemented. The Non-Linear and Linear Blending schemes use the same level of adhesion on the motor trucks when the FSB Mode is selected.

a) Linear Blending Logic Sub-module

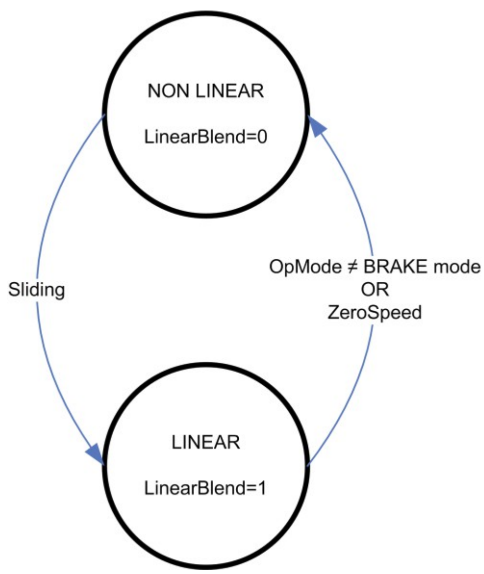


Figure 07-I-03.30 Linear Blending State Machine

The Linear Blending Command is selected by the MoV TCU (and sent to the other TCU and ECUs on the relevant car) when a slide is detected on one of the Motor Trucks (information collected from the TCUs and ECUs) and the Center Truck is not sliding.

When the car switches to linear blending, this mode is retained during the whole braking phase until the mode changes to Coast or Power or until zero speed is reached.

b) Linear Blending Description

The Braking Effort that must be applied by each braking unit is calculated using Figure 07-I-03.31 and Table 07-I-03.24.
The Table gives values that consider an AW4 load effort.
Calculated values must then be adjusted proportionally to the actual load.

The values are obtained by linear interpolation and are displayed in Table 07-I-03.24.

Table 07-I-03.24 Linear Blending

RateReference [%]	**Motor Truck tot. Effort [kW] (ME) (@AW4)**	**Motor Truck Adhesion level [%]**	**Center Truck Effort [kW] (TE) (@AW4)**	**Center Truck Lim. Effort [kW] (TLE) (@AW4)**	**Center Truck Adhesion level [%]**
0	0	0	0	0	0
-100	37.0	16.9	37.1	37.1	16.7

The ME (Motor Truck total Effort) curve represents the Total Brake Effort that must be provided by a Motor Truck.

The TE (Trailer Effort) curve represents the theoretical effort the Center Truck should provide, with no limitation to zero below the 40% performance value.
This curve is used, during a Non Linear Blending mode, to evaluate how much effort (not delivered by the Center Truck - due to the limitation) must be routed to the Motor Truck.
The TLE (Trailer Limited Effort) curve represents the actual effort that must be provided by the Center Truck. In Linear Mode the TE and the TLE efforts are identical.

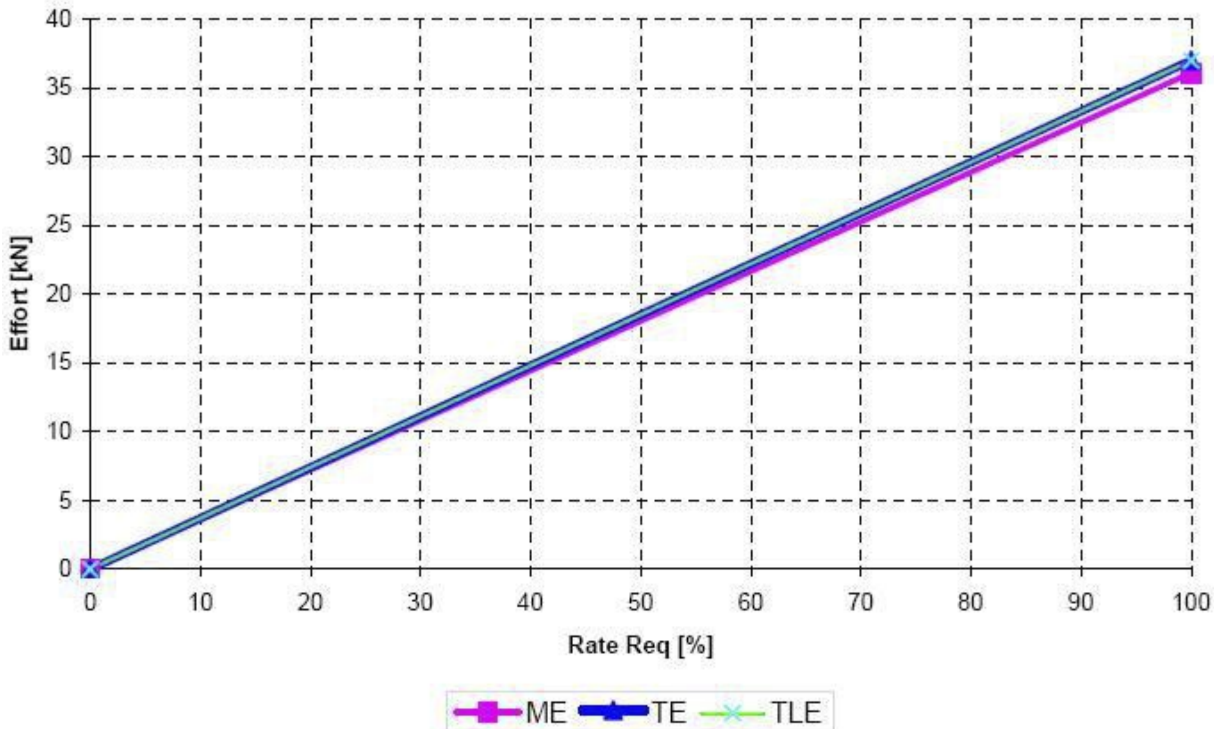


Figure 07-I-03.31 Linear Blending

c) Non Linear Blending Description

The Braking Effort that must be applied on each braking unit is calculated using Figure 07-I-03.32 and Table 07-I-03.25.

The Table gives values that consider an AW4 load effort.

Calculated values must then be adjusted proportionally to the actual load.

The values are obtained by linear interpolation and are displayed in Table 07-I-03.25.

Table 07-I-03.25 Non Linear Blending

RateReference [%]	Motor Truck tot. Effort [kW] (ME) (@AW4)	Motor Truck Adhesion level [%]	Center Truck Effort [kW] (TE) (@AW4)	Center Truck lim. Effort [kW] (TLE) (@AW4)	Center Truck Adhesion level [%]
0	0	0	0	0	0
-40	22.2	10.1	0	0	0
-100	37.0	16.9	37.1	37.1	16.7

The ME (Motor Truck Effort) curve represents the Total Brake Effort that must be provided by a Motor Truck.

The TE (Trailer Effort) curve represents the theoretic effort the Center Truck should have provided with no limitation to zero below the 40% performance value.

This curve is used to evaluate how much effort, not delivered by the Center Truck (due to the limitation) must be routed to the Motor Truck.

The TLE (Trailer Limited Effort) curve represents the actual effort that must be provided by the Center Truck.

The TE and TLE curves are necessary in order to meet the following two requirements in the braking distribution:

- No Braking Effort is requested to the Center Truck below a 40% Rate Reference
- Each Truck must brake in proportion to its own weight

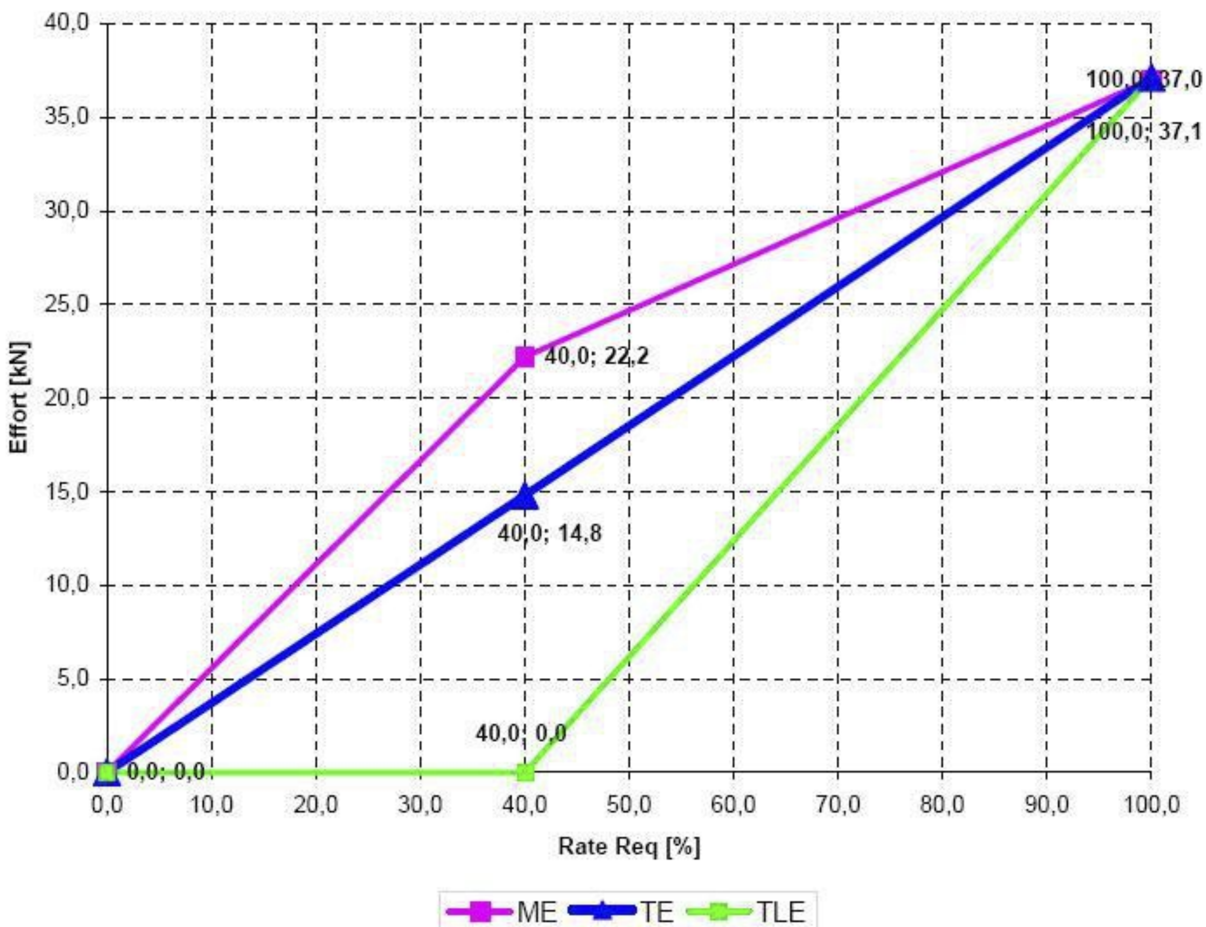


Figure 07-I-03.32 Non linear blending

NOTE: The Braking Effort not applied to the Center Truck is equally distributed on the two Motor Trucks (50% each).

[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.26 Signals used in the Speed Sensors Acquisition Module

Signal	Description
F1	Motor 1 speed sensor 1 (number of teeth counted by the speed sensor)
F3	Motor 2 speed sensor 1 (number of teeth counted by the speed sensor)
fm1	Motor 1 Axle Frequency
fm2	Motor 2 Axle Frequency
fm5	Center Truck Axle Frequency
fmot	Motor Frequency
FSP	Center Truck speed sensor positive signal (number of teeth counted by the speed sensor)

a) fmX and fm5 Sub-Modules:

fmX (X = 1 or 2) is referred to the Motor Truck.
fm5 is referred to the Center Truck
The relevant Axle Frequency is detected starting from the relevant number of teeth counted.

b) fmot Sub-module:

TCU considers the Motor Frequency Value (fmot) as the arithmetic mean between fm1 and fm2. Using the fmot (Motor Frequency), the TCU defines the freal (Power Supply Motor Frequency), the frequency of the voltage that supplies the motors (refer to paragraph 07-I-03.02.03).

[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.27 Signals used by the Spin Control Module

Signal	Description
CarSpeed	Car speed
Torque	Reference torque
fmot	Motor frequency
NinvOn	Number of inverter working on the local vehicle
RateReference	Rate Reference command
Spinning	The spinning status
TorAskSpinD	Reference torque after the spin derivative correction
TorAskSpinS	Reference torque after the spin synchronous correction
TorqueAskSpin	Reference torque after the spin control
WheelDiaCalc	Wheel diameter

When one of the axles of the truck is spinning, the Logic reduces the torque applied to that truck. By reducing the torque the truck regains traction.

There are two ways of detecting a spin:

a) Derivative Detection:

The maximum allowed motor frequency acceleration has been reached.

In this case an axle is declared to spin when the axle acceleration is above a threshold. This threshold is calculated considering two different contributions:

- The first one is based on the rate reference request coming from the Master Controller and the number of active inverters
- The second one is based on the motor frequency

b) Synchronous Detection:

The maximum allowed difference between the motor frequency and the equivalent car speed frequency was exceeded.

In case of spin the Module has two ways for calculating the torque reduction:

- Derivative Correction
- Synchronous Correction

Derivative Correction:

It reduces the torque, and then increases it again, using a step reduction and increase algorithm.

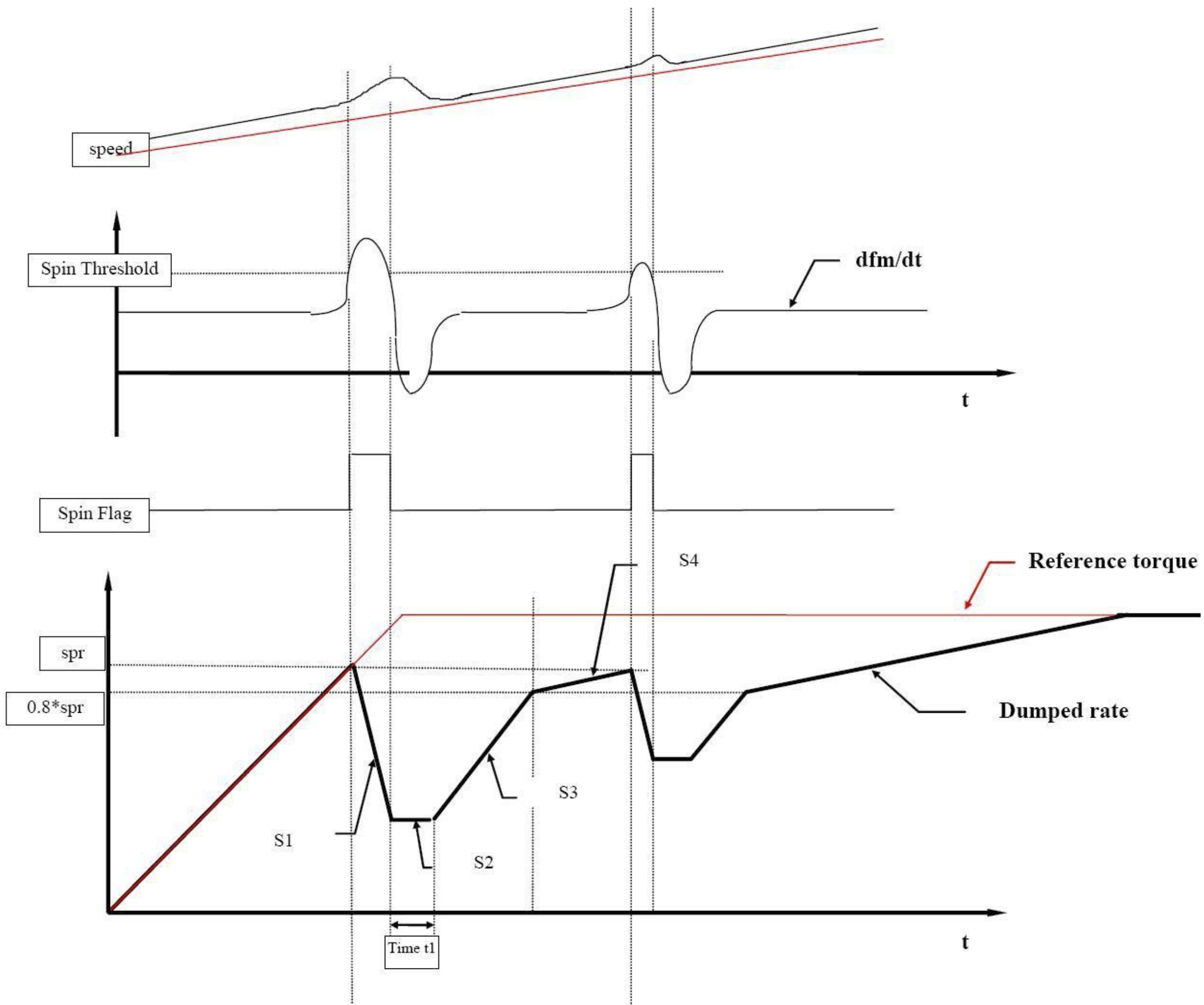


Figure 07-I-03.37 Derivative Spin Correction

Table 07-I-03.28 Derivative Spin Correction Parameters

Name	Value
K1	0.8
J1	1.0/0.3 (100% in 0.3s)
T1	0s
J2	1.0/0.2 (100% in 0.2s)
J3	1.0/5.0 (100% in 5.0s)

When one of the truck axles is spinning, the Logic reduces the torque applied on that truck using the following algorithm (Refer to Figure 07-I-03.37 and Table 07-I-03.28):

- When one of the axles is detected spinning, the spin control system saves the actual rate as “spr” (spin rate) and enters in State
- While in state 1 the Logic decreases the rate limit with a jerk rate j1 until all axles have regained traction. At this point the spin control enters State2
- While in State 2 the rate limit is kept constant for a time t1. After this time the spin control enters State3
- While in State 3 the rate limit is increased with a jerk rate j2 until a rate value equal to spr*k1 is reached. After this the system enters State 4
- While in State 4 the rate limit is increased with a jerk rate j3 until the actual rate reference is reached. This concludes the spin correction and the system goes back to State 0

In any case, if the axles are detected sliding again the system is forced to State 1 and the rate decrease starts again.

Synchronous Correction:

It reduces the torque, and then increases it again, using a continuous reduction and increase algorithm.

Taking into consideration the rotation of the axles under its control, if the TCU identifies a spin condition, then it performs the Spin correction on the whole truck, since the two axle motors are connected to the same inverter.

If the Spinning command is low, this module doesn’t apply torque reduction:

TorqueAskSpin = Torque

NOTE: the SLIDE CORRECTION MODULE (refer to paragraph 07-I-03.02.8:) is in parallel with the SPIN CORRECTION MODULE and, in case of a slide, it reduces the torque value (absolute value) as well.

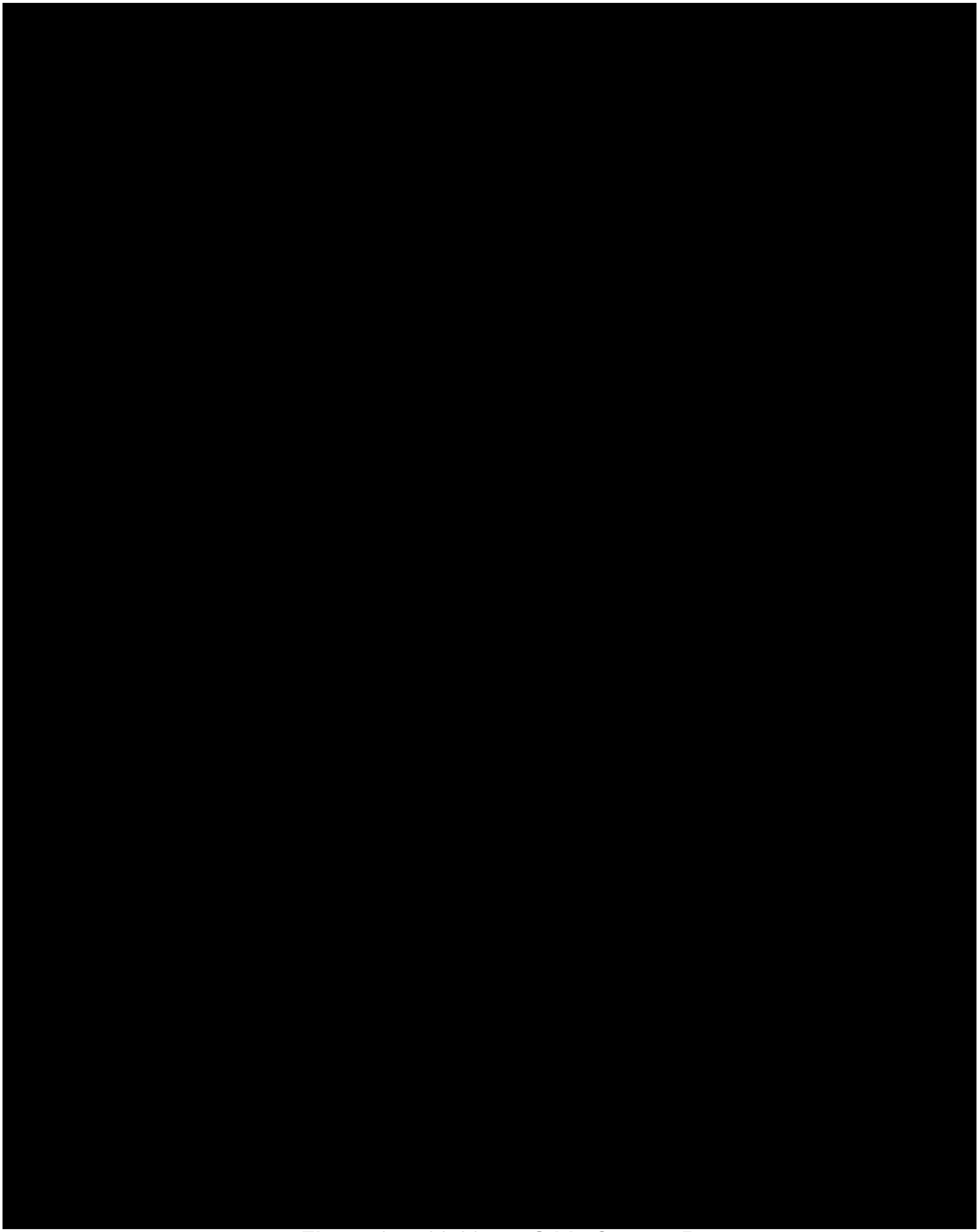


Figure 07-I-03.39 Slide Control BI

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.29 Signals used in the Slide control module

Signal	Description
CarSpeed	Car speed
Torque	Reference torque
fmot	Motor frequency
NinvOn	Number of inverter working on the local vehicle
RateReference	Rate Reference command
Spinning	The spinning status
TorAskSpinD	Reference torque after the spin derivative correction
TorAskSpinS	Reference torque after the spin synchronous correction
TorqueAskSpin	Reference torque after the spin control
Track Brake	The track brake status
WheelDiaCalc	Wheel diameter

There are two ways of detecting a slide:

- Derivative detection
- Synchronous detection

a) Derivative detection:

The minimum allowed motor frequency acceleration has been reached. In this case an axle is declared to slide when the axle acceleration is below a threshold.
This threshold is calculated considering three different contributions:

the first one is based on the rate reference request coming from the Master Controller and the number of active inverters;
the second one is based on the motor frequency;
the third one is based on the Track Brake application.

b) Synchronous detection:

In this case, an axle is declared to slide if the difference between the motor frequency and the equivalent CarSpeed frequency is above a threshold.

c) Derivative Correction:

In case of slide, the torque reduction is calculated only by a Derivative approach:
It reduces the torque, and then increases it again, using a steps reduction and increase algorithm.

Table 07-I-03.30 Derivative Slide Correction Parameters

Name	Value
K1	0.8
J1	1.0/0.3 (100% in 0.3s)
T1	0s
J2	1.0/0.2 (100% in 0.2s)
J3	1.0/5.0 (100% in 5.0s)

When one of the truck axles starts sliding, the Logic reduces the torque applied to that truck using the following algorithm:

- When one of the axles is detected sliding, the Slide Control System saves the actual rate as “spr” (spin rate) and enters State 1
- While in State 1 the logic increases the rate limit with a jerk rate J1 until all axles have regained traction. At this point the slide control enters State2
- While in State 2 the rate limit is kept constant for a time t1. After this time the slide control enters State3
- While in State 3 the rate limit is decreased with a jerk rate J2 until a rate value equal to spr*k1 is reached. After this the system enters State 4
- While in State 4 the rate limit is decreased with a jerk rate J3 until the actual rate reference is reached. This concludes the slide correction and the system goes back to State 0

In any case, if the axles are detected sliding again the system is forced to State 1 and the rate decrease starts again.

Taking into consideration the rotation of the axles under its control, if the TCU, identifies a slide condition, then it performs the Slide Correction on the whole truck, since the two axle motors are connected to the same inverter.

If the Sliding command is low, this module doesn’t apply torque reduction:
TorqueAskSlide = Torque.

NOTE: The SPIN CORRECTION MODULE (refer to paragraph: 07-I-03.02.08) is in parallel with the SLIDE CORRECTION MODULE and, in case of a spin, it reduces the torque value (absolute value) as well.

07-I-03.02.10 Car Speed Calculation Module

[redacted]

The STB board implements this module: it is a software elaboration.

Table 07-I-03.31 Signals used in the Car Speed Calculation Module

Signal	Description
CarAcceleration	Theoretical acceleration
CarSpeed	Car Speed
fm1	Motor 1 axle frequency (*)
fm1_remote	Remote cab Motor 1 axle frequency
fm2	Motor 2 axle frequency (**)
fm2_remote	Remote cab Motor 2 axle frequency
fm5	Center truck axle frequency
fm5_remote	Remote cab Center truck axle frequency
GestRemFreqOK	State of the dataset containing the remote TCU_Axle speed (information correctly transferred from the remote speed sensor)
OpMode	Operating mode request
pkFail1	State of speed sensor 1
pkFail1_remote	State of Remote cab speed sensor 1
pkFail2	State of speed sensor 2
pkFail2_remote	State of Remote cab speed sensor 2
pkFailFS	State of speed sensor center truck
pkFailFS_remote	State of Remote cab speed sensor center truck
(*) for each Motor Truck the motor axle 1 refers to the TM closest to the cow catcher	
(**) for each Motor Truck the motor axle 2 refers to the TM farthest from the cow catcher	

This module calculates the Car Speed reference. The Module uses all the vehicle axles and a virtual axle calculated considering the theoretical acceleration. The virtual axle is used as reference when all the axles are sliding.

a) Bus Control Sub-module:

The GestRemFreqOK is used to check the remote axle speed validity (the TCU communication may not be working). GestRemFreqOK signal is active only in case of a correct MVB data exchange.

b) Pk Control Sub-module:

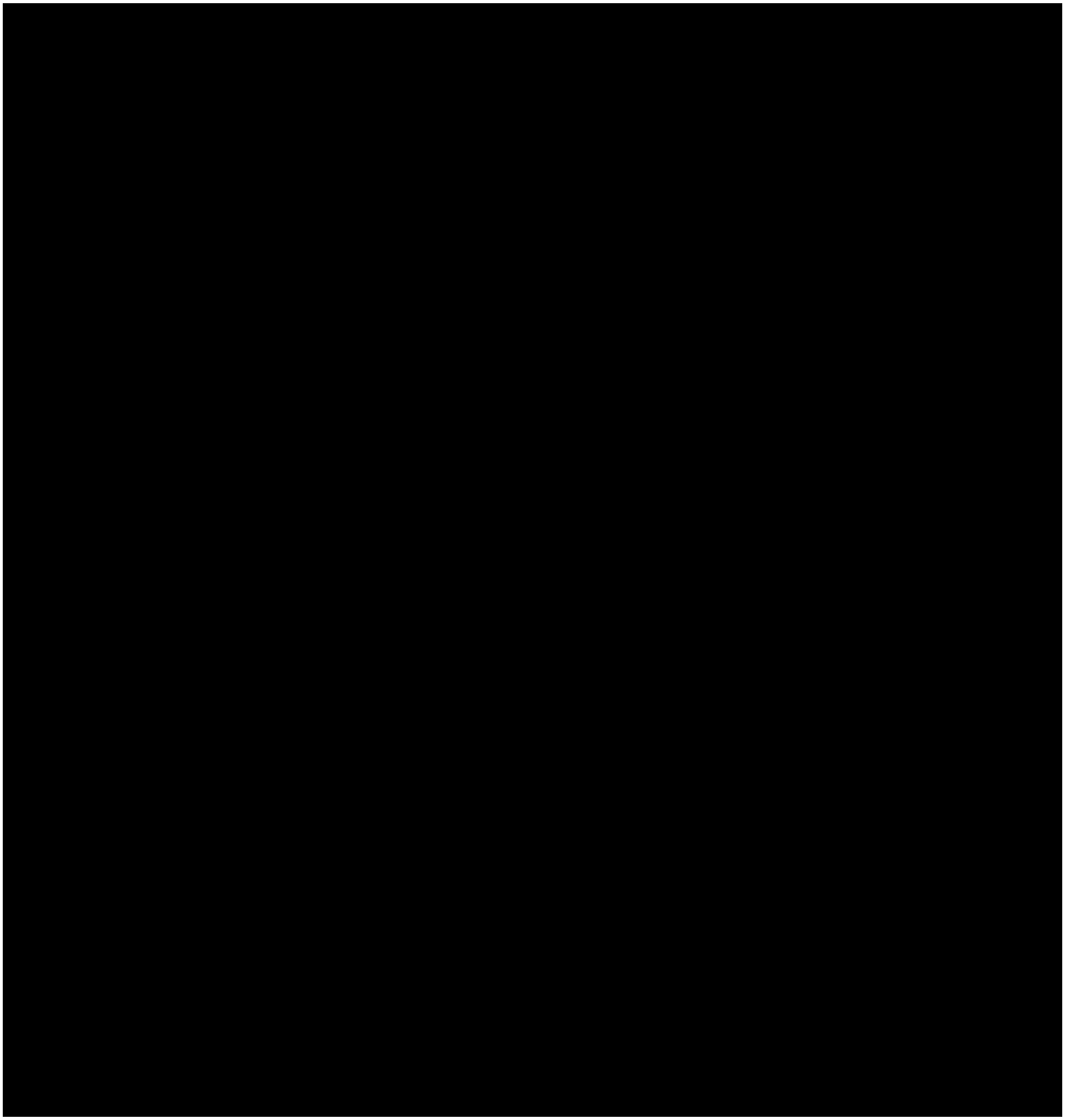
Through this sub-module, only the functioning speed sensors are considered to calculate the CarSpeed value.

c) The CarSpeed Calculation Algorithm: It

depends on the Operating mode:

- Power mode: the car speed calculation is carried out by considering the axle with the minimum frequency value (if the relative pkFail is 0, and, if it is a remote axle, then GestRemFreqOK=1)
- Braking mode: the car speed calculation is carried out by considering the axle with the maximum frequency value (if the relative pkFail is 0, and, if it is a remote axle, then GestRemFreqOK=1)
- Coast mode: the car speed calculation is carried out by considering the last reference axle (if the relative pkFail is 0, and, if it is a remote axle, then GestRemFreqOK=1)

Figure 07-I-03.42 Wheel Diameter Calculation Block Diagram



The STB board implements this module: it is a software elaboration.

Table 07-I-03.32 Signals used by the Wheel Diameter Calculation Module

Signal	Description
CarSpeed	Car Speed
fm1	Motor 1 axle frequency (*)
fm1_remote	Remote cab Motor 1 axle frequency
fm2	Motor 2 axle frequency (**)
fm2_remote	Remote cab Motor 2 axle frequency (**)
fm5	Center truck axle frequency
fm5_remote	Remote cab Center truck axle frequency
GestRemFreqOK	State of the dataset containing the remote TCU_Axle speed (information correctly transferred from the remote speedsensor)
OpMode	Operating mode request
pkFail1	State of speed sensor 1
pkFail1_remote	State of Remote cab speed sensor 1
pkFail2	State of speed sensor 2
pkFail2_remote	State of Remote cab speed sensor 2
pkFailFS	State of speed sensor center truck
pkFailFS_remote	State of Remote cab speed sensor center truck
Wd1	Diameter of the motor 1 axle wheels (*)
Wd2	Diameter of the motor 2 axle wheels (**)
Wd3	Diameter of the center truck axle wheels
Wd4	Remote Cab Diameter of the motor 1 axle wheels (*)
Wd5	Remote Cab Diameter of the motor 2 axle wheels (**)
Wd6	Remote Cab Diameter of the center truck axle wheels
WdRef	Diameter of the reference wheel
WheelDiaCalc	Wheel Diameter
(*) for each Motor Truck the motor axle 1 refers to the TM closest to the cow catcher	
(**) for each Motor Truck the motor axle 2 refers to the TM farthest from the cow catcher	

a) Bus Control Sub-Module:

The GestRemFreqOK is used to check the remote axle speed's validity (maybe the TCU communication is not working). GestRemFreqOK signal is active only in case of a correct MVB data exchange.

b) Pk Control Sub-Module:

Through this Sub-Module, only the working speed sensors are considered for calculating the CarSpeed value.

c) Wheel Diameter Calculation Sub-Module:

The Propulsion Logic makes an on-line measurement of the wheel diameters based on the known value of the reference wheel diameter (WdRef).

The first axle is taken as reference wheel.

The reference wheel diameter must be manually measured in the yard.

Then the measured value is set by means of the IDU which sends it to the TCUs. If the measured value is different from the previous one, the TCUs store the new wheel diameter reference.

The diameter of all other wheels are calculated (filtering the result) while in Coast Mode by comparing the axles' speed.

The algorithm runs only if the actual Operating Mode is COAST Mode for more than 2s. After this time the calculation is performed (for all axles) only if the following conditions are met:

- CarSpeed is above 12Hz (6mph)
- CarSpeed is below 50Hz (25mph)
- The speed sensor is working properly

WheelDiaCalc is the arithmetic mean between the diameters of the two motor axles (Wd1, Wd2) and this signal is then sent to Module 10 TORQUE REFERENCE CALCULATION;Module 17 SPIN CONTROL; Module 18 SLIDE CONTROL; Module 32 STOPPING; and to Module 39 ODOMETER.

WheelDiaCalc can be between 26 inches (660mm) and 28 inches (711mm).

If the algorithm cannot calculate a wheel diameter because a speed sensor failure has been detected on that axle, the wdRef value is taken for that axle.

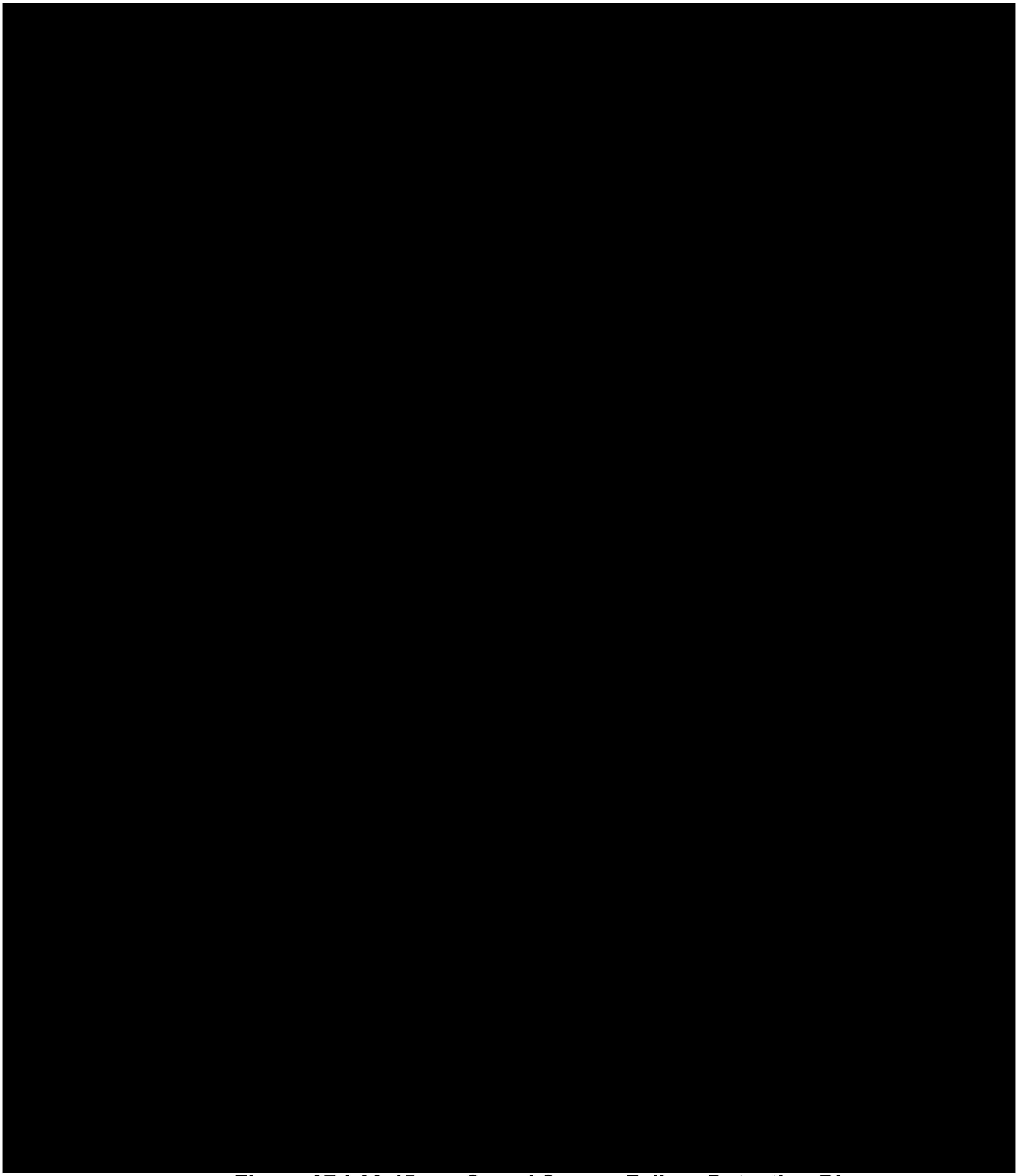


Figure 07-I-03.45 Speed Sensor Failure Detection BI

The STB board implements this module: it is a software elaboration.

Table 07-I-03.33 Signals used in the Speed Sensor failure detection Module

Signal	Description
CarSpeed	Car Speed
fm1	Motor 1 axle frequency (*)
fm1_remote	Remote cab Motor 1 axle frequency
fm2	Motor 2 axle frequency (**)
fm2_remote	Remote cab Motor 2 axle frequency
fm5	Center truck axle frequency
fm5_remote	Remote cab Center truck axle frequency
GestRemFreqOK	State of the dataset containing the remote TCU_Axle speed (information correctly transferred from the remote speedsensor)
OpMode	Operating mode request
pkFail1	State of speed sensor 1
pkFail1_remote	State of Remote cab speed sensor 1
pkFail2	State of speed sensor 2
pkFail2_remote	State of Remote cab speed sensor 2
pkFailFS	State of speed sensor center truck
pkFailFS_remote	State of Remote cab speed sensor center truck
(*) for each Motor Truck the motor axle 1 refers to the TM closest to the cow catcher	
(**) for each Motor Truck the motor axle 2 refers to the TM farthest from the cow catcher	

Each TCU checks if one of the local or remote speed sensors is not working properly by evaluating the speed signal, as follows.

a) Bus Control Sub-module:

The GestRemFreqOK is used to check the remote axle speed validity (the TCU communication may not be working). GestRemFreqOK signal is active only in case of a correct MVB data exchange.

b) Speed Sensor Failure Detection Sub-module:

The algorithm runs only while in COAST Operating Mode.

The algorithm starts the calculations 2s after the COAST Operating Mode is entered. It first considers as valid all those signals coming from the speed sensors that meet the following conditions:

- The vehicle speed is above 12Hz (6mph)
- The vehicle speed is below 50Hz (25mph)

Then, if the previous conditions are met, a speed sensor is considered to be faulty if the axle speed signal is below 10Hz (5mph).

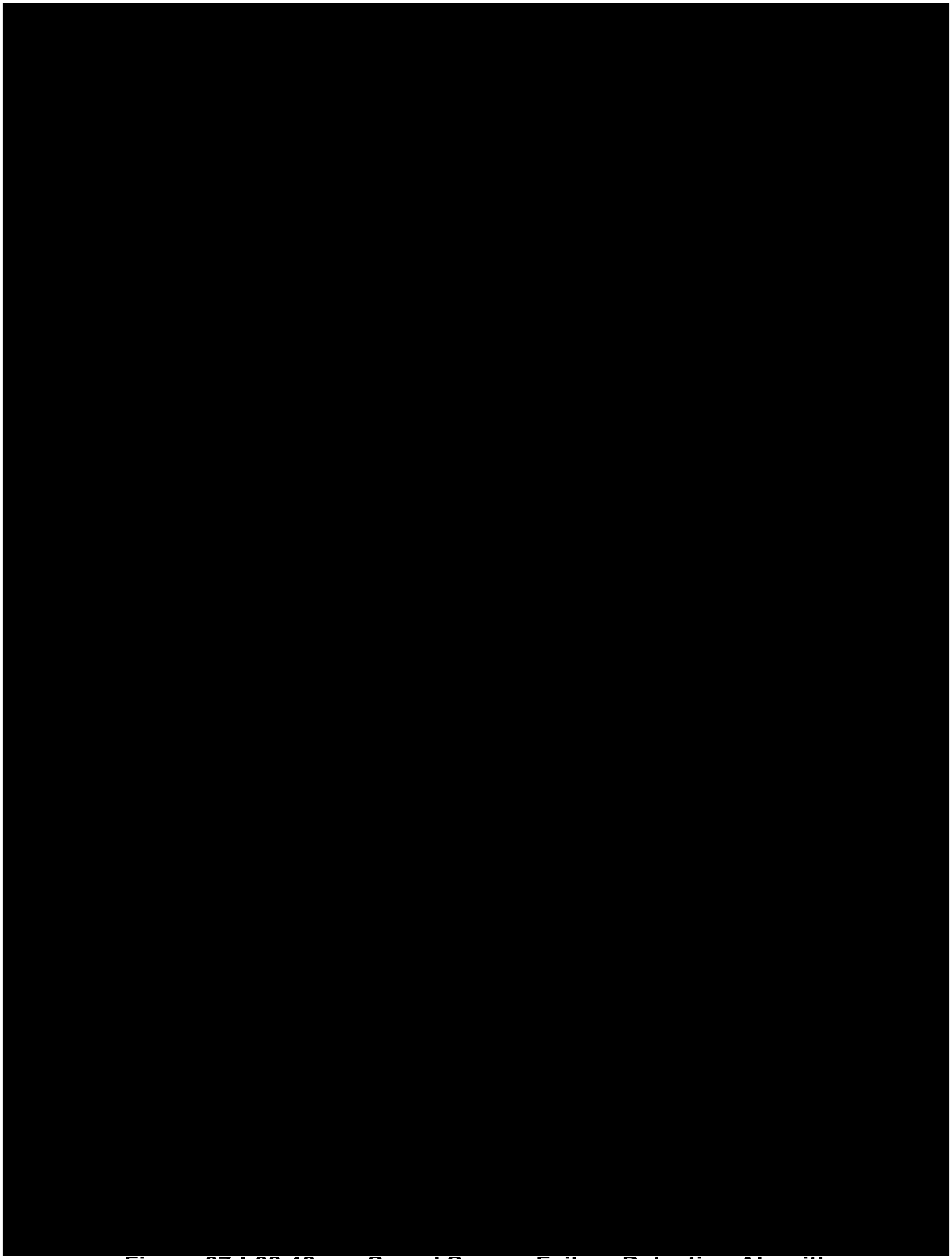
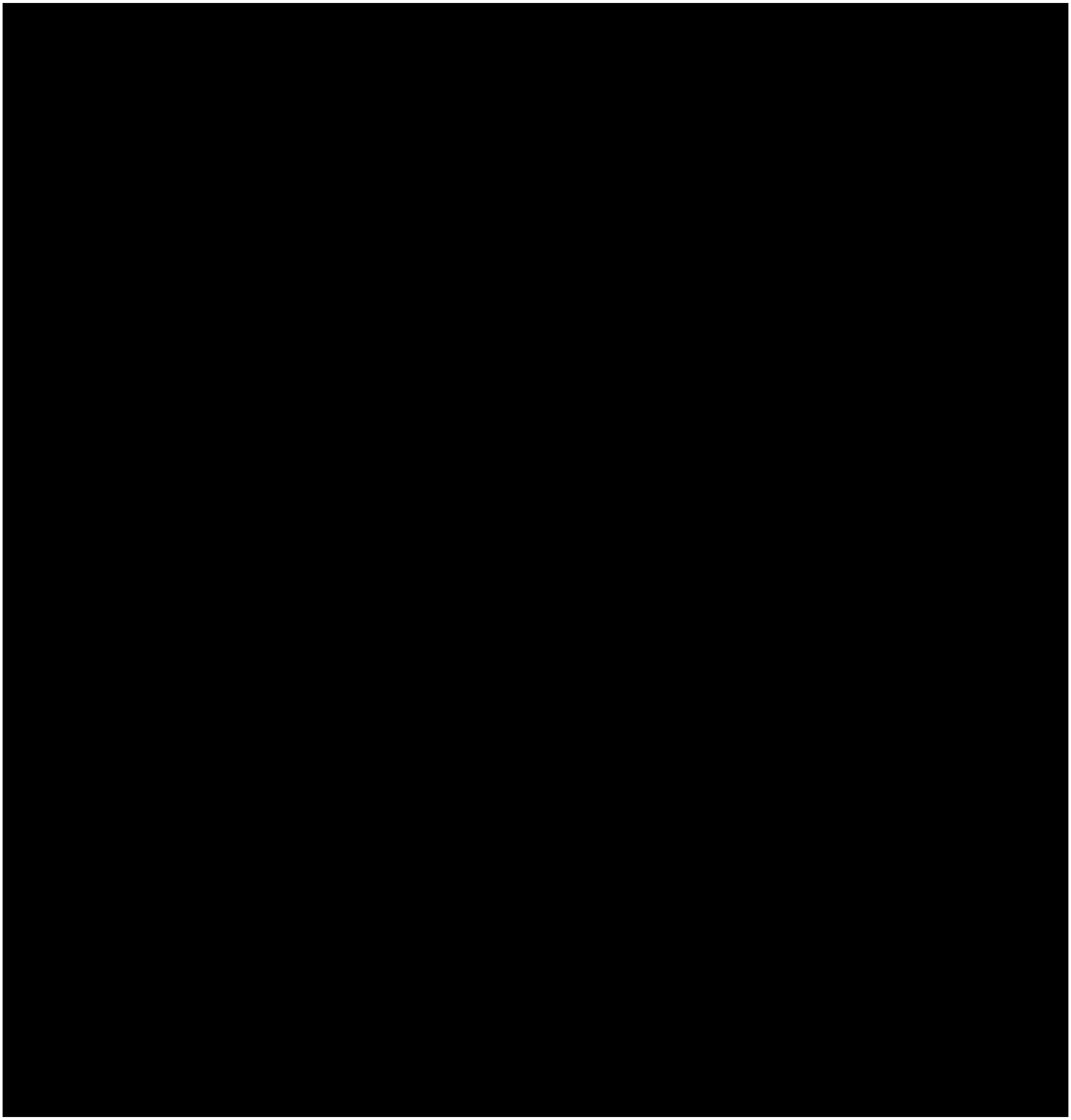


Figure 07-I-03.46 Speed Sensor Failure Detection Algorithm



This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.34 Signals used by the Overspeed Management Module

Signal	Description
CarSpeed	Car Speed
OpMode	Operating Mode Request
OverSpeed	Overspeed Condition status
VeLim	Actual Speed Limit
ZeroSpeed	Zero speed

[redacted]

In case of Overspeed, the MoT TCU generates RateReference = -100% (FSB) (refer to MASTER CONTROLLER MODULE, paragraph: 07-I-03.01.04).

Figure 07-I-03.51 Speed Limit BI

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.35 Signals used by the Speed Limit Module

Signal	Description
CarWashST	Car Wash Mode status
SpeedLim	Speed Limit Trainline status
VeLim	Actual Speed Limit

This module defines the overspeed threshold.

The speed limit threshold, named VeLim, is calculated according to the following priority table:

Table 07-I-03.36 VeLim Determination

CarWashST	SpeedLim	VeLim
0	1	maxSpeed (64mph)
0	0	SLIM (34mph)
1	1	CWSpeed (1.7mph)
1	0	CWSpeed (1.7mph)

CarWashSt status depends on CARWASH MODULE (refer to paragraph: 07-I-03.02.17)

SpeedLim status is determined depending on the following conditions related to the Train status:

- 3S09: By-pass EMI switch
- 3S07: TCU cut-out switch for the A-end and/or B-end
- 7S03: By-pass ECU_A and ECU_B switch
- 7S04: By-pass ECU_C switch
- 3K10: propulsion fault for the A-end and/or B-end
- 7B07: mechanical cut-out truck A or B
- 7B08: mechanical cut-out truck C
- 7K05: Any ECU fault

When Car Wash Mode is active the following Rate Reference limitation versus speed is imposed in Power Mode. No performance reduction is imposed in Braking Mode.

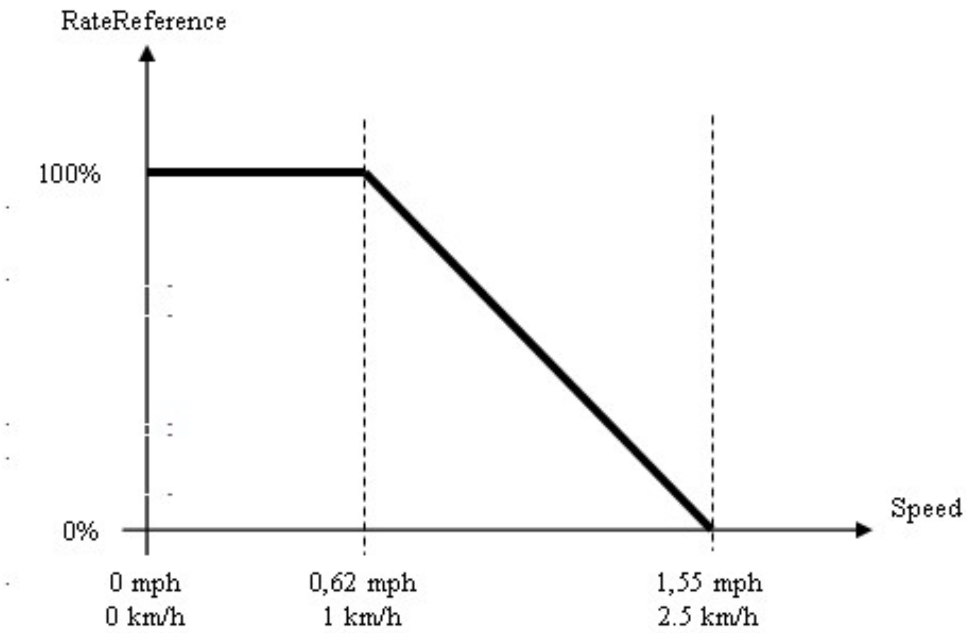


Figure 07-I-03.52 Car Wash Mode Rate Reference Limitation

When the SpeedLim mode is active (and CarWash is not) the following Rate Reference Limitation versus speed is imposed in Power Mode. No performance reduction is imposed in Braking Mode.

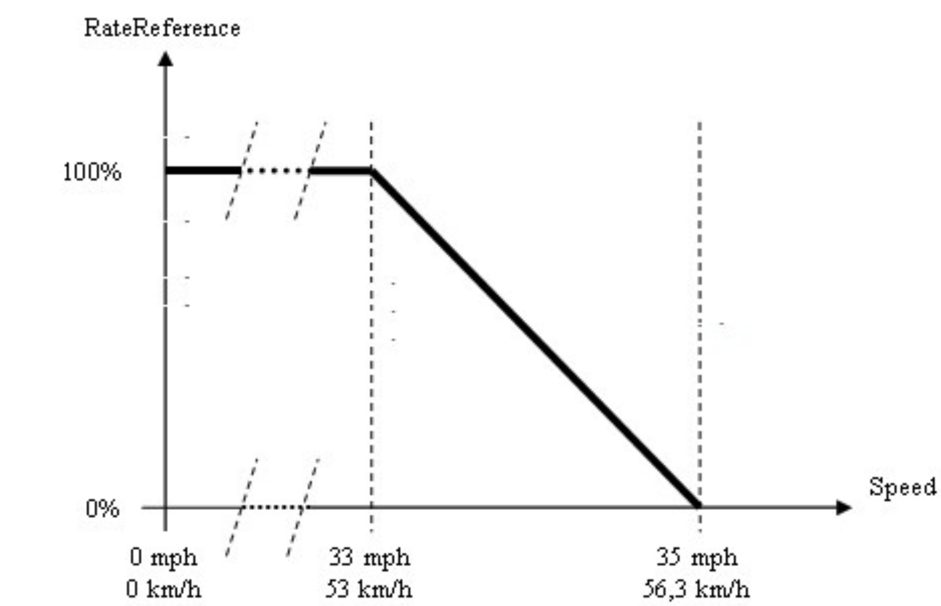


Figure 07-I-03.53 Speed Limit Mode Rate Reference Limitation

When no speed limits are active, the following Rate Reference Limitation versus speed is imposed in Power Mode. No performance reduction is imposed in Braking Mode.

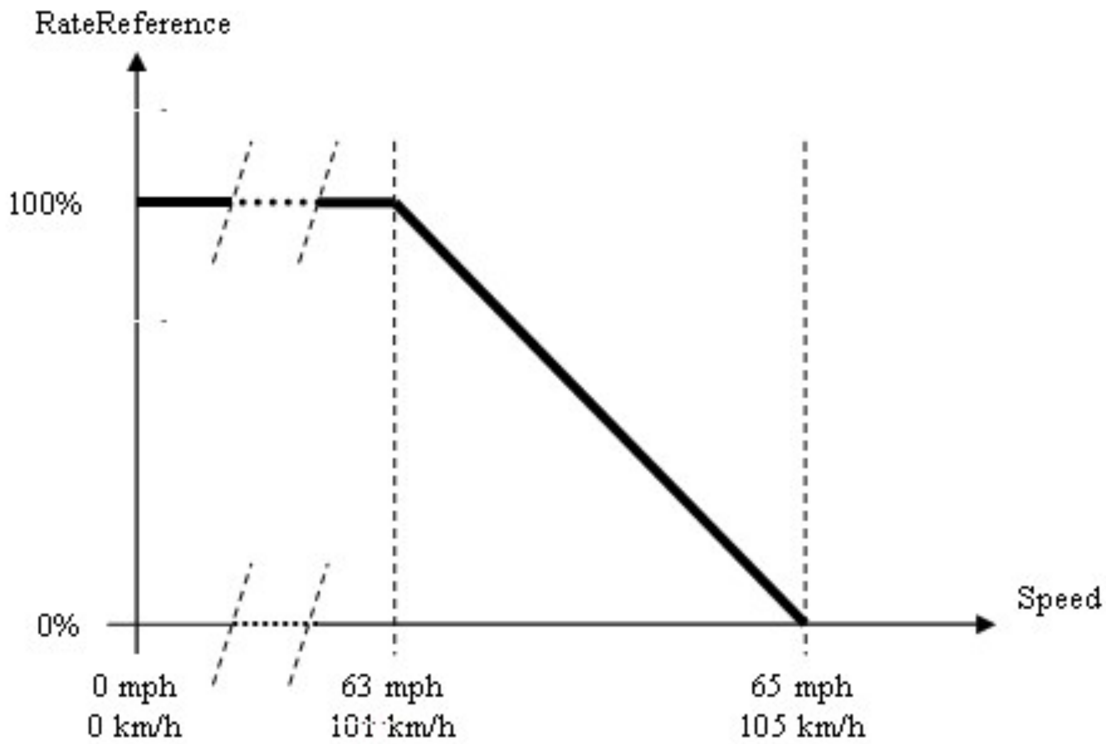


Figure 07-I-03.54 Max Speed Mode Rate Reference Limitation

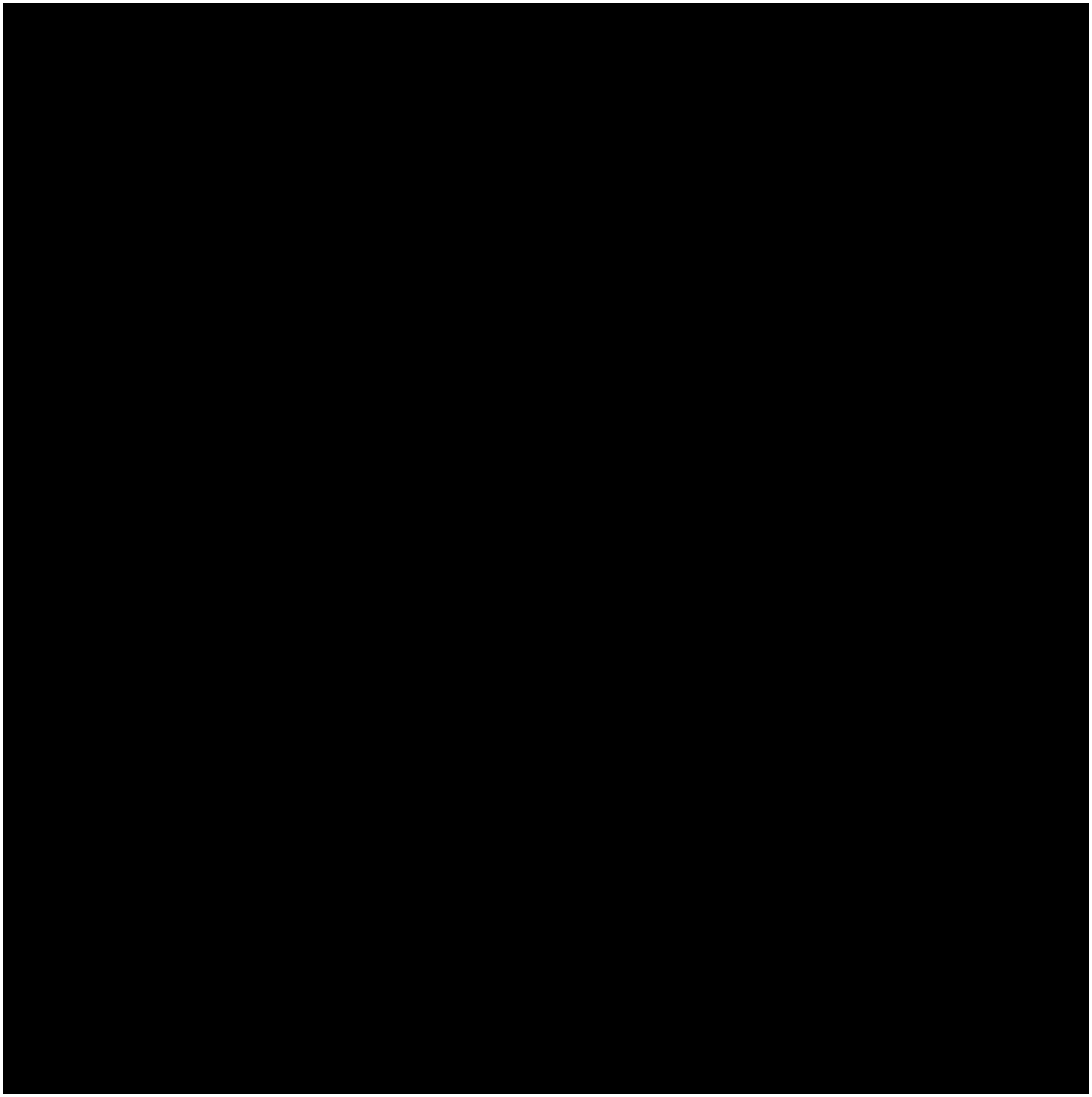


Figure 07-I-03.56 MoV/MoT Determination BI

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.37 Signals used by the MoV/MoT Determination Module

Signal	Description
Cab_A	The A Cab is active
Cab_B	The B Cab is active
MoT	The TCU is Master of Train
MoV	The TCU is Master of Vehicle
MoV_Remote	The remote TCU is Master of Vehicle
RemoteFail	The remote TCU is not working
TCU_A	The TCU is located in the A car body
TCU_B	The TCU is located in the B car body

The MoV/MoT Determination Module is used to select one vehicle TCU as Master of Vehicle (MoV) and one of the MoV TCUs in a train as the Master of Train (MoT).

TCU_B signal logic value (High or Low) is not acquired as input; it is detected starting from the TCU_A signal. In particular, TCU_B logic value is the inverse logic value of TCU_A logic value: TCU_B = not (TCU_A).

a) MoV MoT Control Logic sub-module:

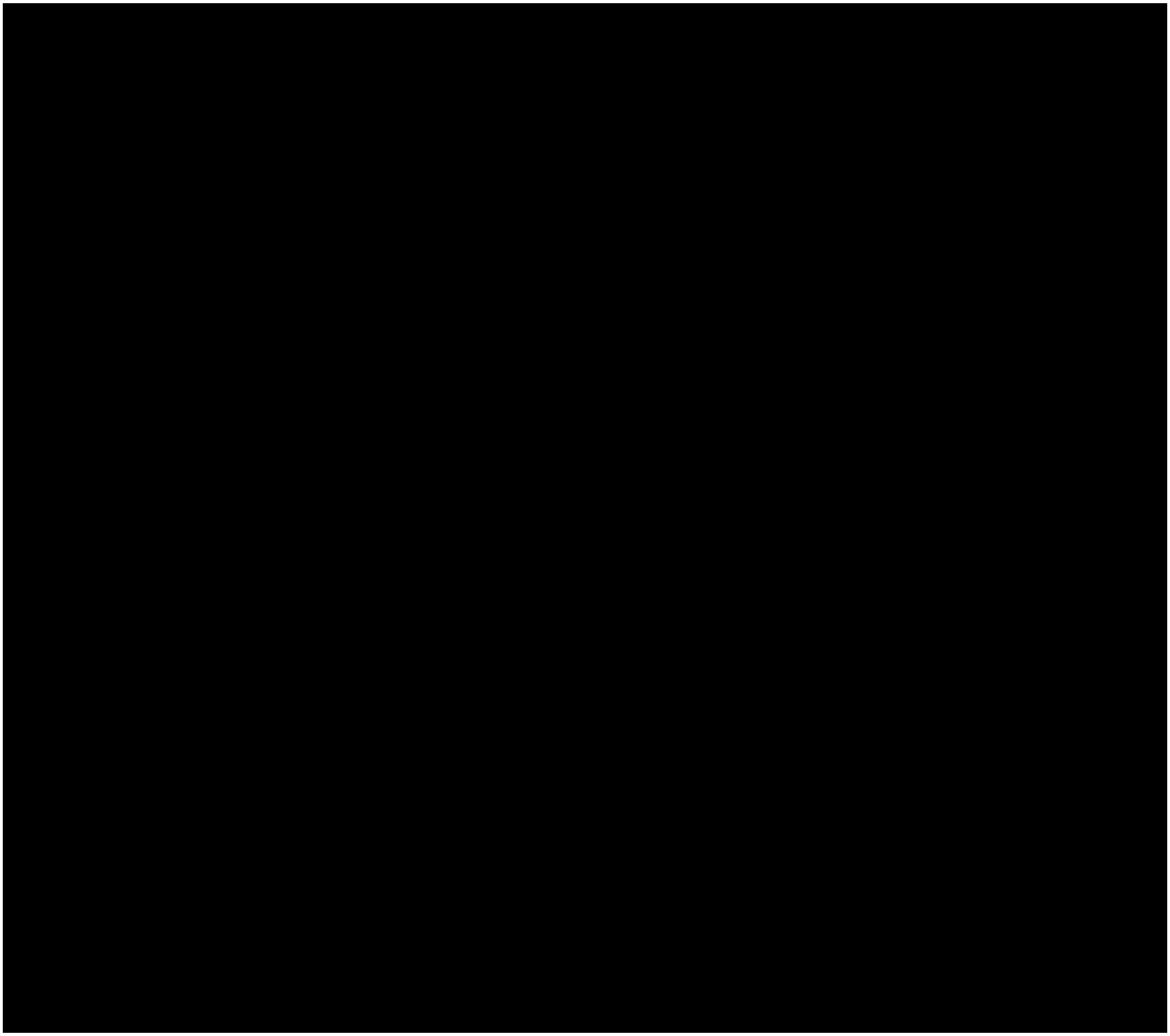
When both TCUs are operating properly, the TCU located in the A Body Section is selected as Master of Vehicle.

The B TCU can be Master of Vehicle only in case the A TCU is not working.

The Master of Vehicle located on the vehicle with the cab active is also Master of Train.

Those TCU that are not MoT nor MoV are Slave TCUs.

[redacted]



This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.38 Signals used by the Tow Mode Module

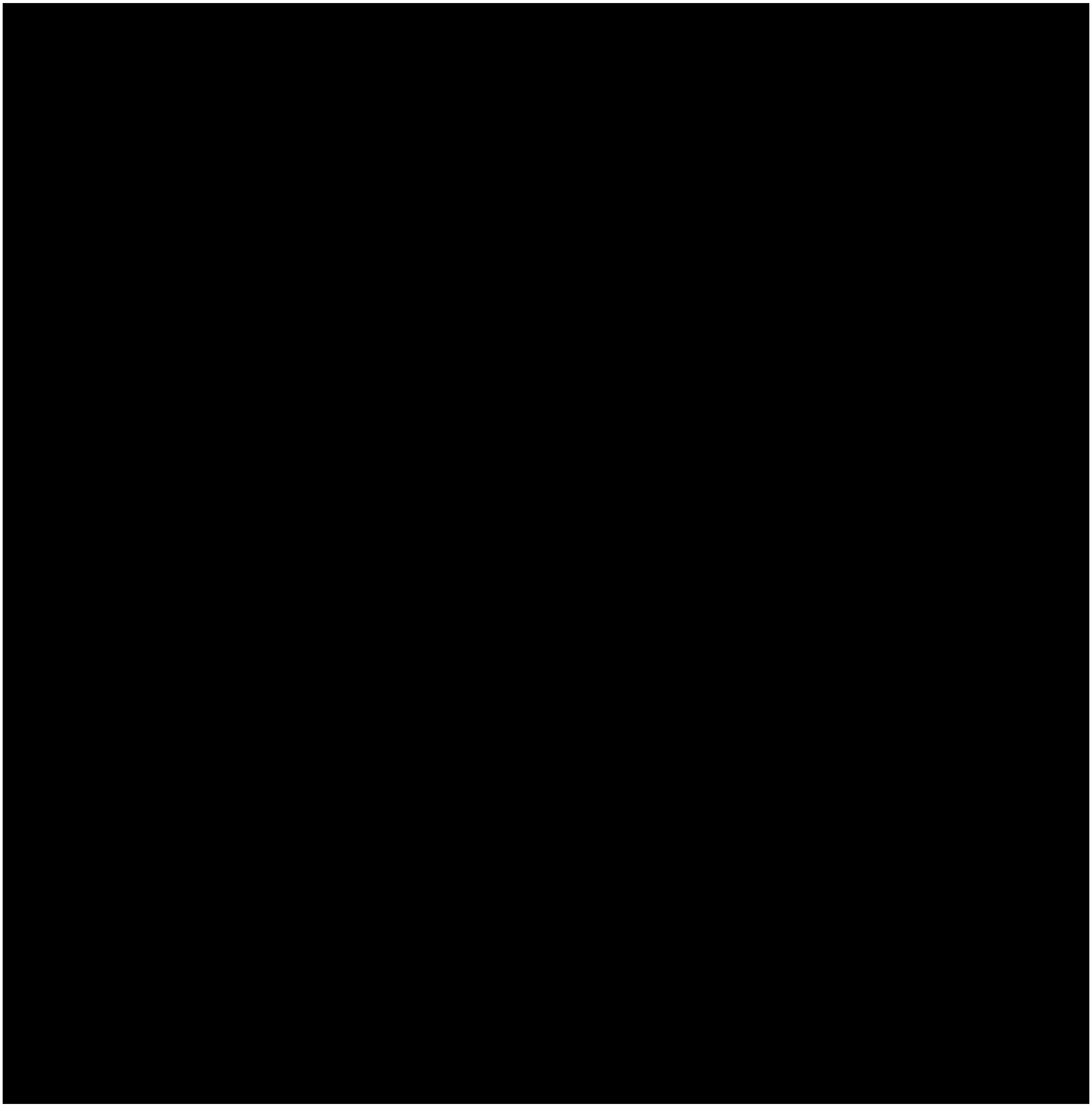
Signal	Description
OpMode	Operating Mode Request
TowingReq	Towing Mode Request status
TowingSt	The Towing Mode status
ZeroSpeed	Zero Speed

This Module is used to enable and disable the Towing Mode.

The Tow Mode can be activated or deactivated only if the vehicle is at zero speed, the Master Controller Handle is in Full Service Brake and the Towing button is kept pressed for 1 second.

The TowingSt command is sent from the Master of Train TCU to all Slave TCUs through the MVB bus.

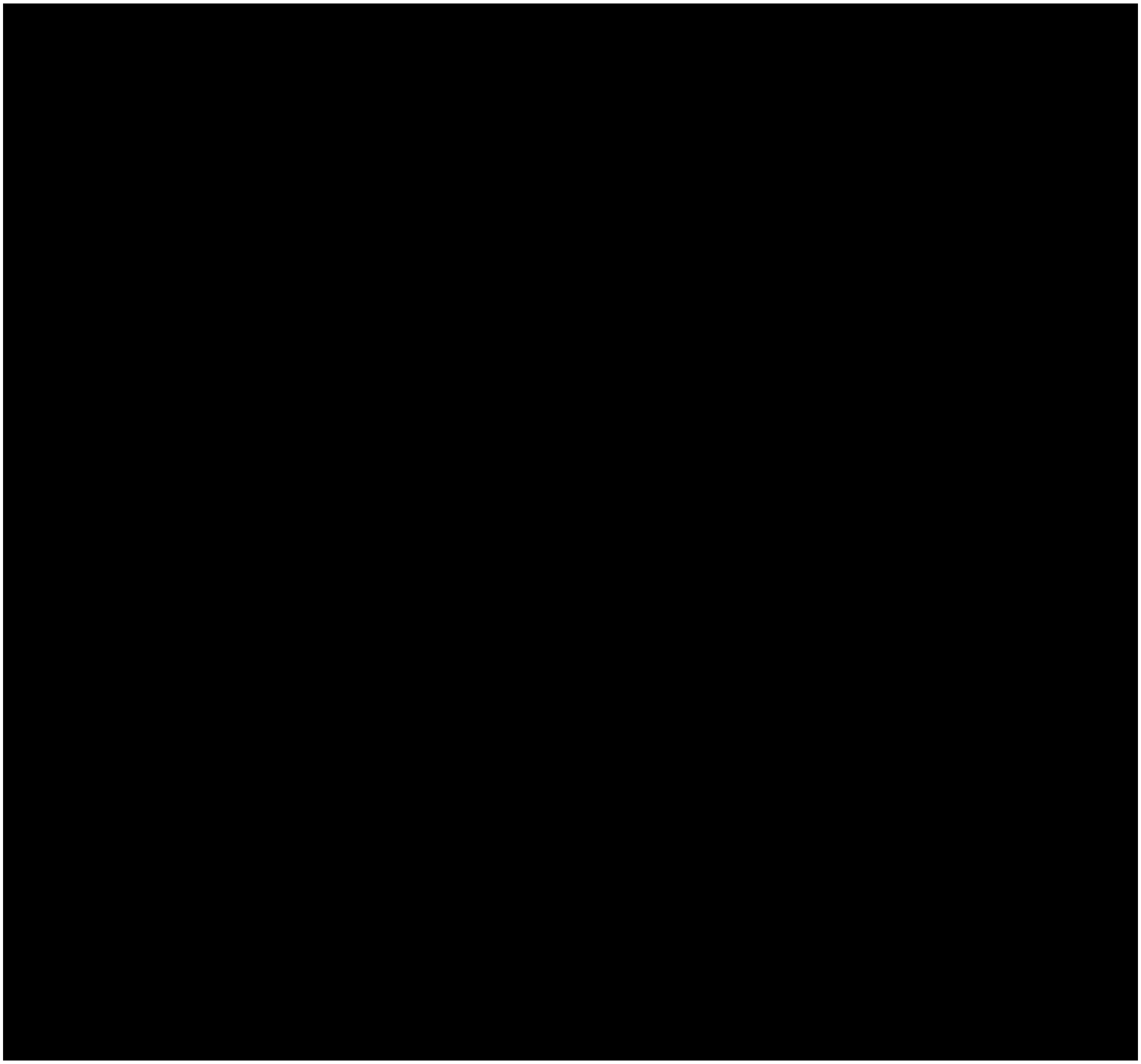
In Towing Mode, all TCUs increase the torque request by 20% (refer to paragraph: 07-I-03.02.01).



Signal	Description
CarWashReq	Car Wash Console Command
ZeroSpeed	Zero Speed
OpMode	Operating Mode Request
CarWashST	The Car Wash Mode Status

The Car Wash Mode Module is used to enable and disable the Car Wash Mode.

The Car Wash Mode can be activated or deactivated only if the vehicle is at zero speed, the Master Controller Handle is in Full Service Brake and the Car Wash button is kept pressed for 1 second.



Each TCU receiving the CarWashSt command from the MoT TCU sets the speed limit at the CWSpeed value (refer to paragraph: 07-I-03.02.14).

[redacted]

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.40 Signals used by the Filter Precharging Module

Signal	Description
CCF	CCF Contactor status
CCFcommand	CCF (Charge Contactor) Command
CP	CP Contactor status
CPcomand	CP (CP Contactor) Command
HSCB	High Speed Circuit Breaker status
iLINP	Positive Line Current (value from TAL1)
PropCutOut	Propulsion Cut Out
vFIL	Filter Voltage (value from TVF)

This module handles the Filter Precharging sequence in order to prevent any damage to the high-voltage filter.

During the Filter Precharging (start-up) the TCU opens the Propulsion Contactor (CP) and closes the Charge Filter Contactor (CCF).

In this way the TCU adds a Filter Charging Resistor (RCF) on the line. (Refer to Figure 07-I-02.9).

The opening and closing of these contactors depend on four conditions:

- Start-up: (CP: open; CCF: closed) At SW startup (when the TCU turns ON), the TCU automatically makes the Charge Filter Contactor (CCF) close and the Propulsion Contactor (CP) open, to prevent any damage to the filter capacitors. Once the HSCB is closed, the Filter Precharging sequence starts and the TCU checks the level of the filter voltage. In this configuration a charge resistor of 100Ω is placed between the filter capacitors and the line voltage and if the pantograph is up the filter starts being charged with a slow time constant.
- End of Precharge: (CP: close; CCF: open) the Module makes the Propulsion Contactor (CP) close and the Charge Filter Contactor (CCF) open. The Module switches ON the End of Precharge signal only when all the following conditions are met (refer to Figure 07-I-03.65):
  - The HSCB is closed
  - The PropCutOut command is not present which means there are no major SW or HW faults present
  - (vFIL>700V for 1sec.) or (600V<vFIL≤700V for 2sec.) or (500<vFIL≤600V for 3sec.). This condition is used to avoid having the Propulsion Contactor (CP) closed at a low level of filter voltage which could cause an instantaneous filter charge with a high current on the capacitors if the line voltage is over 750V. In this way the TCU makes the Propulsion Contactor (CP) close only when the Input Filter Capacitors are already charged
- Normal working condition: the status of CP and CCF doesn't change

- Propulsion Cut-Out: in case of Propulsion Cut-Out (PropCutOut signal active) CP and CCF are open

vFIL and iLINP (in Diagnostic Control sub-module) are used to find a precharge error in order to prevent any damage to the charge resistor.
If a precharge error is detected the Control Logic opens the HSCB contactor (refer to paragraph: 07-I-03.02.21).

[redacted]

Figure 07-I-03.67 Filter Discharging BI

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.41 Signals used by the Filter Discharging Module

Signal	Description
HSCB	High Speed Circuit Breaker status
ScaFil	Command to Discharge the Filter through the Braking Resistor
vFIL	Filter Voltage (Value from TVF)
vFIL1	Filter Voltage (Value from TVF) acquired at the HSCB tripping
vFIL2	Filter Voltage (Value from TVF) acquired 10s after the HSCB tripping

The high voltage filter has a permanent buffer of Discharge Resistors placed in parallel with the filter capacitors.

Every time the HSCB trips, the Filter Discharge starts automatically and the Control checks the Filter Discharging Time Constant.

Each inverter is equipped with 8 discharge resistors, one for each IGBT, for an equivalent discharge resistance of 3.4kΩ.

If the filter voltage is over 500Vdc, the control checks the Filter Discharge Time Constant according to the following algorithm:

- The Control stores the filter voltage after HSCB has tripped (vFIL1)
- The Control checks the filter voltage after a delay of 10s seconds (vFIL2)
- If (vFIL2>77%vFIL1) the control stores a fault named “RSFko” and sets the output SCAFIL at 1. So the chopper is fired with a fixed duty cycle of 10% to discharge the filter faster: the Braking Resistor, in parallel with the filter resistors, reduces the total resistance (refer to paragraph: 07-I-03.02.05)

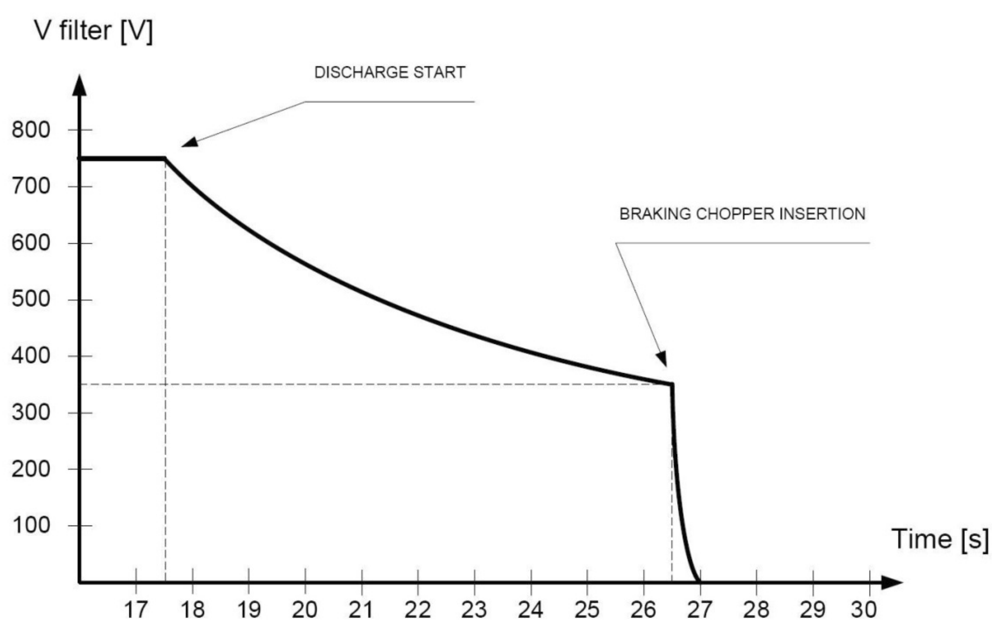


Figure 07-I-03.68 Filter Discharge

[redacted]

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.42 Signals used by the Cut-Out Module

Signal	Description
AutoCutOut	Propulsion Cut-Out Software Request
CabPropCutOut	Propulsion Cut-Out Operator Request status
OpMode	Operating Mode Request
PropCutOut	Propulsion Cut-Out
PropCutOutReq	Propulsion Cut-Out Operator Request
ZeroSpeed	Zero Speed

This Module is used to command the TCU Cut-Out. The Cut-Out command can be requested by the operator or can be forced by the SW in case of a protection intervention.

a) Operator Cut-Out Request Control Logic Sub-module:

This Module acquires and processes the driver CutOut request. This request is processed through the following finite state machine and calculates the CabCutOut signal:

[redacted]

b) The AutoCutOut Signal Generation:

The AutoCutOut Signal generation is calculated as the OR function of the following HW/SW protections:

Table 07-I-03.43 AutoCutOut determination

Protection Name	Description
DiagPerm	An Inverter Phase Module is broken
Ccfko3	Unable to command the CCF contactor
Cpko3	Unable to command the CP contactor
koTAL3	Unable to read the line current from the transducers
koTVF	Unable to read the filter voltage from the transducer
ccIR	HSCB DO channel in short circuit
irBl	Unable to command the HSCB
blkCP3	CP DO channel permanently open
blkCCF3	CCf DO channel permanently open
blkIR3	HSCB DO channel permanently open
apir3	7 HSCB trips in 5 min
KoAllThM	Unable to read the motor thermal sensors
AzioEscl	SW cut out command received by the PTU
tswEscl	A permanent thermoswitch alarm for 30min or 4 different thermoswitch Alarms.

The module calculates the PropCutOut output as the logical OR of autoCutOut and CabCutOut.

In case of CutOut the TCU opens the Propulsion Contactor (CP) and the Charge Filter Contactor (CCF) (refer to FILTER PRECHARGING MODULE, paragraph: 07-I-03.02.18).

Figure 07-I-03.73 HSCB Control BI

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.44 Signals used by the HSCB Control Module

Signal	Description
codPhw	Digital word with the Hardware protection status
codPsw	Digital word with the Software protection status
HSCBcommand	HSCB open request
PropReset	Propulsion Reset command

This module decides the opening and closing of the HSCB contactor.

The TCU must activate a digital output to open the HSCB. In this way, if a TCU is not operating (powered off), it does not prevent the other propulsion system from operating.

In the case where both TCUs are off or failed (detected by the Propulsion Fault output) the HSCB is kept open by the vehicle logic.

This Module commands the HSCB opening in case of an HW or a SW protection is active. In case of HSCB trip, the TCU maintains the HSCB open until:

there are no HW or SW protections active;

the Propulsion Reset button has been pressed by the operator;

the MoT TCU has sent the PropReset command to the MVB bus (refer to paragraph: 07-I-03.02.22).

Table 07-I-03.45 HW Protections that Cause the HSCB Tripping (codPhw)

Name	Description	Activates if	Action
SBF	Phase unbalance	Phase current difference>200A	HSCB trip
SVF2	Filter overvoltage threshold2	vFIL>1050V	HSCB trip
SCL	Line overcurrent	iLINP>600A	HSCB trip
DIAR	Inverter phase A failure	Inverter Phase A Module Diagnostic Signal is high	HSCB trip
DIAS	Inverter phase B failure	Inverter Phase B Module Diagnostic Signal is high	HSCB trip
DIAT	Inverter phase C failure	Inverter Phase C Module Diagnostic Signal is high	HSCB trip
DIACH	Inverter phase CH failure	Inverter Phase CH Module Diagnostic Signal is high	HSCB trip

Table 07-I-03.46 SW Protections that Cause the HSCB Tripping (codPsw)

Name	Description	Activates if	Action
errAT	Wrong position detected for CP contactor	Filter voltage isn't present and the CP Contactor is closed	HSCB trip
svfProl	The SVF1 protection is present for 10.0s. It's used to protect the braking resistor	vFIL>1000V for 10.0s	HSCB trip
errPrec	The maximum energy on the charge resistor has been reached.	EnergyCnt>10.0 kJ	HSCB trip
errHW	Hw doesn't follow the SW commands	Unable to open the HSCB or unable to force the chopper firing	HSCB trip
errDO	DO board failure	A DO channel error has been detected	HSCB trip
errCOM	Command error	(FWD and REV) or (POWER and BRAKE) contemporarily present	HSCB trip
ODAlarm	DO board - power supply failure	Unable to detect the power supply on the DO board	HSCB trip
STBKO	STB board communication failure	The PCA board is unable to communicate with the STB board	HSCB trip
gndFault	Ground fault	iLinP-iLinN>15A	HSCB trip

When one of the above faults occurs, the HSCB is forced open for 10 seconds and the TCU continues to keep the HSCB open as long as the HW/SW protection is active.

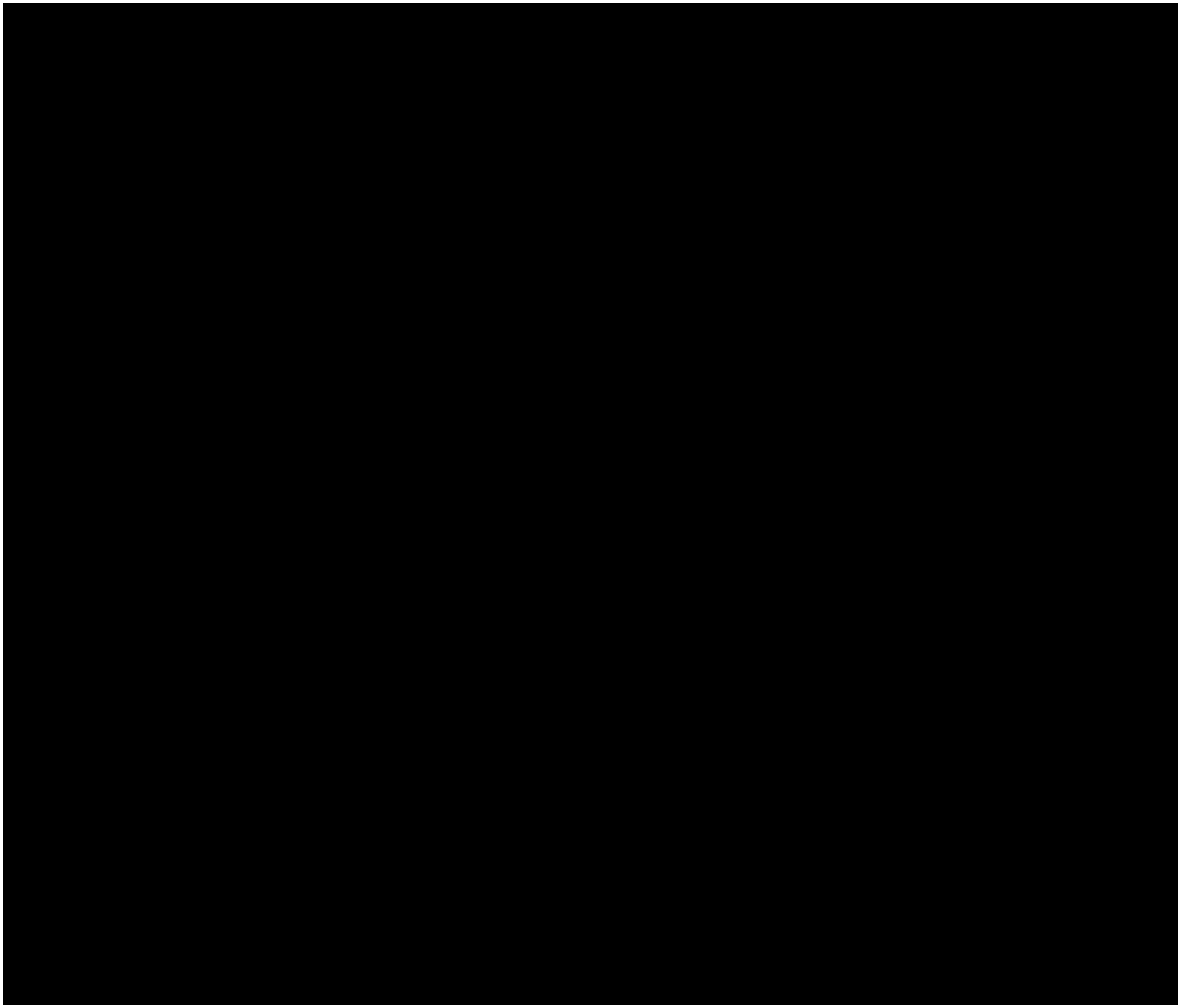


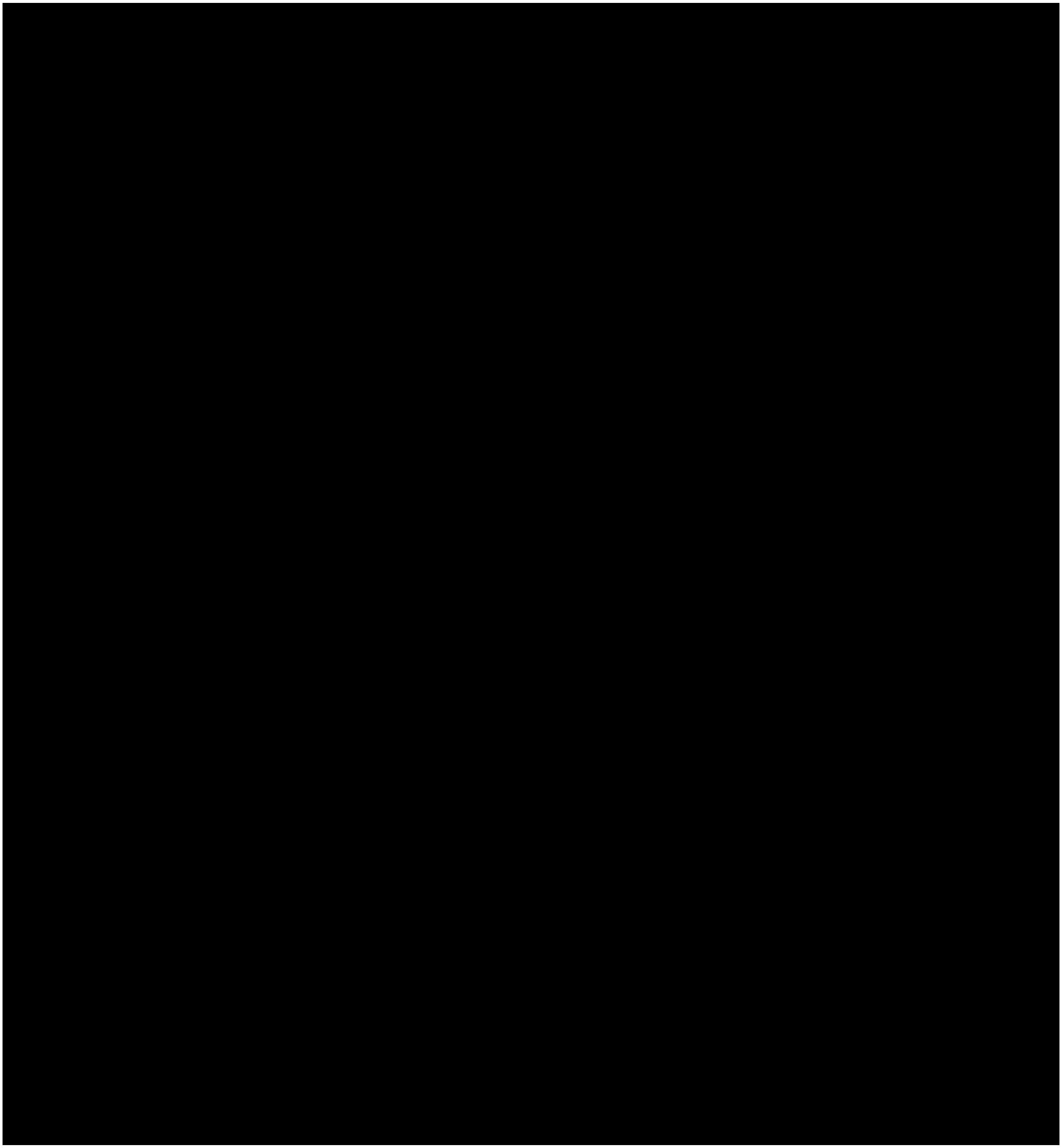
Figure 07-I-03.75 Propulsion Reset BI

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.47 Signals used by the Propulsion Reset Module

Signal	Description
propReset	Propulsion Reset Command
propResetDI	Propulsion Reset Request

The MoT TCU sends a PropReset command to all MoV TCUs if the propResetDI stays high for 300ms. The MoT TCU keeps the PropReset command high for 3 seconds more, after the propResetDI de-energization. In this way we are sure that all the MoV TCUs of the train consist receive the PropReset command.



This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.48 Signals used by the Stopping Module

Signal	Description
CarSpeed	Car speed
DeliveredEffort	The actual propulsion delivered effort
RollBack	Rollback status
Stopping	Stopping signal
TorqueAsk	Reference torque
TorqueAskSlide	Reference torque after the slide control
TorqueAskSpin	Reference torque after the spin control
TowingST	The Towing mode status
WheelDiaCalc	Wheel diameter

A digital stopping signal “stopping” is generated on the MVB bus by the Master of Vehicle TCU. This signal is read by all ECUs.

This module is used to handle the Dynamic/Friction brake coordination during the train blending phase and the initial part of the train departure (refer to paragraph: 07-I-03.02.01)

The stopping command is also used to command a brake application when a rollback is detected.

The stopping module is based on the following Diagram:

[redacted]

The stopping is activated at 6.8mph in Brake Mode, but the fade out sequence starts after 0.5s as described in the TORQUE REFERENCE MODULE (paragraph: 07-I-03.02.01).

The stopping signal is immediately activated every time a rollback is detected.

The stopping is reset over 1.2mph when the OpMode is not a brake mode.

If the vehicle is stopped then the stopping signal is reset when the Power Mode has been selected, and the Tow Mode is not selected, and no rollback is detected, and the trains speed gets to 1.2 mph or greater; or, when the delivered effort is over 15kN and the tow mode is active. This will allow us to accelerate a vehicle in AW4 load conditions up a 6% grade.

[redacted]

Figure 07-I-03.80 Rollback BI

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.49 Signals used in the RollBack Module

Signal	Description
Back	The train direction is not the requested direction
CarSpeed	Car speed
DirCmd	Direction Request
F1	Motor 1 speed sensor 1 (number of teeth detected by the speed sensor)
F2	Motor 1 speed sensor 2 (number of teeth detected by the speed sensor)
F3	Motor 2 speed sensor 1 (number of teeth detected by the speed sensor)
F4	Motor 2 speed sensor 2 (number of teeth detected by the speed sensor)
RollBack	Rollback status

The RollBack Module is used to detect a train rollback and, in that case, to force a Brake Application (refer to STOPPING MODULE, paragraph: 07-I-03.02.23).

a) Phase Control Logic Sub-module:

The two motor speed sensors have a phase displacement of 90° so this module can detect the train direction.

b) Comparator Sub-module:

This Sub-module detects if the vehicle is moving in the wrong direction (Back).

For this goal it compares the two train direction signals coming from the two phase Control Logic Sub-modules (they must be consistent) and it also compares the detected direction with the requested direction (DirCmd). It activates the Back signal if the requested direction (DirCmd) and the detected train direction (output from Phase Control Logic Sub-module) are not consistent.

c) Rollback Control Logic Sub module:

The Rollback is detected if both a maximum distance is traveled backwards or a maximum speed is reached in the reverse direction. The following diagram is implemented:

[redacted]

dRollBack: traveled back distance.

Previous dRollBack: dRollBack previously detected.

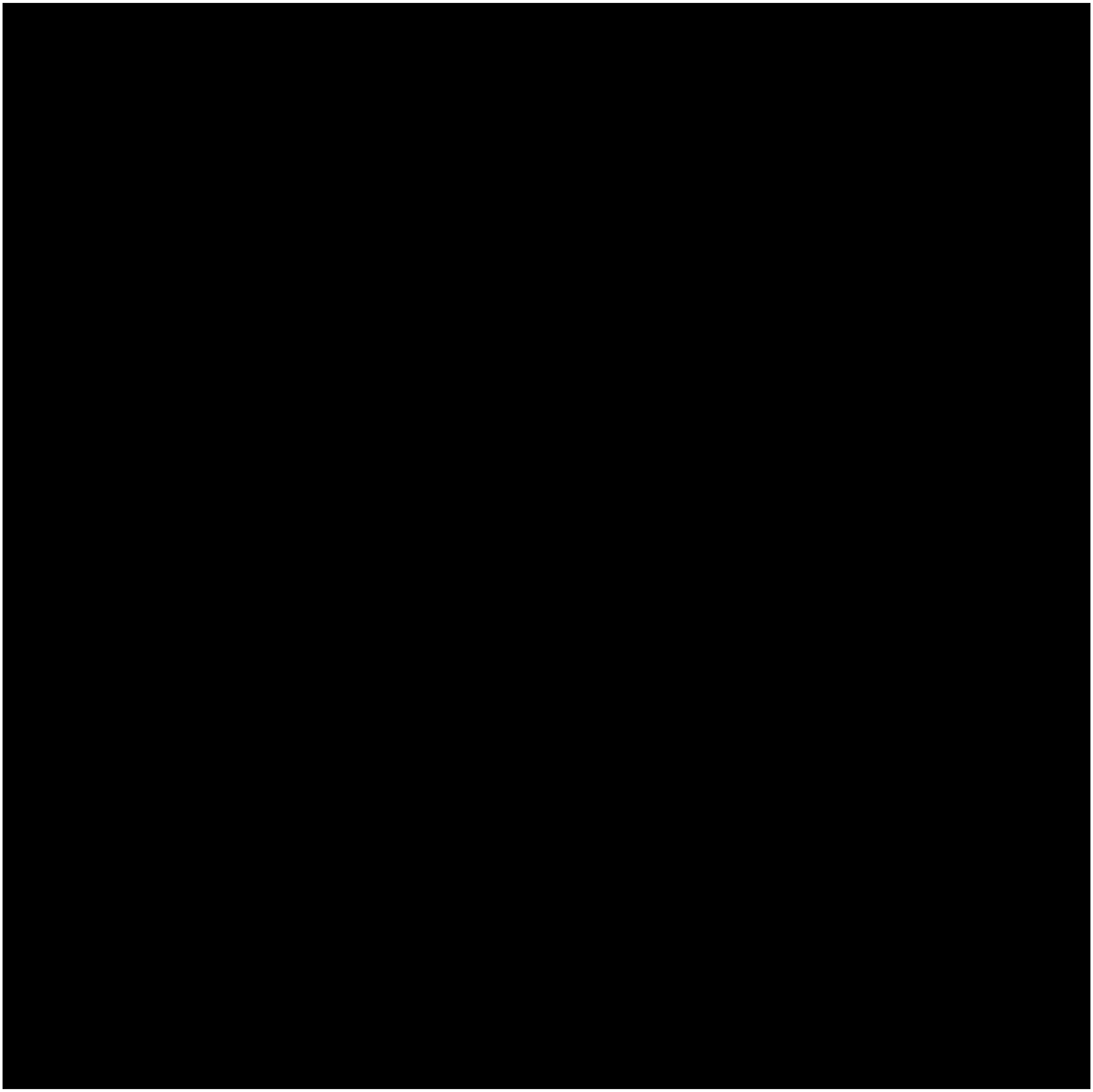


Figure 07-I-03.83 No Motion BI

The STB board implements this module: it is a software elaboration.

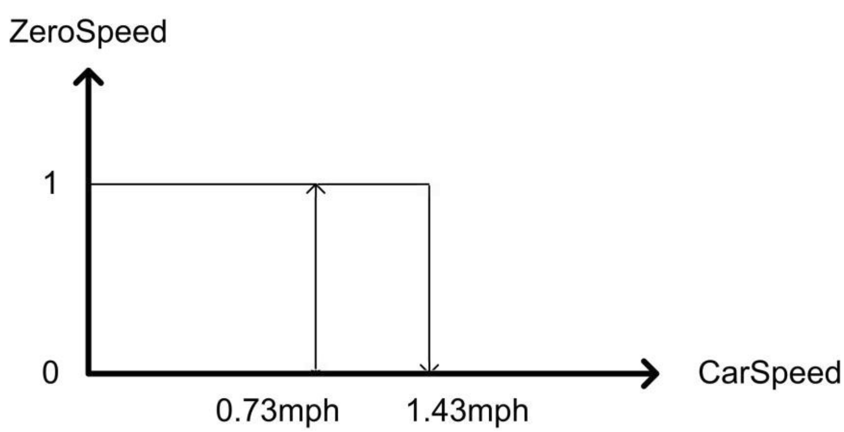
Table 07-I-03.50 Signals used by the No Motion Module

Signal	Description
CarSpeed	Car Speed
WDin	No Motion Relays driven
ZeroSpeed	Zero Speed

a) Zero Speed Evaluation Sub-module:

The vehicle speed CarSpeed is used to handle the No Motion circuit. The CarSpeed is sent to a hysteresis comparator with the following thresholds:

- Raising threshold: 1.43mph (2.3 km/h)
- Falling threshold: 0.73mph (1.4 km/h)



NOTE: When speed is decreasing, the zero speed only goes high at 0.73 mph
When speed is increasing, the zero speed only goes low at 1.43 mph

Figure 07-I-03.84 Zero Speed - Car Speed

b) Oscillator Sub-module:

If the comparator output is high, the FBK board digital input Wdin pin is toggled by the oscillator at every cycle (30ms).

If the comparator output is low, the pin toggling is stopped.

The pin toggling is used to keep the no-motion relay energized on the FBK board, if the pin is solidly high or low the No-Motion relay is not energized (refer to paragraph: 07-I-03.01.03).

[redacted]

This software elaboration is carried out by the PCA controller (C167).

Table 07-I-03.51 Signals used by the Friction Brake Interlock Module

Signal	Description
FBPA	Friction or Park Brake Applied Trainline status
TrackBrake	Track Brakes status
OpMode	Operating Mode request
ZeroSpeed	Zero Speed
FbInterlocked	Friction Brake interlocked

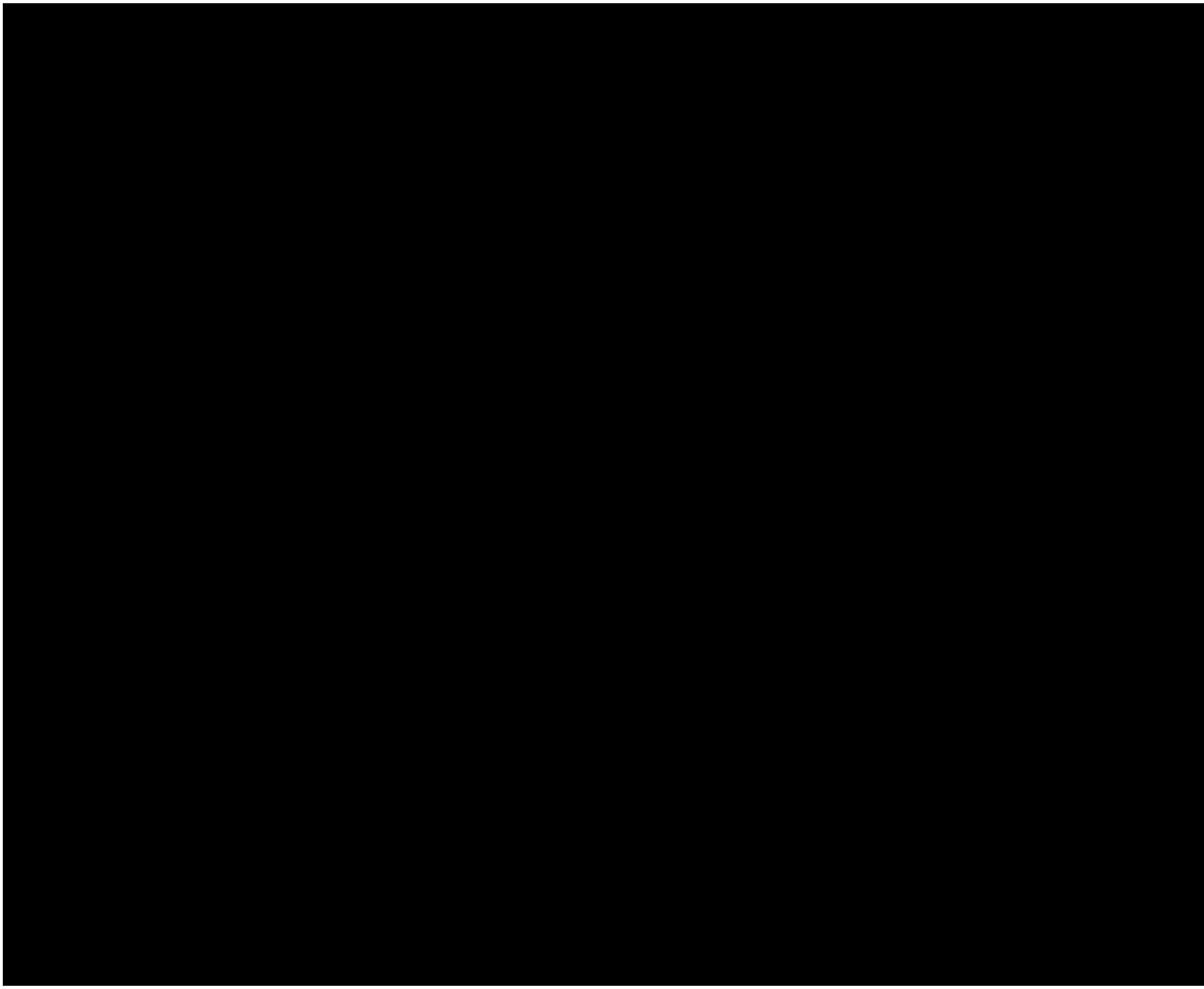
The Friction Brake Interlock Module is responsible for preventing the Power Mode from being applied when one of the friction brakes is not released.

On every vehicle the MoV TCU reads the Friction Brake Applied and the Track Brake Applied.

If either one of these is applied AND the Operating Mode is powered AND the vehicle is moving, a counter is incremented. If the counter reaches the time of 5 seconds, the output of this Module is activated and the Power Mode is disabled.

The output of this Module is de-activated only when a Zero Speed is detected.

The following diagram shows the sub-module logic:



[redacted]

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.52 Signals used by the Odometer Module

Signal	Description
WheelDiaCalc	Wheel Diameter
OdometerOut	Odometer Output (1 mile signal)
F1	Motor 1 Speed Sensor 1 (number of teeth counted by the Speed Sensor)

The Odometer Module is used to drive the electromechanical mileage counter.

Calculation block:

At every Module execution the number of teeth counted by the Speed Sensor of motor 1 (F1) is accumulated in a traveled distance counter.

When a new mile is traveled a one second pulse is generated (OdometerOut).

This signal is sent to the Odometer from the STB board (refer to paragraph: 07-I-03.01.03 Figure 07-I-03.6) to the FBK board which interfaces the TCU and Odometer.

This software elaboration is carried out by the PCA microprocessor (DSP).

Table 07-I-03.53 Signals used by the Inverter Status Module

Signal	Description
TorqueAsk	Reference Torque
TorqueAskSpin	Reference Torque after the Spin Control
TorqueAskSlide	Reference Torque after the Slide Control
StatoInv	Actual Inverter status

This module, starting from the Reference Torque, is able to evaluate the actual Inverter status (POWER or COAST or BRAKE):

Table 07-I-03.54 StatoInv determination

TorqueAsk	StatoInv
> 0	Power
= 0	Coast
< 0	Brake

NOTE: StatoInv follows the OpMode signal, during an OpMode transition. They are not always syncronized for example when the operator asks for a change of OpMode, the Inverter status (StatoInv) does not change immediately.

07-I-03.02.29 MVB Bus Communication Module

Each TCU is equipped with an MVB bus connection located on the STB board.

The MVB is the fastest bus on the vehicle and is used for the following functions:

- Exchange data like RateReference and Truck Load between the TCUs and the ECUs for vehicle performances
- Send commands from the MoT TCU to the other train systems
- Send commands from the MoV TCU to the other vehicle systems
- Send diagnostic data to the IDUs
- Send the TCU state to the IDUs

The MVB Communication Module interfaces the relevant TCU with the MVB (and with the WTB through the GTW). In this way the MVB Communication Module connects the relevant TCU with all TCUs, ECUs, HVACs, Event Recorders, and IDUs of the train.

Many signals flow through the MVB. Some signals are managed by the MoT TCU, while others are managed by the MoV TCU, and other signals are acquired or sent directly.

It is a software STB board elaboration.

[redacted]

[redacted]

Table 07-I-03.55 MoV Signals used by the MVB Bus Communication Module

Signal	Description
FbInterlocked	Friction Brake Interlocked
LinearBlend	Linear Blending Mode
Stopping	Stopping Signal (to the Braking System)

Only the signal coming from the MoV TCU is acquired in order to be used in the following modules of the two TCUs of the vehicle.

NOTE: on the bus signal_0 = signal_1 and the value is the MoV value.

Example: TCU_1 is MoV (MoV_1 is high) and generates a Stopping command.

The signal sent on the bus is: Stopping_1 high. TCU_0 acquires Stopping = Stopping_1 (high) for its TORQUE REFERENCE EVALUATION MODULE (refer to paragraph: 07-I-03.02.01) and sends the signal Stopping_0 = Stopping_1 (high).

Table 07-I-03.56 MoT Signals used in the MVB Bus Communication Module

Signal	Description
CarWashST	Car Wash Mode status
OverSpeed	Over Speed Condition status
PropReset	Propulsion Reset command
RateReference	Rate Reference command
RollBack	Rollback status
TowingSt	Tow Mode status

Only the signal coming from the MoT TCU is acquired and is used in the following Modules of the other vehicle TCUs.

A maximum of four vehicles can be coupled together in a train consist; so maximum number of TCUs to be considered is eight.

NOTE: on the bus signal_0 = signal_1 = signal_2 = signal_3 = signal_4 = signal_5 = signal_6 = signal_7, where the value is the MoT value.

Example: if TCU_4 is MoT (MoT_4 is high) it defines the RateReference value and sends the signal on the bus (RateReference_4); other TCUs acquire RateReference = RateReference_4 for their successive Modules and send the signal RateReference_X = RateReference_4.

[redacted]

Table 07-I-03.57 Signals used in the MVB Bus Communication Module

Signal	Description
diagnostic	ECU Diagnostic Signals
fm1	Motor 1 Axle Frequency
fm1_remote	Remote Cab Motor 1 Axle Frequency
fm2	Motor 2 Axle Frequency
fm2_remote	Remote Cab Motor 2 Axle Frequency
fm5	Center Truck Axle Frequency
fm5_remote	Remote Cab Center Truck Axle Frequency
GestRemFreqOK	State of the dataset containing the remote TCU_Axle speed (information correctly transferred from the remote speedsensor)
LoadC	Center Truck Percentage Load (0% à AW0, 100% à AW4)
LoadX	Local Truck Percentage Load (0% à AW0, 100% à AW4)
NinvOn	Number of Inverters in working conditions on the local vehicle
SandReq	Sand Request (to the sanders)
Sliding	The Sliding Status
Spinning	The Spinning Status
Wd1	Diameter of Motor 1 Axle Wheels
Wd2	Diameter of Motor 2 Axle Wheels
Wd3	Diameter of Center Truck Axle Wheels
Wd4	Remote Cab Diameter of Motor 1 Axle Wheels
Wd5	Remote Cab Diameter of Motor 2 Axle Wheels
Wd6	Remote Cab Diameter of Center Truck Axle Wheels
WdRef	Diameter of the Reference Wheel

NOTE: fm1, fm2, fm5 coming from TCU_A are considered fm1_remote, fm2_remote, fm5_remote by TCU_B and, vice versa, fm1, fm2, fm5 coming from TCU_B are considered fm1_remote, fm2_remote, fm5_remote by TCU_A.

d) MVB Failure Scenario

MVB Bus has a redundant bus architecture that makes MVB Bus failure very sporadic. In any case a vehicle with unoperational MVB Bus must be operated at least to be put out of service in a safe and easy way.

In case of MVB Bus failure the Dynamic-Friction Blending Algorithm is disabled and the vehicle uses only the Friction Brake. The ECUs receive the braking command directly from the trainline and when it occurs, they always apply FSB (the RateReference signal travels on the MVB Bus only, so it is not present).

The 35mph Speed Limit is applied to all vehicle TCUs (it is a trainlined signal).

07-I-03.03 IGBT Theory and PWM description

The Insulated Gate Bipolar Transistor (IGBT) is a three-terminal Power semiconductor device that combines the simple gate drive characteristics of the MOSFETs with the high current and low saturation voltage capability of bipolar transistors by combining an isolated gate for the control input, and a bipolar power transistor as a switch, in a single device.
The IGBT is used in medium to high power applications such as Switched-mode Power Supply, traction motor control and induction heating.

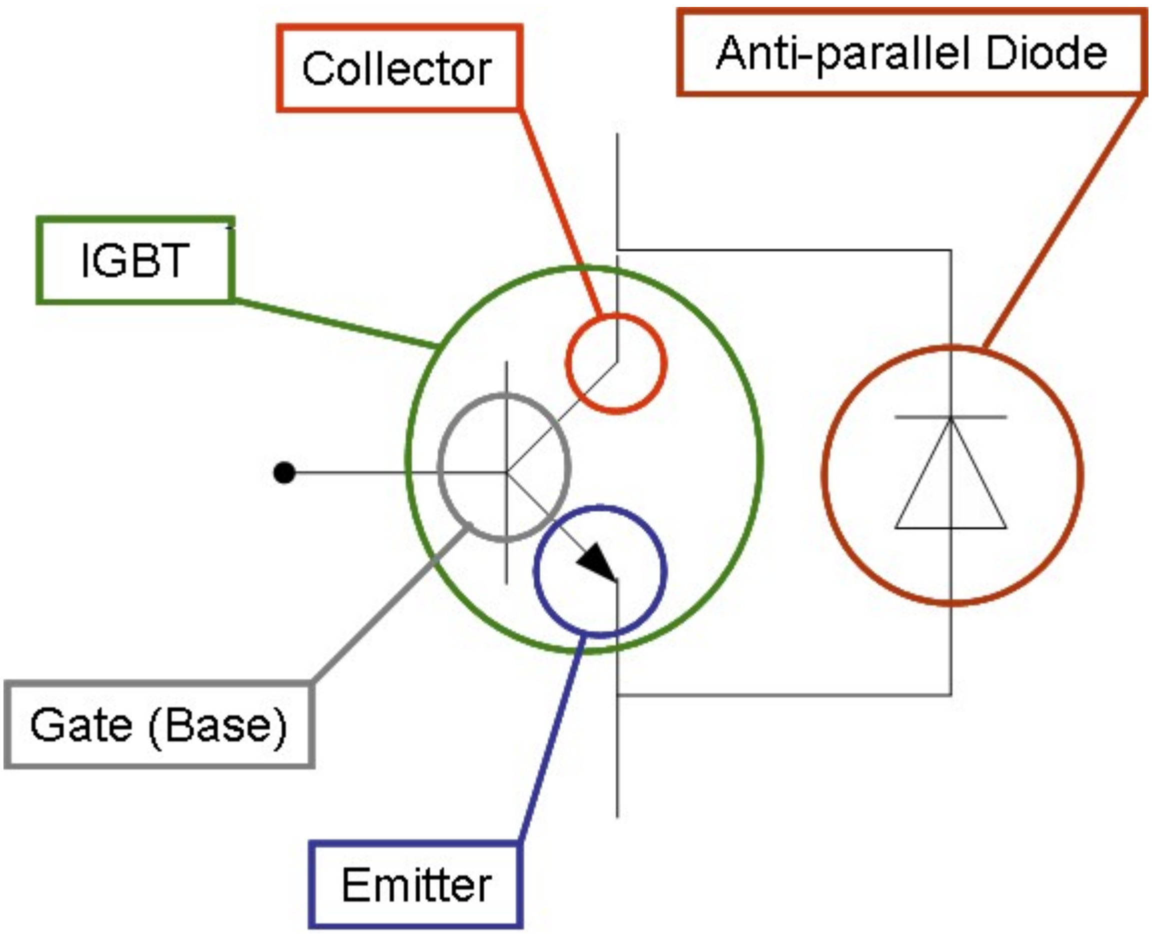


Figure 07-I-03.97 IGBT Diagram

An IGBT (refer to Figure 07-I-03.97) has three connectors: Collector and Emitter (HV) and Gate (LV).
Current flows through an IGBT only if the IGBT is turned ON and only in the direction from the Collector to the Emitter.

An IGBT is turned ON when a high signal, called Command Pulse, is present at the Gate connector; it often toggles from high to low, thus switching the relevant IGBT ON and OFF.

The also called “Free Wheeling Diode” stops the current when the IGBT is turned OFF, but permits a path for the return current from the Emitter to the Collector. It is used during a dynamic braking to permit a current path from the motors to the Catenary Line and/or to the Braking Resistor through the Braking Chopper (refer to paragraph 07-I-02.02.01.01).

Inside an Inverter Phase Module and inside the Braking Chopper the two IGBTs are arranged in half bridge configuration: the Emitter of the first IGBT is connected with the Collector of the second one (refer to Figure 07-I-03.98).

Figure 07-I-03.98 Half Bridge IGBTs configuration

The half bridge configuration allows transforming a direct Voltage (Line Voltage) into an alternate Voltage (Motor Voltage). When the upper IGBT is ON and the lower IGBT is OFF, the Half Bridge output is connected with (P) connector (with the Catenary Voltage). Instead, when the upper IGBT is OFF and the lower IGBT is ON, the Half Bridge output is connected with the (N) connector (with the Ground).

The two IGBTs can be simultaneously OFF, but cannot be simultaneously ON (it will be a short-circuit condition).

The Command Pulses regulate the opening and closing time of the IGBTs in order to control the Amplitude and the Frequency of the Input Motor Voltage, refer to Figure 07-I-03.99.

[redacted]

The Propulsion Inverter controls the Input Motor Voltage and, through this, the Motor Torque (refer to paragraph 07-I-03.04).

A 3-phase Voltage is obtained by using three pairs of IGBTs, one pair per Phase. The phase voltages are regulated in order to have the same amplitude and to be phase shifted by 120° one to the other.

Figure 07-I-03.100 Inverter Phase Modules - Motor Connection

How the Inverter Phase Module must drive the Motors during a Power Mode condition and during a Dynamic Braking condition is described in "Motoring and Dynamic Braking Mode” (refer to 07-I-03.04.04).

07-I-03.03.01 Command Pulses' Generation (PWM)

TCUs generate the Command Pulses to drive the relevant Motors.

The Sinusoidal Wave Form, output of each half-bridge IGBT configuration, depend on the relevant Command Pulses.

A Command Pulse is a toggling signal that closes (when High) the relevant IGBT (the Command Pulse gets to the Gate IGBT connector). To obtain these Command Pulses the TCUs (PCA boards) use a PWM (Pulse Width Modulation).

Figure 07-I-03.101 describes, for one phase, the Command Pulses' generation through a PWM.

[redacted]

A reference sinusoidal wave form, with the same frequency and proportional amplitude to be obtained as output, is compared to a triangular wave form (triangular wave form frequency much higher than the sinusoidal frequency).

During positive sinusoidal half periods, the highest IGBT will toggle and the lowest will be open. Vice versa, during the negative sinusoidal half period, the lowest IGBT will toggle and the highest will be open.

Command Pulse toggling Frequency is the IGBT switching frequency and it cannot exceed 1,000 Hz. This value depends on the IGBT physical construction.

Each Phase IGBT Output has the same wave form of the relevant Highest IGBT Command Pulse - Lowest IGBT Command Pulse, but with amplitude from 0 to 750 V (not considering the IGBT resistance when closed) (refer to Figure 07-I-03.102).

This wave form does not have a sinusoidal profile, but motors receive a sinusoidal wave form due to their input inductances.

07-I-03.04 AC Inductive Motor - Theory

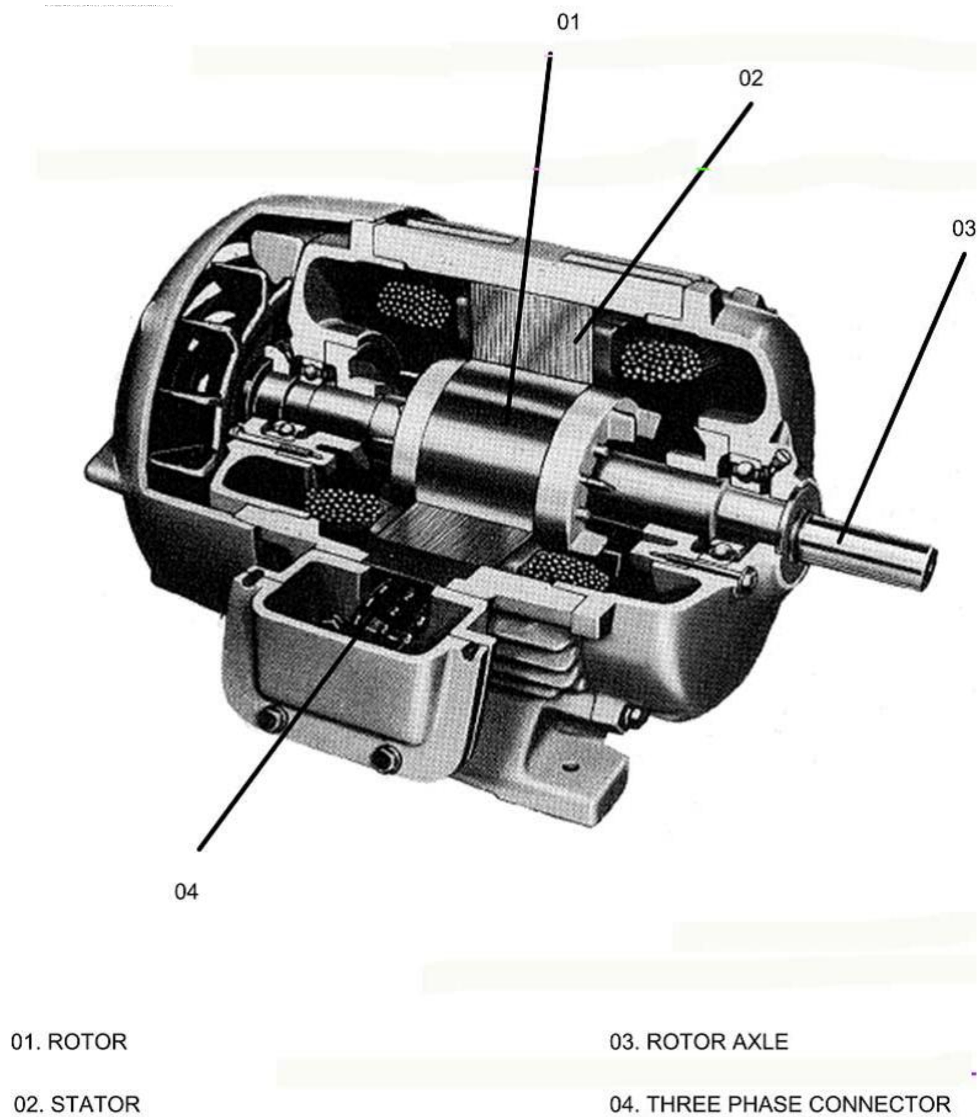


Figure 07-I-03.103 AC Inductive Motor

An AC motor is an electric rotating machine made up of two main parts:

- A Stator (motionless)
- A Rotor (can rotate)

The current in the stator through a three phase connector generates a rotating magnetic flux.

This rotating flux generates a second rotating flux on the rotor which follows the first one and makes the rotor turn.

07-I-03.04.01 Stator Rotating Flux Generation

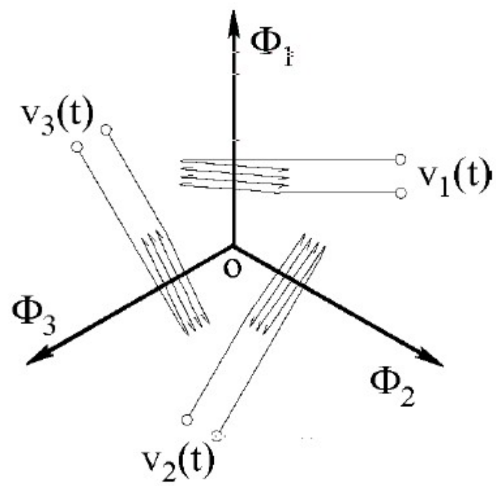


Figure 07-I-03.104 Stator Wiring

The Stator is made up of three identical windings, one per winding axis (refer to Figure 07-I-03.104). Each winding axis is rotated 120° with respect to the others and is supplied with a tern of alternate voltage: V1, V2 and V3.

V1, V2 and V3 have the same amplitude (Va), the same frequency (f) and are phase shifted 120° one to the other. The group of V1, V2 and V3 with these characteristics is called: “Direct Sequence Tern”.

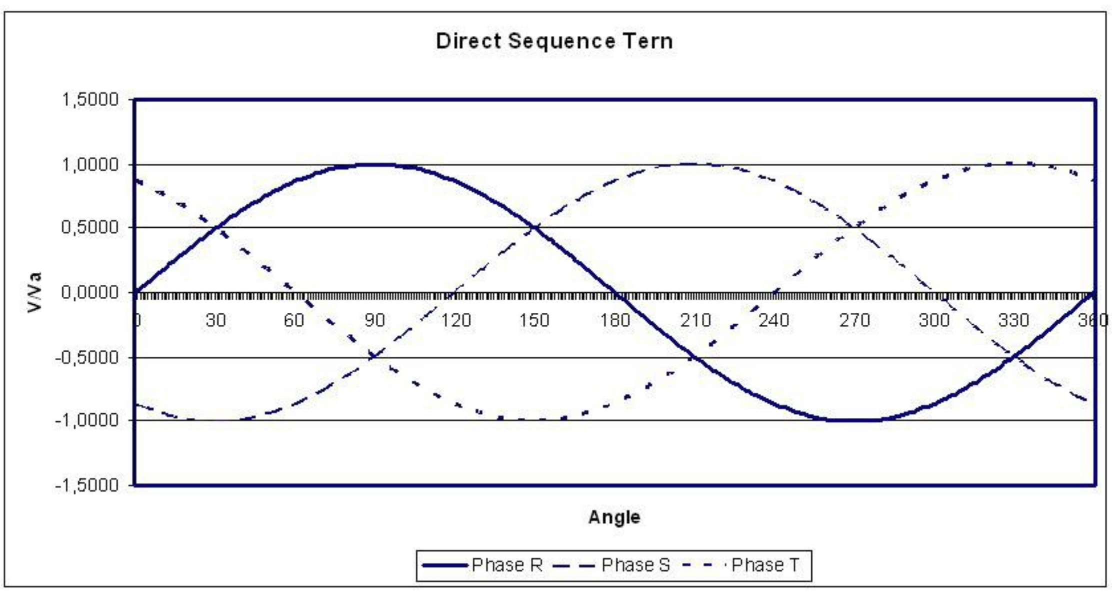


Figure 07-I-03.105 Direct Sequence Tern during a Period

The Stator Windings, supplied by means of V1, V2 and V3, generate three Magnetic Fluxes along the relevant: axis $\Phi 1$, Φ 2, Φ 3. Each axle Stator Flux is supplied with an alternate voltage and oscillates, like the relevant voltage. The sum of Φ 1, Φ 2 and Φ 3 is the Stator Flux.

The Stator Flux is a constant rotating flux. Two different ways to demonstrate it (a theoretical and a practical one) are described in the following.

Demonstration 1: The Stator Flux is a constant rotating flux

Each Axis Flux pulses along the relevant axis from -Φ max to + Φ max.. Φ max is the maximum flux amplitude (refer to Figure 07-I-03 106). Each Axis Flux ($\Phi 1$, $\Phi 2$, $\Phi 3$) can be described as the sum of two constant fluxes Φd (direct flux) and Φi (inverse flux), with constant amplitude (Φmax/2) which rotates with the same angular velocity ($\omega=2\pi f$) but opposite rotation direction with respect to the 'O' point (the center of the Winding Axis).

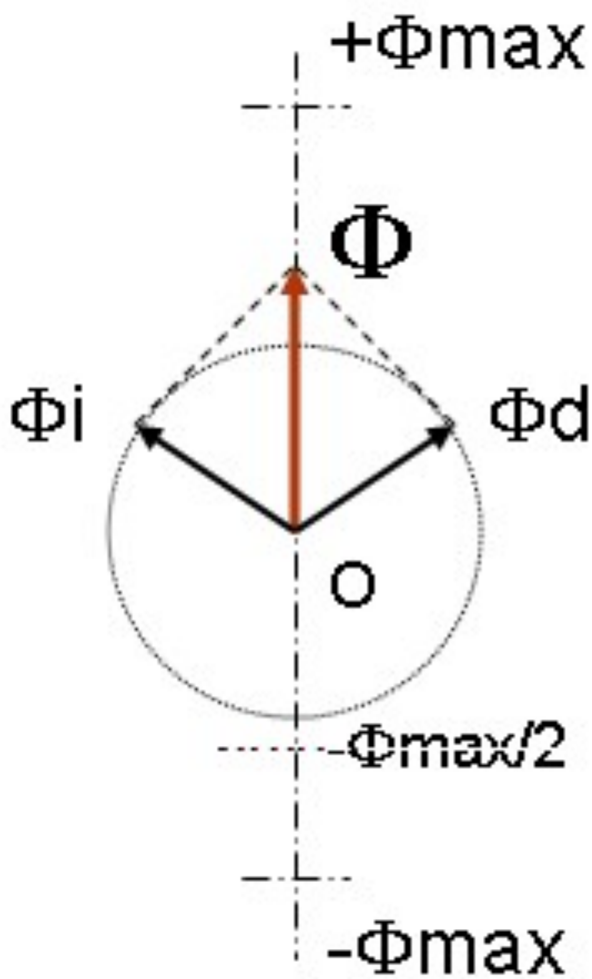


Figure 07-I-03.106 Stator Axis Flux Oscillation

The three Axis Fluxes are phase shifted by 120° one to each other (like V1, V2 and V3 that supply them). Thanks to this, at a given time the following situation can be visualized:

- $\Phi 1d$ and $\Phi 1i$ are both along the $\Phi 1$ axis ($\Phi 1=\Phi max$)
- $\Phi 2d$ and $\Phi 2i$ are not along the $\Phi 2$ axis. They will be along the relevant axis after a time t=T/3 (where T=1/f)
- $\Phi 3d$ and $\Phi 3i$ have a time lag of t=2T/3 in their axis alignment

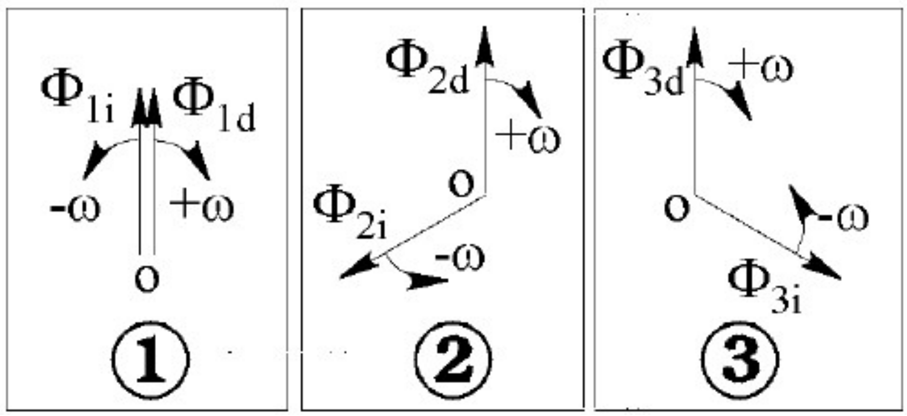


Figure 07-I-03.107 Direct and Inverse Fluxes

So, every time (refer to Figure 07-I-03.108):

- $\Phi 1i+\Phi 2i+\Phi 3i=0$
- $\Phi 1d+\Phi 2d+\Phi 3d = 3 * (\Phi max / 2)$

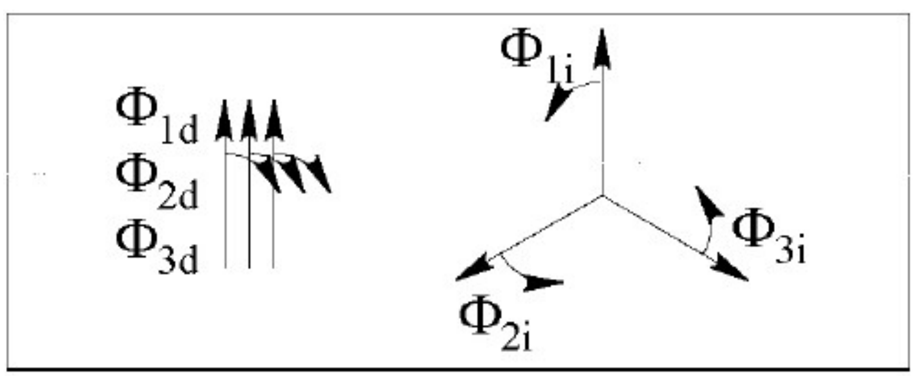


Figure 07-I-03.108 Stator Flux

So the Stator Flux is $\Phi 1+\Phi 2+\Phi 3 = \Phi 1d+\Phi 2d+\Phi 3d = 3 * (\Phi max / 2)$, constant and rotating (sum of constant and rotating, with the same rotation, fluxes).

Demonstration 2: The Stator Flux is a constant rotating flux

We can verify that the Stator Flux is a constant rotating flux by checking it point to point.
Preliminary consideration:

The three Axis Fluxes are phase shifted by 120° one to each other.
Each Phase Flux is proportional to the relevant Voltage.

Every time the sum of the three voltages of the direct Sequence Tern is zero (check Figure 07-I-03.105 to verify it).
Following the above mentioned considerations, we can draw, along the relative axis, each flux proportional to the relevant voltage (refer to Figure 07-I-03.105).

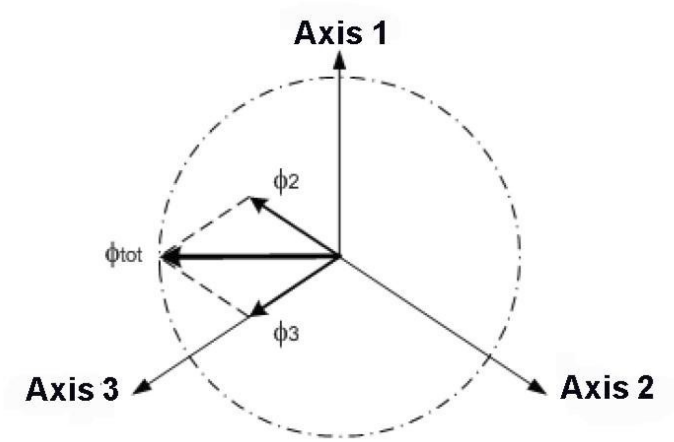
In particular (refer to Figure 07-I-03.109 and Figure 07-I-03.110).

The three fluxes are drawn starting from $\theta=0°$, every 60°, up to 300° (a whole period).

Since every time one flux is zero and the other two have the same amplitude, the chosen angles make the drawing simpler.

For each angle taken into consideration, the total flux will be $\Phi 1+\Phi 2+\Phi 3$ and it is easy to verify that for each angle the total flux amplitude does not change ($3 * (\Phi max / 2)$) and this flux completes a revolution in a Direct Sequence Tern period.

(a)



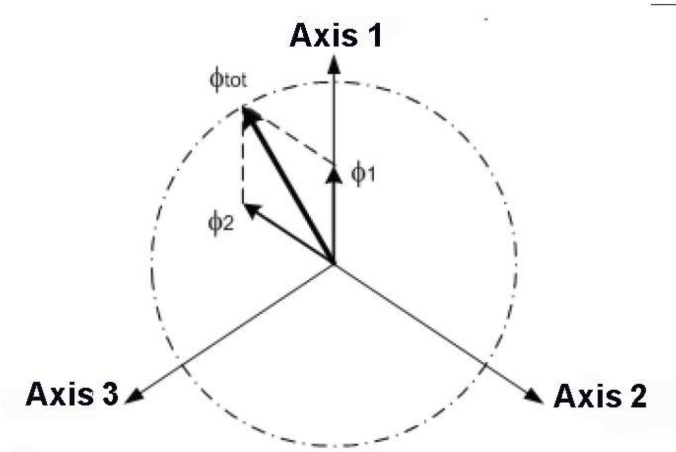
(a)

$\theta = 0°$

$\phi_1 = \phi_{max}\,|\sin(\theta)| = 0$
$\phi_2 = \phi_{max}\,|\sin(\theta\text{-}120°)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_3 = \phi_{max}\,|\sin(\theta\text{-}240°)| = (\sqrt{3}/2)\,\phi_{max}$

$\phi_{tot} = \phi_2\cos(30°) + \phi_3\cos(30°) =$
$= (3/2)\,\phi_{max}$

(b)



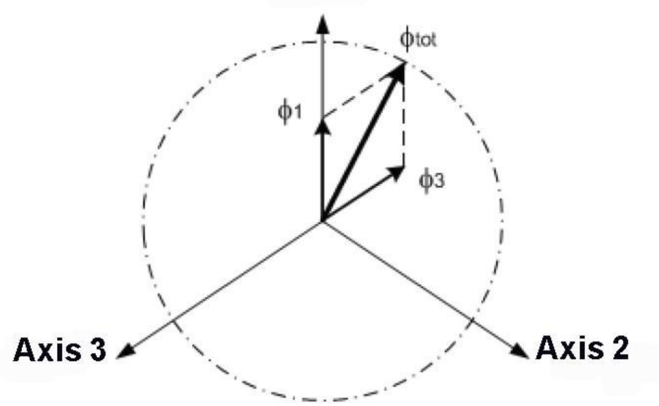
(b)

$\theta = 60°$

$\phi_1 = \phi_{max}\,|\sin(\theta)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_2 = \phi_{max}\,|\sin(\theta\text{-}120°)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_3 = \phi_{max}\,|\sin(\theta\text{-}240°)| = 0$

$\phi_{tot} = \phi_1\cos(30°) + \phi_2\cos(30°) =$
$= (3/2)\,\phi_{max}$

(c)



(c)

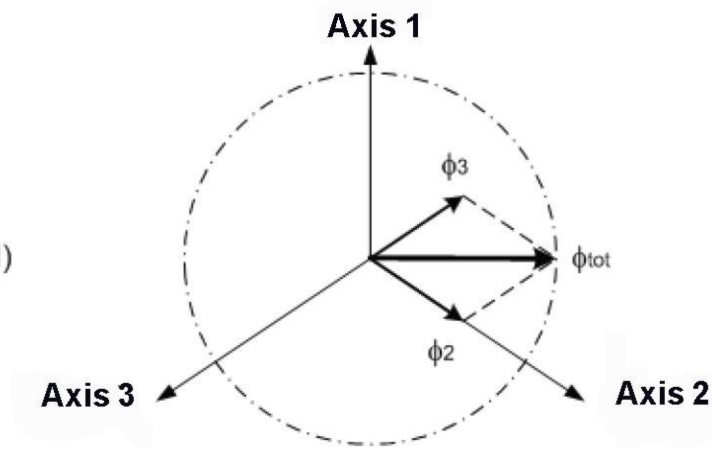
$\theta = 120°$

$\phi_1 = \phi_{max}\,|\sin(\theta)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_2 = \phi_{max}\,|\sin(\theta\text{-}120°)| = 0$
$\phi_3 = \phi_{max}\,|\sin(\theta\text{-}240°)| = (\sqrt{3}/2)\,\phi_{max}$

$\phi_{tot} = \phi_1\cos(30°) + \phi_3\cos(30°) =$
$= (3/2)\,\phi_{max}$

Figure 07-I-03.109 Stator Flux point to point (1/2)

(d)



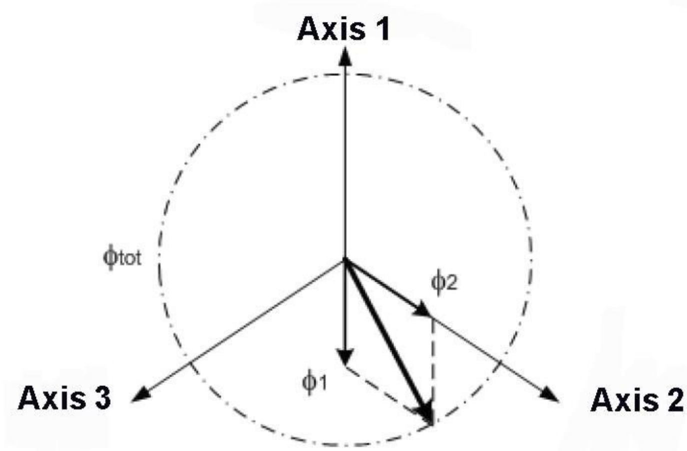
(d)

$\theta = 180°$

$\phi_1 = \phi_{max}\,|\sin(\theta)| = 0$
$\phi_2 = \phi_{max}\,|\sin(\theta-120°)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_3 = \phi_{max}\,|\sin(\theta-240°)| = (\sqrt{3}/2)\,\phi_{max}$

$\phi_{tot} = \phi_2 \cos(30°) + \phi_3 \cos(30°) =$
$= (3/2)\,\phi_{max}$

(e)



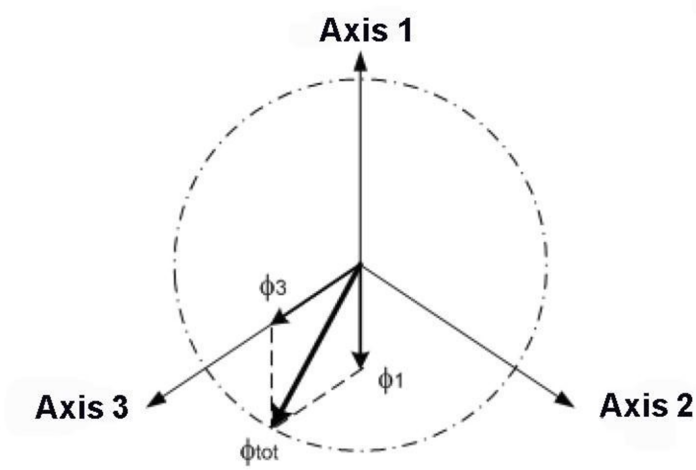
(e)

$\theta = 240°$

$\phi_1 = \phi_{max}\,|\sin(\theta)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_2 = \phi_{max}\,|\sin(\theta-120°)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_3 = \phi_{max}\,|\sin(\theta-240°)| = 0$

$\phi_{tot} = \phi_1 \cos(30°) + \phi_2 \cos(30°) =$
$= (3/2)\,\phi_{max}$

(f)



(f)

$\theta = 300°$

$\phi_1 = \phi_{max}\,|\sin(\theta)| = (\sqrt{3}/2)\,\phi_{max}$
$\phi_2 = \phi_{max}\,|\sin(\theta-120°)| = 0$
$\phi_3 = \phi_{max}\,|\sin(\theta-240°)| = (\sqrt{3}/2)\,\phi_{max}$

$\phi_{tot} = \phi_1 \cos(30°) + \phi_3 \cos(30°) =$
$= (3/2)\,\phi_{max}$

Figure 07-I-03.110 Stator Flux point to point (2/2)

The Stator Flux completes a revolution in one Direct Sequence Tern Period (1/f) then the Flux Rotating Speed [rpm] (also called Synchronous Speed) is n_{sync} = 60*f, where f is the voltage supply frequency.

n_{sync} = 60*f [rpm] is a valid formula when the Motor has a single Polar Couple, but usually the AC Inductive Motors have more than 1 Polar Couple (the P2550 LRV Motor has 2 Polar Couples) so this formula becomes:

n_{sync} = 60*f /p [rpm]

Where “f” is the Voltage Supply Frequency and “p” is the number of polar couples.

That means that the flux completes a revolution every “p” Direct Sequence Tern periods.

07-I-03.04.02 Rotor Magnetic Field and Rotor Movement

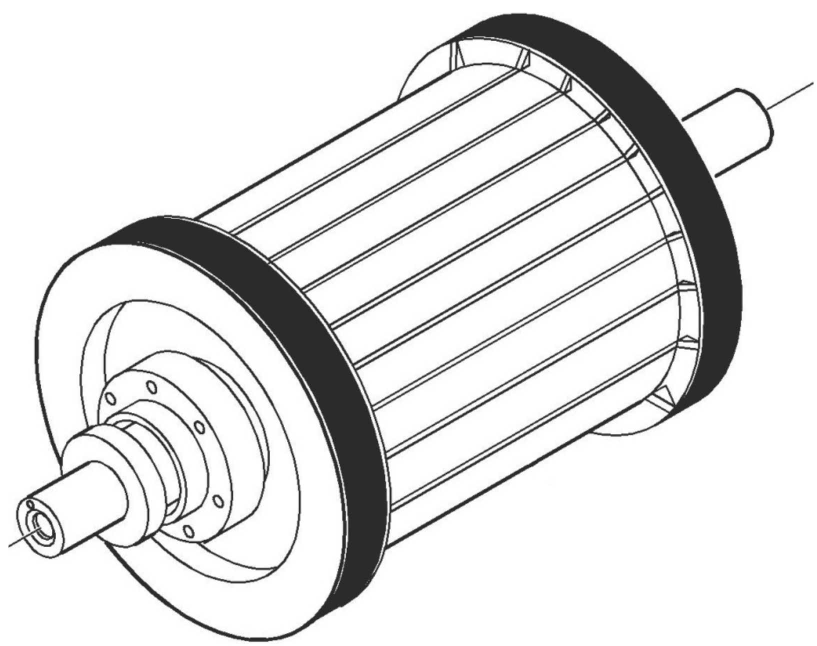


Figure 07-I-03.111 Rotor Structure

Rotors (refer to Figure 07-I-03.111) consist of a series of conducting bars laid in slots carved in the face of the rotor and shorted at either end by large shorting rings.

The rotor bars are short-circuited through the rings.

The Rotating Magnetic Field B_S passes over the rotor bars and induces a voltage in them (refer to Figure 07-I-03.112 (a)).

The voltage induced in a given rotor bar is given by the equation:

$e = (v \times B)*l$

where:
e: induced voltage
v: velocity of rotor bars relative to magnetic field l:
length of rotor bar

It is the relative motion of the rotor compared to the Stator Magnetic Field that induces voltage in a rotor bar.

The velocity of the upper rotor bars relative to the magnetic field (v) is to the left, so the induced voltage in the upper bars is towards the page.

The rotor voltage (refer to Figure 07-I-03.112 (b)) produces a rotor current flow, which lags behind the voltage because of the inductance of the rotor.
The rotor current flow produces a rotor magnetic field (B_R).

The Net Magnetic Field in the motor is $B_{net} = B_S + B_R$. B_{net} and B_R defines the rotor induced Torque (T): $T = k(B_R \times B_{net})$.

The presence of this Torque (Figure 07-I-03.112 (c)) means that there is a Force (F) that makes the Rotor rotate ($T = r \times F$).

The rotor revolution direction is the same of the Rotating Magnetic Field B_S.
However, there is a finite upper limit to the Rotor speed (n_m).

If the rotor were turning at synchronous speed (speed of the Rotating Magnetic Field B_S), then the rotor bars would be stationary relative to the magnetic field and there would be no induced voltage. With e = 0, there would be no rotor current and no rotor magnetic filed. With no rotor magnetic field, the induced torque would be zero, and the rotor would be free from forces and would slow down as a result of friction losses.

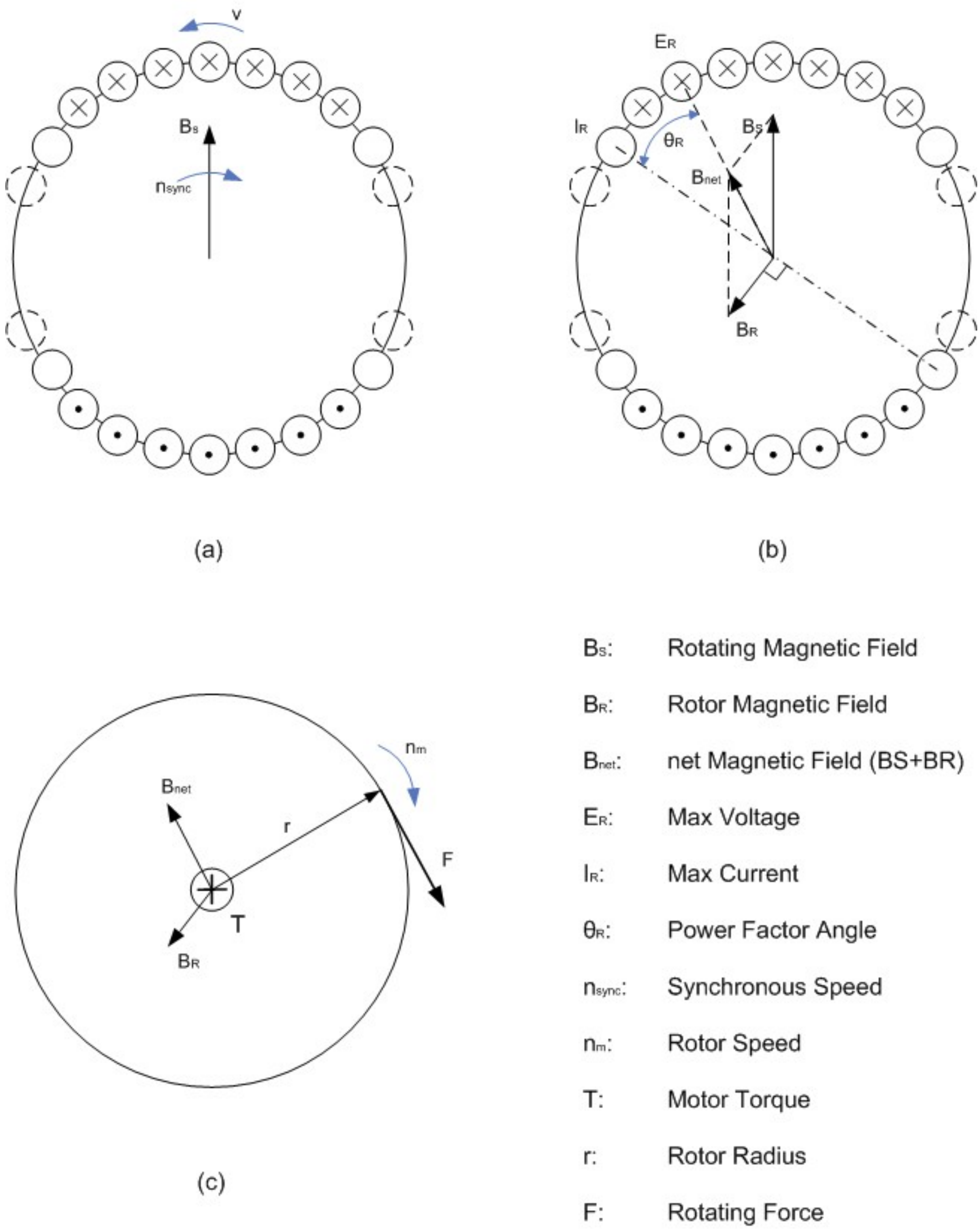


Figure 07-I-03.112 Rotor Revolution Generation

07-I-03.04.03 Motor Torque vs. Rotor Speed

As described above, the Motor Torque depends on the relative speed between the Synchronous Speed and the Rotor Speed (the value of the Induced Voltage depends on this relative speed).
On the basis of these considerations, we can define a Slip Speed as follows:

$n_{slip} = n_{sync} - n_m$ [rpm]

$s = n_{slip} / n_{sync} = (n_{sync} - n_m) / n_{sync}$

where “n_{slip}” is the Slip Speed [rpm] and “s” is the slip [per unit value].

The motor Torque (T) is proportional to the applied voltage (V_A), the applied frequency (f) and the slip as described in the following formula:

$$T \propto \left(\frac{V_A}{f^2} \right) \times s$$

Where: µ means “proportional to”.

The Torque vs. Rotor Speed is shown in the Figure 07-I-03.113. The Torque is Zero when the Rotor Speed is perfectly identical to the Stator Flux Rotating Speed (synchronous speed) [$n_{slip} = n_{sync} - n_m = 0$; ($n_{sync} = n_m$)]

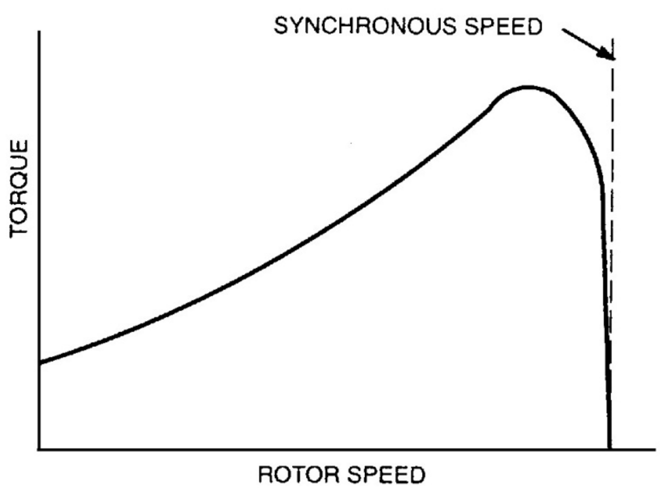


Figure 07-I-03.113 Motor Torque vs Rotor Speed (1)

The Motor Power is Zero when s=0 like the Torque and is also Zero when the Rotor Speed is Zero (no power is converted into mechanical power when the rotor is at zero speed).

07-I-03.04.04 Motoring and Dynamic Braking Mode

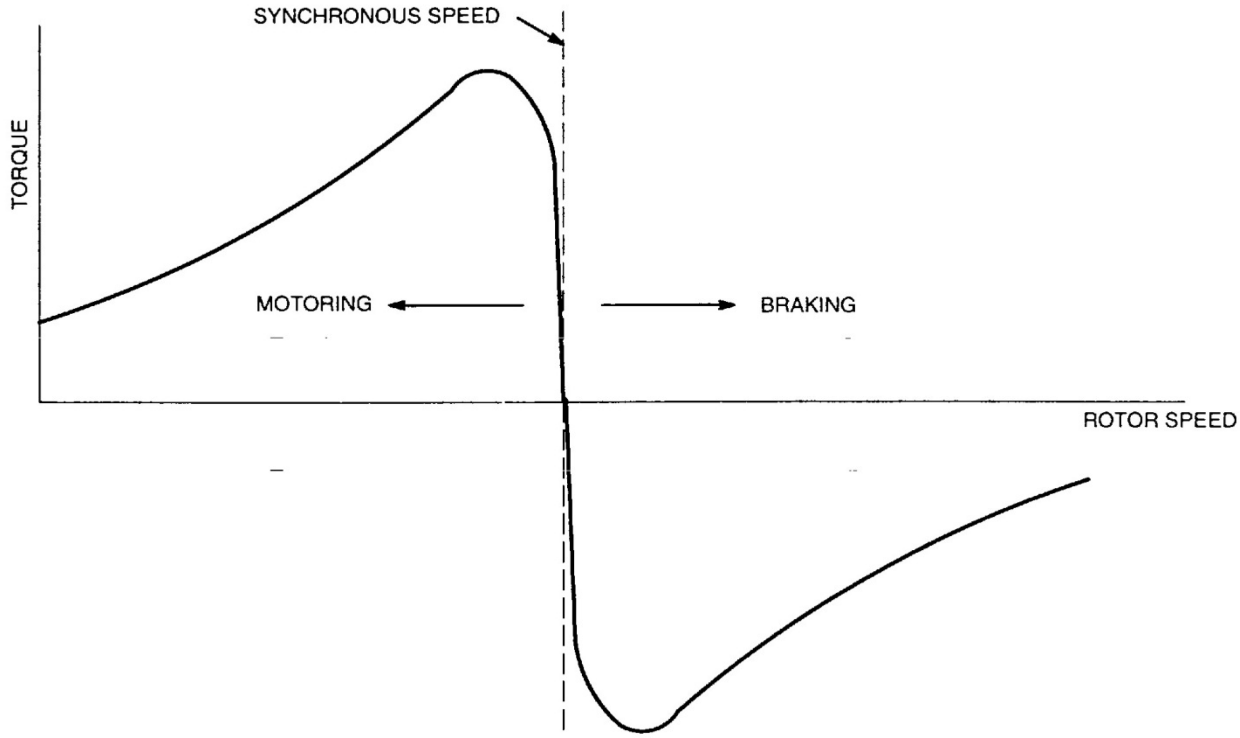
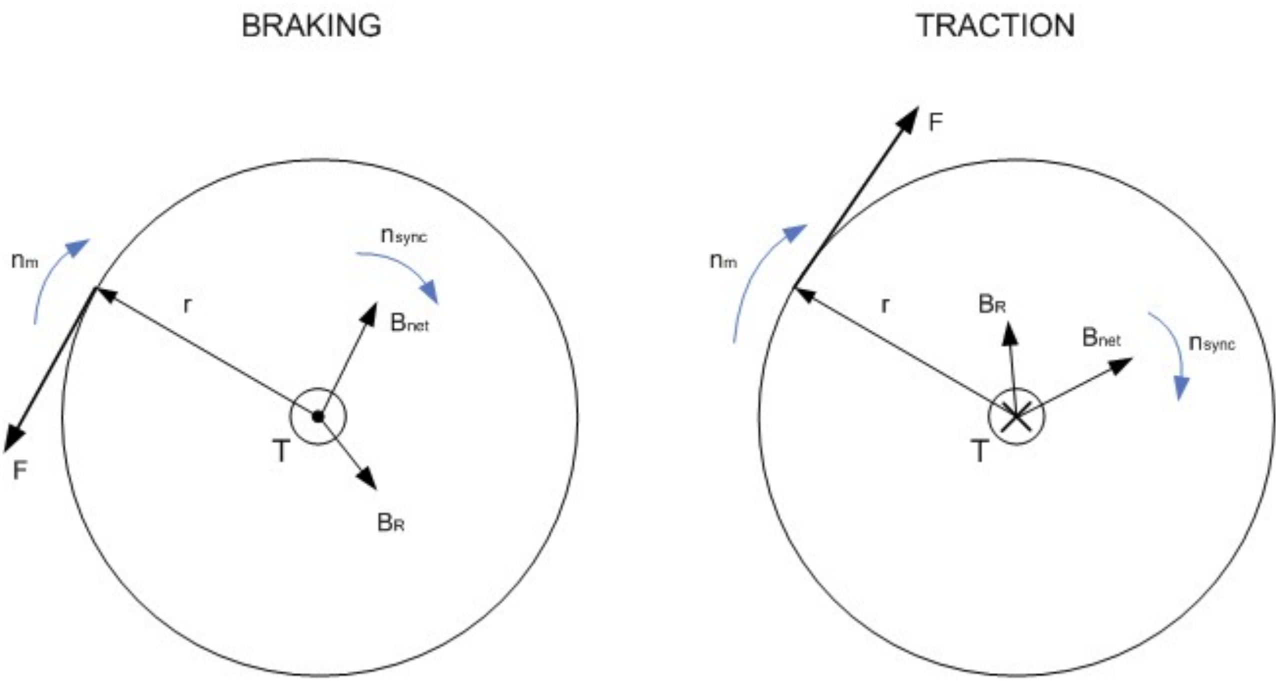


Figure 07-I-03.114 Motor Torque vs Rotor Speed (2)

The Rotor Speed (n_m) attempts to match the Rotating Flux Speed (n_{sync}).

For this reason until $n_m < n_{sync}$ the motor is in Traction Condition and if $n_m > n_{sync}$, the Rotor Speed (n_m) decreases to match the Rotating Flux Speed (n_{sync}).

The latter is a Braking Condition since it means a NEGATIVE Motor Torque which slows down the train.



B_R:	Rotor Magnetic Field	T:	Motor Torque
B_{net}:	net Magnetic Field (BS+BR)	r:	Rotor Radius
n_{sync}:	Synchronous Speed	F:	Rotating Force
n_m:	Rotor Speed		

Figure 07-I-03.115 Traction and Braking Torque

The train can pass from $n_m < n_{sync}$ to $n_m > n_{sync}$ decreasing f (applied voltage frequency) under the frequency related with n_{sync}.

In this way the Synchronous Speed will be below the actual Rotor Speed and, by following the Synchronous Speed, the rotor (connected with the wheels) will slow down the train (an opposite torque is applied).

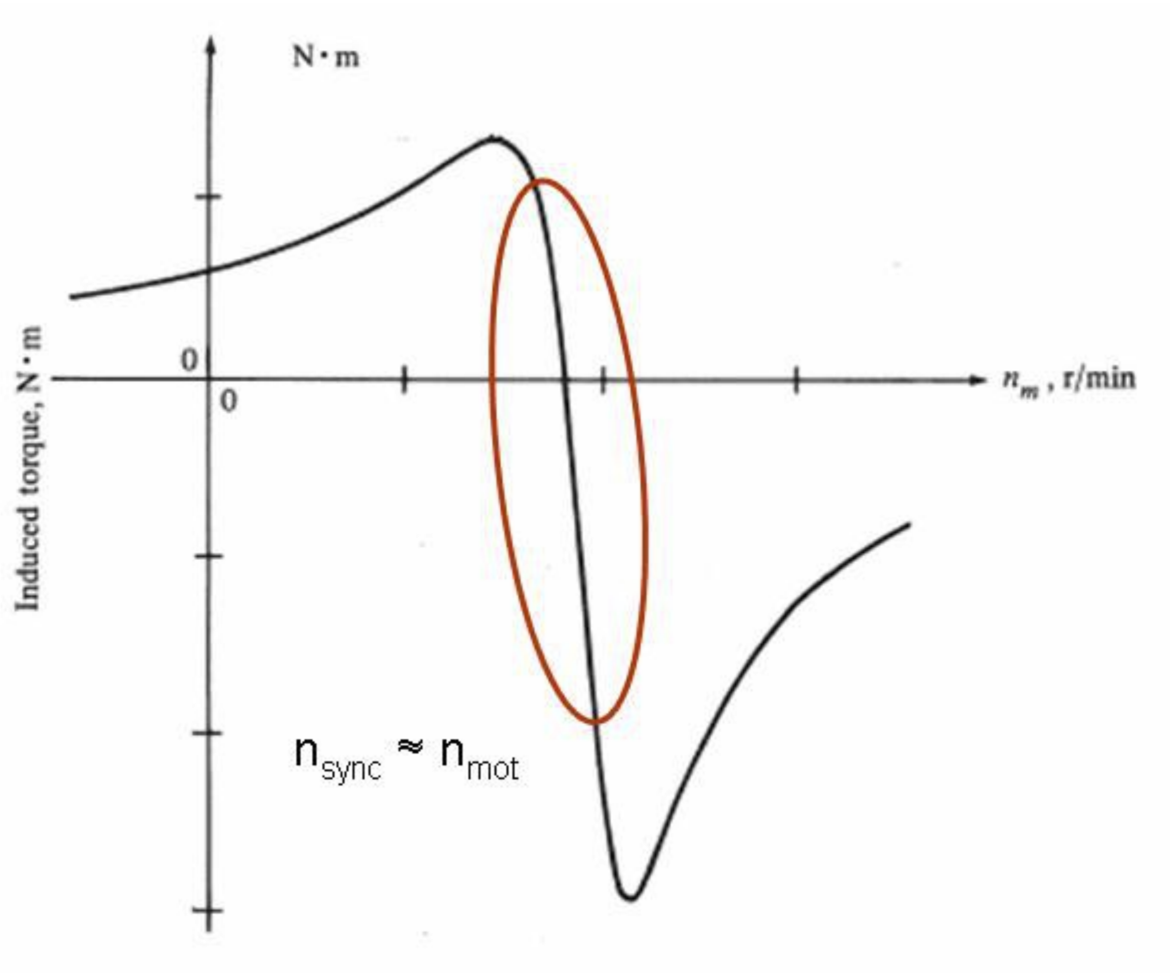


Figure 07-I-03.116 Working Point

The AC Inductive Motor has a Working Point around $n_m = n_{sync}$: $n_m < n_{sync}$ when in traction and $n_m > n_{sync}$ when in braking Mode. In this range the car speed is:

$$CarSpeed = \frac{60 \times f \times Gratio \times Wd \times \mathrm{p}}{p}$$

Where:
"f" is the Applied Voltage Frequency,
"Gratio" is the gear ratio (1/4.493 for this vehicle),
"Wd" is the wheel diameter
"p" is the number of polar couples.

Starting from 0 speed, to increase the rotor speed (and in this way the car speed) the frequency of the applied voltage (f) must be increased.

By increasing f the Torque will decrease: $T \propto \left(\frac{V_A}{f^2}\right) \times s$

To keep the Torque constant also the Applied Voltage (V_A) must be increased.
This method is possible until the maximum Applied Voltage value (V_A) is reached (Constant Torque Zone).
After this point the car speed rise causes a Torque reduction (Constant Horse Power Zone).

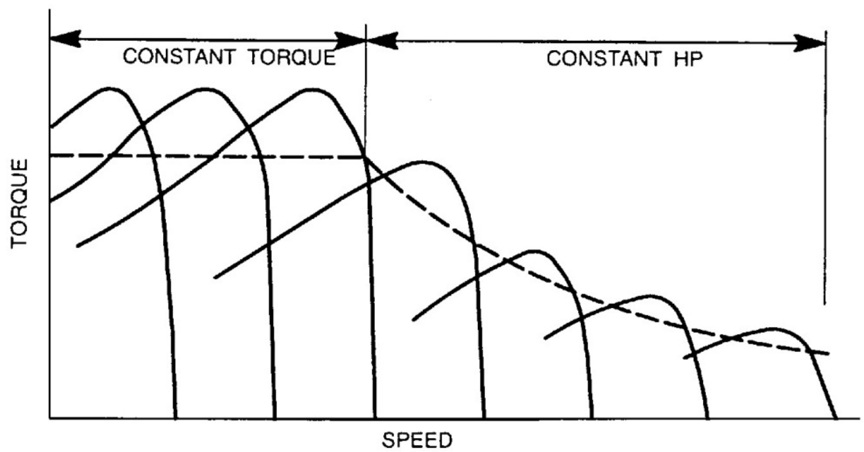


Figure 07-I-03.117 Torque - Car Speed

Summarizing:

The Motor Torque is regulated through the Supplied Voltage Amplitude (V_A) and Frequency (f) regulations.

These regulation are controlled by the TCU and are actuated by means of the Inverter Phase Modules.

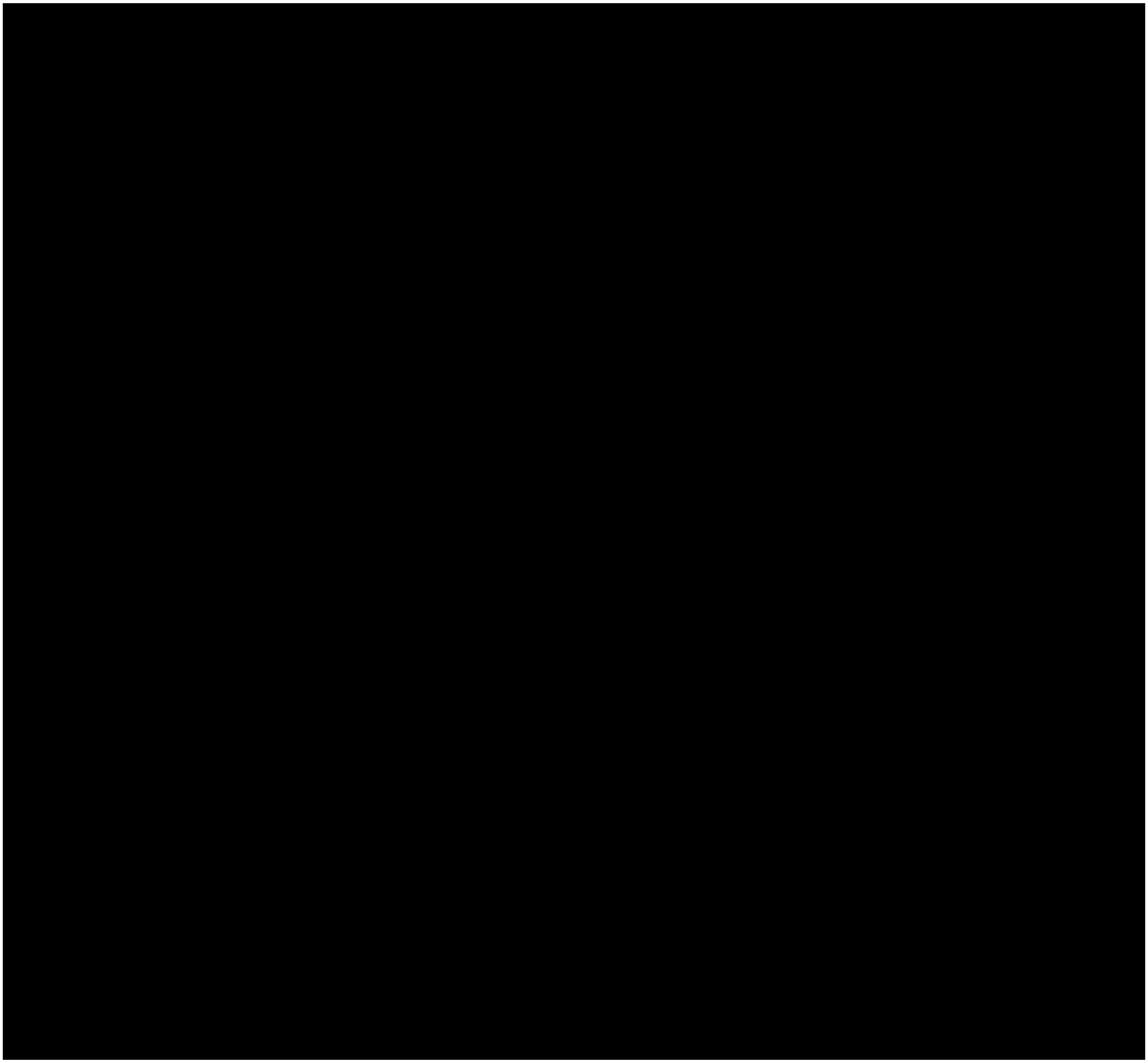
Important consideration about Power Mode and Dynamic Braking Mode:

During a Dynamic Braking ($n_m > n_{sync}$) Motors work like three-phase current generators. So, during a dynamic Braking, the current is acquired from the rails and is sent to the Catenary Line and/or (eventually) to the Braking Resistor.

To obtain this, and in consequence to brake the train, the inverters, also during a braking, must supply the motors in order to create the Stator Flux and the Rotor Flux which slows down the revolution speed.

If the Motors are not supplied, they cannot work as generators and the train is not accelerated nor slowed down: this is the COAST Mode.

In Power Mode and in Dynamic Braking Mode the Stator Voltage is the sum of the voltage from the Inverter (linked to the Line Voltage) Phase Modules and the voltage induced in the Stator from the Rotor (refer to Figure 07-I-03.118).



In Power Mode the Rotor Voltage sets itself against the Voltage from the Inverter and the sum of them is less that the Voltage from the Inverters, for this reason the current flows from the inverters to the motors.

On the contrary, during the Dynamic Braking Mode the Voltage induced in the Stator from the Rotor is in accordance with the Voltage from the Inverters, so the Stator Voltage is higher than the Voltage from the Inverters and the current can flow from the motors (in that case generators) to the Inverters and, using the Antiparallel Diodes, to the Catenary Line and, eventually, to the Braking Resistor.

[redacted]

[redacted]

07-I-03.05 IP Code

As defined in international standard IEC 60529, the IP (Ingress Protection) Code consists of the letters IP followed by two digits and an optional letter.

IP Code classifies the degrees of protection provided against the intrusion of solid objects (including body parts like hands and fingers), dust, accidental contact, and water in electrical enclosures.

Where there is no protection rating with regard to one of the criteria, the digit is replaced with the letter X.

The standard aims to provide users with more detailed information than vague marketing terms such as "waterproof".

Table 07-I-03.58 Ingress Protection Ratings (IP Codes)

Ingress Protection Classification			
First Digit		**Second Digit**	
IP	**Protection Provided**	**IP**	**Protection Provided**
0	No Protection	0	No Protection
1	Protected against solid objects up to 50mm e.g. accidental touch by hands	1	Protected against vertically falling drops of water e.g. condensation
2	Protected against solid objects up to 12mm e.g. fingers	2	Protected against direct sprays of water up to 15 deg from the vertical
3	Protected against solid objects over 2.5mm e.g. tools	3	Protected against direct sprays of water up to 60 deg from the vertical
4	Protected against solid objects over 1mm e.g. wires	4	Protected against water sprayed from all directions - limited ingress permitted
5	Protected against dust - limited ingress (no harmful deposit)	5	Protected against low pressure jets of water from all directions - limited ingress permitted
6	Totally protected against dust	6	Protected against strong jets of water e.g. for use on shipdecks - limited ingress permitted
		7	Protected against the affects of immersion between 15cm and 1m
		8	Protected against long periods of immersion under pressure

07-I-03.06 Insulation Class

Standards established by the *National Electrical Manufacturers Association (NEMA)* to meet motor temperature requirements found in different operating environments.

When a motor is started its temperature will begin to rise above that of surrounding or ambient air.

Each insulation class has an allowable temperature rise which, when added to the ambient, gives the maximum winding temperature. NEMA has standardized an ambient temperature of 104°F (40°C) with a defined attitude range. Allowance is made for a hot spot in the center of the motor's windings.

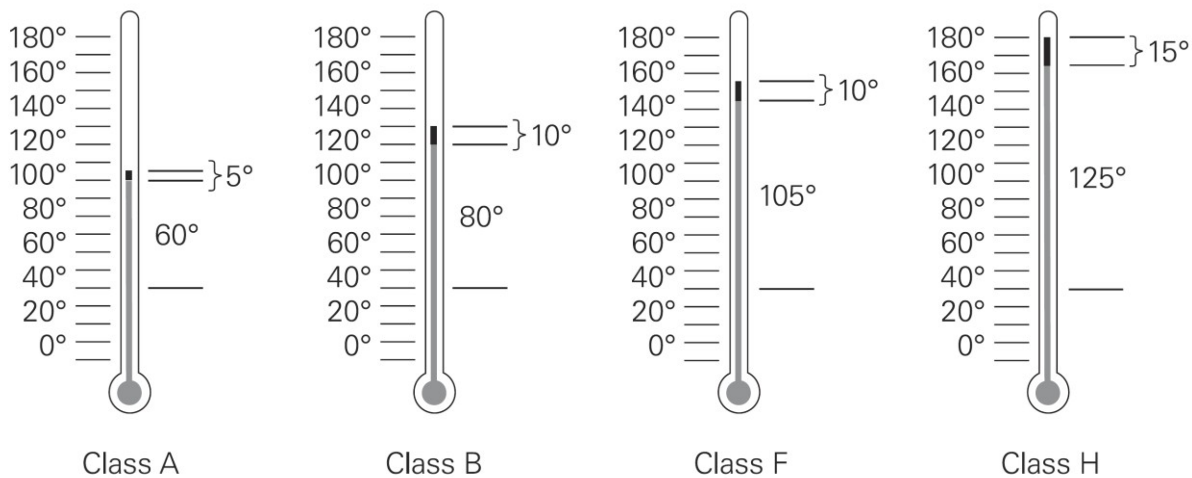


Figure 07-I-03.121 Insulation Class

Table 07-I-03.59 Insulation Class

Class	Rise	Hot Spot
Class A	140°F (60°C)	41°F (5°C)
Class B	176°F (80°C)	50°F (10°C)
Class F	221°F (105°C)	50°F (10°C)
Class H	257°F (125°C)	59°F (15°C)

Operating a motor above the limits of its insulation class reduces the motor's life expectancy.

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LOS ANGELES COUNTY

METROPOLITAN TRANSPORTATION AUTHORITY

LIGHT RAIL VEHICLE

P2550

RUNNING MAINTENANCE
AND
SERVICE MANUAL

VOLUME M-01
PART II
TROUBLESHOOTING
SECTION 07 - PROPULSION

SECTION 07

PROPULSION

PART II

TROUBLESHOOTING

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SECTION 07

PROPULSION SYSTEM

07-II-01 INTRODUCTION

This Section of the Running Maintenance and Service Manual is divided into three Parts:

- Part I: Theory of Operation
- Part II: Troubleshooting
- Part III: Maintenance

Each Paragraph is numbered accordingly, to avoid that paragraphs of the same Section, pertaining to a different Part, have the same number.

Part I - Theory of Operation

Part I gives a thorough overview of the System structure and operation, by means of descriptions, figures, photos, schematics, block diagrams and flow charts, together with references to other documents or Sections when needed.

Part II - Troubleshooting

It gives the Maintenance Technicians a path to troubleshoot the System in every condition by means of the available tools:

- The PTU, equipped with the specific SW program
- The IDU
- The Fault Isolation Table

The Part III - Maintenance consists of:

- Preventive Maintenance
- Corrective Maintenance
- Consumable Materials
- Test Equipment, Tools, & Special Tools

07-II-01.a List of Abbreviations, Acronyms and Symbols

The Abbreviations, Acronyms and Symbols commonly used throughout this manual are given below with their related meaning.

Abbreviation	Meaning
AC	Alternate Current
APS	Auxiliary Power Supply
ATP	Automatic Train Protection
BCU	Brake Control Unit
BI	Board Inside
C/L	Centerline
CCF	Charging Filter Contactor
CEMIPS	Conductive EMI Protection System
CMF	Inverter Fan Contactor
COAST	Coast Mode
CP	Propulsion Contactor
DC	Direct Current
DCU	Door Control Unit
DSP	Digital Signal Processor
EB	Emergency Brake
ECU	(Brake) Electronic Control Unit
EDU	EMI Detector Unit
EMI	Electromagnetic Interferences
FCF	Fuse Charging Filter
FM	Function Module
FPGA	Field Programmable Gate Array
FSB	Full Service Brake Mode
FWD	Forward
GTW	Gateway
HRSB	High Rate Service Brake
HSCB	High Speed Circuit Breaker
HV	High Voltage
HVAC	Heating Ventilation & Air Conditioning
HW	Hardware
IDU	Integrated Diagnostic Unit
IDU_A	Integrated Diagnostic Unit of the 'A' body section
IDU_B	Integrated Diagnostic Unit of the 'B' body section
IGBT	Insulated Gate Bipolar Transistor

Abbreviation	Meaning
LH	Left-Hand Side
LON	Local Operative Network
LRV	Light Rail Vehicle
LV	Low Voltage
LVDS	Low Voltage Distribution System
LVPS	Low Voltage Power Supply
M	Power (Motor) Mode
MBL	Metro Blue Line
MC	Master Controller
MDS	Monitor and Diagnostic System
ME	Motor truck total Effort
MoT	Master Of Train
MoV	Master Of Vehicle
MTBF	Mean Time Between Failure
MVB	Multifunction Vehicle Bus
MVDS	Medium Voltage Distribution System
NVRAM	Non Volatile Random Access Memory
OCS	Overhead Catenary System
PGL	Pasadena Gold Line
PTU	Portable Test Unit
PWM	Pulse Width Modulation
RAM	Random Access Memory
RCF	Filter Charging Resistor
REB	Emergency Brake Relay
REV	Reverse
RH	Right-Hand Side
RMF	Inverter Fan Supply Contactor
RMS	Root Mean Square
ROM	Read Only Memory
RSCEB	Slide Controlled Emergency Brake Relay
RTC	Real Time Clock
SCEB	Slide Controlled Emergency Brake
SW	Software
TA	Current Transducer (from “A” Module to “A” Motors phase)
TAL1	Positive Current Transducer
TAL2	Negative Current Transducer
TB	Current Transducer (from “B” Module to “B” Motors phase)

Abbreviation	Meaning
TBS	To Be Supplied
TC	Current Transducer(from "C" Module to "C" Motors phase)
TCH	Current Transducer(from "Chopper" Module to Braking Resistor
TCMS	Train Control and Monitor and System
TCN	Train Communication Network
TCU	Traction Control Unit
TCU_A	Traction Control Unit of the 'A' body section
TCU_B	Traction Control Unit of the 'B' body section
TE	Trailer (center) truck Effort
TLE	Trailer (center) truck Limited Effort
TVF	Transducer Voltage Filter
TWC	Train-to-Wayside Communication
VVVF	Variable Voltage Variable Frequency
WTB	Wired Train Bus

07-II-01.b LIST OF DEFINITIONS

The Definitions commonly used throughout this manual are given below with their related meaning.

Definition	Meaning
'A' body section	The section of an articulated vehicle containing the pantograph
'B' body section	The section of an articulated vehicle not containing the pantograph
AW0	Empty car operating weight
AW1	Full seated load plus AW0
AW2	Standees at 4 persons per square meter plus AW1
AW3	Standees at 6 persons per square meter plus AW1
AW4	Standees at 8 persons per square meter plus AW1
Front door	The door close to the Operator's Cab
Rear door	The door close to the Articulation Section
MC Handle	Master Controller Handle
"A" Cab (or Cab A)	Operator Cab in the A body section
"B" Cab (or Cab B)	Operator Cab in the B body section

07-II-01.c LIST OF MEASUREMENT UNITS AND SYMBOLS

The Measurement Units commonly used throughout this manual are given below with their related meaning.

Definition	Meaning
ft	Foot (Length)
gal.	Gallon (Volume)
in.	Inch (Length)
kg.	Kilogram - approx 2.205 pounds (Weight)
km.	Kilometer - approx 0.621 miles (Length)
lb.	Pound (Weight)
lb-ft	Pound force (Force)
m	Meter - approx 3.28 feet (Length)
mm	Millimeter - approx 0.0394 inches (Length)
mph	Miles per hour (Velocity)
Km/h	Kilometers per hour (Velocity)
s.	Seconds (Time)
V	Volt (Tension)
Vdc	Direct Voltage (Tension)
Vac	Alternate Voltage (Tension)
kVA	Kilo-Volt-Ampere (Power)
kW	Kilo-Watt (Power)
W	Watt (Power)
F	Farad (Capacity)
H	Henry (Inductance)
Ω	Ohm (Resistance)
°F	Fahrenheit (Temperature)
°C	Celsius (Temperature)
A	Ampere (Current)
Hz	Herz (Frequency)
rpm	Revolution per Minute (Frequency)
N	Newton (Force)
Nm	Newton-Meter (Torque)
mphps	Mile Per Hour Per Second (Acceleration)

07-II-02 TROUBLESHOOTING

The Maintenance personnel have two main tools at their disposal for troubleshooting a system on the P2550 LRV:

- The IDU (Integrated Diagnostic Unit) (refer to paragraph 07-II-02.01)
- The PTU (Portable Test Unit) (refer to paragraph 07-II-02.02)

07-II-02.01 Troubleshooting with the IDU

The IDU interface is made up of a display located in both cabs of a vehicle.
The IDU can be accessed in two Modes:

- Operating Mode, for the Operators (no password needed)
- Maintenance Mode, for Maintenance personnel, accessible by means of a numeric password

The Operating Mode provides the essential information needed to help the operator start troubleshooting or to pass the information on to the ROC (Railway Operating Center)

In Maintenance Mode the IDU can display more detailed information, thus giving the Maintenance personnel the possibility to troubleshoot more in depth and more accurately.

The Propulsion System is connected to all other systems on the vehicle through the MVB bus and LON Works bus (refer to Section 18 of this Manual).

As soon as the vehicle is keyed on, the IDU switches on in Operating Mode.

Through the IDU, the Maintenance personnel can check if all systems are exchanging data through the MVB or LONWorks buses and the trainlines.

In particular, with respect to the Propulsion System, the IDU Screen shows the status of the TCUs on the MVB bus (refer to Figure 07-II-02.1) and the status of the TRAIN LINE commands (through the WTB bus - refer to Figure 07-II-02.2).

The IDU screen also shows the real time status of all train systems. Using this system, the operator/maintainer is capable of detecting a fault (from the IDU fault list) as soon as it occurs.

07-II-02.01.01 Bus and Trainline Control

While in Maintenance Mode (accessible by means of a numerical code), by touching the MONITOR button, the IDU monitor shows information related to the local vehicle and the train. LON Works Bus, MVB bus, Digital I/O and train lines can be monitored.

With regard to the Propulsion System it is possible to check if the two TCUs are working correctly (TCU_A and TCU_B status) by monitoring the MVB bus (selected by touching the MVB BUS button on the MONITOR screen).

The IDU screen shows how much each bus is used by the relevant system (refer to Figure 07-II-02.1). If, for example, the TCU_A status bar does not show any signal exchanged (status = 0), probably the TCU_A is not working properly or is not supplied.

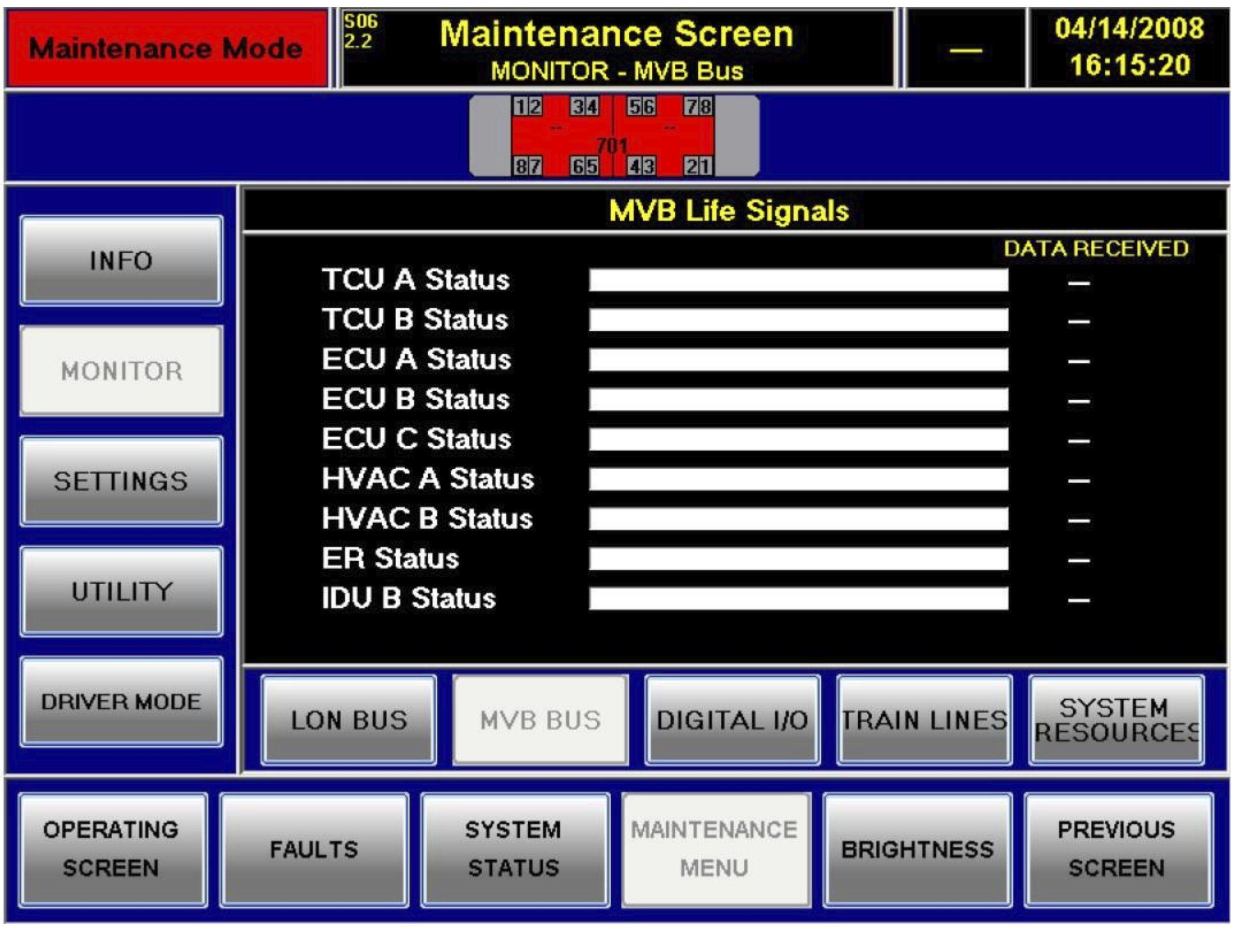

Figure 07-II-02.1 MVB Life Signals

Similarly, while in Maintenance Mode, by touching the TRAIN LINE button, the trainline signals can be monitored and it can be checked if the request coming from a Master Controller Handle has been acquired correctly (refer to Figure 07-II-02.2).

If a line is active, the correspondent label turns green.

The white areas indicate information not available.

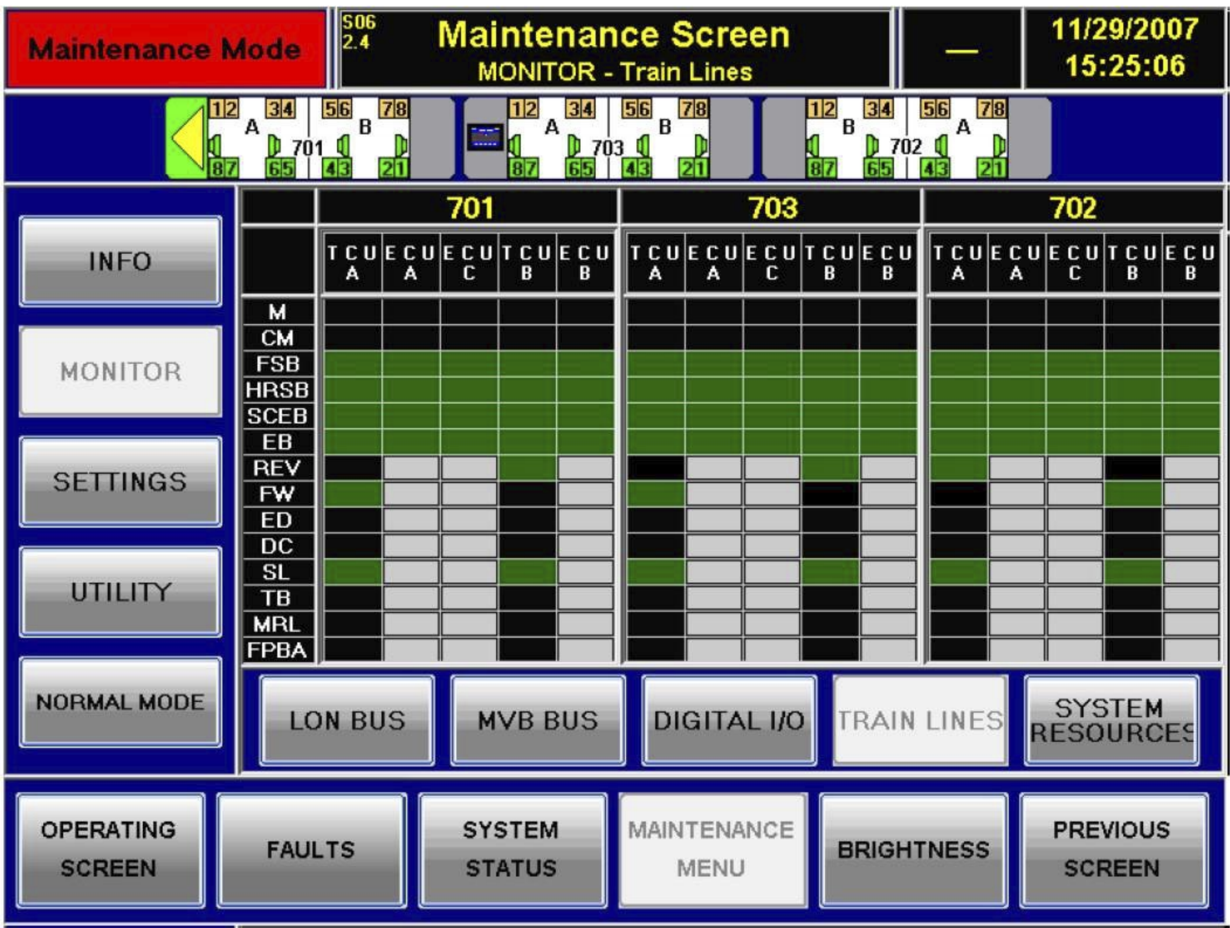

Figure 07-II-02.2 Trainline Status

07-II-02.01.02 Propulsion System Status Screen

The “Propulsion System Status Screen” can be visualized by pushing the “System Status” button on the “IDU Navigation Bar” located at the bottom of the display zone and by selecting the Propulsion System from the buttons on the left of the screen.

In the Operating Mode the operator can only detect what Propulsion System (A or B) is having problems (refer to Figure 07-II-02.3)

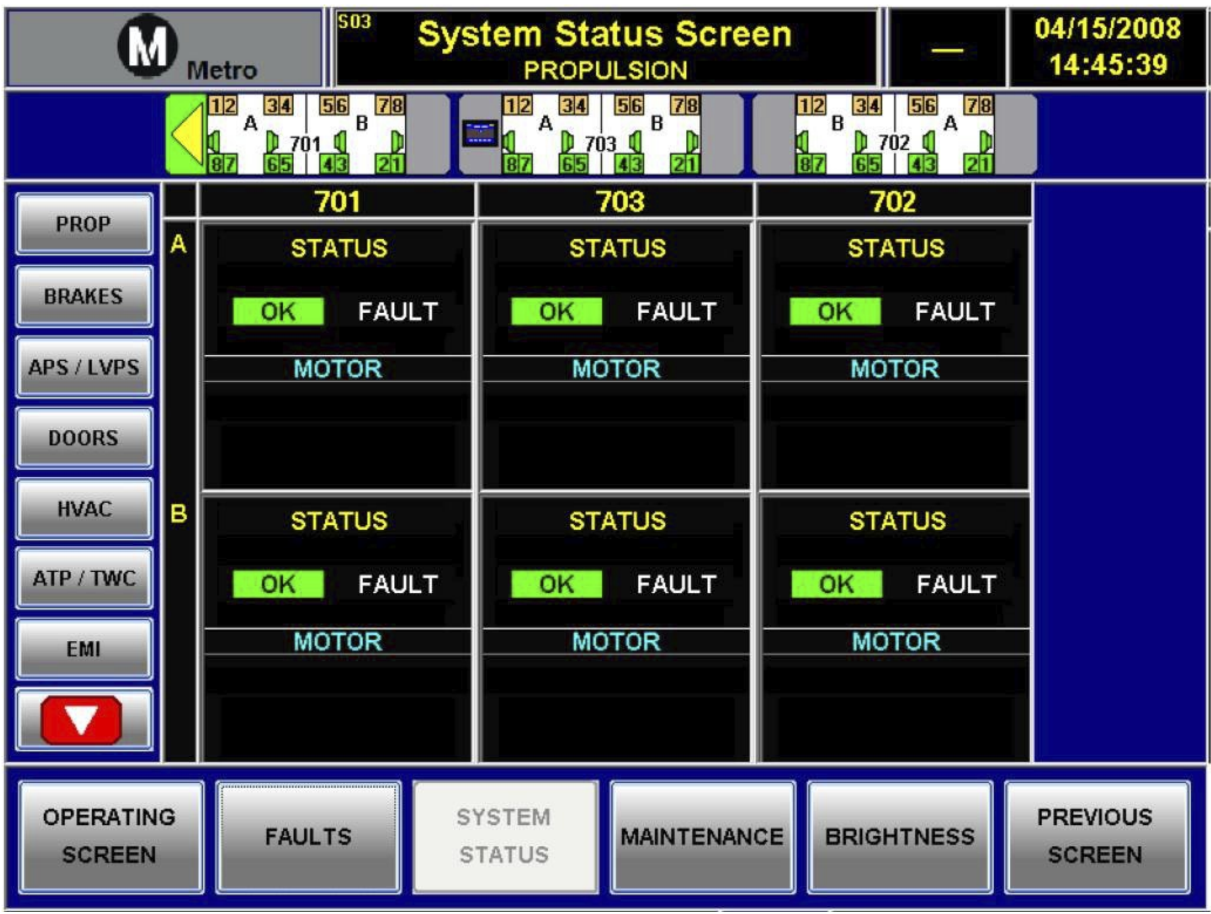

Figure 07-II-02.3 Operating Mode - Propulsion Status Screen

In Maintenance Mode the status of the Propulsion Systems of all vehicles in the train consist is also shown and the most important signal values are displayed (refer to Figure 07-II-02.4).

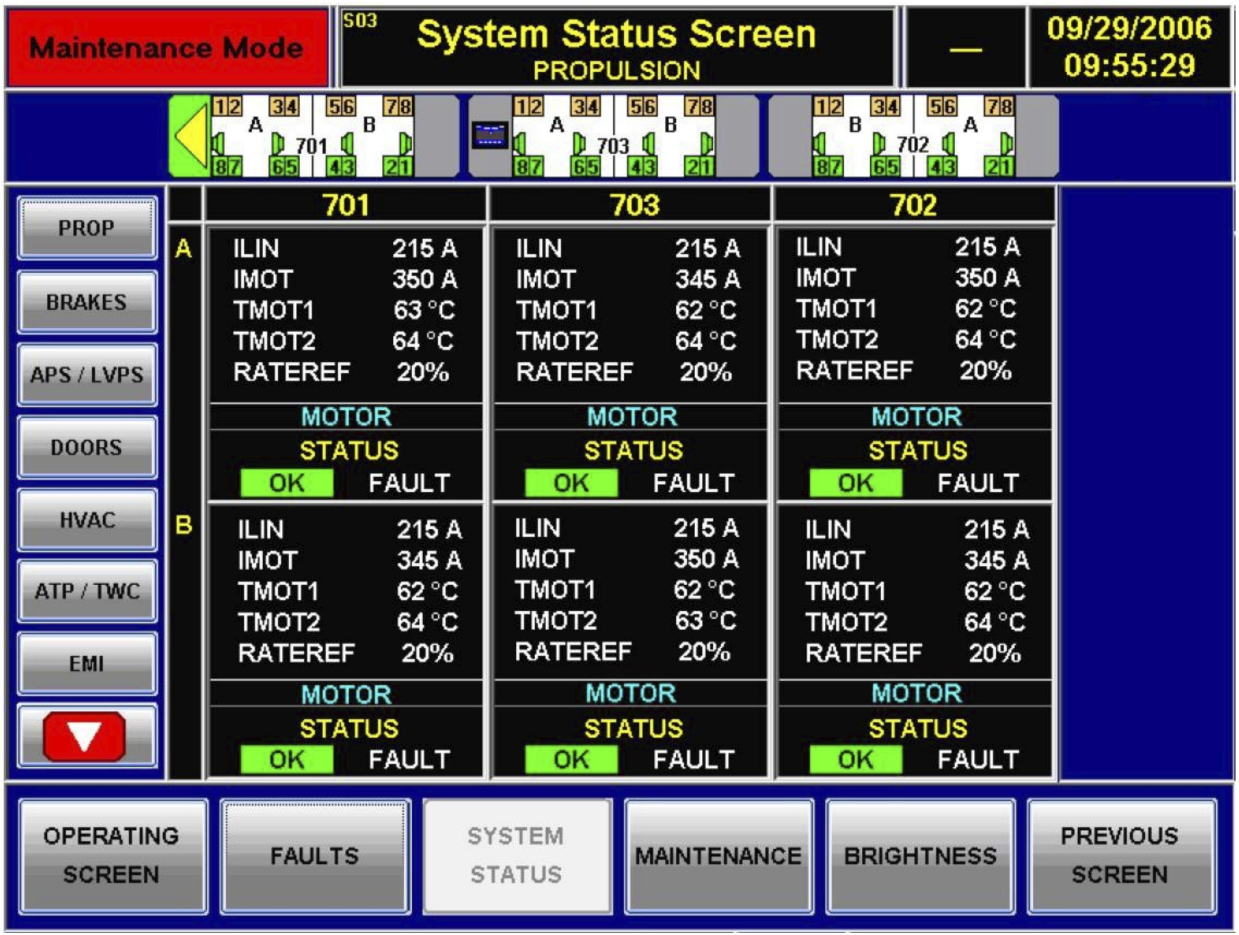

Figure 07-II-02.4 Maintenance Mode - Propulsion Status Screen

07-II-02.01.03 Fault List and Fault Charts

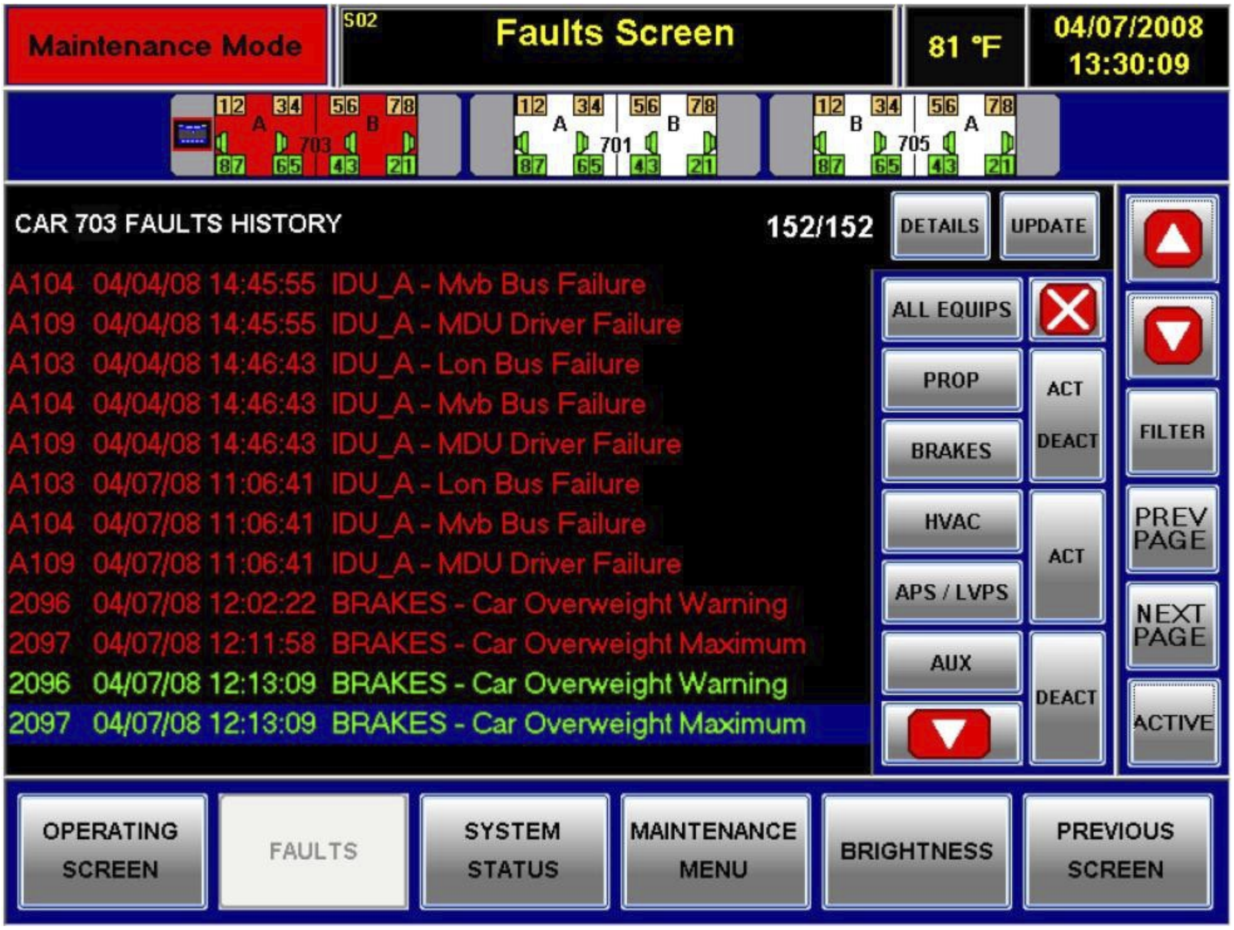

Figure 07-II-02.5 IDU Faults Screen

Through the IDU, the operator has the indication of a fault and other information which permits to immediately start troubleshooting.

In Maintenance mode the fault information is more detailed and the troubleshooting can be more accurate.

The Tables in the following pages list all Propulsion System faults monitored by the IDU, both in Operating and in Maintenance modes.

As soon as a fault occurs (fault “activated”), the Train Control and Monitoring System (TCMS - refer to Section 18) saves the “image” of the fault in a file of the IDU_A memory (no memory is provided for the IDU_B) named “LogFile.dat”.

The system saves an image of the activated fault every 100ms for a period from 1s before and 5s after the activation.

The system saves a sample of the deactivated faults once and with the information present at the time of the memorization.

Each fault has a dedicated line with code, date and time, system and description. A Fault can be red, green or yellow.

When a fault occurs, the label color is red and the date and time are referred to the time of the occurrence.

The same faults are also shown for a few seconds after their resolution; while the label color turns green.

By pressing the “Act” button, only the red faults are shown, while by pressing the “Deact” button, only the green faults are shown.

The “Act Deact” button shows both of them.

The Maintenance personnel can also acknowledge a fault, thus making the label turn yellow.

Paragraph 07-II-03.01 in the APPENDIX describes, for each fault type, how to proceed with the troubleshooting of the Propulsion System by means of the IDU, both in Operating and in Maintenance Mode.

For each fault a suggested action (“Operator Guide”) is displayed on the IDU screen by touching the “DETAILS” button.

The IDU Fault List can be filtered by means of the System button (in this case the Propulsion button - refer to Figure 07-II-02.5).

07-II-02.02 Troubleshooting with the PTU

The PTU (Portable Test Unit) can be connected to the Data download panels in the Electronic lockers at the center of the train. Through the PTU, the Maintenance personnel have more information available than from the IDU. In particular, the information available is more detailed and covers a longer period of time with reference to the fault being investigated.

The monitoring of the Propulsion System by means of the PTU can be done in three different ways:

- By connecting the serial RS232 cable to the 3X28 connector (on the Data Download Panel) to monitor the signals generated by the PCA
- By connecting the serial RS232 cable to the 3X29 connector (on the Data Download Panel) to monitor the signals generated by the STB board
- By connecting the serial RS232 cable or the Ethernet cable to the IDU connector to monitor all the signals sent to the IDU by the Propulsion System

07-II-03 APPENDIX

07-II-03.01 IDU Fault List

07-II-03.01.01 Operating Mode

All faults related to the Propulsion System and monitored by the IDU, are listed in the IDU screen and described in the relevant Fault Charts.

The Operating Mode Fault Charts listed below include, for each fault, the relevant Operator Guide which gives the Operator suggestions on how to overcome the fault

The Operator Guide can be shown by touching the “Detail” button on the screen and is referenced to the fault highlighted on the list.

Refer to Table 07-II-03.1 for Operating Mode Fault List

Refer to Table 07-II-03.2 for Operating Mode Fault Details

Refer to Table 07-II-03.4 for Operating Mode and Maintenance Mode Fault Relationship

Table 07-II-03.1 Operating Mode Fault List

Code	Affected Subsystem	Code	Affected Subsystem	Description
1113	PROP_A	1213	PROP_B	Overspeed command
1196	PROP_A	1296	PROP_B	EB application
1197	PROP_A	1297	PROP_B	SCEB application
11A0	PROP_A	12B0	PROP_B	HSCB open
11C0	PROP_A	12C0	PROP_B	Power Supply/DynBrake cutout Circ Brk
11D0	PROP_A	12D0	PROP_B	Major Fault
11D1	PROP_A	12D1	PROP_B	Medium Fault
11D2	PROP_A	12D2	PROP_B	Minor Fault
11D3	PROP_A	12D3	PROP_B	HSCB open by TCU
11D4	PROP_A	12D4	PROP_B	Reset or Bypass required
11D5	PROP_A	12D5	PROP_B	Bypass required
110F	PROP_A	120F	PROP_B	Fan Circuit Breaker Open

Table 07-II-03.2 Operating Mode Fault Details

Fault#	Date	Time	Vehicle#	System	Description
1113	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Overspeed command
Operator Guide					
Effect::	Forced FSB**.**				
Intervention:	None				
Trigger Conditions:	Active if: CarSpeed > SpeedLimit + 1mph				
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1213	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Overspeed command
Operator Guide					
Effect::	Forced FSB.				
Intervention::	None				
Trigger Conditions:	Active if: CarSpeed > SpeedLimit + 1mph				

Fault#	Date	Time	Vehicle#	System	Description
1196	mm/dd/yy	hh:mm:ss	xxx	PROP_A	EB application
Operator Guide					
Effect::	Inverter shut down.				
Intervention::	None				
Trigger Conditions:	Active if: Emergency Brake application				
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1296	mm/dd/yy	hh:mm:ss	xxx	PROP_B	EB application
Operator Guide					
Effect::	Inverter shut down.				
Intervention:	None				
Trigger Conditions:	Active if: Emergency Brake application				

Table 07-II-03.2 Operating Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1197	mm/dd/yy	hh:mm:ss	xxx	PROP_A	SCEB application
Operator Guide **Intervention:**: None **Trigger Conditions**: Active if: Slide Cotrolled Emergency Brake application					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1297	mm/dd/yy	hh:mm:ss	xxx	PROP_B	SCEB application
Operator Guide **Intervention:** None **Trigger Conditions**: Active if: Slide Cotrolled Emergency Brake application					

Fault#	Date	Time	Vehicle#	System	Description
11A0	mm/dd/yy	hh:mm:ss	xxx	PROP_A	HSCB Open
Operator Guide **Intervention:**Check the High Speed Circuit Breaker (4F01 and/or 4F02 - LV Cabinet Car A). **Trigger Conditions** Active if: DI B board channel 4 is low.					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
12B0	mm/dd/yy	hh:mm:ss	xxx	PROP_B	HSCB Open
Operator Guide **Intervention:**Check the High Speed Circuit Breaker (4F01 - LV Cabinet Car B). **Trigger Conditions** Active if: DI B board channel 4 is low.					

Fault#	Date	Time	Vehicle#	System	Description
11C0	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Power Supply Circ Brk Open
Operator Guide **Intervention:** Check the 3F11 circuit breaker ("A" LV Cabinet) and/or the 3F12 circuit breaker (Cab Panel A) **Trigger Conditions**: Active if: digital input 9 on left GTW is low					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
12C0	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Power Supply Circ Brk Open
Operator Guide **Intervention:** Check the 3F11 circuit breaker ("B" LV Cabinet) and/or the 3F12 circuit breaker (Cab Panel B) **Trigger Conditions**: Active if: digital input 9 on left GTW is low					

Table 07-II-03.2 Operating Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
11D0	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Major Fault
Operator Guide					
Maintenance Intervention is required					

Fault#	Date	Time	Vehicle#	System	Description
12D0	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Major Fault
Operator Guide					
Maintenance Intervention is required					

Fault#	Date	Time	Vehicle#	System	Description
11D1	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Medium Fault
Operator Guide					
No action required. At the end of revenue service, maintenance check is required					

Fault#	Date	Time	Vehicle#	System	Description
12D1	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Medium Fault
Operator Guide					
No action required. At the end of revenue service, maintenance check is required					

Fault#	Date	Time	Vehicle#	System	Description
11D2	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Minor Fault
Operator Guide					
No action required					

Fault#	Date	Time	Vehicle#	System	Description
12D2	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Minor Fault
Operator Guide					
No action required					

Table 07-II-03.2 Operating Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>11D3</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>HSCB open by TCU</td></tr>
<tr><td colspan="6">Operator Guide
Try to close HSCB. If the problem persists, please contact maintenance</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>12D3</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>HSCB open by TCU</td></tr>
<tr><td colspan="6">Operator Guide
Try to close HSCB. If the problem persists, please contact maintenance</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>11D4</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Reset or Bypass required</td></tr>
<tr><td colspan="6">Operator Guide
Try a TCU reset (power supply circuit breaker 3F11 - Electrical Cabinet Car A) .
If the problem persists Bypass TCU</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>12D4</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Reset or Bypass required</td></tr>
<tr><td colspan="6">Operator Guide
Try a TCU reset (power supply circuit breaker 3F11 - - Electrical Cabinet Car B).
If the problem persists Bypass TCU</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>11D5</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Bypass required</td></tr>
<tr><td colspan="6">Operator Guide
Bypass TCU, contact maintenance</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>12D5</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Bypass required</td></tr>
<tr><td colspan="6">Operator Guide
Bypass TCU, contact maintenance</td></tr>
</table>

Table 07-II-03.2 Operating Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
110F	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Fan Circuit Breaker Open
Operator Guide **Intervention:**Check the 2F06 circuit breaker (LV Cabinet Car)					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
120F	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Fan Circuit Breaker Open
Operator Guide **Intervention:** Check the 2F06 circuit breaker (LV Cabinet Car B)					

07-II-03.01.02 Maintenance Mode

All faults related to the Propulsion System and monitored by the IDU in Maintenance Mode are listed in the following Fault Charts.

Differently from the Operating Mode Fault Charts; the Maintenance Mode fault Charts, in addition to the Operator Guide, also show a list of components that can be involved in the fault, the reference Schematic Diagram and the Threshold values eventually applied.

The Operator Guide pops up by touching the "Detail" button on the screen and is referenced to the fault highlighted on the list.

Refer to Table 07-II-03.3 for Maintenance Mode Fault List

Refer to Table 07-II-03.4 for Operating Mode and Maintenance Mode Fault Relationship

Refer to Table 07-II-03.5 for Maintenance Mode Fault Details

Table 07-II-03.3 Maintenance Mode Fault List

Code	Affected Subsystem	Code	Affected Subsystem	Description
1101	PROP_A	1201	PROP_B	Command error
1102	PROP_A	1202	PROP_B	Unable to open the main contactor
1103	PROP_A	1203	PROP_B	Ground fault
1104	PROP_A	1204	PROP_B	Continuous filter over voltage
1105	PROP_A	1205	PROP_B	Braking resistor overtemperature
1107	PROP_A	1207	PROP_B	Motor phase sequence error
1108	PROP_A	1208	PROP_B	STB board communication failure
1109	PROP_A	1209	PROP_B	DO board failure
1110	PROP_A	1210	PROP_B	PCA board -DSP calculation failure
1111	PROP_A	1211	PROP_B	Thermal Switch intervention latched by SW
1112	PROP_A	1212	PROP_B	Precharge error
1113	PROP_A	1213	PROP_B	Overspeed command
1114	PROP_A	1214	PROP_B	HW does not follow the SW commands
1115	PROP_A	1215	PROP_B	Main contactor blocked
1116	PROP_A	1216	PROP_B	Charge contactor blocked
1117	PROP_A	1217	PROP_B	Positive Line current transducer failure
1118	PROP_A	1218	PROP_B	DO board -power supply failure
1119	PROP_A	1219	PROP_B	TCU fault DO channel in short circuit
1120	PROP_A	1220	PROP_B	HSCB command DO channel in short circ.
1121	PROP_A	1221	PROP_B	Main contactor DO channel in short circuit
1122	PROP_A	1222	PROP_B	Charge contactor DO channel in short circ.
1123	PROP_A	1223	PROP_B	TCU fault DO channel blocked
1124	PROP_A	1224	PROP_B	HSCB command DO channel blocked
1125	PROP_A	1225	PROP_B	Main contactor DO channel blocked
1126	PROP_A	1226	PROP_B	Charge contactor DO channel blocked
1127	PROP_A	1227	PROP_B	Sliding algorithm error
1128	PROP_A	1228	PROP_B	Warm motors
1129	PROP_A	1229	PROP_B	Hot motors
1130	PROP_A	1230	PROP_B	Filter transducer failure
1131	PROP_A	1231	PROP_B	High filter voltage derivate
1132	PROP_A	1232	PROP_B	Filter voltage oscillations
1134	PROP_A	1234	PROP_B	Negative line current transducer failure
1135	PROP_A	1235	PROP_B	Dynamic brake failure
1136	PROP_A	1236	PROP_B	Filter discharge resistor fault
1137	PROP_A	1237	PROP_B	Main contactor DO channel blocked

Table 07-II-03.3 Maintenance Mode Fault List (cont'd)

Code	Affected Subsystem	Code	Affected Subsystem	Description
1138	PROP_A	1238	PROP_B	Charge contactor DO channel blocked
1139	PROP_A	1239	PROP_B	HSCB command DO channel blocked
1140	PROP_A	1240	PROP_B	TCU fault DO channel blocked
1141	PROP_A	1241	PROP_B	HSCB trip counter
1142	PROP_A	1242	PROP_B	Repeated thermal switch intervention
1144	PROP_A	1244	PROP_B	Charge contactor permanent blocked
1145	PROP_A	1245	PROP_B	Main contactor permanent blocked
1146	PROP_A	1246	PROP_B	Pos. Line current transd. permanent failure
1147	PROP_A	1247	PROP_B	All motor overheat thermal sensor
1148	PROP_A	1248	PROP_B	IGBT ph A module Thermal Switch interv.
1149	PROP_A	1249	PROP_B	IGBT ph B module Thermal Switch interv.
1150	PROP_A	1250	PROP_B	IGBT ph C module Thermal Switch interv.
1151	PROP_A	1251	PROP_B	IGBT ph CH module Thermal Switch interv.
1152	PROP_A	1252	PROP_B	Motor 1 overheat thermal sensor 1
1153	PROP_A	1253	PROP_B	Motor 1 overheat thermal sensor 2
1154	PROP_A	1254	PROP_B	Motor 2 overheat thermal sensor 1
1155	PROP_A	1255	PROP_B	Motor 2 overheat thermal sensor 2
1156	PROP_A	1256	PROP_B	PCA board -FPGA downloading error
1157	PROP_A	1257	PROP_B	PCA board -DSP downloading error
1158	PROP_A	1258	PROP_B	PIA board -FPGA downloading error
1159	PROP_A	1259	PROP_B	PIA board -VME access error
1160	PROP_A	1260	PROP_B	DI A board -TEST 0 failure
1161	PROP_A	1261	PROP_B	DI A board -TEST 1 failure
1162	PROP_A	1262	PROP_B	DI A board -VME access error
1163	PROP_A	1263	PROP_B	DO board -VME access error
1165	PROP_A	1265	PROP_B	DI B board -TEST 0 failure
1166	PROP_A	1266	PROP_B	DI B board -TEST 1 failure
1167	PROP_A	1267	PROP_B	DI B board -VME access error
1168	PROP_A	1268	PROP_B	DI A board -power supply failure
1169	PROP_A	1269	PROP_B	DI B board -G160 power supply failure
1170	PROP_A	1270	PROP_B	Active speed sensor failure
1171	PROP_A	1271	PROP_B	Passive speed sensor failure
1172	PROP_A	1272	PROP_B	Inverter Phase A overcurrent
1173	PROP_A	1273	PROP_B	Inverter Phase B overcurrent

Table 07-II-03.3 Maintenance Mode Fault List (cont'd)

Code	Affected Subsystem	Code	Affected Subsystem	Description
1174	PROP_A	1274	PROP_B	Inverter Phase C overcurrent
1175	PROP_A	1275	PROP_B	Inverter phases unbalance
1176	PROP_A	1276	PROP_B	IGBT phase module A failure
1177	PROP_A	1277	PROP_B	IGBT phase module B failure
1178	PROP_A	1278	PROP_B	IGBT phase module C failure
1179	PROP_A	1279	PROP_B	IGBT phase module CH failure
1180	PROP_A	1280	PROP_B	Low Voltage Power Supply failure (input 1)
1181	PROP_A	1281	PROP_B	Low Voltage Power Supply failure (input 2)
1182	PROP_A	1282	PROP_B	Watch dog PCA board
1183	PROP_A	1283	PROP_B	Watch dog STB board
1184	PROP_A	1284	PROP_B	Filter over voltage
1185	PROP_A	1285	PROP_B	Line over current
1186	PROP_A	1286	PROP_B	4-20mA loop cab A failure
1187	PROP_A	1287	PROP_B	Wheel diameter 1 failure
1188	PROP_A	1288	PROP_B	Wheel diameter 2 failure
1189	PROP_A	1289	PROP_B	Wheel diameter 3 failure
1190	PROP_A	1290	PROP_B	4-20mA loop Cab B failure
1191	PROP_A	1291	PROP_B	Speed sensor 1 failure
1192	PROP_A	1292	PROP_B	Speed sensor 2 failure
1193	PROP_A	1293	PROP_B	Speed sensor 3 failure
1194	PROP_A	1294	PROP_B	MVB communication failure
1196	PROP_A	1296	PROP_B	EB application
1197	PROP_A	1297	PROP_B	SCEB application
1198	PROP_A	1298	PROP_B	The trainline pattern is not consistent
1199	PROP_A	1299	PROP_B	Master controller direction mismatch
110A	PROP_A	120A	PROP_B	Mismatch rate ref. and trainline pattern
110C	PROP_A	120C	PROP_B	Inverter cut out
110D	PROP_A	120D	PROP_B	No motion cross check failure
110E	PROP_A	120E	PROP_B	Motor blower failure
110F	PROP_A	120F	PROP_B	Fan Circuit Breaker Open
11A0	PROP_A			HSCB Control Circuit breaker
12B0	PROP_B			HSCB Control Circuit breaker
11C0	PROP_A	12C0	PROP_B	Power Supply / Dyn.Brake cutout Circ Brk
11D7	PROP_A	12D7	PROP_B	Chopper fired at zero-speed
11D8	PROP_A	12D8	PROP_B	MVB Communication failure between TCU and ECU

Table 07-II-03.4 Operating Mode and Maintenance Mode Fault Relationship

Operating Mode Fault Codes	Maintenance Mode Fault Codes						
110F	110F						
120F	120F						
11A0	11A0						
11C0	11C0						
12C0	11C0						
11DO	1115	1116	1117	1119	1120	1121	1122
	1123	1124	1125	1126	1127	1129	1130
	1134	1135	1137	1138	1139	1140	1141
	1142	1144	1145	1146	1147	1156	1157
	1158	1159	1160	1161	1162	1163	1165
	1166	1167	1168	1169	1175	1198	1199
	110A	110C	110E				
12DO	1215	1216	1217	1219	1220	1221	1222
	1223	1224	1225	1226	1227	1229	1230
	1234	1235	1237	1238	1239	1240	1241
	1242	1244	1245	1246	1247	1256	1257
	1258	1259	1260	1261	1262	1263	1265
	1266	1267	1268	1269	1275	1298	1299
	120A	120C	120E				
11D1	1128	1136	1152	1153	1154	1155	1180
	1181	1186	1187	1188	1189	1190	1191
	1192	1193	1194	110D	11D8		
12D1	1228	1236	1252	1253	1254	1255	1280
	1281	1286	1287	1288	1289	1290	1291
	1292	1293	1294	120D	12D8		
11D2	1107	1110	1131	1132	1170	1171	1172
	1173	1174	1182	1183	11D7		
12D2	1207	1210	1231	1232	1270	1271	1272
	1273	1274	1282	1283	12D7		

Table 07-II-03.4 Operating Mode and Maintenance Mode Fault Relationship (cont'd)

Operating Mode Fault Codes	Maintenance Mode Fault Codes						
11D3	1101	1102	1103	1104	1109	1112	1184
	1185						
12D3	1201	1202	1203	1204	1209	1212	1284
	1285						
11D4	1108	1118					
12D4	1208	1218					
11D5	1105	1111	1114	1148	1149	1150	1151
	1176	1177	1178	1179			
12D5	1205	1212	1214	1248	1249	1250	1251
	1276	1277	1278	1279			
12B0	12B0						

Table 07-II-03.5 Maintenance Mode Fault Details

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1101</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Command error</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check trainline pattern.
Change TCU DI A board.</td></tr>
<tr><td colspan="6">Involved Components
Master Controller Handle, Reverse Controller Handle, Trainlines, NDI_A board, M/C Encoder, FSB relay (3K29), ATP K1 relay</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1201</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Command error</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check trainline pattern.
Change TCU DI A board.</td></tr>
<tr><td colspan="6">Involved Components
Master Controller Handle, Reverse Controller Handle, Trainlines, NDI_A board, M/C Encoder, FSB relay (3K29), ATP K1 relay</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram
Figure 07-II-03.10</td></tr>
</table>

NOTE: Faults 1101 and 1201 are activated when the relative TCU detects Forward (FWD) and Reverse (REV) Commands or Power and Brake Commands at the same time.

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault #	Date	Time	Vehicle#	System	Description
1102	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Unable to open the Main Contactor
Operator Guide **Effect:** HSCB trip. **Intervention:** Check main contactor is working. Check the wiring connections. Change TCU DI A board.					
Involved Components CP contactor, CP wirings, NDI A board, NDO board, Mother board, PCA Board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1202	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Unable to open the main contactor
Operator Guide **Effect:** HSCB trip. **Intervention:** Check main contactor is working. Check the wiring connections. Change TCU DI A board.					
Involved Components CP contactor, CP wirings, NDI A board, NDO board, Mother board, PCA Board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram Figure 07-II-03.10					

NOTE: Faults 1102 and 1202 are activated when the HSCB is opened, but the CP contactor (Main Contactor) stays closed.

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1103</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Ground fault
<u>NOTE:</u> Pay attention to the (2403 wiring) ground system, we might have a floating Ground</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip
Intervention:
Check positive line current transducer.
Check negative line current transducer.
Check propulsion inverter high voltage wiring.</td></tr>
<tr><td colspan="6">Involved Components
A dispersion current is along the current path between the Positive (TAL1) and the Negative (TAL2) Current Transducers; or a Current transducer is not working or a component/system along the current path between them is damaged.</td></tr>
<tr><td colspan="6">Threshold
TAL1 value - TAL2 value > 15A</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram
Figure 07-II-03.15 Grounding System</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1203</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Ground fault
<u>NOTE:</u> Pay attention to the (2403 wiring) ground system, we might have a floating Ground</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check positive line current transducer.
Check negative line current transducer.
Check propulsion inverter high voltage wiring.</td></tr>
<tr><td colspan="6">Involved Components
A dispersion current is along the current path between the Positive (TAL1) and the Negative (TAL2) Current Transducers; or a Current transducer is not working or a component/system along the current path between them is damaged.</td></tr>
<tr><td colspan="6">Threshold
TAL1 value - TAL2 value > 15A</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram
Figure 07-II-03.15 Grounding System</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1104	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Continuous filter over voltage Check Braking Resistor Grid for any loose connection or hardware.
Operator Guide **Effect:** HSCB trip. **Intervention:** Check filter voltage transducer. Check the braking chopper module is working.					
Involved Components TVF, Transducer, PIA Board					
Threshold Threshold: 950 Vdc					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1204	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Continuous filter over voltage Check Braking Resistor Grid for any loose connection or hardware.
Operator Guide **Effect:** HSCB trip. **Intervention:** Check filter voltage transducer. Check the braking chopper module is working.					
Involved Components TVF, Transducer, PIA Board					
Threshold Threshold: 950 Vdc					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1105</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Braking resistor overtemperature</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Electric brake inhibition.
Intervention:
Check the braking chopper module is working.
Check the braking resistor value.</td></tr>
<tr><td colspan="6">Involved Components
Braking Resistor, Chopper Module, Braking Resistor wirings.</td></tr>
<tr><td colspan="6">Threshold
752°F (400°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle #</th><th>System</th><th>Description</th></tr>
<tr><td>1105</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Braking resistor overtemperature</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Electric brake inhibition.
Intervention:
Check the braking chopper module is working.
Check the braking resistor value.</td></tr>
<tr><td colspan="6">Involved Components
Braking Resistor, Chopper Module, Braking Resistor wirings.</td></tr>
<tr><td colspan="6">Threshold
752°F (400°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1107	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Motor phase sequence error
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check inverter phase sequence.					
Involved Components Inverter Phase Module - TCU connections, Inverter Phase Module - Motors connections					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1207	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Motor phase sequence error
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check inverter phase sequence.					
Involved Components Inverter Phase Module - TCU connections, Inverter Phase Module - Motors connections					
Reference Diagrams Figure 07-II-03.13					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1108	mm/dd/yy	hh:mm:ss	xxx	PROP_A	STB board communication failure
Operator Guide **Effect:** HSCB trip. **Intervention**: Check PCA and STB software versions. Change STB board. Change PCA board.					
Involved Components STB board, PCA board, STB connection wirings, Mother board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1208	mm/dd/yy	hh:mm:ss	xxx	PROP_B	STB board communication failure
Operator Guide **Effect:** HSCB trip. **Intervention**: Check PCA and STB software versions. Change STB board. Change PCA board.					
Involved Components STB board, PCA board, STB connection wirings, Mother board					

NOTE: Faults 1108 and 1208 are activated when the PCA board is unable to communicate with the STB board.

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1109	mm/dd/yy	hh:mm:ss	xxx	PROP A	DO board failure

Operator Guide

Effect: HSCB trip.
Intervention:
Check DO board wiring.
Change DO board.

Involved Components

NDO board

Fault#	Date	Time	Vehicle#	System	Description
1209	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DO board failure

Operator Guide

Effect: HSCB trip.
Intervention:
Check DO board wiring.
Change DO board.

Involved Components

NDO board

Fault#	Date	Time	Vehicle#	System	Description
1110	mm/dd/yy	hh:mm:ss	xxx	PROP_A	PCA board - DSP calculation failure

Operator Guide

Effect: Inverter shut down.
Intervention: None

Involved Components

PCA board

Fault#	Date	Time	Vehicle#	System	Description
1210	mm/dd/yy	hh:mm:ss	xxx	PROP_B	PCA board - DSP calculation failure

Operator Guide

Effect: Inverter shut down.
Intervention: None

Involved Components

PCA board

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1111	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Thermal Switch intervention latched by SW
Operator Guide **Effect:** Disabled power mode for 3 min. **Intervention**: Wait 30min to cool the modules. Check the thermal switch is working. Change the module.					
Involved Components Inverter Phase Module, NDO board, Mother board					
threshold 221°F (105°C)					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1211	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Thermal Switch intervention latched by SW
Operator Guide **Effect:** Disabled power mode for 3 min. **Intervention**: Wait 30min to cool the modules. Check the thermal switch is working. Change the module.					
Involved Components Inverter Phase Module, NDO board, Mother board					
threshold 221°F (105°C)					
Reference Diagrams Figure 07-II-03.13					

NOTE: Faults 1111 and 1211 are activated when at least an Inverter Phase Module Thermal Switch signal is low (overtemperature detected)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1112</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Precharge error</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the filter voltage transducer.
Check the line current transducer.
Check the precharge contactor is working.
Check the precharge fuse.
Check the precharge resistor.</td></tr>
<tr><td colspan="6">Involved Components
TVF, TAL1, CCF, CP, FCF, RCF, Line Reactor, Phase Modules' Capacitors, PCA Board</td></tr>
<tr><td colspan="6">Threshold
The maximum energy on the charge resistor (10kJ) has been reached.</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1212</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Precharge error</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the filter voltage transducer.
Check the line current transducer.
Check the precharge contactor is working.
Check the precharge fuse.
Check the precharge resistor.</td></tr>
<tr><td colspan="6">Involved Components
TVF, TAL1, CCF, CP, FCF, RCF, Line Reactor, Phase Modules' Capacitors, PCA Board</td></tr>
<tr><td colspan="6">Threshold
The maximum energy on the charge resistor (10kJ) has been reached.</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1113</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Overspeed command</td></tr>
<tr><td colspan="6">Operator Guide
Effect:: Forced FSB.
Intervention: None
Trigger Conditions: Active if: CarSpeed > SpeedLimit + 1mph</td></tr>
<tr><td colspan="6">Involved Components
Speed Sensors, PIA board, PCA board, STB board, Mother board</td></tr>
<tr><td colspan="6">Threshold
CarSpeed > SpeedLim + 1mph</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.1 Vehicle Logic - TCU_A Interface
Figure 07-II-03.2 Vehicle Logic - TCU_B Interface
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1213</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Overspeed command</td></tr>
<tr><td colspan="6">Operator Guide
Effect:: Forced FSB.
Intervention: None
Trigger Conditions: Active if: CarSpeed > SpeedLimit + 1mph</td></tr>
<tr><td colspan="6">Involved Components
Speed Sensors, PIA board, PCA board, STB board, Mother board</td></tr>
<tr><td colspan="6">Threshold
CarSpeed > SpeedLim + 1mph</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.1 Vehicle Logic - TCU_A Interface
Figure 07-II-03.2 Vehicle Logic - TCU_B Interface
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1114	mm/dd/yy	hh:mm:ss	xxx	PROP_A	HW does not follow the SW commands
Operator Guide **Effect:** HSCB trip. **Intervention**: Change the PIA board.					
Involved Components PIA board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1214	mm/dd/yy	hh:mm:ss	xxx	PROP_B	HW does not follow the SW commands
Operator Guide **Effect:** HSCB trip. **Intervention**: Change the PIA board.					
Involved Components PIA board					

Fault#	Date	Time	Vehicle#	System	Description
1115	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Main contactor blocked Check DO Negative signal to the Main Contactor
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the main contactor is working. Check the wiring between the main contactor and the DIA board. Check DIA board. Change DIA board.					
Involved Components CP, CP wirings, NDI_A board, NDO board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1215	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Main contactor blocked. Check DO Negative signal to the Main Contactor
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the main contactor is working. Check the wiring between the main contactor and the DIA board. Check DIA board. Change DIA board.					
Involved Components CP, CP wirings, NDI_A board, NDO board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1116	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Charge contactor blocked Check DO Negative signal to the Charging Contactor
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the precharge contactor is working. Check the wiring between the precharge contactor and the DIA board. Check DIA board. Change DIA board.					
Involved Components CCF, CCF wirings, NDI_A board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1216	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Charge contactor blocked Check DO Negative signal to the Charging Contactor
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the precharge contactor is working. Check the wiring between the precharge contactor and the DIA board. Check DIA board. Change DIA board.					
Involved Components CCF, CCF wirings, NDI_A board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1117	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Positive Line current transducer failure
Operator Guide **Intervention:** Check positive current transducer. Check the wiring connection to the TCU Mother board connector. Change the PIA board.					
Involved Components TAL1, TAL1 wirings, PIA board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1217	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Positive Line current transducer failure
Operator Guide **Intervention:** Check positive current transducer. Check the wiring connection to the TCU Mother board connector. Change the PIA board.					
Involved Components TAL1, TAL1 wirings, PIA board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1118	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DO board - power supply failure
Operator Guide **Effect:** HSCB trip. **Intervention:** Check the power supply on the DO board. Change the DO board.					
Involved Components NDO board, TCU Power Supply Unit					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1218	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DO board - power supply failure
Operator Guide **Effect:** HSCB trip. **Intervention:** Check the power supply on the DO board. Change the DO board.					
Involved Components NDO board, TCU Power Supply Unit					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1119	mm/dd/yy	hh:mm:ss	xxx	PROP_A	TCU fault DO channel in short circuit Also consider a floating Ground problem.
Operator Guide **Intervention:** Check the DO channel is not in short circuit. Change DO board.					
Involved Components NDO board, NDO wirings					
Reference Diagrams Figure 07-II-03.9 Propulsion Converter - Schematic Diagram Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1219	mm/dd/yy	hh:mm:ss	xxx	PROP_B	TCU fault DO channel in short circuit Also consider a floating Ground problem.
Operator Guide **Intervention:** Check the DO channel is not in short circuit. Change DO board.					
Involved Components NDO board, NDO wirings					
Reference Diagrams Figure 07-II-03.9 Propulsion Converter - Schematic Diagram Figure 07-II-03.10					

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1120</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>HSCB command DO channel in short circuit
Also consider a floating Ground problem.</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the wiring from the HSCB to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
NDO board, HSCB, HSCB - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.12</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1220</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>HSCB command DO channel in short circuit
Also consider a floating Ground problem.</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the wiring from the HSCB to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
NDO board, HSCB, HSCB - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1121	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Main contactor DO channel in short circuit Also consider a floating Ground problem.
Operator Guide **Effect:** HSCB trip. **Intervention:** Check the wiring from the main contactor to the DO channel. Change DO board.					
Involved Components CP, NDO board, CP-NDO wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1221	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Main contactor DO channel in short circuit Also consider a floating Ground problem.
Operator Guide **Effect:** HSCB trip. **Intervention:** Check the wiring from the main contactor to the DO channel. Change DO board.					
Involved Components CP, NDO board, CP-NDO wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1122</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Charge contactor DO channel in short circuit
Also consider a floating Ground problem.</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the wiring from the precharge contactor to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
CCF, NDO board, CCF - NDO board wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1222</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Charge contactor DO channel in short circuit
Also consider a floating Ground problem.</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the wiring from the precharge contactor to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
CCF, NDO board, CCF - NDO board wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1123	mm/dd/yy	hh:mm:ss	xxx	PROP_A	TCU fault DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the TCUOK wiring channel. Change DO board.					
Involved Components NDO board, 3K10 Relay wiring					
Reference Diagrams Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1223	mm/dd/yy	hh:mm:ss	xxx	PROP_B	TCU fault DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the TCUOK wiring channel. Change DO board.					
Involved Components NDO board, 3K10 Relay wiring					
Reference Diagrams Figure 07-II-03.10					

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1124</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>HSCB command DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the wiring from the HSCB to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
NDO board, HSCB, HSCB - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1224</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>HSCB command DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the wiring from the HSCB to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
NDO board, HSCB, HSCB - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1125</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Main contactor DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention:
Check the wiring from the main contactor to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
CP, NDO board, CP - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1225</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Main contactor DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention:
Check the wiring from the main contactor to the DO channel.
Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
CP, NDO board, CP - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

(Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1126	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Charge contactor DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the wiring from the precharge contactor to the DO channel. Change DO board.					
Involved Components CCF, NDO board, CCF - NDO wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Fault#	Date	Time	Vehicle#	System	Description
1226	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Charge contactor DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention:** Check the wiring from the precharge contactor to the DO channel. Change DO board.					
Involved Components CCF, NDO board, CCF - NDO wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1127	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Sliding algorithm error
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check speed sensors.					
Involved Components Speed Sensors, Speed sensor wirings, PIA board, PCA board, Mother board					
Reference Diagrams Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1227	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Sliding algorithm error
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check speed sensors.					
Involved Components Speed Sensors, Speed sensor wirings, PIA board, PCA board, Mother board					
Reference Diagrams Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1128</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Warm motors</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention:
Check there are no obstructions on the motors ventilation grid.
Check the thermal sensors wiring from the motors to the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
Motor, Motor thermal sensors, PIA board, Motor thermal Sensors - PIA wirings</td></tr>
<tr><td colspan="6">Threshold
284°F (140°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.12</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1228</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Warm motors</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention:
Check there are no obstructions on the motors ventilation grid.
Check the thermal sensors wiring from the motors to the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
Motor, Motor thermal sensors, PIA board, Motor thermal Sensors - PIA wirings</td></tr>
<tr><td colspan="6">Threshold
284°F (140°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.12</td></tr>
</table>

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1129	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Hot motors
Operator Guide					
Effect: Inverter shut down. **Intervention:** Check there are no obstructions on the motors ventilation grid. Check the thermal sensors wiring from the motors to the PIA board.					
Involved Components					
Motor, Motor thermal sensors, PIA board, Motor thermal Sensors - PIA wirings					
Threshold					
356°F (180°C)					
Reference Diagrams					
Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1229	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Hot motors
Operator Guide					
Effect: Inverter shut down. **Intervention:** Check there are no obstructions on the motors ventilation grid. Check the thermal sensors wiring from the motors to the PIA board.					
Involved Components Motor, Motor thermal sensors, PIA board, Motor thermal Sensors - PIA wirings					
Threshold 356°F (180°C)					
Reference Diagrams Figure 07-II-03.12					

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1130</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Filter transducer failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the filter voltage transducer.
Check the wiring connection to the the TCU Mother board connector.
Change the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
TVF, TVF wiring, PIA board, Mother board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1230</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Filter transducer failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the filter voltage transducer.
Check the wiring connection to the TCU Mother board connector.
Change the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
TVF, TVF wiring, PIA board, Mother board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1131	mm/dd/yy	hh:mm:ss	xxx	PROP_A	High filter voltage derivate
Operator Guide **Effect:** Inverter shut down. **Intervention**: None					
Involved Components TVF, TVF wiring, PIA board, Mother board					
Threshold Max 1000 V/s for each 10 Inverter Cycles					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle #**	**System**	**Description**
1231	mm/dd/yy	hh:mm:ss	xxx	PROP_B	High filter voltage derivate
Operator Guide **Effect:** Inverter shut down. **Intervention**: None					
Involved Components TVF, TVF wiring, PIA board, Mother board					
Threshold Max 1000 V/s for each 10 Inverter Cycles					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1132</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Filter voltage oscillations</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention: None</td></tr>
<tr><td colspan="6">Involved Components
TVF, TVF wiring, PIA board, Mother board</td></tr>
<tr><td colspan="6">Threshold
Max 100Vpp oscillation for more that 1 s</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle #</th><th>System</th><th>Description</th></tr>
<tr><td>1232</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Filter voltage oscillations</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention: None</td></tr>
<tr><td colspan="6">Involved Components
TVF, TVF wiring, PIA board, Mother board</td></tr>
<tr><td colspan="6">Threshold
Max 100Vpp oscillation for more that 1 s</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1134	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Negative line current transducer failure
Operator Guide **Intervention**: Check negative current transducer. Check the wiring connection to the the TCU Mother board connector. Change the PIA board.					
Involved Components TAL2 current transducer, PIA board, TAL - PIA wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1234	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Negative line current transducer failure
Operator Guide **Intervention**: Check negative current transducer. Check the wiring connection to the TCU Mother board connector. Change the PIA board.					
Involved Components TAL2 current transducer, PIA board, TAL - PIA wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1135	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Dynamic brake failure
Operator Guide **Effect:** Dynamic brake inhibition. **Intervention**: Check the braking chopper module. Check the braking resistor value. Check the wiring from the module to the TCU. Change the PIA board. Change the braking chopper module.					
Involved Components Braking Chopper Module, Braking Chopper Module wiring, PIA board, Braking Resistor, Braking Resistor wiring					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1235	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Dynamic brake failure
Operator Guide **Effect:** Dynamic brake inhibition. **Intervention**: Check the braking chopper module. Check the braking resistor value. Check the wiring from the module to the TCU. Change the PIA board. Change the braking chopper module.					
Involved Components Braking Chopper Module, Braking Chopper Module wiring, PIA board, Braking Resistor, Braking Resistor wiring					
Reference Diagrams Figure 07-II-03.13					

NOTE: Faults 1135 and 1235 are activated when a Brake Mode has been requested and the Inverter is not working.

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1136	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Filter discharge resistor fault
Operator Guide **Intervention**: Measure discharge resistors value. Check the filter voltage transducer. Check the wiring from the filter voltage transducer to the the TCU Mother board connector. Check the PIA board.					
Involved Components RCF, PIA board, TVF Voltage Transducer, TVF - PIA wiring, Mother board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1236	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Filter discharge resistor fault
Operator Guide **Intervention**: Measure discharge resistors value. Check the filter voltage transducer. Check the wiring from the filter voltage transducer to the the TCU Mother board connector. Check the PIA board.					
Involved Components RCF, PIA board, TVF Voltage Transducer, TVF - PIA wiring, Mother board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1137</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Main contactor DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention: Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
CP, NDO board, CP - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1237</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Main contactor DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention: Change DO board.</td></tr>
<tr><td colspan="6">Involved Components</td></tr>
<tr><td colspan="6">Reference Diagrams</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1138	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Charge contactor DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention**: Change DO board.					
Involved Components CCF, NDO board, CCF - NDO wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1238	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Charge contactor DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention**: Change DO board.					
Involved Components CCF, NDO board, CCF - NDO wiring					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1139</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>HSCB command DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention: Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
NDO board, HSCB, HSCB - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1239</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>HSCB command DO channel blocked</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention: Change DO board.</td></tr>
<tr><td colspan="6">Involved Components
NDO board, HSCB, HSCB - NDO wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1140	mm/dd/yy	hh:mm:ss	xxx	PROP_A	TCU fault DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention**: Change DO board.					
Involved Components NDO board, 3K10 Relay wiring					
Reference Diagrams Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1240	mm/dd/yy	hh:mm:ss	xxx	PROP_B	TCU fault DO channel blocked
Operator Guide **Effect:** Inverter cut out. **Intervention**: Change DO board.					
Involved Components NDO board, 3K10 Relay wiring					
Reference Diagrams Figure 07-II-03.10					

Fault#	Date	Time	Vehicle#	System	Description
1141	mm/dd/yy	hh:mm:ss	xxx	PROP_A	HSCB trip counter
Operator Guide **Effect:** Inverter cut out. **Intervention**: Find the reason of the HSCB trip and solve it.					
Threshold HSCB trip > 7 in 5 min.					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1241	mm/dd/yy	hh:mm:ss	xxx	PROP_B	HSCB trip counter
Operator Guide **Effect:** Inverter cut out. **Intervention**: Find the reason of the HSCB trip and solve it.					
Threshold HSCB trip > 7 in 5 min.					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1142</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Check DO board as well, this board provides the negative to contactor coil.</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the inverter thermal switches.
Check the wiring from thermal switch to DIA board.
Change DIA board.
Change the broken module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Modules, Thermal Switches, NDI_A board</td></tr>
<tr><td colspan="6">Threshold
221°F (105°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1242</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Check DO board as well, this board provides the negative to contactor coil.</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the inverter thermal switches.
Check the wiring from thermal switch to DIA board.
Change DIA board.
Change the broken module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Modules, Thermal Switches, NDI_A board</td></tr>
<tr><td colspan="6">Threshold
221°F (105°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1144	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Check DO board as well, this board provides the negative to contactor coil.

Operator Guide

Effect: Inverter cut out.
Intervention:
Check the precharge contactor is working.
Check the wiring between the precharge contactor and the DIA board.
Check DIA board.
Change DIA board.

Involved Components

CCF, NDI A, CCF - NDI A wiring

Reference Diagrams

Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram

Fault#	Date	Time	Vehicle#	System	Description
1244	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Check DO board as well, this board provides the negative to contactor coil.

Operator Guide

Effect: Inverter cut out.
Intervention:
Check the precharge contactor is working.
Check the wiring between the precharge contactor and the DIA board.
Check DIA board.
Change DIA board.

Involved Components

CCF, NDI A, CCF - NDI A wiring

Reference Diagrams

Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1145	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Check DO board as well, this board provides the negative to contactor coil.
Operator Guide **Effect:** Inverter cut out. **Intervention**: Check the main contactor. Check the wiring between the main contactor and the DIA board. Check DIA board. Change DIA board.					
Involved Components CP, CP wirings, NDI A board, NDO board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1245	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Check DO board as well, this board provides the negative to contactor coil.
Operator Guide **Effect:** Inverter cut out. **Intervention**: Check the main contactor. Check the wiring between the main contactor and the DIA board. Check DIA board. Change DIA board.					
Involved Components CP, CP wirings, NDI A board, NDO board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1146	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Positive Line current transducer permanent failure
Operator Guide **Effect:** Inverter cut out. **Intervention**: Check the positive current transducer contactor is working. Check the wiring between the transducer and the PIA board. Check PIA board. Change PIA board.					
Involved Components TAL1, TAL1 wirings, PIA board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1246	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Positive Line current transducer permanent failure
Operator Guide **Effect:** Inverter cut out. **Intervention**: Check the positive current transducer contactor is working. Check the wiring between the transducer and the PIA board. Check PIA board. Change PIA board.					
Involved Components TAL1, TAL1 wirings, PIA board					
Reference Diagrams Figure 07-II-03.8 Propulsion Converter Figure 07-II-03.9 Propulsion Converter - Schematic Diagram					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1147</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>All motor overheat thermal sensor</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the thermal sensors.
Check the wiring from the motors to the PIA board.
Change the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
Thermal Sensors, Motor Wiring (HV and LV), PIA board, PCA board, Mother board</td></tr>
<tr><td colspan="6">threshold
Temp > 284°F (140°C) or Temp > 464°F (240°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.12
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1247</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>All motor overheat thermal sensor</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter cut out.
Intervention:
Check the thermal sensors.
Check the wiring from the motors to the PIA board.
Change the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
Thermal Sensors, Motor Wiring (HV and LV), PIA board, PCA board, Mother board</td></tr>
<tr><td colspan="6">threshold
Temp > 284°F (140°C) or Temp > 464°F (240°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.12
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle #	System	Description
1148	mm/dd/yy	hh:mm:ss	xxx	PROP_A	IGBT ph A module Thermal Switch intervention
Operator Guide **Intervention**: Check DI channel wiring. Wait 30min to cool the modules. Check the thermal switch is working. Change the module.					
Involved Components Inverter Phase Module A, NDI_A board, NDI_A - Inverter Phase Module A wiring					
Threshold 221°F (105°C)					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle #**	**System**	**Description**
1248	mm/dd/yy	hh:mm:ss	xxx	PROP_B	IGBT ph A module Thermal Switch intervention
Operator Guide **Intervention**: Check DI channel wiring. Wait 30min to cool the modules. Check the thermal switch is working. Change the module.					
Involved Components Inverter Phase Module A, NDI_A board, NDI_A - Inverter Phase Module A wiring					
Threshold 221°F (105°C)					
Reference Diagrams Figure 07-II-03.13					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle #	System	Description
1149	mm/dd/yy	hh:mm:ss	xxx	PROP_A	IGBT ph B module Thermal Switch intervention
Operator Guide **Intervention**: Check DI channel wiring. Wait 30min to cool the modules. Check the thermal switch is working. Change the module.					
Involved Components Inverter Phase Module B, NDI_A board, NDI_A - Inverter Phase Module B wiring					
Threshold 221°F (105°C)					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle #**	**System**	**Description**
1249	mm/dd/yy	hh:mm:ss	xxx	PROP_B	IGBT ph B module Thermal Switch intervention
Operator Guide **Intervention**: Check DI channel wiring. Wait 30min to cool the modules. Check the thermal switch is working. Change the module.					
Involved Components Inverter Phase Module B, NDI_A board, NDI_A - Inverter Phase Module B wiring					
Threshold 221°F (105°C)					
Reference Diagrams Figure 07-II-03.13					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle #</th><th>System</th><th>Description</th></tr>
<tr><td>1150</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>IGBT ph C module Thermal Switch intervention</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check DI channel wiring.
Wait 30min to cool the modules.
Check the thermal switch is working.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module C, NDI_A board, NDI_A - Inverter Phase Module C wiring</td></tr>
<tr><td colspan="6">Threshold
221°F (105°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle #</th><th>System</th><th>Description</th></tr>
<tr><td>1250</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>IGBT ph C module Thermal Switch intervention</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check DI channel wiring.
Wait 30min to cool the modules.
Check the thermal switch is working.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module C, NDI_A board, NDI_A - Inverter Phase Module C wiring</td></tr>
<tr><td colspan="6">Threshold
221°F (105°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle #</th><th>System</th><th>Description</th></tr>
<tr><td>1151</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>IGBT ph CH module Thermal Switch interv.</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check DI channel wiring.
Wait 30min to cool the modules.
Check the thermal switch is working.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module CH, NDI_A board, NDI_A - Inverter CH Module wiring</td></tr>
<tr><td colspan="6">Threshold
221°F (105°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle #</th><th>System</th><th>Description</th></tr>
<tr><td>1251</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>IGBT ph CH module Thermal Switch interv.</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check DI channel wiring.
Wait 30min to cool the modules.
Check the thermal switch is working.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module CH, NDI_A board, NDI_A - Inverter CH Module wiring</td></tr>
<tr><td colspan="6">Threshold
221°F (105°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle #	System	Description
1152	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Motor 1 overheat thermal sensor 1
Operator Guide **Intervention**: Check the thermal sensor. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor 1, Thermal sensor 1, PIA board, Mother Board, PIA - Thermal Sensor 1 wiring					
Threshold Temp < -78°F (-61°C) or Temp > 464°F (240°C)					
Reference Diagrams Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle #**	**System**	**Description**
1252	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Motor 1 overheat thermal sensor 1
Operator Guide **Intervention**: Check the thermal sensor. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor 1, Thermal sensor 1, PIA board, Mother Board, PIA - Thermal Sensor 1 wiring					
Threshold Temp < -78°F (-61°C) or Temp > 464°F (240°C)					
Reference Diagrams Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle #	System	Description
1153	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Motor 1 overheat thermal sensor 2
Operator Guide **Intervention**: Check the thermal sensor. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor 1, Thermal sensor 2, PIA board, Mother Board, PIA - Thermal Sensor 2 wiring					
Threshold Temp < -78°F (-61°C) or Temp > 464°F (240°C)					
Reference Diagrams Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle #**	**System**	**Description**
1253	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Motor 1 overheat thermal sensor 2
Operator Guide **Intervention**: Check the thermal sensor. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor 1, Thermal sensor 2, PIA board, Mother Board, PIA - Thermal Sensor 2 wiring					
Threshold Temp < -78°F (-61°C) or Temp > 464°F (240°C)					
Reference Diagrams Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1154	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Motor 2 overheat thermal sensor 1
Operator Guide **Intervention**: Check the thermal sensor. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor 2, Thermal sensor 1, PIA board, Mother Board, PIA - Thermal Sensor 1 wiring					
Threshold Temp < -78°F (-61°C) or Temp > 464°F (240°C)					
Reference Diagrams Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1254	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Motor 2 overheat thermal sensor 1
Operator Guide **Intervention**: Check the thermal sensor. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor 2, Thermal sensor 1, PIA board, Mother Board, PIA - Thermal Sensor 1 wiring					
Threshold Temp < -78°F (-61°C) or Temp > 464°F (240°C)					
Reference Diagrams Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1155</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Motor 2 overheat thermal sensor 2</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the thermal sensor.
Check the wiring from the motor to the PIA board.
Change the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
Motor 2, Thermal sensor 2, PIA board, Mother Board, PIA - Thermal Sensor 2 wiring</td></tr>
<tr><td colspan="6">Threshold
Temp < -78°F (-61°C) or Temp > 464°F (240°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.12</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1255</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Motor 2 overheat thermal sensor 2</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the thermal sensor.
Check the wiring from the motor to the PIA board.
Change the PIA board.</td></tr>
<tr><td colspan="6">Involved Components
Motor 2, Thermal sensor 2, PIA board, Mother Board, PIA - Thermal Sensor 2 wiring</td></tr>
<tr><td colspan="6">Threshold
Temp < -78°F (-61°C) or Temp > 464°F (240°C)</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.12</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1156	mm/dd/yy	hh:mm:ss	xxx	PROP_A	PCA board - FPGA downloading error
Operator Guide **Intervention**: Change the PCA board.					
Involved Components PCA board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1256	mm/dd/yy	hh:mm:ss	xxx	PROP_B	PCA board - FPGA downloading error
Operator Guide **Intervention**: Change the PCA board.					
Involved Components PCA board					

Fault#	Date	Time	Vehicle#	System	Description
1157	mm/dd/yy	hh:mm:ss	xxx	PROP_A	PCA board - DSP downloading error
Operator Guide **Intervention**: Change the PCA board.					
Involved Components PCA board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1257	mm/dd/yy	hh:mm:ss	xxx	PROP_B	PCA board - DSP downloading error
Operator Guide **Intervention**: Change the PCA board.					
Involved Components PCA board					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1158	mm/dd/yy	hh:mm:ss	xxx	PROP_A	PIA board - FPGA downloading error
Operator Guide **Intervention**: Change the PIA board.					
Involved Components PIA board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1258	mm/dd/yy	hh:mm:ss	xxx	PROP_B	PIA board - FPGA downloading error
Operator Guide **Intervention**: Change the PIA board.					
Involved Components PIA board					

Fault#	Date	Time	Vehicle#	System	Description
1159	mm/dd/yy	hh:mm:ss	xxx	PROP_A	PIA board - VME access error
Operator Guide **Intervention**: Change the PIA board.					
Involved Components PIA board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1259	mm/dd/yy	hh:mm:ss	xxx	PROP_B	PIA board - VME access error
Operator Guide **Intervention**: Change the PIA board.					
Involved Components PIA board					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1160	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI A board - TEST 0 failure
Operator Guide **Intervention**: Check the DIA board. Change the DIA board.					
Involved Components NDI_A board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1260	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI A board - TEST 0 failure
Operator Guide **Intervention**: Check the DIA board. Change the DIA board.					
Involved Components NDI_A board					

Fault#	Date	Time	Vehicle#	System	Description
1161	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI A board - TEST 1 failure
Operator Guide **Intervention**: Check the DIA board. Change the DIA board.					
Involved Components NDI_A board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1261	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI A board - TEST 1 failure
Operator Guide **Intervention**: Check the DIA board. Change the DIA board.					
Involved Components NDI_A board					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1162	mm/dd/yy	hh:mm:ss	xxx	PROP A	DI A board - VME access error

Operator Guide

Intervention:
Check the DIA board.
Check the PCA board.
Change the DIA board.
Change the PCA board.

Involved Components

NDI_A board

Fault#	Date	Time	Vehicle#	System	Description
1262	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI A board - VME access error

Operator Guide

Intervention:
Check the DIA board.
Check the PCA board.
Change the DIA board.
Change the PCA board.

Involved Components

NDI_A board

Fault#	Date	Time	Vehicle#	System	Description
1163	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DO board - VME access error

Operator Guide

Intervention:
Check the DO board.
Check the PCA board.
Change the DO board.
Change the PCA board.

Involved Components

NDO board

Fault#	Date	Time	Vehicle#	System	Description
1263	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DO board - VME access error

Operator Guide

Intervention:
Check the DO board.
Check the PCA board.
Change the DO board.
Change the PCA board.

Involved Components

NDO board

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1165	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI B board - TEST 0 failure

Operator Guide

Intervention:
Check the DIB board.
Change the DIB board.

Involved Components

NDI_B board

Fault#	Date	Time	Vehicle#	System	Description
1265	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI B board - TEST 0 failure

Operator Guide

Intervention:
Check the DIB board.
Change the DIB board.

Involved Components

NDI_B board

Fault#	Date	Time	Vehicle#	System	Description
1166	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI B board - TEST 1 failure

Operator Guide

Intervention:
Check the DIB board.
Change the DIB board.

Involved Components

NDI_B board

Fault#	Date	Time	Vehicle #	System	Description
1266	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI B board - TEST 1 failure

Operator Guide

Intervention:
Check the DIB board.
Change the DIB board.

Involved Components

NDI_B board

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1167	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI B board - VME access error
Operator Guide					
Intervention: Check the DIB board. Check the PCA board. Change the DIB board. Change the PCA board.					
Involved Components					
NDI_B board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1267	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI B board - VME access error
Operator Guide					
Intervention: Check the DIB board. Check the PCA board. Change the DIB board. Change the PCA board.					
Involved Components					
NDI_B board					

Fault#	Date	Time	Vehicle#	System	Description
1168	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI A board - power supply failure
Operator Guide					
Intervention: Check the power supply on DIA. Change DIA board.					
Involved Components					
NDI_A board, Mother board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1268	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI A board - power supply failure
Operator Guide					
Intervention: Check the power supply on DIA. Change DIA board.					
Involved Components					
NDI_A board, Mother board					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1169	mm/dd/yy	hh:mm:ss	xxx	PROP_A	DI B board - power supply failure
Operator Guide **Intervention**: Check the power supply on DIB. Change DIB board.					
Involved Components NDI_B board, Mother board					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1269	mm/dd/yy	hh:mm:ss	xxx	PROP_B	DI B board - power supply failure
Operator Guide **Intervention**: Check the power supply on DIB. Change DIB board.					
Involved Components NDI_B board, Mother board					

Fault#	Date	Time	Vehicle#	System	Description
1170	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Active speed sensor failure
Operator Guide **Intervention**: Check motor speed sensors. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor Speed sensor, PIA board, speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1270	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Active speed sensor failure
Operator Guide **Intervention**: Check motor speed sensors. Check the wiring from the motor to the PIA board. Change the PIA board.					
Involved Components Motor Speed sensor, PIA board, speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1171</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Passive speed sensor failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the speed sensor.
Check the wiring from the motor to the PCA board.
Change the PCA board.</td></tr>
<tr><td colspan="6">Involved Components
Passive Speed Sensor, Speed Sensor Wiring, PIA board, Motherboard, PCA board</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1271</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Passive speed sensor failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the speed sensor.
Check the wiring from the motor to the PCA board.
Change the PCA board.</td></tr>
<tr><td colspan="6">Involved Components
Passive Speed Sensor, Speed Sensor Wiring, PIA board, Motherboard, PCA board</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1172</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Inverter Phase A overcurrent
If the fault does not clear by itself within a few minutes, then it has be investigated.</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention: Check the wiring from the motors to the inverter.</td></tr>
<tr><td colspan="6">Involved Components
Motor, Motor wiring, Inverter Phase Module A, TA Current Transducer, PIA board, PCA board</td></tr>
<tr><td colspan="6">Threshold
1,600A</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.12</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1272</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Inverter Phase A overcurrent
If the fault does not clear by itself within a few minutes, then it has be investigated.</td></tr>
<tr><td colspan="6">Operator Guide
Effect: Inverter shut down.
Intervention: Check the wiring from the motors to the inverter.</td></tr>
<tr><td colspan="6">Involved Components
Motor, Motor wiring, Inverter Phase Module A, TA Current Transducer, PIA board, PCA board</td></tr>
<tr><td colspan="6">Threshold
1,600A</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1173	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Inverter Phase B overcurrent If the fault does not clear by itself within a few minutes, then it has be investigated.
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check the wiring from the motors to the inverter.					
Involved Components Motor, Motor wiring, Inverter Phase Module B, TB Current Transducer, PIA board, PCA board					
Threshold 1,600A					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1273	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Inverter Phase B overcurrent If the fault does not clear by itself within a few minutes, then it has be investigated.
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check the wiring from the motors to the inverter.					
Involved Components Motor, Motor wiring, Inverter Phase Module B, TB Current Transducer, PIA board, PCA board					
Threshold 1,600A					
Reference Diagrams Figure 07-II-03.13					

(cont'd)

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1174	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Inverter Phase C overcurrent If the fault does not clear by itself within a few minutes, then it has be investigated.
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check the wiring from the motors to the inverter.					
Involved Components Motor, Motor wiring, Inverter Phase Module C, TC Current Transducer, PIA board, PCA board					
Threshold 1,600A					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1274	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Inverter Phase C overcurrent If the fault does not clear by itself within a few minutes, then it has be investigated.
Operator Guide **Effect:** Inverter shut down. **Intervention**: Check the wiring from the motors to the inverter.					
Involved Components Motor, Motor wiring, Inverter Phase Module C, TC Current Transducer, PIA board, PCA board					
Threshold 1,600A					
Reference Diagrams Figure 07-II-03.13					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1175	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Inverter phases unbalance Check the IGBT Phases for any abnormality. Pay attention to any unusual AC motor noise. Also consier TCU Mother board when this fault happens.
Operator Guide **Effect:** HSCB trip. **Intervention**: Check the wiring from the motors to the inverter.					
Involved Components Motor, Motor wiring, Inverter Phase Modules A, B, C, CH, Current Transducers TA, TB, TC, TCH .					
Threshold 1,600A					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1275	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Inverter phases unbalance Check the IGBT Phases for any abnormality. Pay attention to any unusual AC motor noise. Also consider TCU Mother board when this fault happens.
Operator Guide **Effect:** HSCB trip. **Intervention**: Check the wiring from the motors to the inverter.					
Involved Components Motor, Motor wiring, Inverter Phase Modules A, B, C, CH, Current Transducers TA, TB, TC, TCH .					
Threshold 1,600A					
Reference Diagrams Figure 07-II-03.13					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1176</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>IGBT phase module A failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the wiring from the module to the PIA board.
Change the PIA board. Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module A, PIA board, Inverter Phase Module - PIA wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1276</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>IGBT phase module A failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the wiring from the module to the PIA board.
Change the PIA board. Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module A, PIA board, Inverter Phase Module - PIA wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1177</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>IGBT phase module B failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the wiring from the module to the PIA board.
Change the PIA board.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module B, PIA board, Inverter Phase Module - PIA wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1277</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>IGBT phase module B failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the wiring from the module to the PIA board.
Change the PIA board.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module B, PIA board, Inverter Phase Module - PIA wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1178</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>IGBT phase module C failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the wiring from the module to the PIA board.
Change the PIA board.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module C, PIA board, Inverter Phase Module - PIA wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1278</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>IGBT phase module C failure</td></tr>
<tr><td colspan="6">Operator Guide
Effect: HSCB trip.
Intervention:
Check the wiring from the module to the PIA board.
Change the PIA board.
Change the module.</td></tr>
<tr><td colspan="6">Involved Components
Inverter Phase Module C, PIA board, Inverter Phase Module - PIA wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.13</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1179	mm/dd/yy	hh:mm:ss	xxx	PROP_A	IGBT phase module CH failure
Operator Guide **Effect:** HSCB trip. **Intervention:** Check the wiring from the module to the PIA board. Change the PIA board. Change the module.					
Involved Components Inverter Phase Module CH, PIA board, Inverter Phase Module - PIA wiring					
Reference Diagrams Figure 07-II-03.13					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1279	mm/dd/yy	hh:mm:ss	xxx	PROP_B	IGBT phase module CH failure
Operator Guide **Effect:** HSCB trip. **Intervention:** Check the wiring from the module to the PIA board. Change the PIA board. Change the module.					
Involved Components Inverter Phase Module CH, PIA board, Inverter Phase Module - PIA wiring					
Reference Diagrams Figure 07-II-03.13					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1180</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Low Voltage Power Supply failure (input 1)</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the TCU power supply.
Change the TCU power supply.</td></tr>
<tr><td colspan="6">Involved Components
TCU Power Supply Unit, TCU Power Supply Unit wiring</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1280</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Low Voltage Power Supply failure (input 1)</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the TCU power supply.
Change the TCU power supply.</td></tr>
<tr><td colspan="6">Involved Components
TCU Power Supply Unit, TCU Power Supply Unit wiring</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1181</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Low Voltage Power Supply failure (input 2)</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the TCU power supply.
Change the TCU power supply.</td></tr>
<tr><td colspan="6">Involved Components
TCU Power Supply Unit, TCU Power Supply Unit wiring</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1281</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Low Voltage Power Supply failure (input 2)</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the TCU power supply.
Change the TCU power supply.</td></tr>
<tr><td colspan="6">Involved Components
TCU Power Supply Unit, TCU Power Supply Unit wiring</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1182</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Watch dog PCA board</td></tr>
<tr><td colspan="6">Operator Guide
Effect: SW reset.
Intervention:
Check the PCA SW version.
Change PCA board.</td></tr>
<tr><td colspan="6">Involved Components
PCA board</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1282</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Watch dog PCA board</td></tr>
<tr><td colspan="6">Operator Guide
Effect: SW reset.
Intervention:
Check the PCA SW version.
Change PCA board.</td></tr>
<tr><td colspan="6">Involved Components
PCA board</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1183</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Watch dog STB board</td></tr>
<tr><td colspan="6">Operator Guide
Effect: SW reset.
Intervention:
Check the STB SW version.
Change STB board.</td></tr>
<tr><td colspan="6">Involved Components
STB board</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1283</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Watch dog STB board</td></tr>
<tr><td colspan="6">Operator Guide
Effect: SW reset.
Intervention:
Check the STB SW version.
Change STB board.</td></tr>
<tr><td colspan="6">Involved Components
STB board</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1184</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Filter over voltage
Also check Braking Resistor Grid for any loose connection or hardware</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the filter voltage transducer.
Check the wiring from the transducer to the TCU Mother board connector.
Check the braking chopper.</td></tr>
<tr><td colspan="6">Involved Components
Catenary Line, Line Reactor, TVF Voltage Transducer, PIA board, Mother board,
TVF - PIA wiring</td></tr>
<tr><td colspan="6">Threshold
1,050 Vdc</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1284</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Filter over voltage
Also check Braking Resistor Grid for any loose connection or hardware</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the filter voltage transducer.
Check the wiring from the transducer to the TCU Mother board connector.
Check the braking chopper.</td></tr>
<tr><td colspan="6">Involved Components
Catenary Line, Line Reactor, TVF Voltage Transducer, PIA board, Mother board,
TVF - PIA wiring</td></tr>
<tr><td colspan="6">Threshold
1,050 Vdc</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1185</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP A</td><td>Line over current</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the line current transducer.
Check the wiring from the transducer to the TCU Mother board connector.</td></tr>
<tr><td colspan="6">Involved Components
Catenary Line, Line Reactor, TAL1 Current Transducer, PIA board, Mother board,
TAL1 - PIA wiring</td></tr>
<tr><td colspan="6">Threshold
600 A</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1285</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Line over current</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the line current transducer.
Check the wiring from the transducer to the TCU Mother board connector.</td></tr>
<tr><td colspan="6">Involved Components
Catenary Line, Line Reactor, TAL1 Current Transducer, PIA board, Mother board,
TAL1 - PIA wiring</td></tr>
<tr><td colspan="6">Threshold
600 A</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1186	mm/dd/yy	hh:mm:ss	xxx	PROP_A	4-20mA loop cab A failure Check Encoder. Check Encoder Power Supply.
Operator Guide **Intervention**: Check the 4-20mA current loop of the master controller in CAB A. Check the wiring from the master controller to the FBK board. Change the FBK board. Change the master controller.					
Involved Components Master Controller, FBK board, MC Encoder - FBK wiring					
Reference Diagrams Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1286	mm/dd/yy	hh:mm:ss	xxx	PROP_B	4-20mA loop cab A failure Check Encoder. Check Encoder Power Supply.
Operator Guide **Intervention**: Check the 4-20mA current loop of the master controller in CAB A. Check the wiring from the master controller to the FBK board. Change the FBK board. Change the master controller.					
Involved Components Master Controller, FBK board, MC Encoder - FBK wiring					
Reference Diagrams Figure 07-II-03.10					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1187</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Wheel diameter 1 failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check on the IDU the value of the reference wheel diameter.</td></tr>
<tr><td colspan="6">Involved Components
Wheel diameter, Speed Sensor, PIA board, Speed Sensor - PIA wiring, STB board, Mother board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.1 Vehicle Logic - TCU_A Interface
Figure 07-II-03.12</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1287</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Wheel diameter 1 failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check on the IDU the value of the reference wheel diameter.</td></tr>
<tr><td colspan="6">Involved Components
Wheel diameter, Speed Sensor, PIA board, Speed Sensor - PIA wiring, STB board, Mother board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.2 Vehicle Logic - TCU_B Interface
Figure 07-II-03.12</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1188</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Wheel diameter 2 failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check on the IDU the value of the reference wheel diameter.</td></tr>
<tr><td colspan="6">Involved Components
Wheel diameter, Speed Sensor, PIA board, Speed Sensor - PIA wiring, STB board, Mother board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.1 Vehicle Logic - TCU_A Interface
Figure 07-II-03.12</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1288</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Wheel diameter 2 failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check on the IDU the value of the reference wheel diameter.</td></tr>
<tr><td colspan="6">Involved Components
Wheel diameter, Speed Sensor, PIA board, Speed Sensor - PIA wiring, STB board, Mother board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.2 Vehicle Logic - TCU_B Interface
Figure 07-II-03.12</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1189	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Wheel diameter 3 failure
Operator Guide **Intervention**: Check on the IDU the value of the reference wheel diameter.					
Involved Components Wheel diameter, Speed Sensor, PIA board, Speed Sensor - PIA wiring, STB board, Mother board					
Reference Diagrams Figure 07-II-03.1 Vehicle Logic - TCU_A Interface Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1289	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Wheel diameter 3 failure
Operator Guide **Intervention**: Check on the IDU the value of the reference wheel diameter.					
Involved Components Wheel diameter, Speed Sensor, PIA board, Speed Sensor - PIA wiring, STB board, Mother board					
Reference Diagrams Figure 07-II-03.2 Vehicle Logic - TCU_B Interface Figure 07-II-03.12					

Fault#	Date	Time	Vehicle#	System	Description
1190	mm/dd/yy	hh:mm:ss	xxx	PROP_A	4-20mA loop Cab B failure Check Encoder. Check Encoder Power Supply.
Operator Guide **Intervention**: Check the 4-20mA current loop of the master controller in CAB B. Check the wiring from the master controller to the FBK board. Change the FBK board. Change the master controller.					
Involved Components Master Controller, FBK board, MC Encoder - FBK wiring					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1290	mm/dd/yy	hh:mm:ss	xxx	PROP_B	4-20mA loop Cab B failure Check Encoder. Check Encoder Power Supply.
Operator Guide **Intervention**: Check the 4-20mA current loop of the master controller in CAB B. Check the wiring from the master controller to the FBK board. Change the FBK board. Change the master controller.					
Involved Components Master Controller, FBK board, MC Encoder - FBK wiring					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1191	mm/dd/yy	hh:mm:ss	xxx	PROP A	Speed sensor 1 failure
Operator Guide **Intervention**: Check the speed sensor. Check the wiring from the speed sensor to the PIA board. Change the speed sensor. Change the PIA board.					
Involved Components Speed Sensor, PIA board, Speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.1 Vehicle Logic - TCU_A Interface Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1291	mm/dd/yy	hh:mm:ss	xxx	PROP B	Speed sensor 1 failure
Operator Guide **Intervention**: Check the speed sensor. Check the wiring from the speed sensor to the PIA board. Change the speed sensor. Change the PIA board.					
Involved Components Speed Sensor, PIA board, Speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.2 Vehicle Logic - TCU_B Interface Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1192	mm/dd/yy	hh:mm:ss	xxx	PROP A	Speed sensor 2 failure
Operator Guide **Intervention**: Check the speed sensor. Check the wiring from the speed sensor to the PIA board. Change the speed sensor. Change the PIA board.					
Involved Components Speed Sensor, PIA board, Speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.1 Vehicle Logic - TCU_A Interface Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1292	mm/dd/yy	hh:mm:ss	xxx	PROP B	Speed sensor 2 failure
Operator Guide **Intervention**: Check the speed sensor. Check the wiring from the speed sensor to the PIA board. Change the speed sensor. Change the PIA board.					
Involved Components Speed Sensor, PIA board, Speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.2 Vehicle Logic - TCU_B Interface Figure 07-II-03.12					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1193	mm/dd/yy	hh:mm:ss	xxx	PROP A	Speed sensor 3 failure
Operator Guide **Intervention**: Check the speed sensor. Check the wiring from the speed sensor to the PIA board. Change the speed sensor. Change the PIA board.					
Involved Components Speed Sensor, PIA board, Speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.1 Vehicle Logic - TCU_A Interface Figure 07-II-03.12					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1293	mm/dd/yy	hh:mm:ss	xxx	PROP B	Speed sensor 3 failure
Operator Guide **Intervention**: Check the speed sensor. Check the wiring from the speed sensor to the PIA board. Change the speed sensor. Change the PIA board.					
Involved Components Speed Sensor, PIA board, Speed Sensor - PIA wiring					
Reference Diagrams Figure 07-II-03.2 Vehicle Logic - TCU_B Interface Figure 07-II-03.12					

NOTE: A fault that shows on the trains and is not mentioned here is, "PROP_A or PROP_B: wrong speed sensor direction". The cause of this fault can be a wiring problem on the speed sensor (active sensors only, motor) or a defective speed sensor.

Table 07-II-03.5   Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1194</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>MVB communication failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the gateway is working.
Check TCU MVB wiring.
Change the STB board.</td></tr>
<tr><td colspan="6">Involved Components
Gateway, MVB connectors of all MVB interfaced Systems, STB board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.11</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1294</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>MVB communication failure</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the gateway is working.
Check TCU MVB wiring.
Change the STB board.</td></tr>
<tr><td colspan="6">Involved Components
Gateway, MVB connectors of all MVB interfaced Systems, STB board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.11</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1196</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>EB application</td></tr>
<tr><td colspan="6">Operator Guide
Effect:: Inverter shut down.
Intervention: None
Trigger Conditions: Active if: Emergency Brake application</td></tr>
<tr><td colspan="6">Involved Components
EB Emergency Pushbutton, EB Loop wiring, ATP, NDI_A board</td></tr>
<tr><td colspan="6">Reference Diagrams</td></tr>
<tr><td colspan="6">Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1296</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>EB application</td></tr>
<tr><td colspan="6">Operator Guide
Effect:: Inverter shut down.
Intervention: None
Trigger Conditions: Active if: Emergency Brake application</td></tr>
<tr><td colspan="6">Involved Components
EB Emergency Pushbutton, EB Loop wiring, ATP, NDI_A board</td></tr>
<tr><td colspan="6">Reference Diagrams</td></tr>
<tr><td colspan="6">Figure 07-II-03.10</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1197</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>SCEB application</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: None
Trigger Conditions: Active if: Slide Cotrolled Emergency Brake application</td></tr>
<tr><td colspan="6">Involved Components
MC Handle, MC Handle wiring, NDI_A board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1297</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>SCEB application</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: None
Trigger Conditions: Active if: Slide Cotrolled Emergency Brake application</td></tr>
<tr><td colspan="6">Involved Components
MC Handle, MC Handle wiring, NDI_A board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1198</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>The trainline pattern is not consistent</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the master controller trainline pattern.
Check the wiring from the master controller to the DIA board.
Change the DIA board.
Change the Master controller.</td></tr>
<tr><td colspan="6">Involved Components
MC Handle, MC Handle wiring, NDI A board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>1298</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>The trainline pattern is not consistent</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the master controller trainline pattern.
Check the wiring from the master controller to the DIA board.
Change the DIA board.
Change the Master controller.</td></tr>
<tr><td colspan="6">Involved Components
MC Handle, MC Handle wiring, NDI A board</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
1199	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Master controller direction mismatch
Operator Guide **Intervention:** Check the master controller direction trainline. Check the wiring from the master controller to the DIA board. Change the DIA board. Change the Master controller.					
Involved Components MC Handle, MC Reverse Handle, MC wiring, NDI_A board					
Reference Diagrams Figure 07-II-03.3 Mode Selection 1 Figure 07-II-03.4 Mode Selection 2 Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
1299	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Master controller direction mismatch
Operator Guide **Intervention:** Check the master controller direction trainline. Check the wiring from the master controller to the DIA board. Change the DIA board. Change the Master controller.					
Involved Components MC Handle, MC Reverse Handle, MC wiring, NDI_A board					
Reference Diagrams Figure 07-II-03.3 Mode Selection 1 Figure 07-II-03.4 Mode Selection 2 Figure 07-II-03.10					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>110A</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Mismatch rate ref. and trainline pattern</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the gateway is working.
Check TCU MVB wiring.
Check the master controller 4-20mA current loop.
Change the FBK board.
Change the STB board.
Change the master controller.</td></tr>
<tr><td colspan="6">Involved Components
MC Handle, MC Encoder, FBK board, Encoder - FBK wiring, STB board, NDI_A board, MC Handle - NDI_A wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>120A</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Mismatch rate ref. and trainline pattern</td></tr>
<tr><td colspan="6">Operator Guide
Intervention:
Check the gateway is working.
Check TCU MVB wiring.
Check the master controller 4-20mA current loop.
Change the FBK board.
Change the STB board.
Change the master controller.</td></tr>
<tr><td colspan="6">Involved Components
MC Handle, MC Encoder, FBK board, Encoder - FBK wiring, STB board, NDI_A board, MC Handle - NDI_A wiring</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.3 Mode Selection 1
Figure 07-II-03.4 Mode Selection 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
110C	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Inverter cut out
Operator Guide **Intervention**: Find the cut out reason and solve it.					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
120C	mm/dd/yy	hh:mm:ss	xxx	PROP_B	Inverter cut out
Operator Guide **Intervention**: Find the cut out reason and solve it.					

Fault#	Date	Time	Vehicle#	System	Description
110D	mm/dd/yy	hh:mm:ss	xxx	PROP_A	No motion cross check failure
Operator Guide **Intervention**: Check the no motion relay on both TCU. Check the wiring from the no motion cross check digital input to the no motion relay. Change DIA board. Change FBK board on the other TCU. Change the STB board on the other TCU.					
Involved Components STB board, FBK board, 3K26 relay, 3K05/1 and 3K05/2 relays, NDI_A board, Mother Board					
Reference Diagrams Figure 07-II-03.10					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
120D	mm/dd/yy	hh:mm:ss	xxx	PROP_B	No motion cross check failure
Operator Guide **Intervention**: Check the no motion relay on both TCU. Check the wiring from the no motion cross check digital input to the no motion relay. Change DIA board. Change FBK board on the other TCU. Change the STB board on the other TCU.					
Involved Components STB board, FBK board, 3K26 relay, 3K05/1 and 3K05/2 relays, NDI_A board, Mother Board					
Reference Diagrams Figure 07-II-03.10					

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
110E	mm/dd/yy	hh:mm:ss	xxx	PROP A	Motor blower failure

Operator Guide

Intervention:
Check the motor blower contactor and phase sequence relay.
Check the wiring from the contactor and the relay to the TCU.
Check the motor blower.
Change the DIA board.
Change the DO board.
Change the motor blower.

Involved Components

2F06 Circuit Breaker (LV Cabinet Car A), RMF relay and CMF contactor, NDI_A board, NDO board, Inverter Fan

Reference Diagrams

Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram

Fault#	Date	Time	Vehicle#	System	Description
120E	mm/dd/yy	hh:mm:ss	xxx	PROP B	Motor blower failure

Operator Guide

Intervention:
Check the motor blower contactor and phase sequence relay.
Check the wiring from the contactor and the relay to the TCU.
Check the motor blower.
Change the DIA board.
Change the DO board.
Change the motor blower.

Involved Components

2F06 Circuit Breaker (LV Cabinet Car B), RMF relay and CMF contactor, NDI_A board, NDO board, Inverter Fan

Reference Diagrams

Figure 07-II-03.8 Propulsion Converter
Figure 07-II-03.9 Propulsion Converter - Schematic Diagram

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>110F</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>Fan Circuit Breaker Open</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check the 2F06 circuit breaker (LV Cabinet Car)</td></tr>
<tr><td colspan="6">Involved Components
2F06 circuit breaker</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>120F</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>Fan Circuit Breaker Open</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check the 2F06 circuit breaker (LV Cabinet Car B)</td></tr>
<tr><td colspan="6">Involved Components
2F06 circuit breaker</td></tr>
</table>

<table>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>11A0</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_A</td><td>HSCB Control Circuit Breaker</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check the High Speed Circuit Breaker (4F01 and/or 4F02 - LV Cabinet Car A).
Trigger Conditions Active if: DI B board channel 4 is low.</td></tr>
<tr><td colspan="6">Involved Components
HSCB, NDI_A board, 4F01 and 4F02 circuit breakers, 4K02 relay</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.1 Vehicle Logic - TCU_A Interface
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
<tr><th>Fault#</th><th>Date</th><th>Time</th><th>Vehicle#</th><th>System</th><th>Description</th></tr>
<tr><td>12B0</td><td>mm/dd/yy</td><td>hh:mm:ss</td><td>xxx</td><td>PROP_B</td><td>HSCB Control Circuit Breaker</td></tr>
<tr><td colspan="6">Operator Guide
Intervention: Check the High Speed Circuit Breaker (4F01 - LV Cabinet Car B).
Trigger Conditions Active if: DI B board channel 4 is low.</td></tr>
<tr><td colspan="6">Involved Components
HSCB, NDI_A board, 4F01 and 4F02 circuit breakers, 4K02 relay</td></tr>
<tr><td colspan="6">Reference Diagrams
Figure 07-II-03.2 Vehicle Logic - TCU_B Interface
Figure 07-II-03.5 HSCB 1
Figure 07-II-03.6 HSCB 2
Figure 07-II-03.10</td></tr>
</table>

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
11C0	mm/dd/yy	hh:mm:ss	xxx	PROP A	Power Supply Circ Brk Open

Operator Guide

Intervention:

Check the 3F11 circuit breaker ("A" LV Cabinet) and/or the 3F12 circuit breaker (Cab Panel A)
Trigger Conditions: Active if: digital input 9 on left GTW is low

Involved Components

3F11 and 3F12 circuit breakers

Fault#	Date	Time	Vehicle#	System	Description
12C0	mm/dd/yy	hh:mm:ss	xxx	PROP B	Power Supply Circ Brk Open

Operator Guide

Intervention:

Check the 3F11 circuit breaker ("B" LV Cabinet) and/or the 3F12 circuit breaker (Cab Panel B)
Trigger Conditions: Active if: digital input 9 on left GTW is low

Involved Components

3F11 and 3F12 circuit breakers

Fault#	Date	Time	Vehicle#	System	Description
11D7	mm/dd/yy	hh:mm:ss	xxx	PROP_A	Chopper fired at zero-speed

Operator Guide

Intervention:
If the fault is present for more than 5 times per day, check TCU and chopper module
Trigger Conditions: Active if: Chopper module is fired AND the vehicle is at zero-speed AND the firing command is not coming from the PTU

Involved Components

Chopper Module, TCU

Fault#	Date	Time	Vehicle#	System	Description
12D7	mm/dd/yy	hh:mm:ss	xxx	PROP B	Chopper fired at zero-speed

Operator Guide

Intervention:
If the fault is present for more than 5 times per day, check TCU and chopper module

Trigger Conditions: Active if: Chopper module is fired AND the vehicle is at zero-speed AND the firing command is not coming from the PTU

Involved Components

Chopper Module, TCU

Table 07-II-03.5 Maintenance Mode Fault Details (cont'd)

Fault#	Date	Time	Vehicle#	System	Description
11D8	mm/dd/yy	hh:mm:ss	xxx	PROP_A	MVB Communication failure between TCU and ECU
Operator Guide **Intervention**: Check ECU A is communicating on MVB **Trigger Conditions**: Active if: TCU does not receive a valid signal from the relative ECU on the MVB for 3s. The failure is deactivated as soon as the communication starts again.					
Involved Components TCU, ECU, MVB					
Fault#	**Date**	**Time**	**Vehicle#**	**System**	**Description**
12D8	mm/dd/yy	hh:mm:ss	xxx	PROP_B	MVB Communication failure between TCU and ECU
Operator Guide **Intervention**: Check ECU B is communicating on MVB **Trigger Conditions**: Active if: TCU does not receive a valid signal from the relative ECU on the MVB for 3s. The failure is deactivated as soon as the communication starts again.					
Involved Components TCU, ECU, MVB					

NOTE: A fault that shows on the trains and is not mentioned here is, "PROP_A or PROP_B: wrong speed sensor direction". The cause of this fault can be a wiring problem on the speed sensor (active sensors only, motor) or a defective speed sensor.

07-II-03.01.03 Reference Schematic Diagrams

This paragraph provides a cross-reference between the Figures of the manual and the relevant AnsaldoBreda document number and sheet number, to be used for troubleshooting purposes.

Table 07-II-03.6 Cross-reference Figures-AB Drawings

FIGURE		REFER TO DOCUMENT	
#	TITLE	P/N	SHEET
07-II-03.1	Vehicle Logic - TCU_A Interface	AA03ATW	27
07-II-03.2	Vehicle Logic - TCU_B Interface	AA03ATW	29
07-II-03.3	Mode Selection 1	AA03ATW	32
07-II-03.4	Mode Selection 2	AA03ATW	33
07-II-03.5	HSCB 1	AA03ATW	45
07-II-03.6	HSCB 2	AA03ATW	46
07-II-03.7	Master Controller Reverser Switch	AA03ATW	135
07-II-03.8	Propulsion Converter - Schematic Diagram 1	AA03KDD	2
07-II-03.9	Propulsion Converter - Schematic Diagram 2	AA03KDD	3
07-II-03.10	Propulsion Converter - Schematic Diagram 3	AA03KDD	4
07-II-03.11	Propulsion Converter - Schematic Diagram 4	AA03KDD	5
07-II-03.12	Propulsion Converter - Schematic Diagram 5	AA03KDD	6
07-II-03.13	Propulsion Converter - Schematic Diagram 6	AA03KDD	7
07-II-03.14	Schematic Diagram Inverter Module	AA03KDG	2
07-II-03.15	Grounding System	AA04YJU	1

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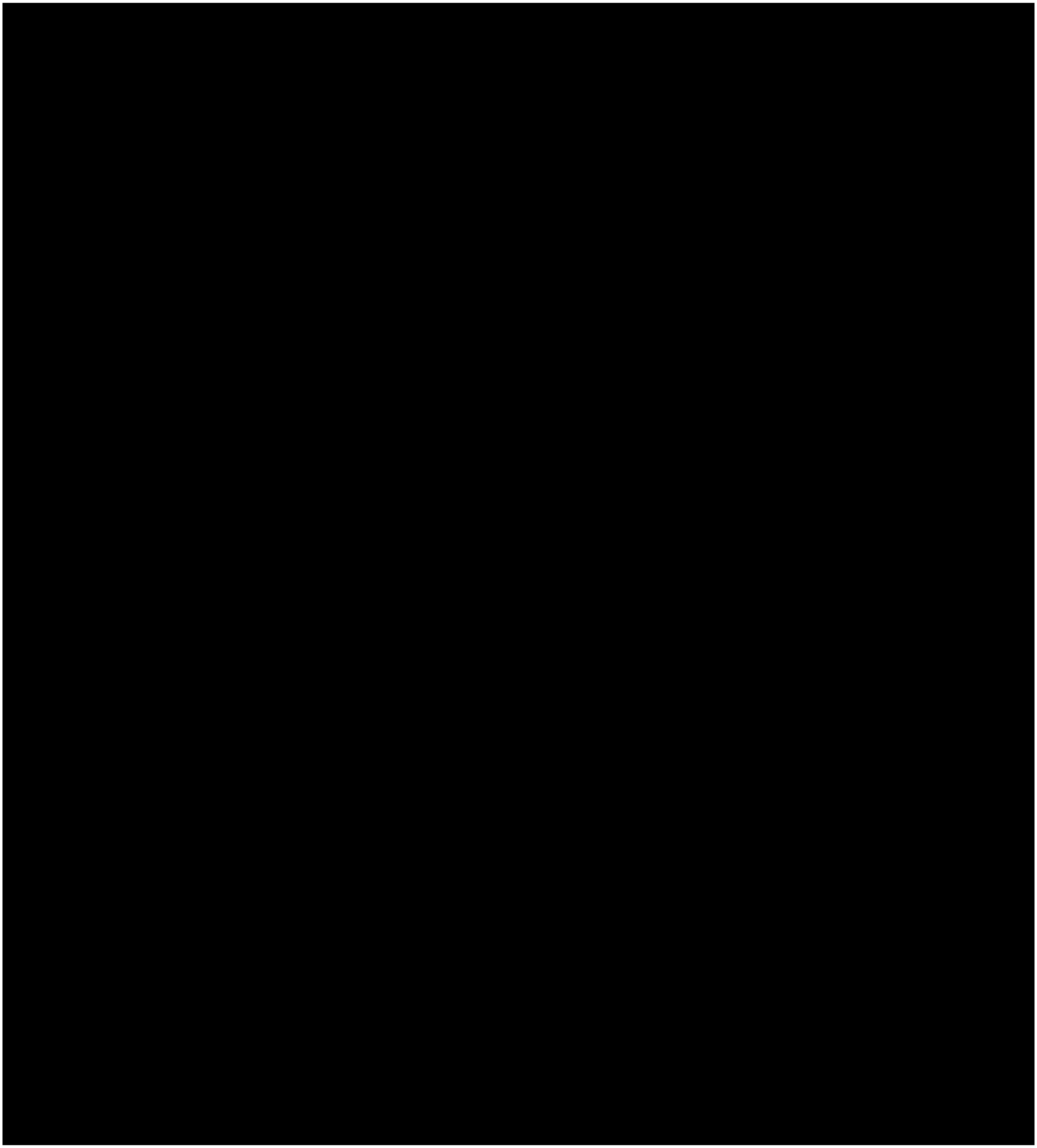
[redacted]

[redacted]



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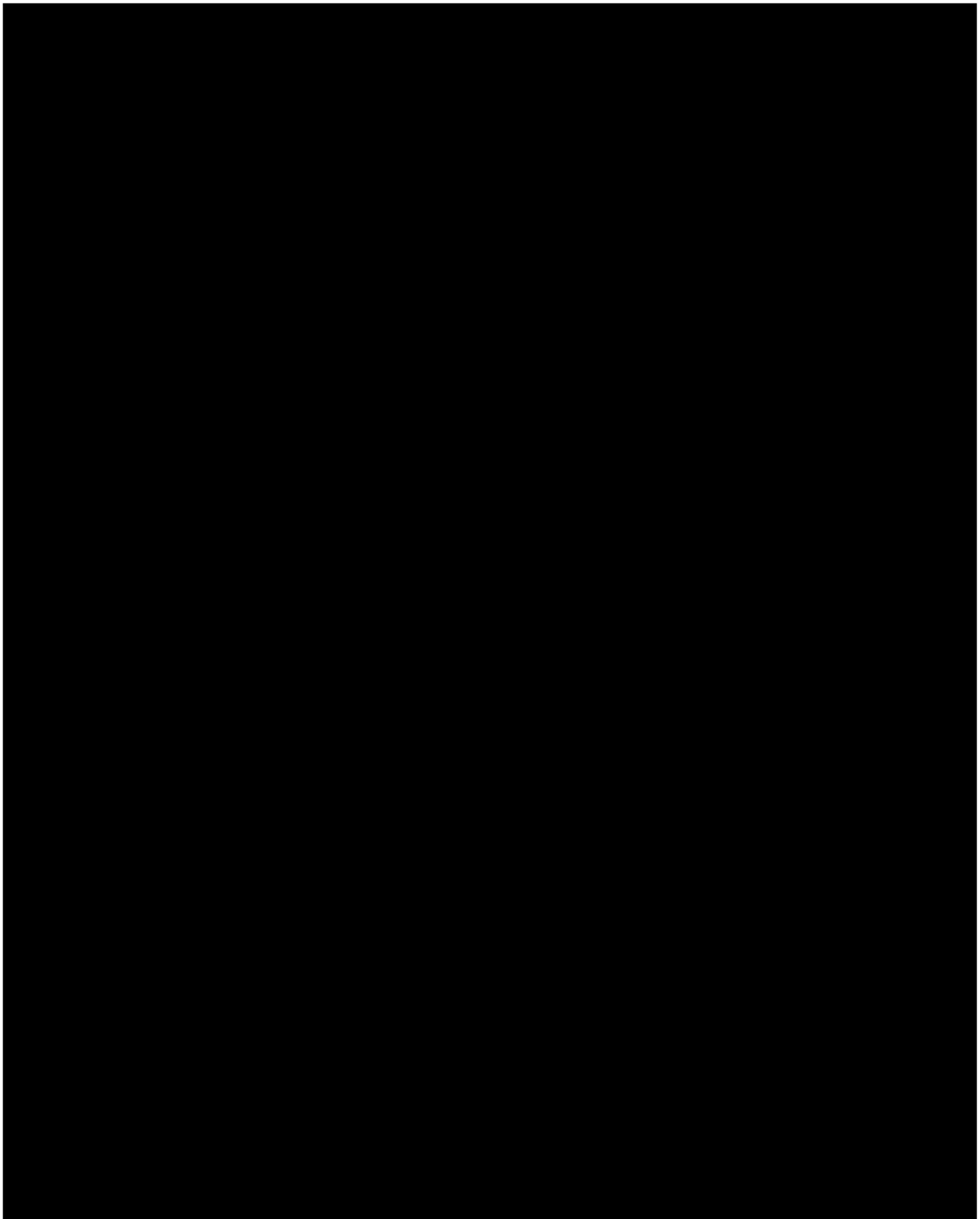

Figure 07-II-03.14 Inverter Module - Schematic Diagram

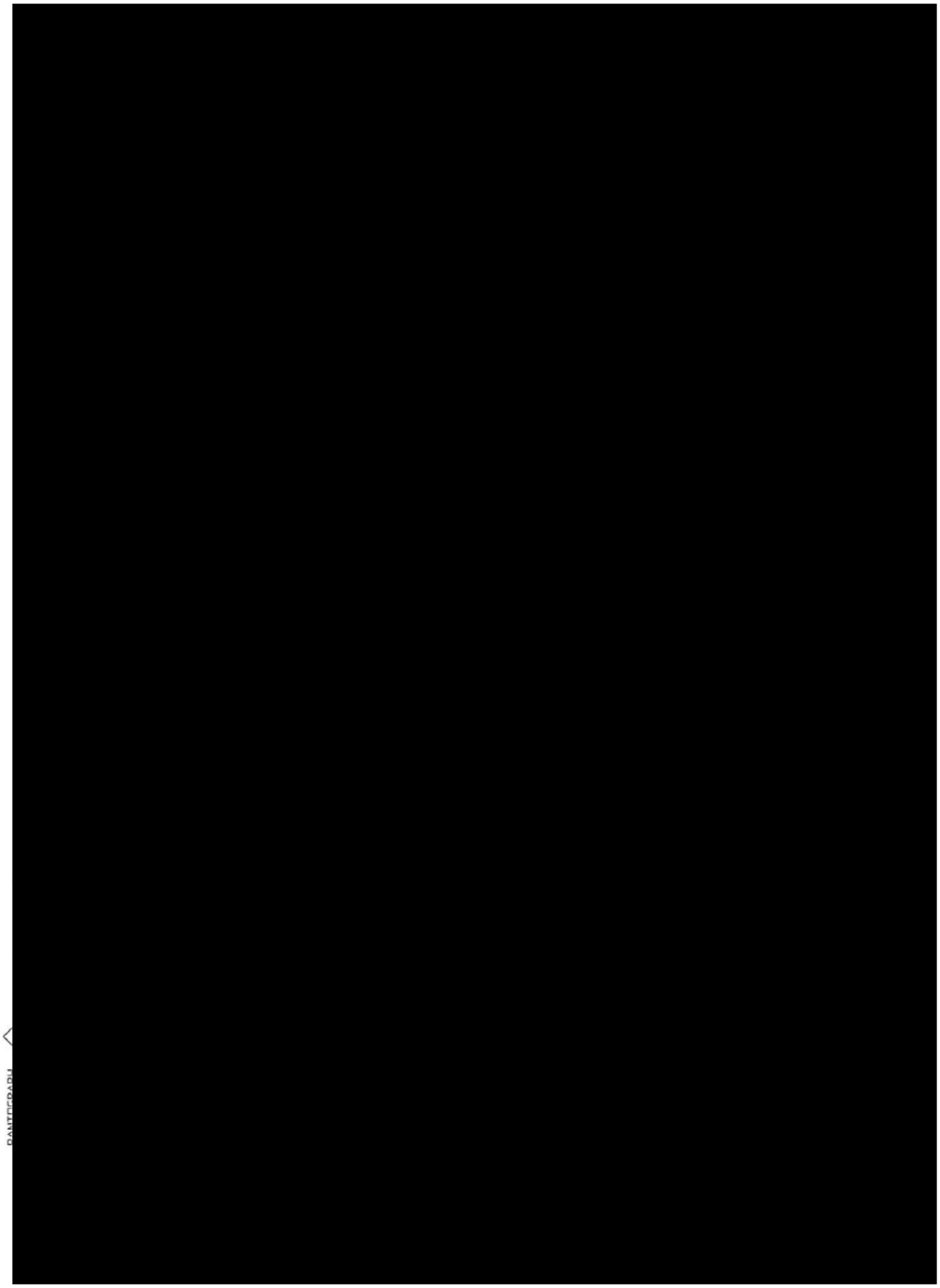

Figure 07-II-03.15 Grounding System

LOS ANGELES COUNTY

METROPOLITAN TRANSPORTATION AUTHORITY

LIGHT RAIL VEHICLE
P2550

RUNNING MAINTENANCE
AND
SERVICE MANUAL

VOLUME M-01-A
PART III
MAINTENANCE
SECT 07 PROPULSION

SECTION 07

PROPULSION

PART III

MAINTENANCE

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SECTION 07

PROPULSION

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LIST OF TABLES

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SECTION 07

PROPULSION SYSTEM

07-III-02 INTRODUCTION

The Propulsion System Part III - Maintenance consists of:

- Preventive Maintenance
- Corrective Maintenance
- Consumable Materials
- Test Equipment & Special Tools

07-III-02.a List of Abbreviations, Acronyms & Symbols

The Abbreviations, Acronyms and Symbols commonly used throughout this Section are given below with their relevant meaning.

Abbreviation	Meaning
AB	AnsaldoBreda
AC	Alternate Current
APS	Auxiliary Power Supply
ASSY	Assembly
ATP	Automatic Train Protection
BCU	Brake Control Unit
BI	Board Inside
CCF	Charging Filter Contactor
CEMIPS	Conductive EMI Protection System
C/L	Centerline
CMF	Inverter Fan Contactor
COAST	Coast Mode
CP	Propulsion Contactor
DC	Direct Current
DCU	Door Control Unit
DSP	Digital Signal Processor
EB	Emergency Brake
ECU	Electronic Control Unit
EDU	EMI Detector Unit
ELE	Electronic
EMI	Electro Magnetic Interference
FCF	Fuse Charging Filter
FM	Function Module
FPGA	Field Programmable Gate Array
FSB	Full Service Brake Mode
FWD	Forward
GTW	Gateway
H-CML	Heavy Consumable Material List
H-CMS	Heavy Corrective Maintenance Sheet
HRSB	High Rate Service Brake
HSCB	High Speed Circuit Breaker
HV	High Voltage
HVAC	Heating Ventilation & Air Conditioning
HW	Hardware
IDU	Integrated Diagnostic Unit
IDU_A	Integrated Diagnostic Unit of the 'A' body section
IDU_B	Integrated Diagnostic Unit of the 'B' body section
IGBT	Insulated Gate Bipolar Transistor
IPC	Illustrated Parts Catalog
LH	Left-Hand Side

(cont'd)

Abbreviation	Meaning
LON	Local Operative Network
LRV	Light Railway Vehicle
LV	Low Voltage
LVDC	Low Voltage Direct Current
LVDS	Low Voltage Distribution System
LVPS	Low Voltage Power Supply
M	Power (Motor) Mode
MBL	Metro Blue Line
MC	Master Controller
MDS	Monitor and Diagnostic System
ME	Motor truck total Effort
MoT	Master Of Train
MoV	Master Of Vehicle
MTBF	Mean Time Between Failure
MVB	Multifunction Vehicle Bus
MVDS	High Voltage Distribution System
NVRAM	Non Volatile Random Access Memory
OCS	Overhead Catenary System
PGL	Pasadena Gold Line
PS	Power Supply
PTU	Portable Test Unit
PWM	Pulse Width Modulation
RAM	Random Access Memory
RCF	Filter Charging Resistor
R-CML	Running Consumable Material List
R-CMS	Running Corrective Maintenance Sheet
REB	Emergency Brake Relay
REV	Reverse
RH	Right-Hand Side
RMF	Inverter Fan Supply Contactor
RMS	Root Mean Square
RMSM	Running Maintenance & Service Manual
ROM	Read Only Memory
R-PMM	Running Preventive Maintenance Matrix
R-PMR	Running Preventive Maintenance Report
R-PMS	Running Preventive Maintenance Sheet
RSCEB	Slide Controlled Emergency Brake
RTC	Real Time Clock
R-TESTL	Running Test Equipment, Tools & Special Tools List
SCEB	Slide Controlled Emergency Brake
SCPM	Safety Critical Preventive Maintenance
SYS	System
SW	Software

(cont'd)

(cont'd)

Abbreviation	Meaning
TA	Current Transducer (from "A" Module to "A" Motors phase)
TAL1	Positive Current Transducer
TAL2	Negative Current Transducer
TB	Current Transducer (from "B" Module to "B" Motors phase)
TBD	To Be Defined
TBS	To Be Supplied
TC	Current Transducer (from "C" Module to "C" Motors phase)
TCH	Current Transducer (from "Chopper" Module to Braking Resistor
TCN	Train Communication Network
TCU	Traction Control Unit
TCU_A	Traction Control Unit of the 'A' body section
TCU_B	Traction Control Unit of the 'B' body section
TE	Trailer (center) truck Effort
TLE	Trailer (center) truck Limited Effort
TOC	Table Of Content
TTEM	Tools & Test Equipment Manual
TVF	Transducer Voltage Filter
TWC	Train-to-Wayside Communication
VAC	Voltage Alternate Current
VDC	Voltage Direct Current
VVVF	Variable Voltage Variable Frequency
W/	With
W/O	Without
WTB	Wired Train Bus

07-III-02.b List of Definitions

The Definitions commonly used throughout this Section are given below with their relevant meaning.

Definition	Meaning
’A’ body section	The section of an articulated vehicle containing the pantograph
’B’ body section	The section of an articulated vehicle not containing the pantograph
AW0	Empty car operating weight
AW1	Full seated load plus AW0
AW2	Standees at 4 persons per square meter plus AW1
AW3	Standees at 6 persons per square meter plus AW1
AW4	Standees at 8 persons per square meter plus AW1
Front door	The door close to the Operator’s Cab
Rear door	The door close to the Articulation Section
MC Handle	Master Controller Handle
“A” Cab (or Cab A)	Operator Cab in the A body section
“B” Cab (or Cab B)	Operator Cab in the B body section

07-III-02.c List of Measurement Units

The Measurement Units commonly used throughout this Section are given below with their relevant meaning.

Definition	Meaning	
ft	Foot	(Length)
gal	Gallon	(Volume)
in	Inch	(Length)
kg	Kilogram - approx 2.205 pounds	(Weight)
km	Kilometer - approx 0.621 miles	(Length)
lb	Pound	(Weight)
lb-ft	Pound force	(Force)
m	Meter - approx 3.28 feet	(Length)
mm	Millimeter - approx 0.0394 inches	(Length)
mph	Miles per hour	(Velocity)
Km/h	Kilometers per hour	(Velocity)
s	Seconds	(Time)
V	Volt	(Tension)
Vdc	Direct Voltage	(Tension)
Vac	Alternate Voltage	(Tension)
kVA	Kilo-Volt-Ampere	(Power)
kW	Kilo-Watt	(Power)
W	Watt	(Power)
F	Farad	(Capacity)
H	Henry	(Inductance)
Ω	Ohm	(Resistance)
°F	Fahrenheit	(Temperature)
°C	Celsius	(Temperature)
A	Ampere	(Current)
Hz	Hertz	(Frequency)
rpm	Revolution per Minute	(Frequency)
N	Newton	(Force)
Nm	Newton-Meter	(Torque)
mphps	Mile Per Hour Per Second	(Acceleration)

07-III-02.d References

Refer to Section 00 of this RMSM for details relevant to the following Topics:

07-III-03 P2550 ANSALDOBREDA MAINTENANCE PLAN

The AB Preventive Maintenance Plan (PMP) has been designed in order to permit a 30-year Structural and Service Vehicle Life with the following basic assumptions:

- Yearly mileage: 120,000 Miles
- Motor and Trailer Truck removal: every 5 years. (600,000 Miles)

The AB Preventive Maintenance Plan (PMP) provides the Preventive Maintenance Tasks to be performed according the following Mileage Intervals:

Running Maintenance		Heavy Maintenance	
Daily			
10,000	Miles		
30,000	Miles	600,000	Miles
60,000	Miles	1,200,000	Miles
120,000	Miles	1,800,000	Miles

In accordance with the Preliminary Version of the AB Preventive Maintenance Plan, the Scheduled Maintenance Tasks for the entire Vehicle Life have been grouped into:

- Running Preventive Maintenance
- Heavy Preventive Maintenance

In accordance with the AB Corrective Maintenance Analysis, the Corrective Maintenance Tasks for the entire Vehicle Life have been grouped into:

- Running Corrective Maintenance
- Heavy Corrective Maintenance

07-III-04 RUNNING -PREVENTIVE MAINTENANCE

07-III-04.01 Running -Preventive Maintenance Matrixes (R-PMM)

The “Propulsion System” Running -Preventive Maintenance Matrix (R-PMM) provides the Preventive Maintenance Plan of the “ Propulsion System “ up to 120,000 Miles.

The “Propulsion System” (R-PMM) is provided in two different arrangements as follows:

- **R-PMM Component Based**

It lists the “Propulsion System” Running - Preventive Maintenance Tasks ordered by Subsystem /Assemblies / Component break down, followed by the PM Task Description and Scheduled Task Interval and linked to the relevant R-PM Sheet Code.

The R-PMM Component Based provides the Maintainer with the following data:

- SYSTEM/SUBSYSTEM /ASSEMBLY/UNIT/COMPONENT
- TASK
- SCPM
- INSPECTION INTERVAL SHEET CODE

- **R-PMM Mileage Based**

It lists the “Propulsion System” Running - Preventive Maintenance Tasks ordered by Scheduled Maintenance Interval and broken down into the related Subsystem /Assemblies/Component followed by the PM Task Description and Person Hours and linked to the relevant R-PM Sheet Code.

The R-PMM Mileage Based provides the Maintainer with the following data:

- INSPECTION INTERVAL
- SYSTEM/SUBSYSTEM /ASSEMBLY/UNIT/COMPONENT
- TASK
- SCPM
- PERSON HOURS
- SHEET CODE

The data listed in this Matrix are the same of those listed in the R-PMM Component Based with the exception of the PERSON HOURS.

07-III-04.01.01 Definitions

The following definitions are applicable to both types of R-PMM

Tasks

Cleaning: Methods and processes required (Step-By-Step Procedural Instructions) for cleaning specific parts or areas of the Vehicle.

Inspection: Preventive Maintenance procedures such as those required to ascertain the serviceability of a Part, Assembly, System or the specific interrelationship of Parts that perform a functional operation.

Lubrication: Provides component lubrication Instructions.

Replacement Provides the Components / Assemblies and Subassemblies removal & installation in a logical sequential order.
Maintenance procedures identified in this topic include Components that are replaced within a 4 hours window.

Service: Operation performed to replenish Sand, Windshield Wiper Washer Fluid, HVAC Coolant, Gear and Compressor Oil, and Vehicle Lubrication.

Test: Procedures and Parameters to evaluate the operational efficiency and integrity of a System /Subsystem/Component and the interrelationship of Parts performing functional operations.

07-III-04.01.02 Inspection Intervals

The Running - Preventive Maintenance Intervals for the P2550 LRV Fleet are scheduled as follows:

Daily 10,000 Miles 30,000 Miles 60,000 Miles 120,000 Miles

The marker ”●“ in the INSPECTIONS INTERVAL column, indicates the periodicity of the corresponding Task.

07-III-04.01.03 Safety Critical Preventive Maintenance (SCPM) Tasks

The marker “☑“ in the SCPM column, indicates that the corresponding Task is a Safety Critical Preventive Maintenance (SCPM) Task, as per the results of the Safety Analyses performed, on Vehicle Subsystems, according to Vehicle Specification.

07-III-04.01.04 Sheet Code

The Sheet Code column, indicates the reference to Running -Preventive Maintenance Sheet where the Procedure to be performed is described and illustrated.

THE SHEET CODE IS THE EXPLICIT LINK BETWEEN R-PM MATRIXES, R-PMR /JOB CARDS AND R-PM SHEETS

Refer to Paragraph 07-III-03.03.01 for Running- Preventive Maintenance Sheet (R-PMS) Form for detailed explanation.

07-III-04.01.05 Person Hours

It indicates the time required to perform the corresponding Task with the basic assumption that the Vehicle is on an Inspection Pit or Stand Up Rail and the Consumables, Tools and Spare Parts needed to accomplish the Task are available at the Location of the Equipment to be maintained.

Refer to:

- Table 07-III-04.1 for Running - Preventive Maintenance Matrix (R-PMM) (Component Based)
- Table 07-III-04.2 for Running - Preventive Maintenance Matrix (R-PMM) (Mileage Based)

07-III-04.01.06 Running Preventive Maintenance Matrix (Component Based)

Table 07-III-04.1 Running Preventive Maintenance Matrix (Component Based)

SYSTEM 07 PROPULSION								
SUBSYSTEM ASSY/UNIT/COMPONENT	TASK	SCPM	INSPECTION INTERVAL MILES					SHEET CODE
			Daily	10K	30K	60K	120K	
-**PRECHARGE SYSTEM**								
--CONTACTOR PROPULSION (CP)	INSPECTION				●			R-P-07-01-01-00/I-00
--CONTACTOR CHARGE FILTER (CCF)	INSPECTION				●			R-P-07-01-02-00/I-00
-RETURN CURRENT SYSTEM / GROUND BRAIDS	INSPECTION	☑				●		R-P-07-02-00-00/I-00
-RETURN CURRENT SYSTEM / GROUNDING CONTACT	INSPECTION	☑				●		R-P-07-02-00-00/I-01
-TRACTION INVERTER HV COMPONENTS / AIR GRILLE	CLEANING				●			R-P-07-03-00-00/C-00
-TRACTION INVERTER HV COMPONENTS	CLEANING					●		R-P-07-03-00-00/C-01
-TRACTION INVERTER HV COMPONENTS	INSPECTION						●	R-P-07-03-00-00/I-00
--LINE REACTOR (1L01)	INSPECTION					●		R-P-07-03-01-00/I-00
--BRAKING RESISTOR	CLEANING				●			R-P-07-03-06-00/C-00
--INVERTER COOLING MOTOR FAN	CLEANING				●			R-P-07-03-07-00/C-00
--INVERTER COOLING MOTOR FAN	INSPECTION					●		R-P-07-03-07-00/I-00
--CONTACTOR MOTOR FAN (CMF)	INSPECTION					●		R-P-07-03-08-00/I-00
-TRACTION CONTROL UNIT (TCU)	INSPECTION					●		R-P-07-04-00-00/I-00
-**TRACTION MOTOR**								
--TRACTION MOTOR	INSPECTION					●		R-P-07-05-01-00/I-00
--ACTIVE SPEED SENSOR	INSPECTION					●		R-P-07-05-02-00/I-00
-GEARBOX ASSY								
--GEARBOX	INSPECTION			●				R-P-07-06-01-00/I-00
--GEARBOX	SERVICE			●				R-P-07-06-01-00/S-00
--GEARBOX	SERVICE				●			R-P-07-06-01-00/S-01
--GEARBOX	SERVICE					●		R-P-07-06-01-00/S-02
--COUPLING	SERVICE						●	R-P-07-06-02-00/S-00
-MASTER CONTROLLER	INSPECTION	☑				●		R-P-07-08-00-00/I-00

07-III-04.01.07 Running Preventive Maintenance Matrix (Mileage Based)

Table 07-III-04.2 Running Preventive Maintenance Matrix (Mileage Based)

SYSTEM 07 PROPULSION

SUBSYSTEM	TASK	SCPM	PERSON HOURS	SHEET CODE
10,000 MILES				
-GEARBOX ASSY				
--GEARBOX	INSPECTION		0.2	R-P-07-06-01-00/I-00
--GEARBOX	SERVICE		1	R-P-07-06-01-00/S-00
30,000 MILES				
-PRECHARGE SYSTEM				
--CONTACTOR PROPULSION (CP)	INSPECTION		0.5	R-P-07-01-01-00/I-00
--CONTACTOR CHARGE FILTER (CCF)	INSPECTION		0.6	R-P-07-01-02-00/I-00
-TRACTION INVERTER HV COMPONENTS / AIR GRILLE	CLEANING		0.4	R-P-07-03-00-00/C-00
--BRAKING RESISTOR	CLEANING		0.4	R-P-07-03-06-00/C-00
--INVERTER COOLING MOTOR FAN	CLEANING		0.3	R-P-07-03-07-00/C-00
-GEARBOX ASSY				
--GEARBOX	SERVICE		1	R-P-07-06-01-00/S-01
60,000 MILES				
-RETURN CURRENT SYSTEM / GROUND BRAIDS	INSPECTION	☑	0.25	R-P-07-02-00-00/I-00
-RETURN CURRENT SYSTEM / GROUNDING CONTACT	INSPECTION	☑	1	R-P-07-02-00-00/I-01
-TRACTION INVERTER HV COMPONENTS	CLEANING		0.8	R-P-07-03-00-00/C-01
--LINE REACTOR (1L01)	INSPECTION		0.6	R-P-07-03-01-00/I-00
--INVERTER COOLING MOTOR FAN	INSPECTION		0.7	R-P-07-03-07-00/I-00
--CONTACTOR MOTOR FAN (CMF)	INSPECTION		0.5	R-P-07-03-08-00/I-00
-TRACTION CONTROL UNIT (TCU)	INSPECTION		0.16	R-P-07-04-00-00/I-00
-TRACTION MOTOR				
--TRACTION MOTOR	INSPECTION		1	R-P-07-05-01-00/I-00
--ACTIVE SPEED SENSOR	INSPECTION		1.66	R-P-07-05-02-00/I-00
-GEARBOX ASSY				
--GEARBOX	SERVICE		1	R-P-07-06-01-00/S-02
-MASTER CONTROLLER	INSPECTION	☑	0.5	R-P-07-08-00-00/I-00

(cont'd)

(con'd)

Table 07-III-04.2 Running Preventive Maintenance Matrix (Mileage Based)

SYSTEM 07 PROPULSION

SUBSYSTEM	TASK	SCPM	PERSON HOURS	SHEET CODE
120,000 MILES				
-**GEARBOX ASSY**				
--GEARBOX	INSPECTION		0.2	R-P-07-06-01-00/I-00
--GEARBOX	SERVICE		1	R-P-07-06-01-00/S-00

07-III-04.02 Running -Preventive Maintenance Reports (R-PMR/Job Cards)

This paragraph describes the contents of the “Propulsion System” Running -Preventive Maintenance Reports (R-PMR/Job Cards) for the Running - Preventive Maintenance Tasks.

07-III-04.02.01 R-PMR/Job Card Form Content

The R-PMR/JOB CARDS are broken down into two main topics:

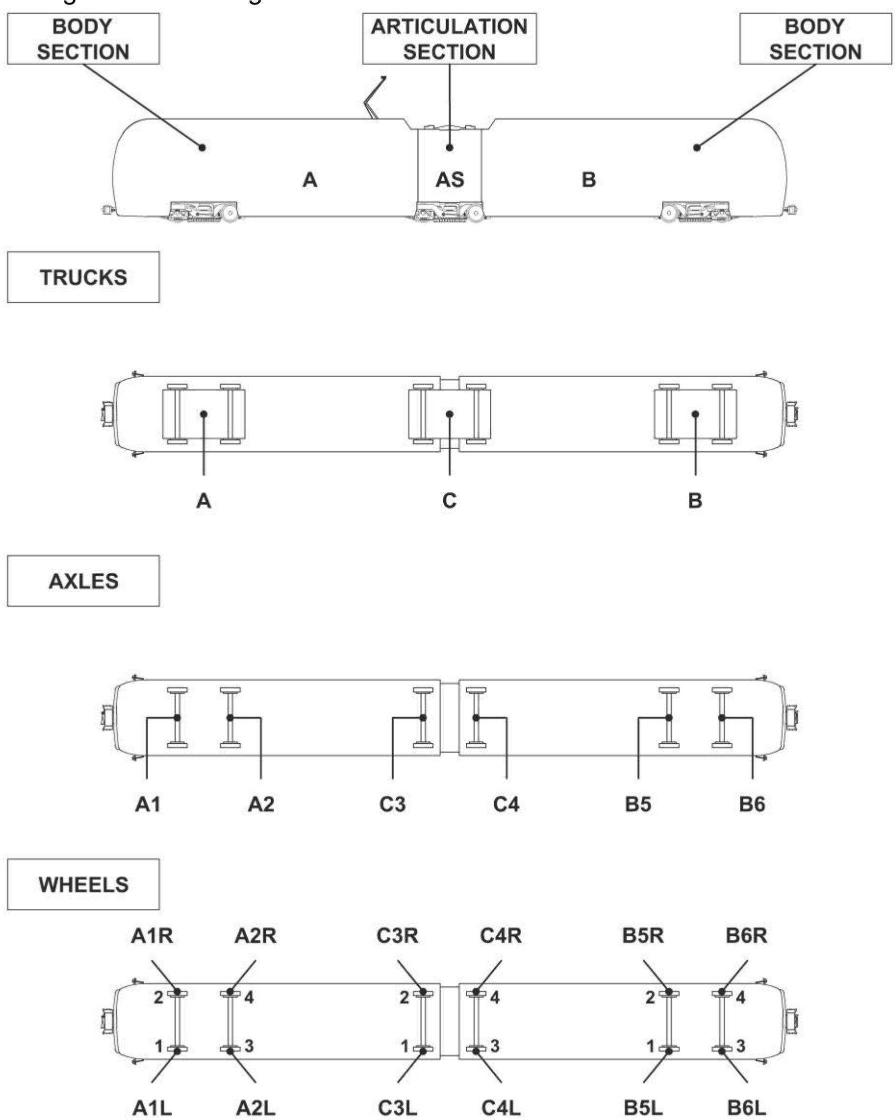
Specific Data and R-PM Data

Refer to Figure 07-III-04.1 for R-PMR/JOB CARD Form example

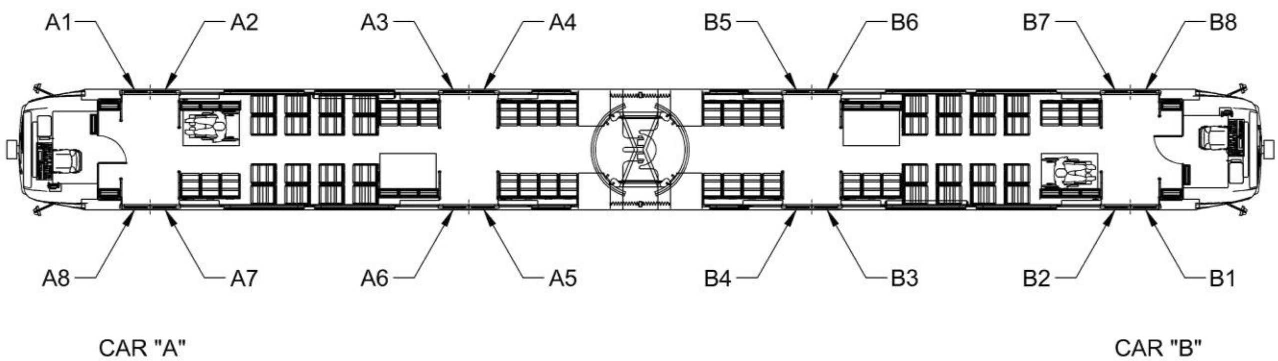
RUNNING PREVENTIVE MAINTENANCE REPORTS (R-PMR/JOB CARDS) FORM		
SPECIFIC DATA TO BE FILLED IN BY THE MAINTAINER		
ITEM #	**TITLE**	**EXPLANATORY NOTE**
1	**VEHICLE #**	This field indicates the Vehicle Identification Number
2	**DATE**	This field indicates the Date on which the Vehicle entered the Maintenance Shop
3	**RUNNING HOURS**	This field indicates the Vehicle Running Hours at the above Date
4	**MILES**	This field indicates the Vehicle Running Miles at the above Date.
5	**EMPLOYEE # & SIGNATURE**	This Field indicates the Employee # & Signature of the Maintainer(s) that perform the referred Task(s)
6	**STARTING DATE**	This field indicates the Starting Date of the referred Task(s).
7	**WORK HOURS**	This field indicates the Work duration to perform the referred Task(s).
8	**COMPLETION DATE**	This field indicates the Completion Date of the referred Task(s).
9	**DEFECT FOUND/COMMENTS**	This field indicates the result of the Task(s) execution and/ or note related to any items of the maintained Equipment requiring Corrective Maintenance
A	**P2550 RUNNING PREVENTIVE MAINTENANCE REPORT SYSTEM (Maintenance Interval) JOB CARD**	This field provides R-PMR Title. The R-PM Maintenance Intervals are the following: Daily; 10,000 Miles; 30,000 Miles; 60,000 Miles;120,000 Miles
B	**WORK AREA**	This column lists the On Vehicle Areas where the Equipment to be maintained is located The Work Areas are provided to optimize the jobs organization of the Preventive Maintenance tasks in order to: 1- respect the Safety Precautions to be followed 2- complete the preparation and the availability of the Consumables, Tools and Spare Parts, needed to perform the referred Task. 3- respect the time (PERSON HOURS) established to perform the referred Task (with the basic assumption that the Vehicle is on an Inspection Pit or Stand Up Rail and the Consumables, Tools and Spare Parts are available at the location of the Equipment to be maintained.) The On Vehicle Work Areas are the following: Exterior - Interior - Roof - Truck - Undercar - Vehicle (Vehicle as a whole)

RUNNING PREVENTIVE MAINTENANCE REPORTS (R-PMR/JOB CARDS) FORM

SPECIFIC DATA TO BE FILLED IN BY THE MAINTAINER

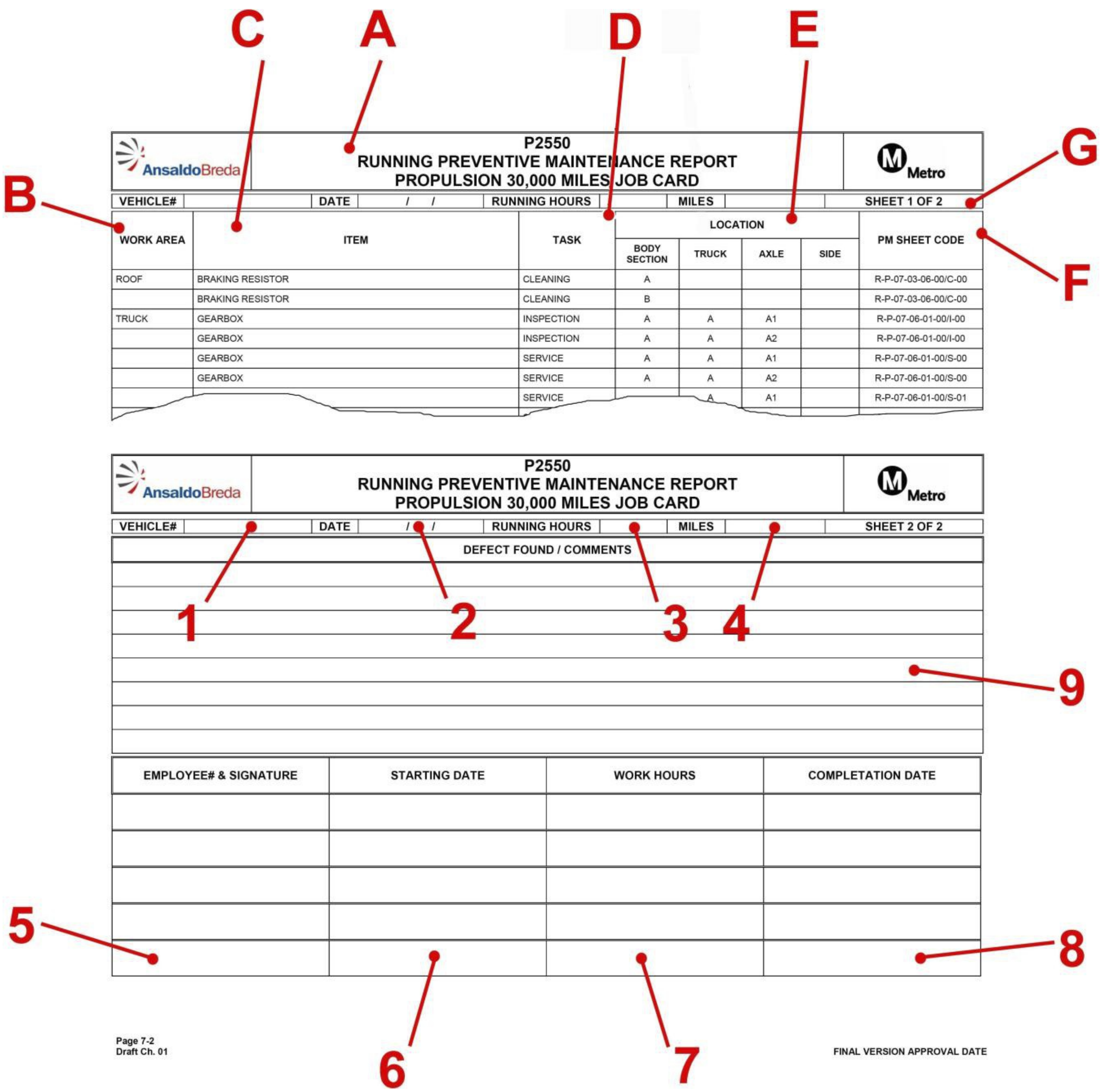
ITEM #	TITLE	EXPLANATORY NOTE
C	ITEM	This column lists the Subsystem/Assembly, Unit, Component to be maintained
D	TASK	This column lists the R-PM tasks to be performed for each Assembly/Unit/Component (i.e., Cleaning, Inspection, Test) The R-PM Tasks are the following: Cleaning - Inspection -Lubrication - Replacement - Service- Test
E	LOCATION	This column lists the On Board Vehicle Location of all Equipment to be maintained according to the following Location identification Codes 

RUNNING PREVENTIVE MAINTENANCE REPORTS (R-PMR/JOB CARDS) FORM	
SPECIFIC DATA TO BE FILLED IN BY THE MAINTAINER	
ITEM #	**TITLE**
E (cont'd)	**LOCATION (cont'd)**
EXPLANATORY NOTE	



Door Numbering

ITEM #	TITLE	EXPLANATORY NOTE
F	PM SHEET CODE	This column lists the reference to Running-Preventive Maintenance Sheet where the Procedure to be performed is described and illustrated. Refer to Running-Preventive Maintenance Sheet (R-PMS) Form for detailed explanation.
G	SHEET ….OF……	This field indicates the progressive sheet page number of each. R-PMR/JOB CARD



AnsaldoBreda | P2550 RUNNING PREVENTIVE MAINTENANCE REPORT PROPULSION 30,000 MILES JOB CARD | Metro

VEHICLE# | DATE / / | RUNNING HOURS | MILES | SHEET 1 OF 2

WORK AREA	ITEM	TASK	LOCATION				PM SHEET CODE
			BODY SECTION	TRUCK	AXLE	SIDE	
ROOF	BRAKING RESISTOR	CLEANING	A				R-P-07-03-06-00/C-00
	BRAKING RESISTOR	CLEANING	B				R-P-07-03-06-00/C-00
TRUCK	GEARBOX	INSPECTION	A	A	A1		R-P-07-06-01-00/I-00
	GEARBOX	INSPECTION	A	A	A2		R-P-07-06-01-00/I-00
	GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-00
	GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-00
		SERVICE		A	A1		R-P-07-06-01-00/S-01

AnsaldoBreda | P2550 RUNNING PREVENTIVE MAINTENANCE REPORT PROPULSION 30,000 MILES JOB CARD | Metro

VEHICLE# | DATE / / | RUNNING HOURS | MILES | SHEET 2 OF 2

DEFECT FOUND / COMMENTS

EMPLOYEE# & SIGNATURE	STARTING DATE	WORK HOURS	COMPLETATION DATE

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FINAL VERSION APPROVAL DATE

Figure 07-III-04.1 R-PMR/Job Card Form -Example

07-III-04.02.02 R-PMR/Job Card Sequence

The R-PMR/JOB CARDS provided in this Section are grouped according to the following sequence:

Daily 10,000 Miles 30,000 Miles 60,000 Miles 120,000 Miles

07-III-04.02.03 Running -Preventive Maintenance Cycle & R-PMR/Job Card Content

The Running -Preventive Maintenance Cycle and the relevant R-PMR/JOB CARD content are as follows:

MAINTENANCE INTERVAL	PMR /JOB CARD TITLE	PMR /Job Card CONTENT
DAILY	DAILY JOB CARD	• List of Assemblies/Components and related Tasks to be performed **DAILY**
10,000 Miles	10,000 MILES JOB CARD	• DAILY Job Card content + List of Assemblies/Components and related Tasks to be performed at **10,000** Miles
30,000 Miles	30,000 MILES JOB CARD	• DAILY Job Card content + 10,000 Job Card content + List of Assemblies/Components and related Tasks to be performed at **30,000** Miles
60,000 Miles	60,000 MILES JOB CARD	• DAILY Job Card content + 10,000 Job Card content + 30,000 Job Card content + List of Assemblies/Components and related Tasks to be performed at **60,000** Miles
120,000 MILES	120,000 MILES JOB CARD	• DAILY Job Card content + 10,000 Job Card content + 30,000 Job Card content + 60,000 Job Card content + List of Assemblies/Components and related Tasks to be performed at **120,000** Miles

07-III-04.02.04 R-PMR/Job Card Data Presentation Sequence

The Subsystems / Assemblies / Units / Components listed in the ITEMS column of each R-PMR/JOB CARD are grouped by Work Area and Vehicle Systems' and sequenced, in alphabetical order, in conjunction with their On Vehicle Locations and Tasks to be performed.

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07-III-04.02.05 Running Preventive Maintenance Reports R-PMR/Job Cards

PROPULSION

Running - Preventive Maintenance Reports

R-PMR/JOB CARDS

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" PROPULSION SYSTEM "
RUNNING PREVENTIVE MAINTENANCE REPORT
10,000 MILES JOB CARD

VEHICLE #		DATE		RUNNING HOURS		MILES		SHEET 1 OF 1

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
TRUCK	PROPULSION	GEARBOX	INSPECTION	A	A	A1		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	A	A	A2		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-00
		GEARBOX	INSPECTION	B	B	B5		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	B	B	B6		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-00

DEFECT FOUND / COMMENTS

EMPLOYEE # & SIGNATURE	STARTING DATE	WORK HOURS	COMPLETION DATE

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“ PROPULSION SYSTEM “ RUNNING PREVENTIVE MAINTENANCE REPORT 30,000 MILES JOB CARD								
VEHICLE #		**DATE**		**RUNNING HOURS**		**MILES**		**SHEET 1 OF 2**

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
ROOF	PROPULSION	BRAKING RESISTOR	CLEANING	A				R-P-07-03-06-00/C-00
		BRAKING RESISTOR	CLEANING	B				R-P-07-03-06-00/C-00
TRUCK	PROPULSION	GEARBOX	INSPECTION	A	A	A1		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	A	A	A2		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-01
		GEARBOX	INSPECTION	B	B	B5		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	B	B	B6		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-01
UNDERCAR	PROPULSION	CONTACTOR CHARGE FILTER (CCF)	INSPECTION	A				R-P-07-01-02-00/I-00
		CONTACTOR PROPULSION (CP)	INSPECTION	A				R-P-07-01-01-00/I-00
		INVERTER COOLING MOTOR FAN	CLEANING	A				R-P-07-03-07-00/C-00
		TRACTION INVERTER HV COMPONENTS - AIR GRILLE	CLEANING	A				R-P-07-03-00-00/C-00
		CONTACTOR CHARGE FILTER (CCF)	INSPECTION	B				R-P-07-01-02-00/I-00
		CONTACTOR PROPULSION (CP)	INSPECTION	B				R-P-07-01-01-00/I-00
		INVERTER COOLING MOTOR FAN	CLEANING	B				R-P-07-03-07-00/C-00
		TRACTION INVERTER HV COMPONENTS - AIR GRILLE	CLEANING	B				R-P-07-03-00-00/C-00

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" PROPULSION SYSTEM " - RUNNING PREVENTIVE MAINTENANCE REPORT - 30,000 MILES JOB CARD								
VEHICLE#		DATE		RUNNING HOURS		MILES		SHEET 2OF 2

DEFECT FOUND / COMMENTS

EMPLOYEE # & SIGNATURE	STARTING DATE	WORK HOURS	COMPLETION DATE

" PROPULSION SYSTEM "
RUNNING PREVENTIVE MAINTENANCE REPORT
60,000 MILES JOB CARD

VEHICLE #		DATE		RUNNING HOURS		MILES		SHEET 1 OF 3

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
INTERIOR	PROPULSION	MASTER CONTROLLER	INSPECTION	A				R-P-07-08-00-00/I-00
		MASTER CONTROLLER	INSPECTION	B				R-P-07-08-00-00/I-00
ROOF	PROPULSION	BRAKING RESISTOR	CLEANING	A				R-P-07-03-06-00/C-00
		BRAKING RESISTOR	CLEANING	B				R-P-07-03-06-00/C-00
TRUCK	PROPULSION	ACTIVE SPEED SENSOR	INSPECTION	A	A	A1		R-P-07-05-02-00/I-00
		ACTIVE SPEED SENSOR	INSPECTION	A	A	A2		R-P-07-05-02-00/I-00
		GEARBOX	INSPECTION	A	A	A1		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	A	A	A2		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-02
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-02
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	A	A	A1	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	A	A	A2	LH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	A	A	A1	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	A	A	A2	LH	R-P-07-02-00-00/I-01
		TRACTION MOTOR	INSPECTION	A	A	A1		R-P-07-05-01-00/I-00
		TRACTION MOTOR	INSPECTION	A	A	A2		R-P-07-05-01-00/I-00

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" PROPULSION SYSTEM " RUNNING PREVENTIVE MAINTENANCE REPORT 60,000 MILES JOB CARD								
VEHICLE #		DATE		RUNNING HOURS		MILES		SHEET 2 OF 3

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
TRUCK (cont'd)	PROPULSION	GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	AS	C	C3	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	AS	C	C4	LH	R-P-07-02-00-00/I-01
		ACTIVE SPEED SENSOR	INSPECTION	B	B	B5		R-P-07-05-02-00/I-00
		ACTIVE SPEED SENSOR	INSPECTION	B	B	B6		R-P-07-05-02-00/I-00
		GEARBOX	INSPECTION	B	B	B5		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	B	B	B6		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-02
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-02
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	B	B	B5	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	B	B	B6	LH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	B	B	B5	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	B	B	B6	LH	R-P-07-02-00-00/I-01
		TRACTION MOTOR	INSPECTION	B	B	B5		R-P-07-05-01-00/I-00
		TRACTION MOTOR	INSPECTION	B	B	B6		R-P-07-05-01-00/I-00

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" PROPULSION SYSTEM " - RUNNING PREVENTIVE MAINTENANCE REPORT - 60,000 MILES JOB CARD								
VEHICLE#		DATE		RUNNING HOURS		MILES		SHEET 3OF 3

DEFECT FOUND / COMMENTS

EMPLOYEE # & SIGNATURE	STARTING DATE	WORK HOURS	COMPLETION DATE

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" PROPULSION SYSTEM " RUNNING PREVENTIVE MAINTENANCE REPORT 120,000 MILES JOB CARD								
VEHICLE #		DATE		RUNNING HOURS		MILES		SHEET 1 OF 4

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
INTERIOR	PROPULSION	MASTER CONTROLLER	INSPECTION	A				R-P-07-08-00-00/I-00
		MASTER CONTROLLER	INSPECTION	B				R-P-07-08-00-00/I-00
ROOF	PROPULSION	BRAKING RESISTOR	CLEANING	A				R-P-07-03-06-00/C-00
		BRAKING RESISTOR	CLEANING	B				R-P-07-03-06-00/C-00
TRUCK	PROPULSION	ACTIVE SPEED SENSOR	INSPECTION	A	A	A1		R-P-07-05-02-00/I-00
		ACTIVE SPEED SENSOR	INSPECTION	A	A	A2		R-P-07-05-02-00/I-00
		COUPLING	SERVICE	A	A	A1		R-P-07-06-02-00/S-00
		COUPLING	SERVICE	A	A	A2		R-P-07-06-02-00/S-00
		GEARBOX	INSPECTION	A	A	A1		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	A	A	A2		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	A	A	A1		R-P-07-06-01-00/S-02
		GEARBOX	SERVICE	A	A	A2		R-P-07-06-01-00/S-02
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	A	A	A1	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	A	A	A2	LH	R-P-07-02-00-00/I-01

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" PROPULSION SYSTEM " - RUNNING PREVENTIVE MAINTENANCE REPORT - 120,000 MILES JOB CARD								
VEHICLE#		**DATE**		**RUNNING HOURS**		**MILES**		**SHEET 2 OF 4**

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
TRUCK (cont'd)	PROPULSION	GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	A	A	A1	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	A	A	A2	LH	R-P-07-02-00-00/I-01
		TRACTION MOTOR	INSPECTION	A	A	A1		R-P-07-05-01-00/I-00
		TRACTION MOTOR	INSPECTION	A	A	A2		R-P-07-05-01-00/I-00
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	AS	C	C3	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	AS	C	C4	LH	R-P-07-02-00-00/I-01
		ACTIVE SPEED SENSOR	INSPECTION	B	B	B5		R-P-07-05-02-00/I-00
		ACTIVE SPEED SENSOR	INSPECTION	B	B	B6		R-P-07-05-02-00/I-00
		COUPLING	SERVICE	B	B	B5		R-P-07-06-02-00/S-00
		COUPLING	SERVICE	B	B	B6		R-P-07-06-02-00/S-00
		GEARBOX	INSPECTION	B	B	B5		R-P-07-06-01-00/I-00
		GEARBOX	INSPECTION	B	B	B6		R-P-07-06-01-00/I-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-00
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-01
		GEARBOX	SERVICE	B	B	B5		R-P-07-06-01-00/S-02
		GEARBOX	SERVICE	B	B	B6		R-P-07-06-01-00/S-02

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"PROPULSION SYSTEM" - RUNNING PREVENTIVE MAINTENANCE REPORT - 120,000 MILES JOB CARD								
VEHICLE#		DATE		RUNNING HOURS		MILES		SHEET 3OF 4

WORK AREA	SYSTEM	ITEM	TASK	LOCATION				PM SHEET CODE
				BODY SECT	TRUCK	AXLE	SIDE	
TRUCK (cont'd)	PROPULSION	GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	B	B	B5	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - GROUND BRUSHES	INSPECTION	B	B	B6	LH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	B	B	B5	RH	R-P-07-02-00-00/I-01
		GROUNDING CONTACT - RETURN CURRENT BRUSHES	INSPECTION	B	B	B6	LH	R-P-07-02-00-00/I-01
		TRACTION MOTOR	INSPECTION	B	B	B5		R-P-07-05-01-00/I-00
		TRACTION MOTOR	INSPECTION	B	B	B6		R-P-07-05-01-00/I-00

DEFECT FOUND / COMMENTS

(cont'd)

(cont'd)

" PROPULSION SYSTEM " - RUNNING PREVENTIVE MAINTENANCE REPORT - 120,000 MILES JOB CARD								
VEHICLE#		DATE		RUNNING HOURS		MILES		SHEET 4 OF 4

DEFECT FOUND / COMMENTS

EMPLOYEE # & SIGNATURE	STARTING DATE	WORK HOURS	COMPLETION DATE

07-III-04.03 Running -Preventive Maintenance Sheets (R-PMS)

Each R-PMS provides the following data consistent with Preventive Maintenance Plan (PMP), AB Design Documentation and Vehicle Systems Functional Tree:

- **R-PM Sheet Code**
- **SYSTEM, SUBSYSTEM /ASSEMBLY, UNIT**, **Component** (Names)
- **SYSTEM, SUBSYSTEM /ASSEMBLY, UNIT**, **Component** (Location)
- **Maintenance Interval** (Miles)
- **Maintenance Task**,
- **Man Hours**, needed to perform the Task
- **SPARE PARTS**, needed to perform the Task

Each R-PMS also provides:

- **SAFETY PRECAUTIONS**, to be followed to safely accomplish the Task
- **TOOLS**, including Special Tools and Test Equipment, needed to accomplish the Task **CONSUMABLES**, required to accomplish the Task and consistent with those used by MTA
- **PROCEDURE**, consisting of **Preliminary Operations** and **Procedural Steps**, to be followed while performing Maintenance Tasks
- **Illustrations** and **Pictures** are inserted in the text to facilitate the understanding of the topics and/or to explain step-by-step procedure.

07-III-04.03.01 Running- Preventive Maintenance Sheet (R-PMS) Form

The R-PMS Form (refer to Figure 07-III-04.2) consists of several fields containing the following data/ information:

RUNNING -PREVENTIVE MAINTENANCE SHEET (RPMS) Form			
ITEM #	**TITLE**	**CONTENT**	**EXPLANATORY NOTES**
1	**Card code**	**Sheet code**	The Sheet Code is an alphanumerical code that identifies each R-PM Sheet. **THE SHEET CODE IS THE EXPLICIT LINK BETWEEN R-PM MATRIXES, R-PMR /JOB CARDS AND R-PM SHEETS** The Sheet Code consists of letters R-P followed by an 11 digit code number as follows: **R-P-nn-mm-zz-ww/Y-kk** **R** = **R**unning **P**= **P**reventive **nn** may vary from 02 to 19, identifying the System/ Manual Section number. **mm-zz-ww** each one may vary from 00 to 99, according to AB System Functional Tree, allowing the identification of the Assembly/Unit/Component **Y** Maintenance Task Code. It may be one of the following: **C**=**C**leaning **I** =**I**nspection **L** = **L**ubrication **R**=**R**eplacement **S**=**S**ervice **T**=**T**est **kk** It may vary from 00 to 99. It is a progressive number allowing the univocal identification of RPMS when one of the following cases occur: 1- same Maintenance Task pertaining to vehicle as a whole or to the same System/Subsystem/Assembly to be performed at same Maintenance Interval in different Vehicle Area (i.e Vehicle as a Whole DAILY Exterior /Interior INSPECTION) 2- same Maintenance Task pertaining to the same Assembly/Unit/Component to be performed at different Maintenance Intervals and for this reason consisting of different Maintenance Procedure
2	**System**	**System name**	This field indicates the System to which the Assembly/Unit/Component belongs.
3	Subsystem/ **Assembly**	**Subsystem/ Assembly name**	This field indicates the Subsystem/Assembly to which the Unit/Component belongs.
4	**Unit**	**Unit name**	This field indicates the Unit to which the Component belongs.
5	**Component**	**Component name**	This field indicates the Component the Maintenance Task is referring to
6	**Maintenance Task**	**Maintenance Task name**	This field indicates the Maintenance Task to be performed.
7	**Interval Miles**	**Number**	This field indicates the maintenance Interval Miles. It may be DAILY, 10,000 Miles, 30,000 Miles, 60,000 Miles, 120,000 Miles

RUNNING -PREVENTIVE MAINTENANCE SHEET (RPMS) Form (cont'd)			
ITEM #	**TITLE**	**CONTENT**	**EXPLANATORY NOTES**
8	**Man Hours**	**Number**	The Man Hour field indicates the time needed to perform the corresponding Maintenance Task, with the basic assumption that the Vehicle is staged on an Inspection Pit/Jacking tracks with the required Consumables, Tools And Materials Available.
9	**Sheet**	**Pages numbering**	This field indicates the progressive R-PMS sheet page number.
10	**LOCATION**	**Illustration**	This field indicates the On Board Location of the Equipment to be maintained The following Graphic Symbols are used for: Assembly/Unit/Component for System/Subsystem/Vehicle as a Whole
11	**R**	**Letter**	This field indicates that the Sheet pertains to Running Maintenance
12	**P**	**Letter**	This field indicates that the Sheet pertains to Preventive Maintenance
13	**nn**	**Number**	This field indicates the System/Manual Section number to which the Sheet pertains. It may vary from 01 to 19
14	**rr**	**Number**	This field indicates the Sheet Revision number
15	**Page ##**	**Page ##**	This field indicates the RMSM Section Page number
16	**-#**	**Number**	This field indicates the RMSM Section Revision number
17	**SAFETY PRECAUTIONS**	**Text**	This field presents the General and/or specific Safety Precautions to be followed to safely accomplish the relevant Maintenance Tasks.
18	**TOOLS**	**Text**	This field lists the description and the P/N of the Standard tools, Special Tools and Test Equipment needed to accomplish the Maintenance Task. Refer to the TTE Manual for the TE and Special Tools detailed descriptions and tools maintenance.
19	**CONSUMABLES**	**Text**	This field lists the Consumables Materials (consistent with those used by MTA with the related P/N.) needed to accomplish the Maintenance Task. Cleaning agents are included
20	**SPARE PARTS**	**Text**	This field lists the Description and PN of Spare Parts (consistent with Illustrated Parts Catalog) needed to accomplish the Maintenance Task.
21	**PROCEDURE**	**Text**	The Procedure field provides Preliminary Operations and Procedural step by step Instructions to be followed while performing the Maintenance Task. Illustrations and Pictures are inserted in the text to facilitate the understanding of the topics and/or to explain step-by-step procedure.

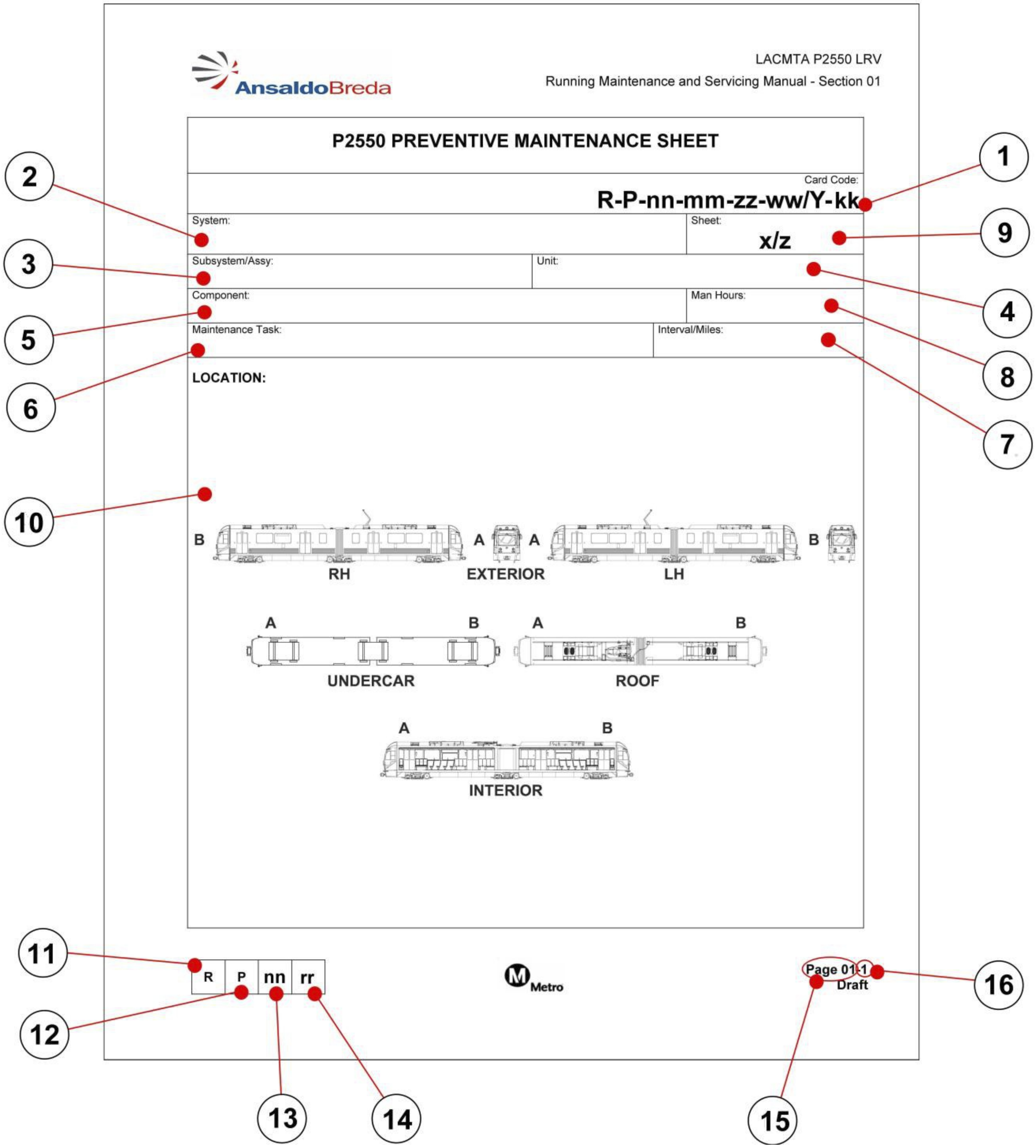
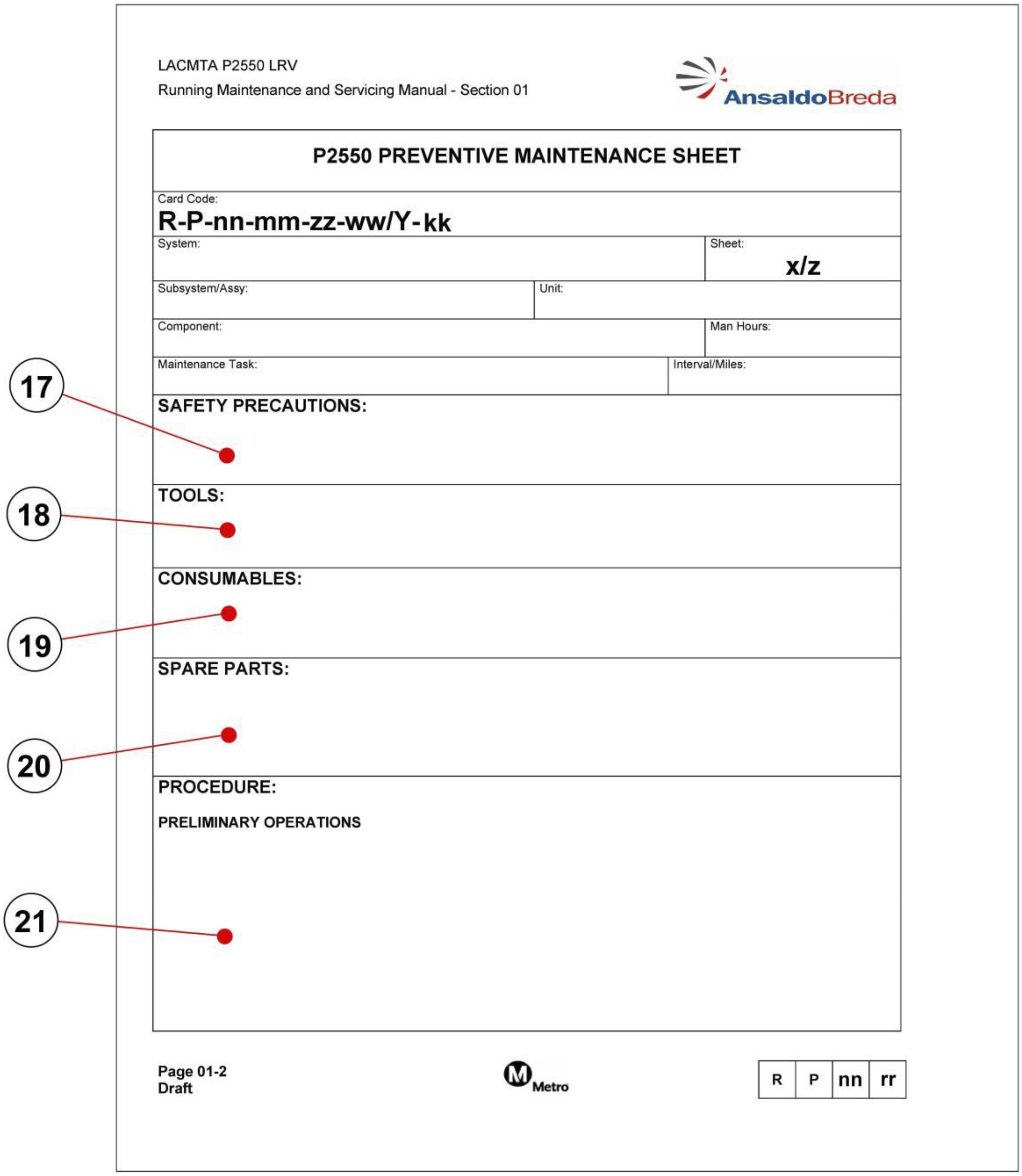


Figure 07-III-04.2 R-PMS Form
(Sheet 1 of 2)



LACMTA P2550 LRV
Running Maintenance and Servicing Manual - Section 01

AnsaldoBreda

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-nn-mm-zz-ww/Y-kk

System:	Sheet: x/z
Subsystem/Assy:	Unit:
Component:	Man Hours:
Maintenance Task:	Interval/Miles:

SAFETY PRECAUTIONS:

TOOLS:

CONSUMABLES:

SPARE PARTS:

PROCEDURE:

PRELIMINARY OPERATIONS

Page 01-2
Draft

Metro

R	P	nn	rr

Figure 07-III-04.2 R-PMS Form
(Sheet 2 of 2)

07-III-04.03.02 How to Use the R-PM Sheets and R-PMR /Job Cards

To optimize the job organization, proceed as follows:

1. **At Scheduled Preventive Maintenance Interval Expiration Date**
   a) Use the relevant (Maintenance Interval) R-PMR/JOB CARD where the Subsystems/Assemblies/Units/Components, listed in the ITEMS column, are grouped by Work Area and Vehicle System and sequenced, in alphabetical order, in conjunction with their On Vehicle Location and Task to be performed.
   b) Select the Work Area and the System
   c) Select the first Equipment listed in the ITEMS column and the Sheet Code listed in conjunction with the Task to be performed and gather the relevant Sheet
   d) Read carefully the Sheet to fully understand the provided Data/Instructions.
   e) Carefully read:
      - The Safety Precautions to perform the Task safely
      - The Preliminary Operations to set the Vehicle in safety conditions according to MTA Maintenance Shop Regulations
      - The Tools, Consumables and Spare Parts listed in each Sheet which are needed to accomplish the Task, in order to have all of them available next to the location of the Equipment to be maintained before starting the activities
   f) Fill the R-PMR/JOB CARD with the data required by the Maintainer at the start of the Maintenance Activities

2. **Task Execution**
   a) Follow carefully the prescribed Safety Precautions and Maintenance Procedural Steps provided in the R-PM Sheet.
   b) Perform the Maintenance Task Procedure on the first Equipment (listed in the ITEMS column of the relevant R-PMR /JOB CARD) at its On Vehicle LOCATION. as indicated in the LOCATION column of the R-PMR /JOB CARD.
   c) Upon completing the Maintenance Task on the first Equipment, highlight (with a flag) its LOCATION field on the R-PMR / JOB CARD.
   d) Note Equipment Defect Found and / or your Comments on the End Page of the R-PMR / JOB CARD
   e) Proceed to perform the same Task on the second (same) Equipment listed in the R-PMR / JOB CARD at its On Vehicle LOCATION, (different from the previous one) as indicated in the LOCATION column of the R-PMR /JOB CARD.
   f) Proceed as above to perform the same Task on every Equipment (to which the same Sheet Code refers) listed in the ITEMS column of the relevant (Maintenance Interval) R-PMR /JOB CARD.
   g) During Task execution, note any Areas / Items of the Assembly / Unit/ Component under Preventive Maintenance Process requiring Corrective Maintenance.
   h) Gather as much information about the Equipment as is practical to increase your Equipment knowledge (i.e.; knowledge about the malfunction in terms of correctly operating and incorrectly operating equipment processes).

3 At every Task Completion

a) Follow carefully the prescribed Safety Precautions before restoring Electrical Power to Vehicle.

b) Check the correct operation and/or functions of the Subsystem to which the maintained Equipment pertains.

c) Perform this check on the IDU “A “as follows:

NOTE: Through the IDU you can check if all Systems are exchanging data through the MVB or LonWorks Bus and the Trainlines Status.

The IDU Display also shows in real time the Status of all Vehicle Systems. Reading the IDU Fault List it is possible to immediately detect a fault . Using the IDU in the Operating Mode the Fault Indications are generic. Using the IDU in Maintenance Mode the same Fault has a detailed description.

For more in depth troubleshooting use the PTU connected to the relevant system that requires further troubleshooting.

1. On IDU “A” access to the Maintenance Menu first and then to the “Faults” Screen by selecting, in sequence, the relevant icons.
2. Check, On IDU “A” through the list of the Current Active Faults shown in the “Faults” Screen, for “Fault” Codes related to the Subsystem to which the maintained Equipment pertains.

   Refer to Section 18 of RMSM for Fault Signals Details.
3. As per “Fault” Codes check results proceed as follows:

- **No Faults are listed in the “Faults” Screen**

  a) Key OFF the Vehicle.

  b) Record Service and Test results on the Defect Report Card for administrative and maintenance planning.

  c) Fill the R-PMR /JOB CARD with the data required from the Maintainer at the completion of the Maintenance Activities and include your comments

- **Fault Codes are listed in the "Faults" Screen**

a) Investigate/troubleshoot the Equipment previously maintained first and then the System/Subsystem/Assembly/Unit for Fault Probable Causes

b) Gather as much information about the failure symptoms as is practical.

c) Refer to Section 18 of RMSM for Fault Signals Details

d) Try to identify the malfunction in terms of correctly operating and incorrectly operating equipment processes.

e) Identify which equipment signals or parameters will best help you to localize the failure.

f) Identify the source of the problem.

g) Repair or replace the defective component.

h) Verify that the repair is effective in eliminating all of the failure symptoms.

i) Evaluate whether or not the defective component was the root cause of the failure.

j) Once the Fault Codes are not found in the "Faults" Screen perform steps from 3-a through 3-c (previous subparagraph **"No Faults are listed in the "Faults" Screen)**

07-III-04.03.03 Running- Preventive Maintenance Sheet (R-PMS) List

The " Propulsion System " Running- Preventive Maintenance Sheets (R-PMS) List is provided in the following pages.

The R-PM Sheets are listed by Subsystem / Assembly / Unit / Component and sequenced by Maintenance Interval in conjunction with their Sheet Codes and Tasks (including SCPM flag) to be performed.

Table 07-III-04.3 Running Preventive Maintenance Sheets List

SYSTEM	07		PROPULSION		
SUBSYSTEM/ ASSY	**ASSY /UNIT/ COMPONENT**	**SCPM**	**TASK**	**MAINTEN. INTERVAL (MILES)**	**SHEET CODE**
PRECHARGE SYSTEM	CONTACTOR PROPULSION (CP)		INSPECTION	30,000	R-P-07-01-01-00/I-00
PRECHARGE SYSTEM	CONTACTOR CHARGE FILTER (CCF)		INSPECTION	30,000	R-P-07-01-02-00/I-00
RETURN CURRENT SYSTEM	RETURN CURRENT SYSTEM - GROUND BRAIDS	☑	INSPECTION	60,000	R-P-07-02-00-00/I-00
RETURN CURRENT SYSTEM	RETURN CURRENT SYSTEM - GROUNDING CONTACT	☑	INSPECTION	60,000	R-P-07-02-00-00/I-01
TRACTION INVERTER HV COMPONENTS	TRACTION INVERTER HV COMPONENTS - AIR GRILLE		CLEANING	30,000	R-P-07-03-00-00/C-00
TRACTION INVERTER HV COMPONENTS	BRAKING RESISTOR		CLEANING	30,000	R-P-07-03-06-00/C-00
TRACTION INVERTER HV COMPONENTS	INVERTER COOLING MOTOR FAN		CLEANING	30,000	R-P-07-03-07-00/C-00
TRACTION INVERTER HV COMPONENTS	TRACTION INVERTER HV COMPONENTS		CLEANING	60,000	R-P-07-03-00-00/C-01
TRACTION INVERTER HV COMPONENTS	LINE REACTOR (1L01)		INSPECTION	60,000	R-P-07-03-01-00/I-00
TRACTION INVERTER HV COMPONENTS	INVERTER COOLING MOTOR FAN		INSPECTION	60,000	R-P-07-03-07-00/I-00
TRACTION INVERTER HV COMPONENTS	CONTACTOR MOTOR FAN (CMF)		INSPECTION	60,000	R-P-07-03-08-00/I-00
TRACTION INVERTER HV COMPONENTS	TRACTION INVERTER HV COMPONENTS		INSPECTION	120,000	R-P-07-03-00-00/I-00
TRACTION CONTROL UNIT (TCU)	TRACTION CONTROL UNIT (TCU)		INSPECTION	60,000	R-P-07-04-00-00/I-00
TRACTION MOTOR	TRACTION MOTOR		INSPECTION	60,000	R-P-07-05-01-00/I-00
TRACTION MOTOR	ACTIVE SPEED SENSOR		INSPECTION	60,000	R-P-07-05-02-00/I-00
GEARBOX ASSY	GEARBOX		INSPECTION	10,000	R-P-07-06-01-00/I-00
GEARBOX ASSY	GEARBOX		SERVICE	10,000	R-P-07-06-01-00/S-00
GEARBOX ASSY	GEARBOX		SERVICE	30,000	R-P-07-06-01-00/S-01
GEARBOX ASSY	GEARBOX		SERVICE	60,000	R-P-07-06-01-00/S-02
GEARBOX ASSY	COUPLING		SERVICE	120,000	R-P-07-06-02-00/S-00
MASTER CONTROLLER	MASTER CONTROLLER	☑	INSPECTION	60,000	R-P-07-08-00-00/I-00

INTENTIONALLY LEFT BLANK

07-III-04.03.04 Running- Preventive Maintenance Sheets (R-PMS)

PROPULSION

Running - Preventive Maintenance Sheets

R-PMS

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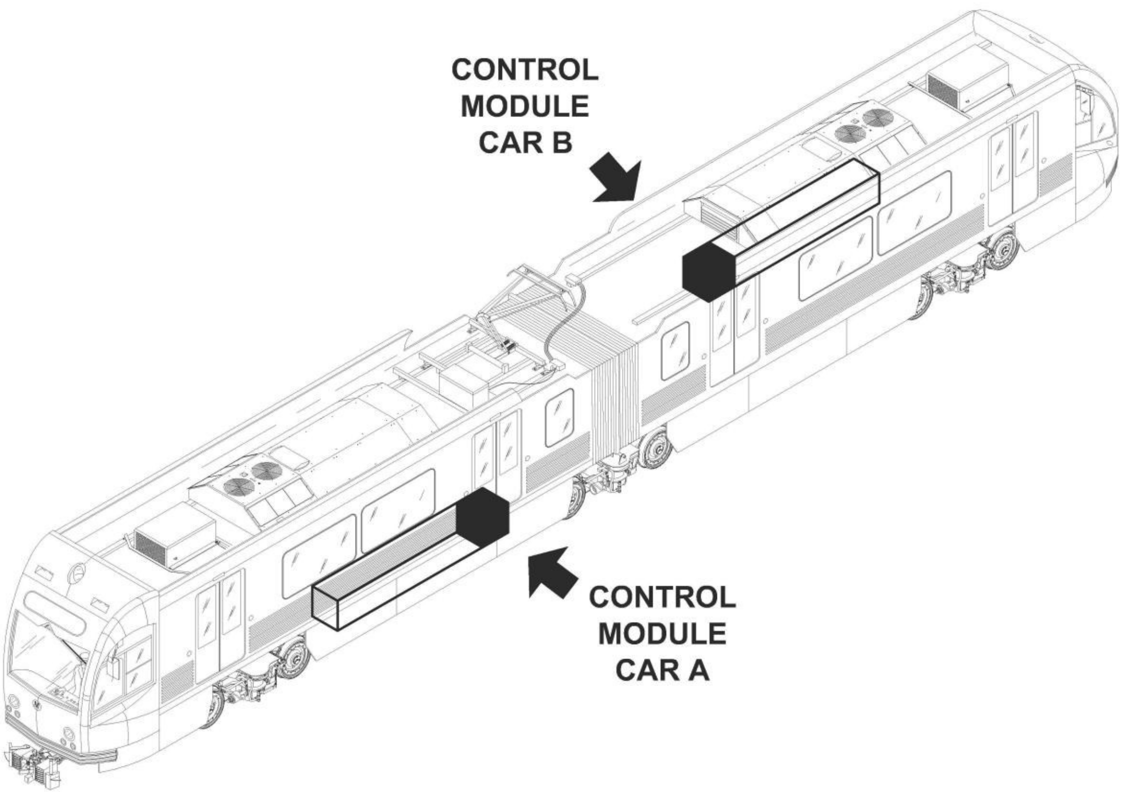
P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-01-01-00/I-00**		
System: **PROPULSION**		Sheet: **1/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**	
Component:		Man Hours: **0.5**
Maintenance Task: **INSPECTION**		Interval/Miles: **30,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-01-01-00/I-00

System:	Sheet:
PROPULSION	**2/6**

Subsystem/Assy:	Unit:
PRECHARGE SYSTEM	**CONTACTOR PROPULSION (CP)**

Component:	Man Hours:
	0.5

Maintenance Task:	Interval/Miles:
INSPECTION	**30,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT. REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM. LOCK OUT THE POWER SOURCE, AND ATTACH A TAG THAT CONTAINS THE NAME OF THE PERSON WHO REMOVED POWER FROM THE EQUIPMENT. THAT PERSON KNOWS WHY THE POWER WAS REMOVED AND WHEN IT IS SAFE TO RESTORE IT. ONLY THE INDIVIDUAL WHOSE NAME APPEARS ON THE TAG OR A PERSON WITH HIS APPROVAL SHOULD REMOVE THE TAG AND RESTORE POWER.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

**WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.**

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

TOOLS:
LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

CRC 2000 Contact Cleaner		
CRC Industrial - Precision Cleaner M3	PN	147535

SPARE PARTS:

CP CONTACTOR Type LTHS320	P/N	211VK00732B

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-01-01-00/I-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

(Refer to Figures 1 through 3)

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module

2. Gain access to CP contactor by removing the Grounding Cable, Safety Latches and cover from the Control Module

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1

3. Inspect CP Contactor for damage, signs of arcing, or overheating.

4. Replace, as per inspection result, according to Sheet R-C-07-01-01-00/ R-00.

5. Clean the Insulator Plate using the recommended agent.

6. Check the CP Contactor mechanical parts for smooth movement.

7. Inspect Arc Chute for damage, cracks or burns.

8. Inspect the Arcing Horns for deep burns.

9. Inspect the Flexible Shunt for wear, frays or burn marks.

10. Check the connections of the Auxiliary and Main Circuits for tightness and/or burns. (tighten if loose or replace if burned)

11. Clean the Auxiliary and Main contacts with the recommended agent and a lint-free rag.

12. Inspect the CP contactor for loose hardware. Tighten, as per check result.

13. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

14. Reconnect the Grounding Cable

15. Record task results on the Defect Report Card for administrative and maintenance planning.

16. Once completed, proceed as follows:

a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

b. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-01-01-00/I-00**	
System: **PROPULSION**	Sheet: **4/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):

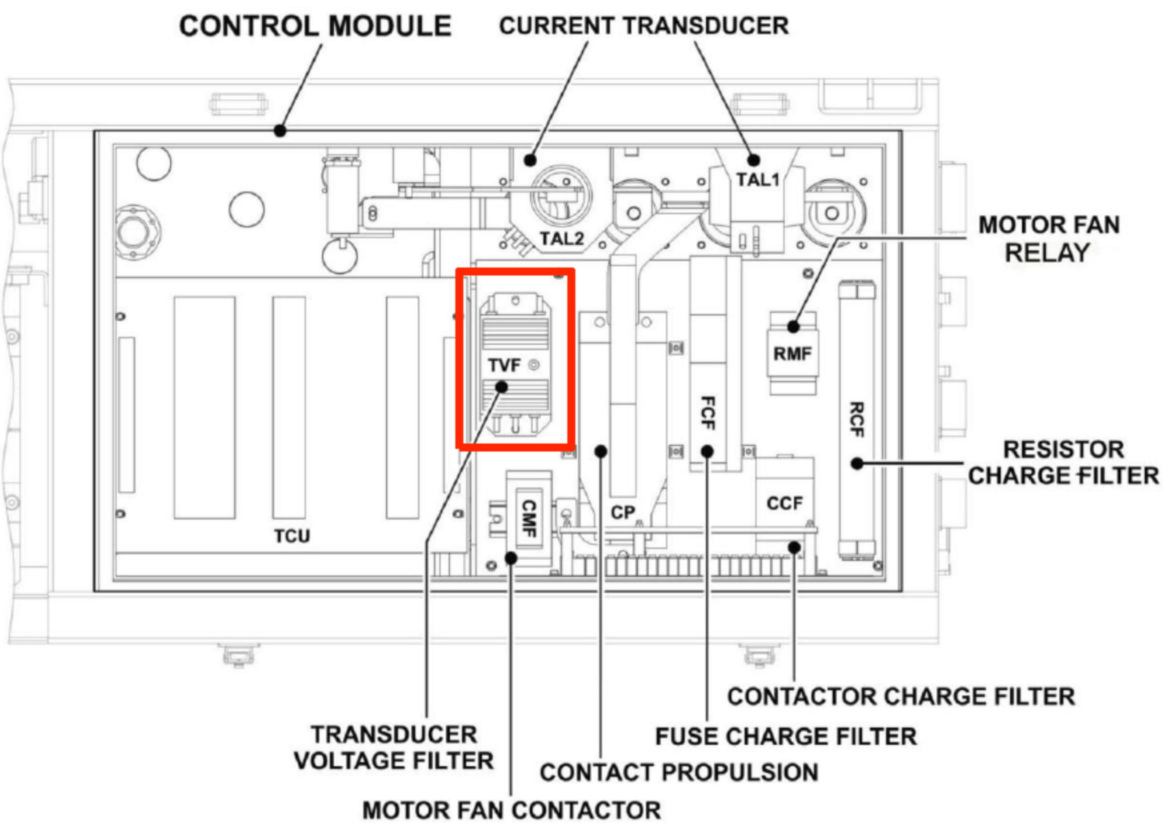
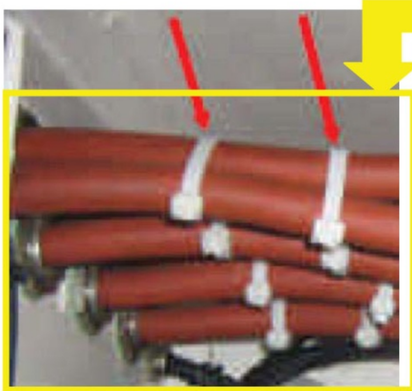


Figure 1 - CONTROL MODULE

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-01-01-00/I-00**	
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):



DETAIL"A"
Two ties each couple of
"P" and "N" cables

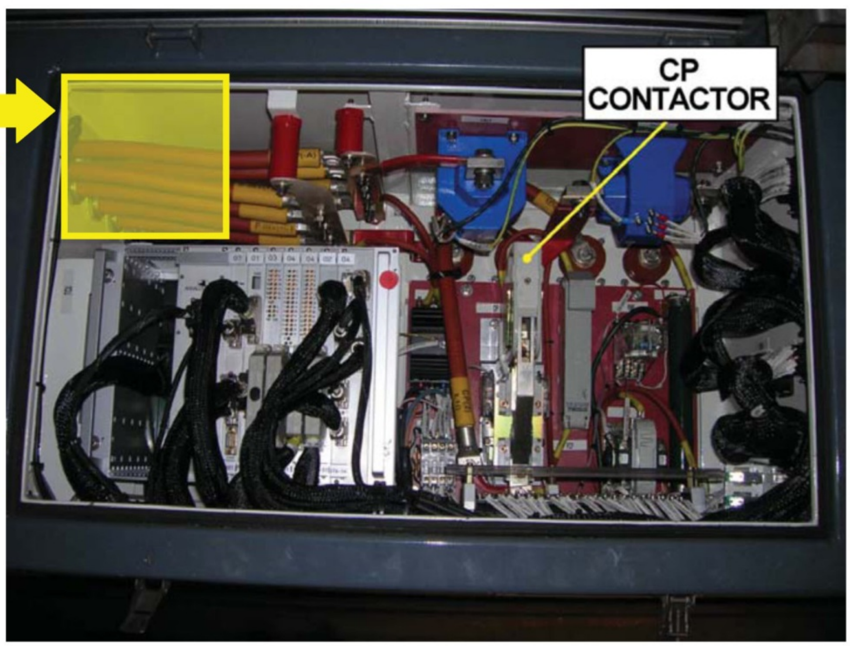


Figure 2 - CONTROL MODULE INTERIOR

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-01-01-00/I-00**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):

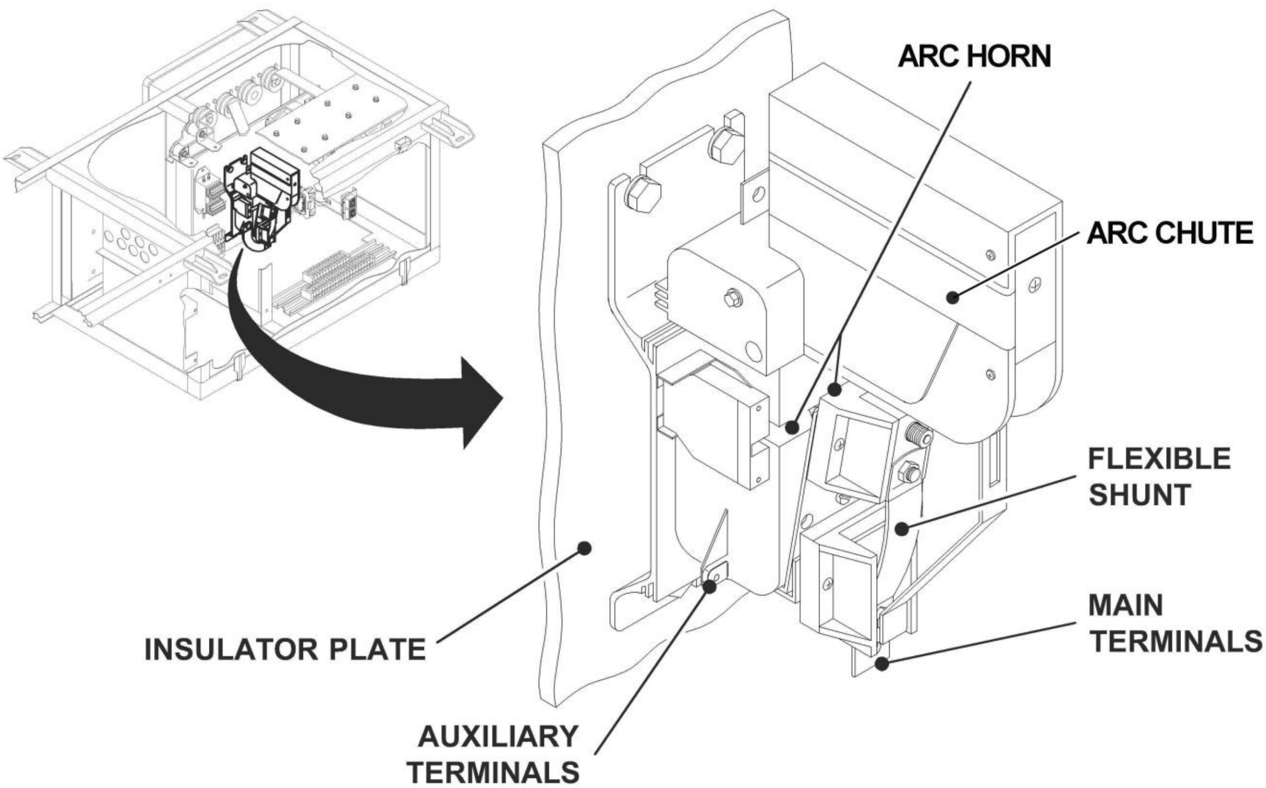
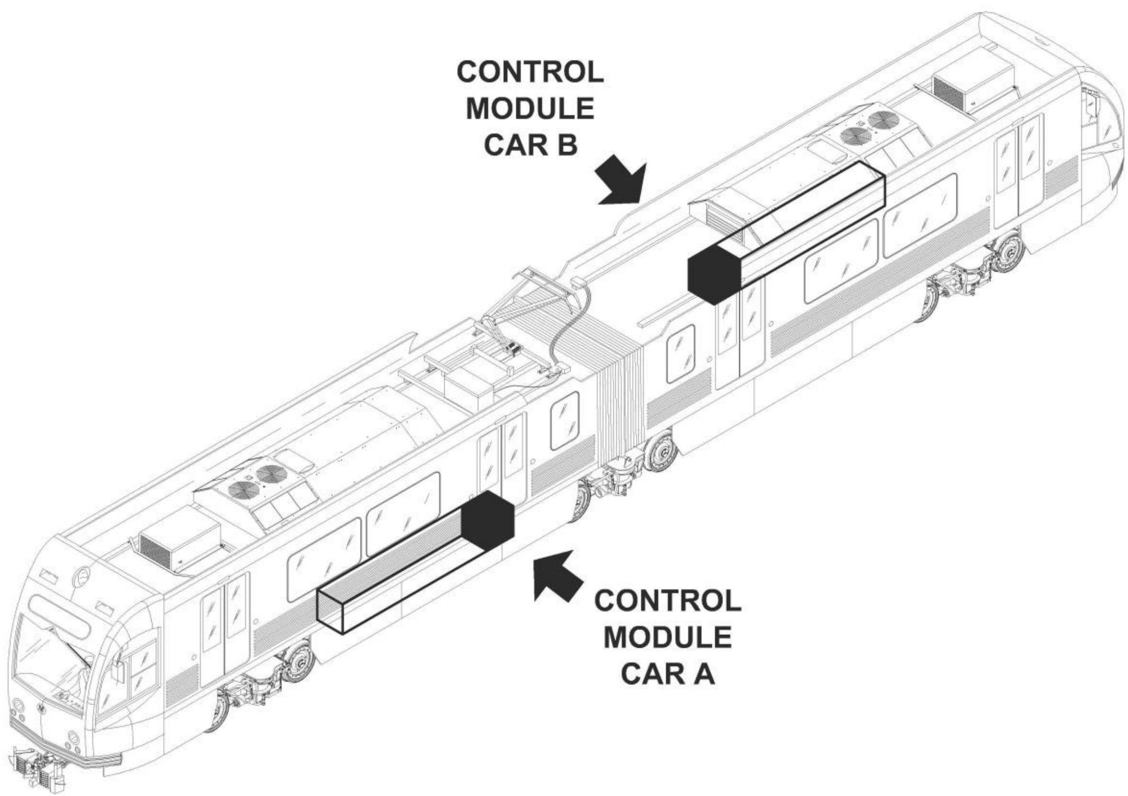


Figure 3 - CONTROL MODULE - CP CONTACTOR

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-01-02-00/I-00**
System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**
Component:	Man Hours: **0.6**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-01-02-00/I-00

System:	Sheet:
PROPULSION	**2/6**

Subsystem/Assy:	Unit:
PRECHARGE SYSTEM	**CONTACTOR CHARGE FILTER (CCF)**

Component:	Man Hours:
	0.6

Maintenance Task:	Interval/Miles:
INSPECTION	**30,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit
Inspection Mirror

CONSUMABLES:

CRC Industrial - Precision Cleaner M3 PN 147535
CRC 2000 Contact Cleaner

SPARE PARTS:

CCF CONTACTOR TYPE LTC100 P/N 211VK01326B

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-01-02-00/I-00**		
System: **PROPULSION**		Sheet: **3/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**	
Component:		Man Hours: **0.6**
Maintenance Task: **INSPECTION**		Interval/Miles: **30,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it. Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

(Refer to Figures 1 through 3)

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module

2. Gain access to CCF contactor by removing the Grounding Cable, Safety Latches and cover from the Control Module.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1

3. Inspect CCF Contactor for damage, signs of arcing, or overheating.

4. Replace, as per inspection result, according to Sheet R-C-07-01-02-00/ R-00.

5. Clean the Insulator Plate using the recommended agent.

6. Check the CCF Contactor mechanical parts for smooth movement.

7. Check the connections of the Auxiliary and Main Circuits for tightness and/or burns. (tighten if loose or replace if burned)

8. Inspect and check for signs of damage and over heating.

9. Clean the Auxiliary and Main contacts with the recommended agent and a lint-free rag.

10. Inspect the CCF Contactor for loose hardware. Tighten, as per check result.

11. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

12. Reconnect the Grounding Cable

13. Record task results on the Defect Report Card for administrative and maintenance planning.

14. Once completed, proceed as follows:

a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

b. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-01-02-00/I-00**	
System: **PROPULSION**	Sheet: **4/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**
Component:	Man Hours: **0.6**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):

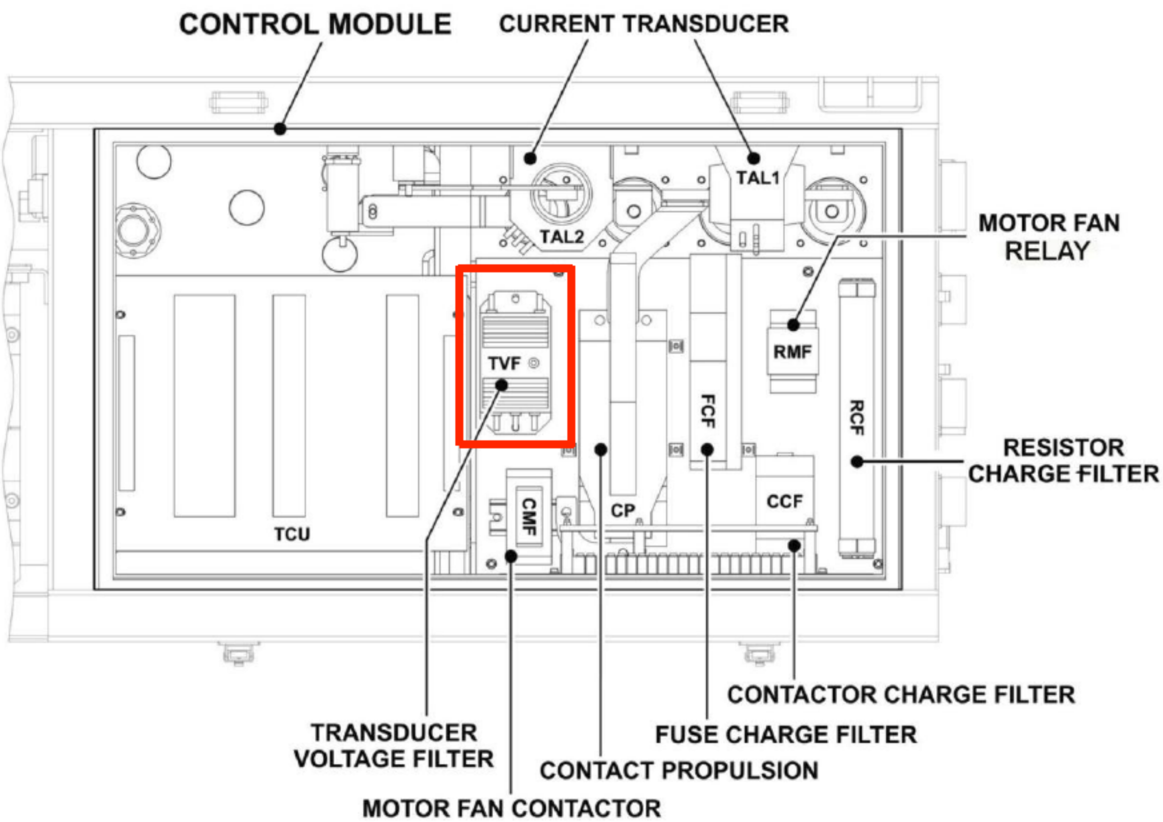
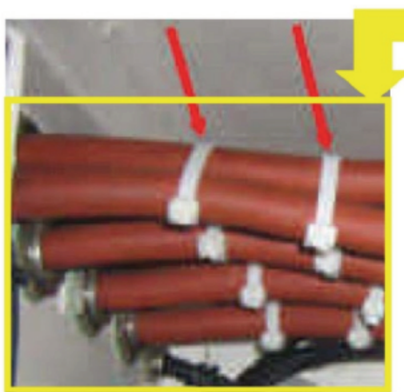


Figure 1 - CONTROL MODULE

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-01-02-00/I-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**
Component:	Man Hours: **0.6**
Maintenance Task: **INSPECTION**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):



DETAIL"A"
Two ties each couple of
"P" and "N" cables

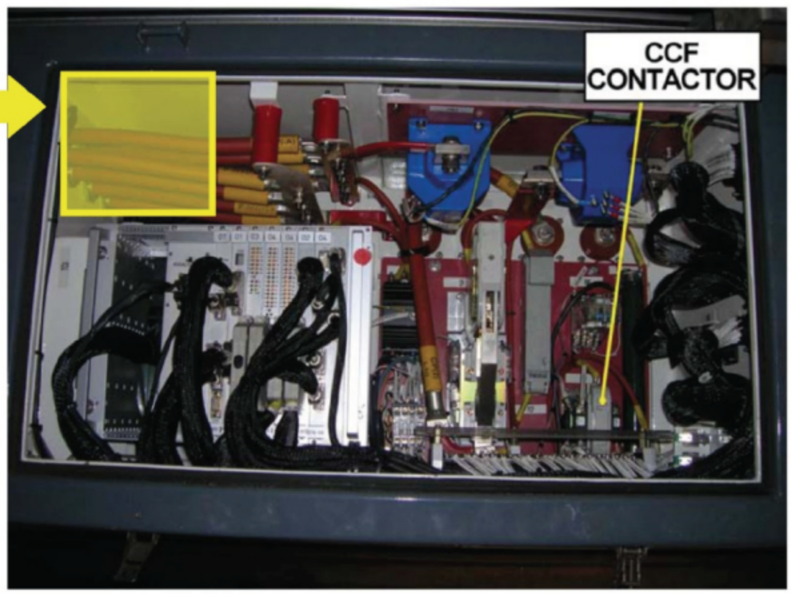


Figure 2 - CONTROL MODULE INTERIOR

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-01-02-00/I-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**	
Component:		Man Hours: **0.6**
Maintenance Task: **INSPECTION**		Interval/Miles: **30,000**

PROCEDURE (CONT'D):

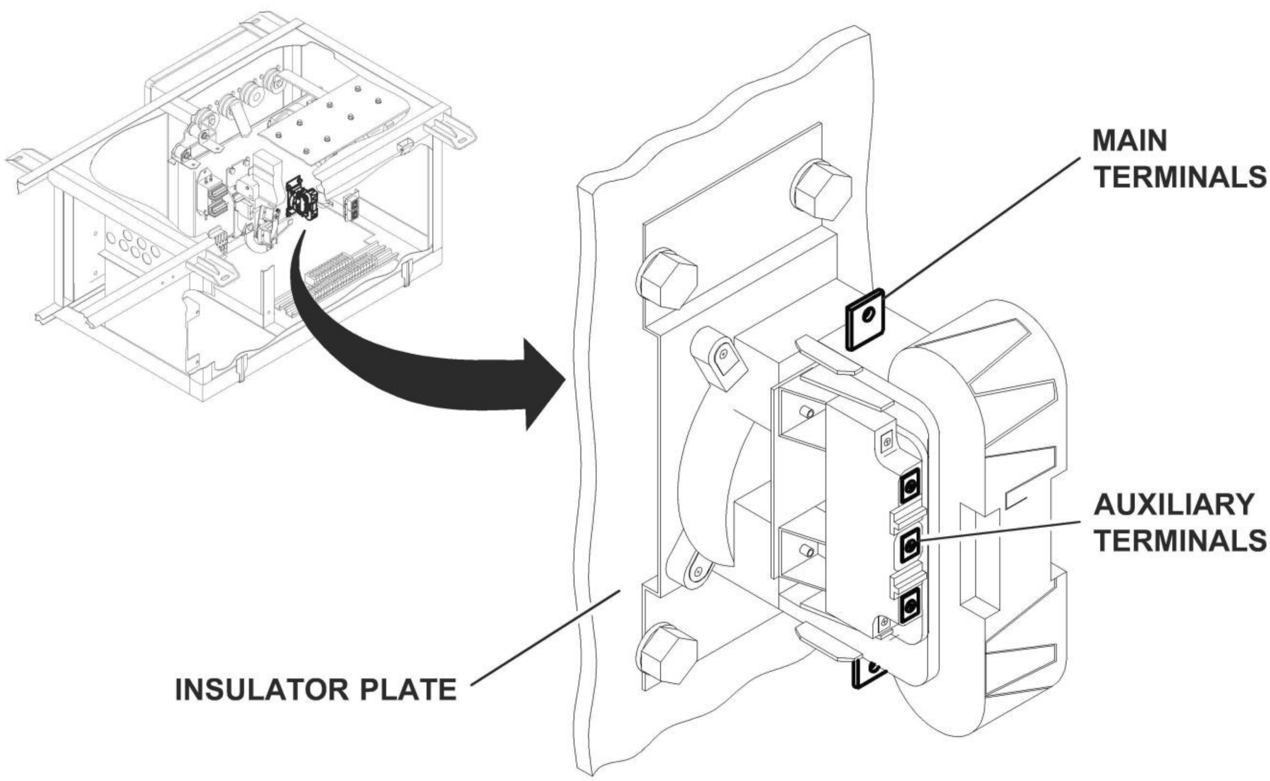
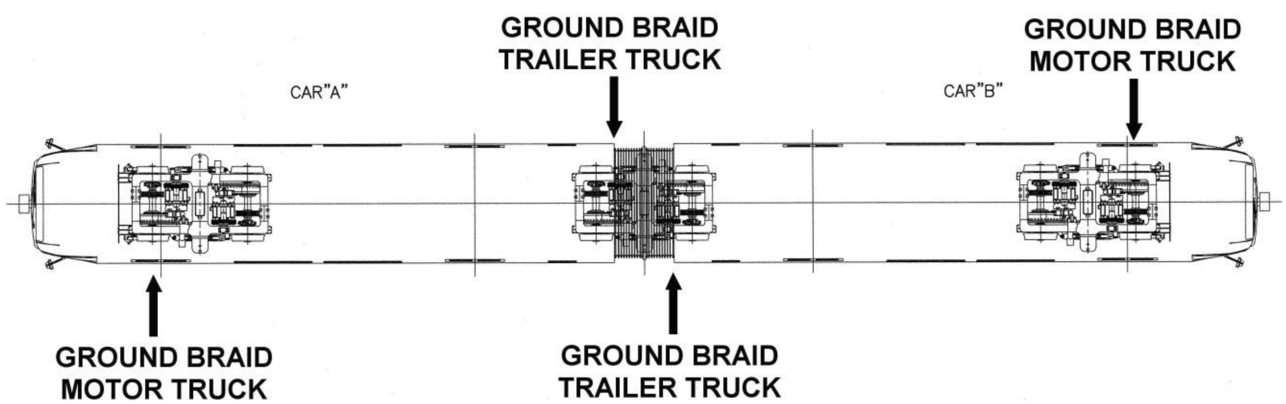


Figure 3 - CONTROL MODULE - CCF CONTACTOR

P2550 PREVENTIVE MAINTENANCE SHEET

		Card Code: **R-P-07-02-00-00/I-00**
System: **PROPULSION**		Sheet: **1/6**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUND BRAIDS**		Man Hours: **0.25**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-02-00-00/I-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUND BRAIDS**	Man Hours: **0.25**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

LACMTA Maintenance Shop Safety Regulations

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

Cleaner / Degreaser, as needed
Anti-Oxidant Joint Compound Korp - Shield, as needed (P/N AA00FFX)

CRC 2000 Contact Cleaner

SPARE PARTS:

Motor Truck Grounding Wires (P/N AA04XLA) QTY = 2
Trailer Truck Grounding Wires (P/N AA04XLC) QTY = 1
Trailer Truck Grounding Wires (P/N AA04XLB) QTY = 2

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:	**R-P-07-02-00-00/I-00**
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUND BRAIDS**	Man Hours: **0.25**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

To perform the task proceed as follows:
(refer to Figures 1 through 3)

NOTE: The following procedure is applicable to the Ground Braids connecting
a) Carbody to both Motor Trucks.
b) Articulation Structure to Trailer Truck.

1. Inspect Grounding Braids and Terminals for damage, loose / missing parts and signs of fraying, overheating, rust and / or visible conditions that could lead to a bad contact. Replace, as per check result.
2. Clean Grounding Braids and Terminals with the recommended agent.
3. Remove stubborn dirt using a sash brush and recommended cleaner.
4. Check Terminals Connections for the proper torque of **30 ft-lb**.
5. Record Inspection results on the Defect Report Card for administrative and maintenance planning.
6. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-02-00-00/I-00**			
System: **PROPULSION**			Sheet: **4/6**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:		
Component: **GROUND BRAIDS**			Man Hours: **0.25**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

PROCEDURE (CONT'D):

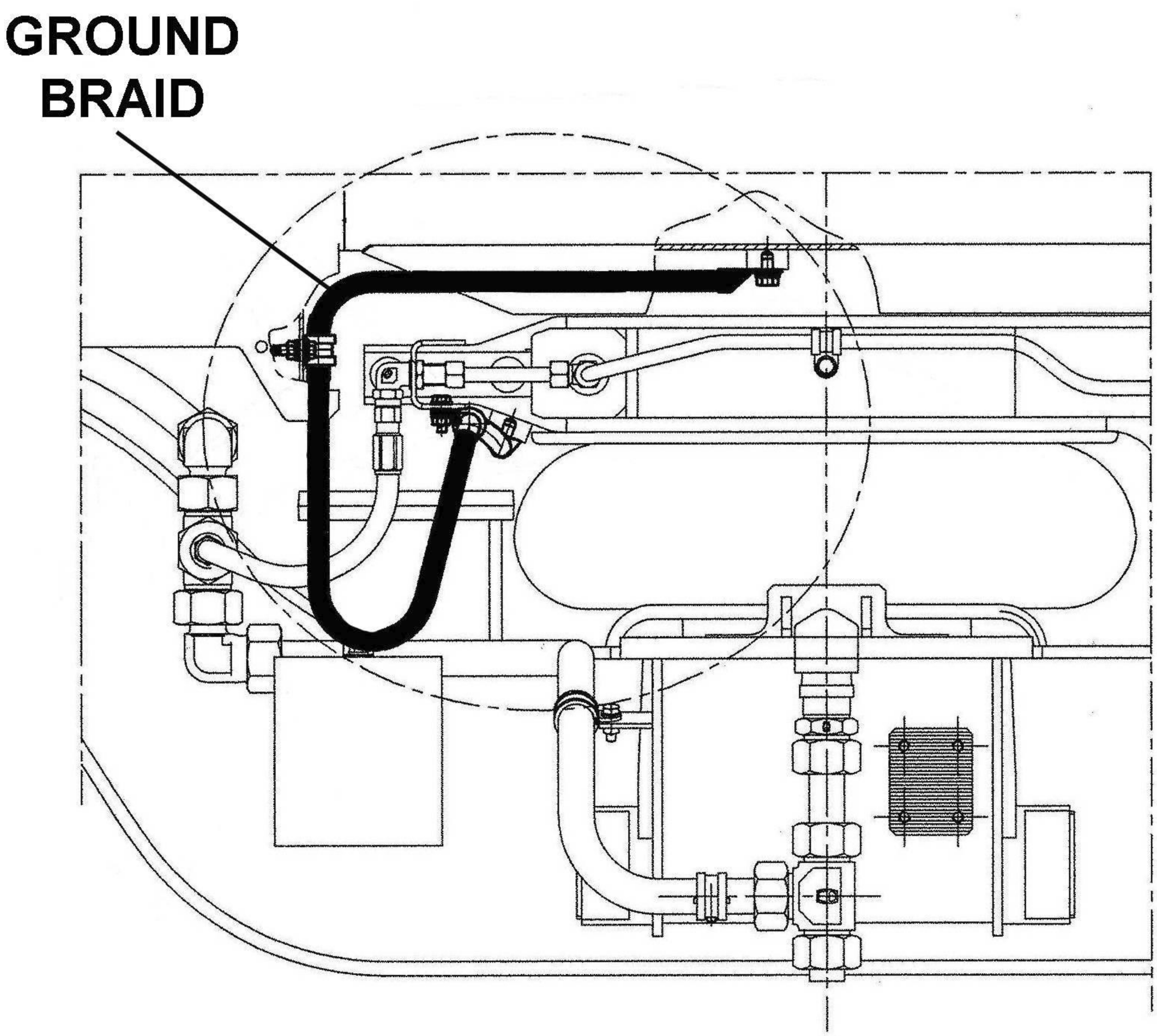


Figure 1 - GROUND BRAID - MOTOR TRUCK

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-02-00-00/I-00**		
System: **PROPULSION**		Sheet: **5/6**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUND BRAIDS**		Man Hours: **0.25**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

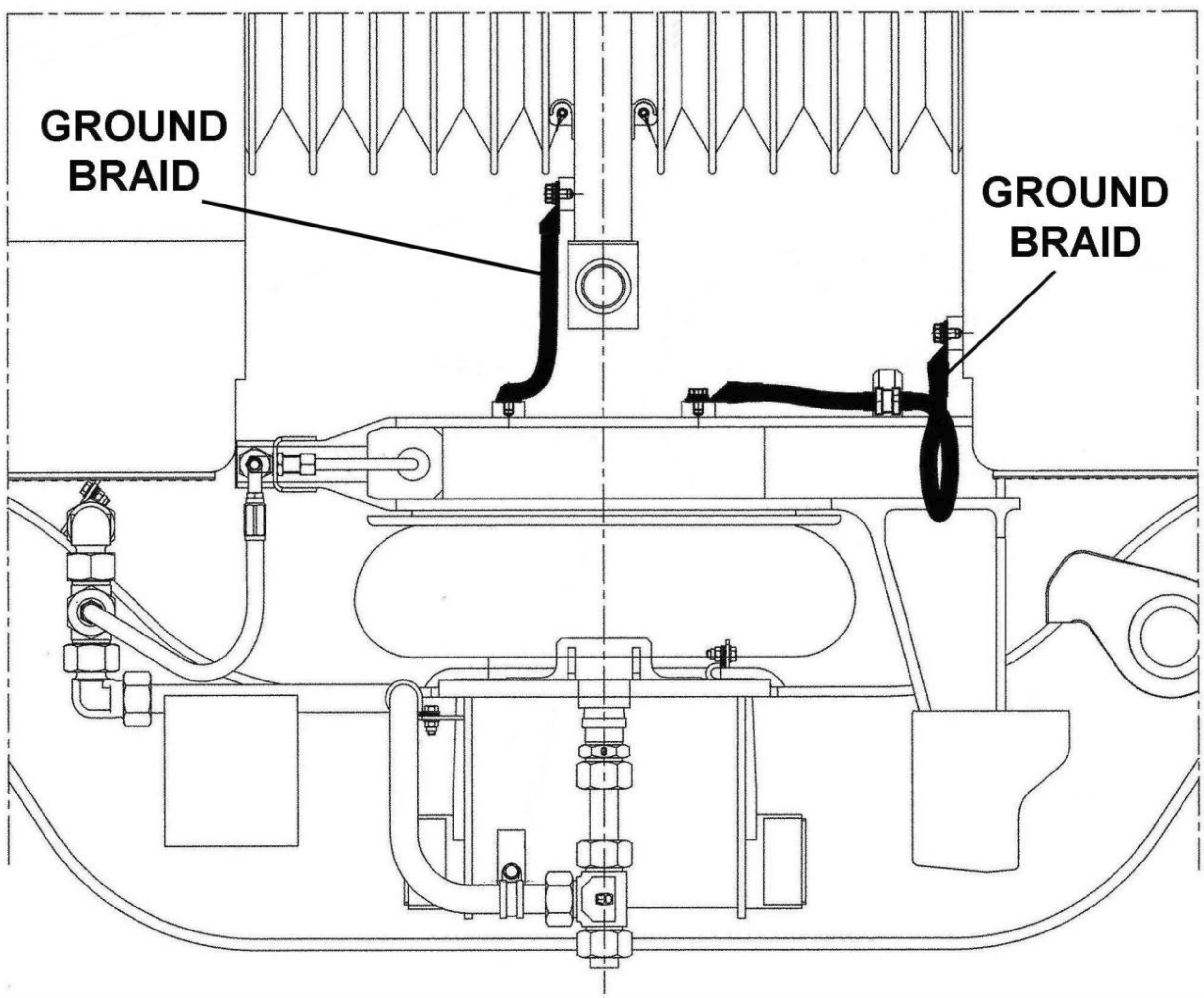


Figure 2 - GROUND BRAID - TRAILER TRUCK -LH

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-02-00-00/I-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUND BRAIDS**		Man Hours: **0.25**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

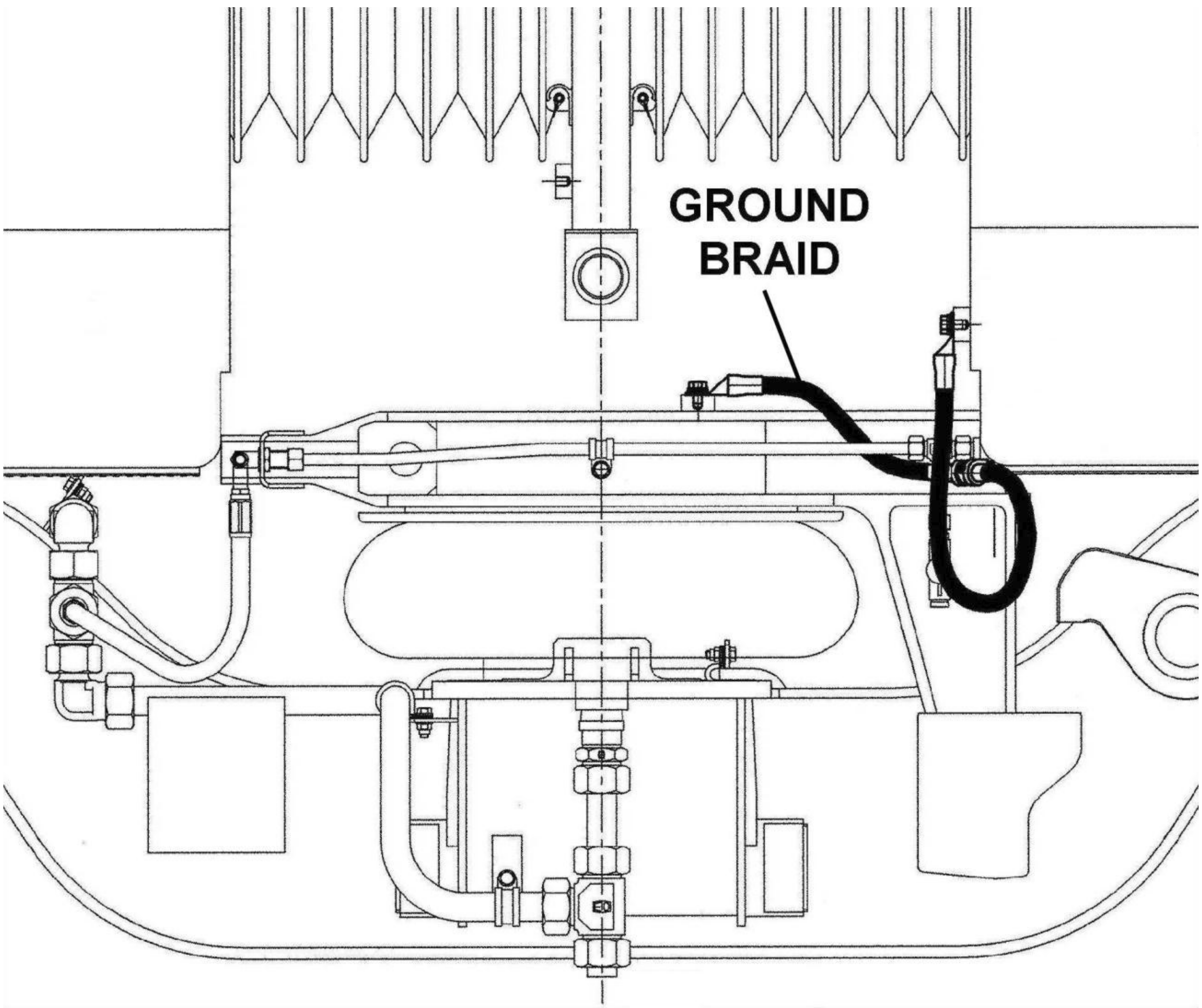
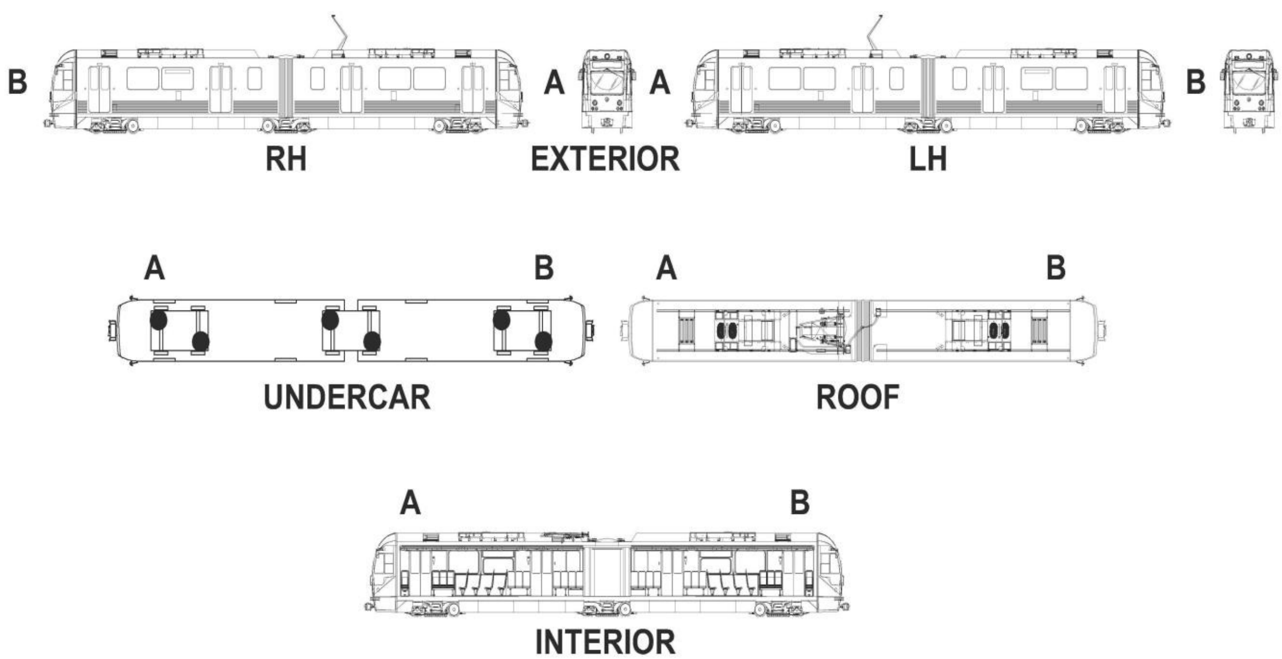


Figure 3 - GROUND BRAID - TRAILER TRUCK -RH

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-02-00-00/I-01**
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-02-00-00/I-01**	
System: **PROPULSION**	Sheet: **2/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

CAUTION IT IS IMPERATIVE THAT NO OIL, GREASE OR DIRT IS LEFT ON THE GROUND / RETURN CURRENT BRUSHES.
RESIDUE OF ANY KIND WILL CAUSE FAILURE TO THE GROUNDING CONTACT.
CLEAN GROUND / RETURN CURRENT BRUSHES WITH A CLEAN CLOTH USING WHITE ALCOHOL SPIRITS ONLY.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-02-00-00/I-01**
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

Cleaner / Degreaser, as needed.

White Alcohol Spirits as needed.

Anti-Oxidant Joint Compound Korp - Shield, as needed (P/N AA00FFX).

SPARE PARTS:

Ground / Return Brushes (PN 06.21.0076.13)
Housing LH (PN 06.50.0151.00)
Housing RH (PN 06.50.0151.01)
Housing LH Gasket (PN tbd)
Housing RH Gasket (PN tbd)

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-02-00-00/I-01**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUNDING CONTACT**		Man Hours: **1**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

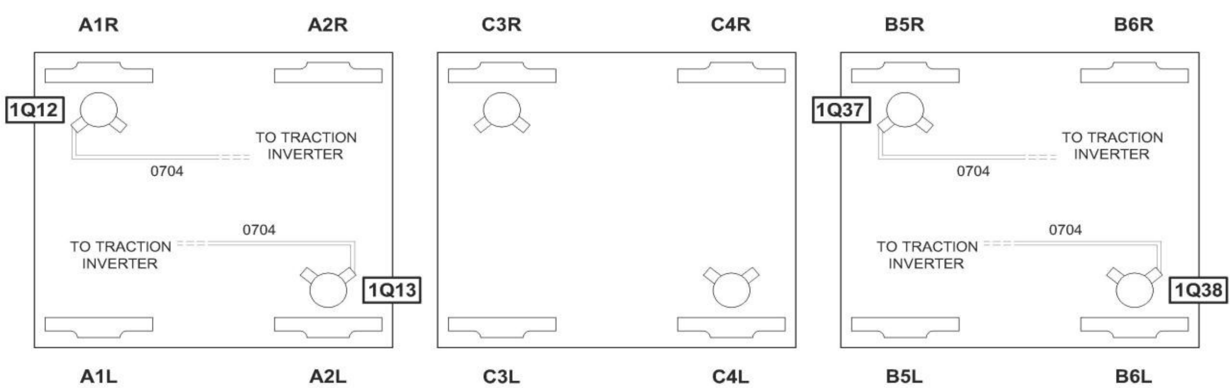


Figure 1 - RETURN CURRENT BRUSHES - LOCATION AND CONNECTIONS

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-02-00-00/I-01**
System: **PROPULSION**	Sheet: **5/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

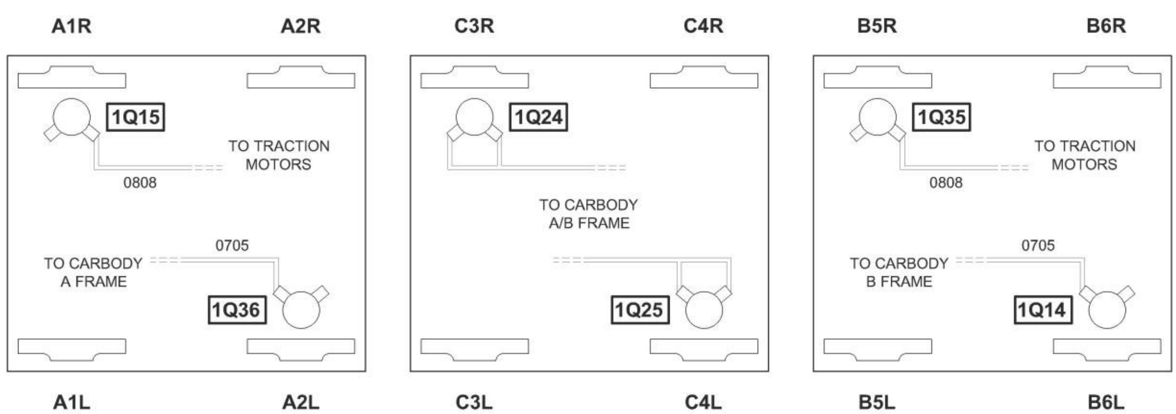


Figure 2 - GROUND BRUSHES - LOCATION AND CONNECTIONS

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-02-00-00/I-01**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

INSPECTION

(Refer to figures 1 through 4)

To perform the task proceed as follows:

WARNING: **ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.**

CAUTION: IT IS IMPERATIVE THAT NO OIL, GREASE OR DIRT IS LEFT ON THE GROUND / RETURN CURRENT BRUSHES.
RESIDUE OF ANY KIND WILL CAUSE FAILURE TO THE GROUNDING CONTACT.
CLEAN GROUND / RETURN CURRENT BRUSHES WITH A CLEAN CLOTH USING WHITE ALCOHOL SPIRITS ONLY.

1. Check Return Current and Grounding Brush Housings for damage / loose / missing parts.
2. Clean Brush Housings of all excessive grease.
3. Inspect Terminals and Cables for damage / loose / missing parts and burns.
4. Check Terminals connections for proper torque of **30 ft-lb**.
5. Remove Brush Housing, inspect the Remove Cover and replace as needed.
6. Check Brush for wear. If the reference line is not visible replace according to Sheet R-C-07-02-00-00-00 /R-00.
7. Slide Out the Pressure Device from the slot in the Brush Guide to disengage the Brush Terminals.
8. Check Brush Terminals for signs of oxidation / dirty. Clean using recommended agent.
9. Check Brush Pigtails for signs of fraying.
10. Replace as per check result, according to Sheet R-C-07-02-00-00-00 /R-00.
11. Reinstall the Brush and re-engage the Brush Terminals into the Pressure Device.
12. Slide the Pressure Device into slot of the Brush Guide (until it “clicks“ into place) to engage the Brush Terminals.
13. Check Pressure Devices for good tension..
14. Clean both mating surfaces for the Cover Gasket using recommended agent first and then install new Cover Gasket.
15. Reinstall Housing Cover and tighten the relevant attaching parts to **10 ft-lb.**
16. Record inspection results on the Defect Report Card for administrative and maintenance planning.
17. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-02-00-00/I-01**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

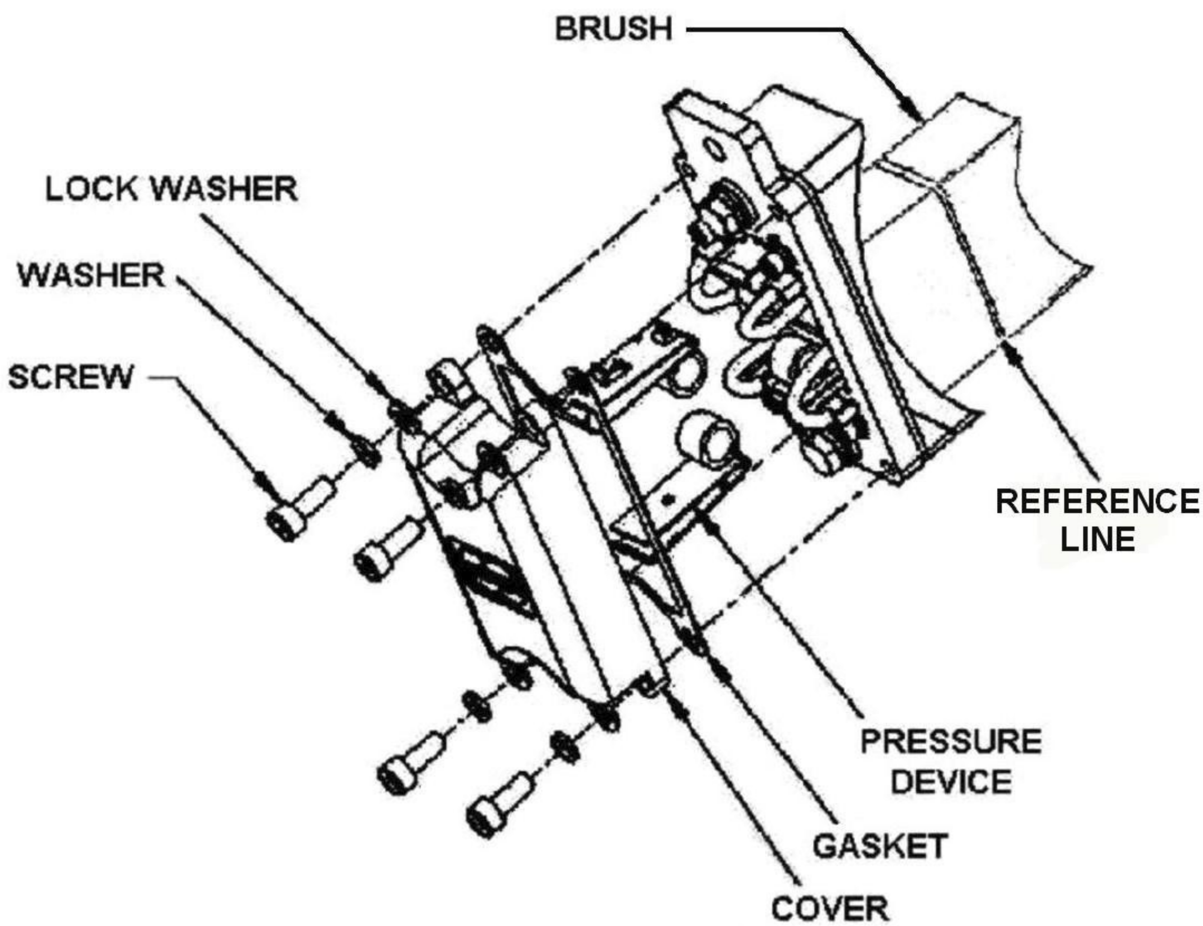


Figure 3 - GROUND / RETURN CURRENT BRUSHES - MAIN COMPONENTS

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-02-00-00/I-01**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

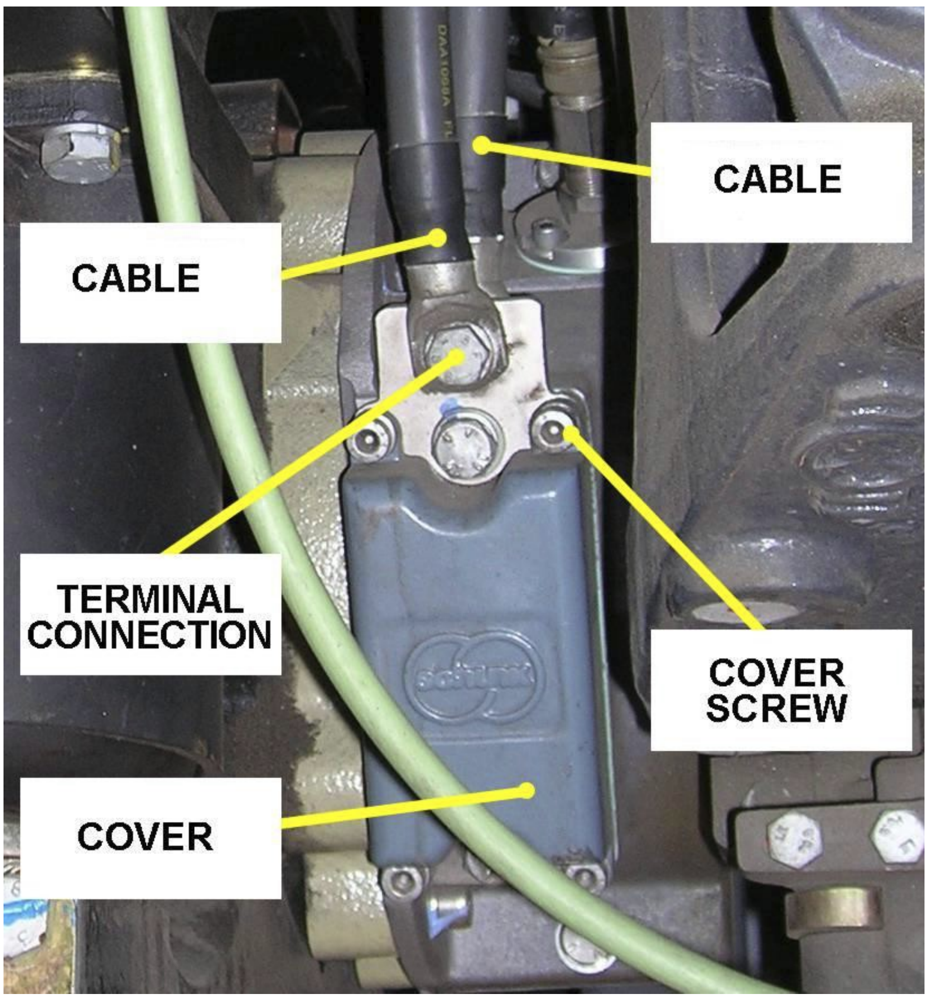


Figure 4 - GROUND / RETURN CURRENT BRUSH HOUSING

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-00-00/C-00

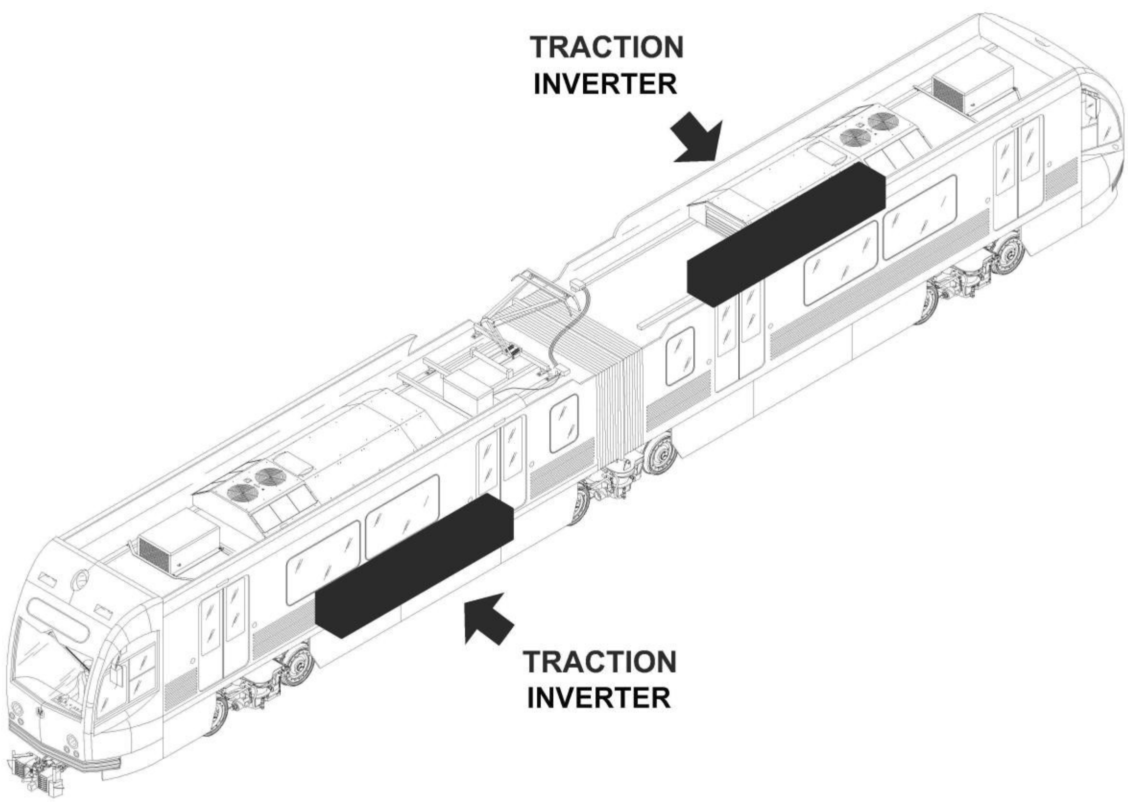
System:	Sheet:
PROPULSION	**1/4**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	

Component:	Man Hours:
AIR GRILLE	**0.4**

Maintenance Task:	Interval/Miles:
CLEANING	**30,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Field	Value
Card Code:	**R-P-07-03-00-00/C-00**
System:	**PROPULSION**
Sheet:	**2/4**
Subsystem/Assy:	**TRACTION INVERTER HV COMPONENTS**
Unit:	
Component:	**AIR GRILLE**
Man Hours:	**0.4**
Maintenance Task:	**CLEANING**
Interval/Miles:	**30,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP, SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:
Vacuum Cleaner

CONSUMABLES:
Cleaner / Degreaser

SPARE PARTS:
N/A

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/C-00**

System: **PROPULSION**	Sheet: **3/4**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component: **AIR GRILLE**	Man Hours: **0.4**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

CLEANING

To perform the task proceed as follows (refer to Fig. 1):

1. Remove both Air Inlet Grilles by loosening relevant attaching screws.
2. Clean the Traction Inverter Modules Heat Sink Air Duct using air, paying attention to not damage Heat Sinks Fins.
3. Remove dirt from Air Inlet grilles using sash brush and cleaning rags.
4. Clean the air outlet Grill of all excessive dirt and debris.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: R-P-07-03-00-00/C-00		
System: PROPULSION		Sheet: 4/4
Subsystem/Assy: TRACTION INVERTER HV COMPONENTS	Unit:	
Component: AIR GRILLE		Man Hours: 0.4
Maintenance Task: CLEANING		Interval/Miles: 30,000

PROCEDURE (CONT'D):

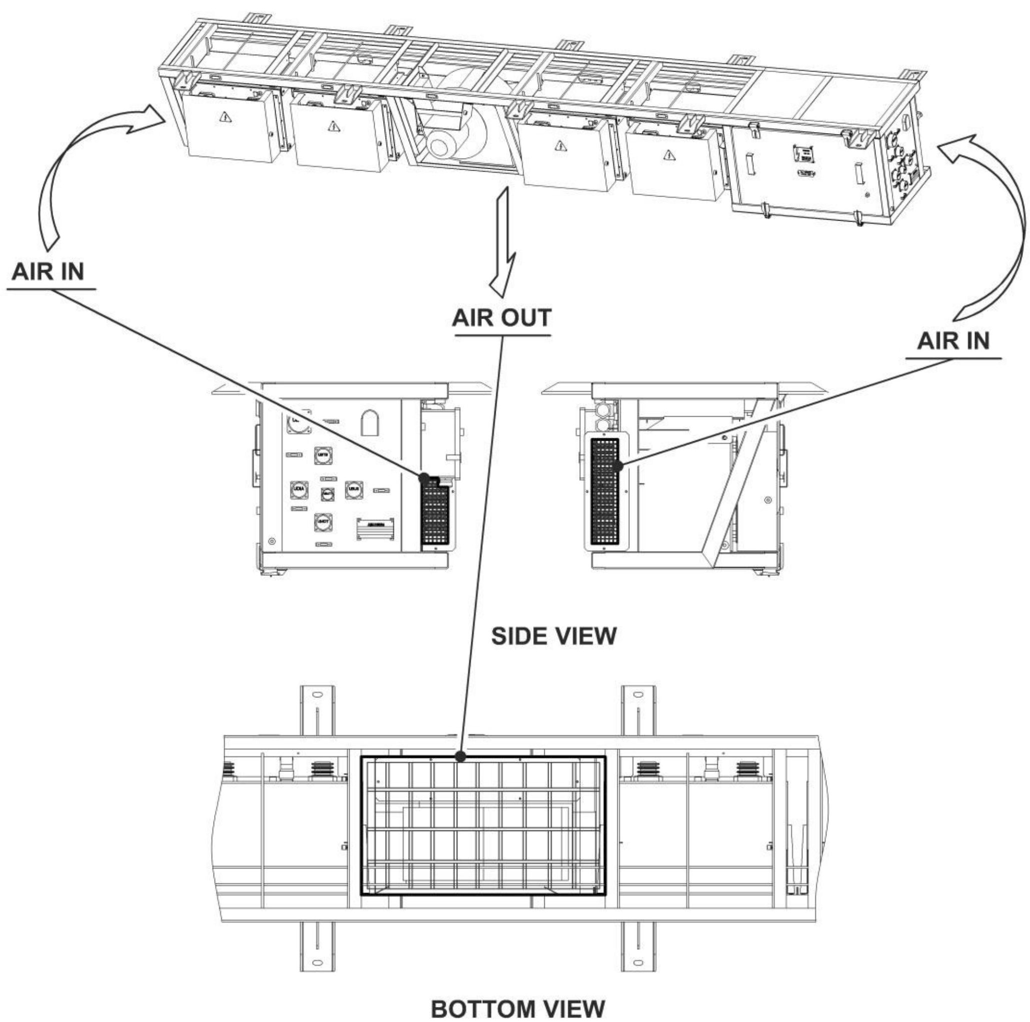


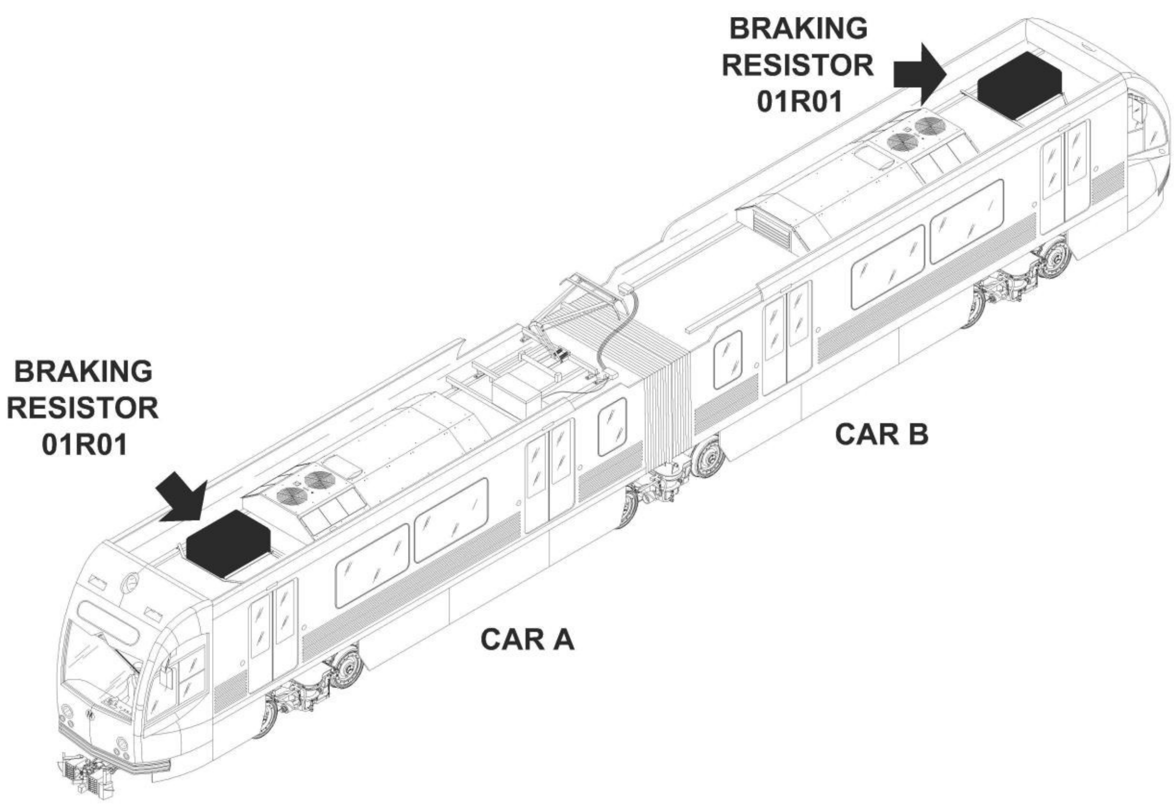
Figure 1 - TRACTION INVERTER - AIR COOLING GRILLES LOCATIONS

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-06-00/C-00

System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **0.4**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-06-00/C-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **0.4**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: DANGER OF PERSONAL INJURY EXISTS DUE TO ELECTRICAL POWER.(750V) ENSURE PANTOGRAPH IS LOWERED, AND CATENARY POWER IS REMOVED AND ISOLATED PER LACMTA SAFETY RULES AND PROCEDURES. IF POSSIBLE, WORK SHOULD BE DONE IN AN AREA WITHOUT OVERHEAD CATENARY.

WARNING: DANGER OF PERSONAL INJURY EXISTS DUE TO THE WORKING ON THE ROOF. FOLLOW SAFETY PROCEDURES FOR ACCESSING ROOF. ALWAYS WEAR SAFETY BELT TO ACCESS THE ROOF.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT. REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

CAUTION USE RUNNING WATER (NOT HIGH PRESSURE) AND A BRISTLE BRUSH.
DO NOT USE CLEANING AGENTS OR SOLVENT

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-06-00/C-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **0.4**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

Cleaner

SPARE PARTS:

Braking Resistor	(P/N AA03KDX) (	P/N 211VR01198B)
Bank Insulator		P/N ISSTE50M10

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-06-00/C-00**	
System: **PROPULSION**	Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **0.4**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE: The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

To perform the task proceed as follows:
(Refer to Figures 1 and 2)

WARNING: DANGER OF PERSONAL INJURY EXISTS DUE TO THE WORKING ON THE ROOF. FOLLOW SAFETY PROCEDURES FOR ACCESSING ROOF. ALWAYS WEAR A SAFETY HARNESS WHEN ACCESSING THE ROOF

1. Remove the Braking Resistor Protection Grille.
2. Inspect Braking Resistor Resistance Banks for damage, missing / loose hardware, cracks, burns and signs of flashover.
3. Inspect Bank Insulators for damage, cracks, burns and signs of flashover.
4. Clean the insulator.
5. Note any areas / items requiring corrective maintenance.
6. Remove the Braking Resistor Protection Grille.
7. Clean all the insulators manually with a wet cloth.
8. Reinstall the Braking Resistor Protection Grille.
9. Check the four bolts that fix the Braking Resistor (torque of **24 lb-ft**).
10. Restore the power.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-06-00/C-00

System:	Sheet:
PROPULSION	**5/6**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**BRAKING RESISTOR**

Component:	Man Hours:
	0.4

Maintenance Task:	Interval/Miles:
CLEANING	**30,000**

PROCEDURE (CONT'D):

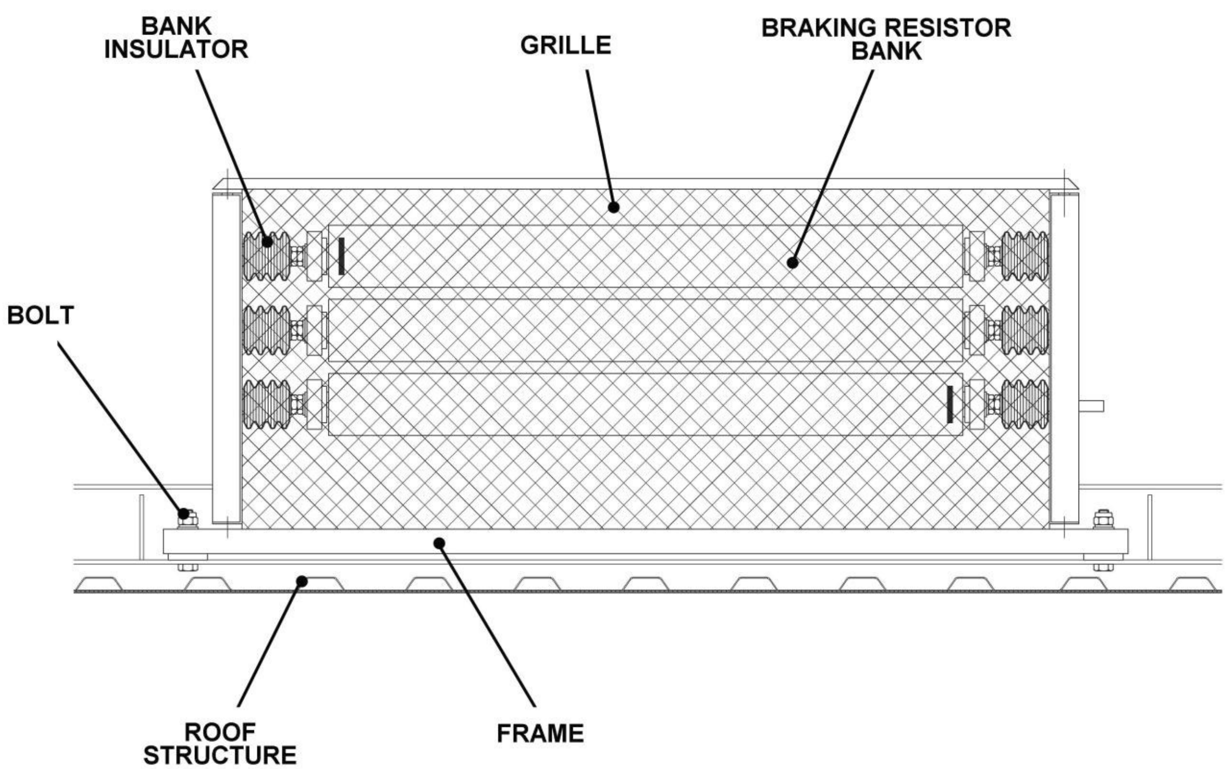


Figure 1 - BRAKING RESISTOR COMPONENTS -FRONT VIEW

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-06-00/C-00**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **0.4**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):

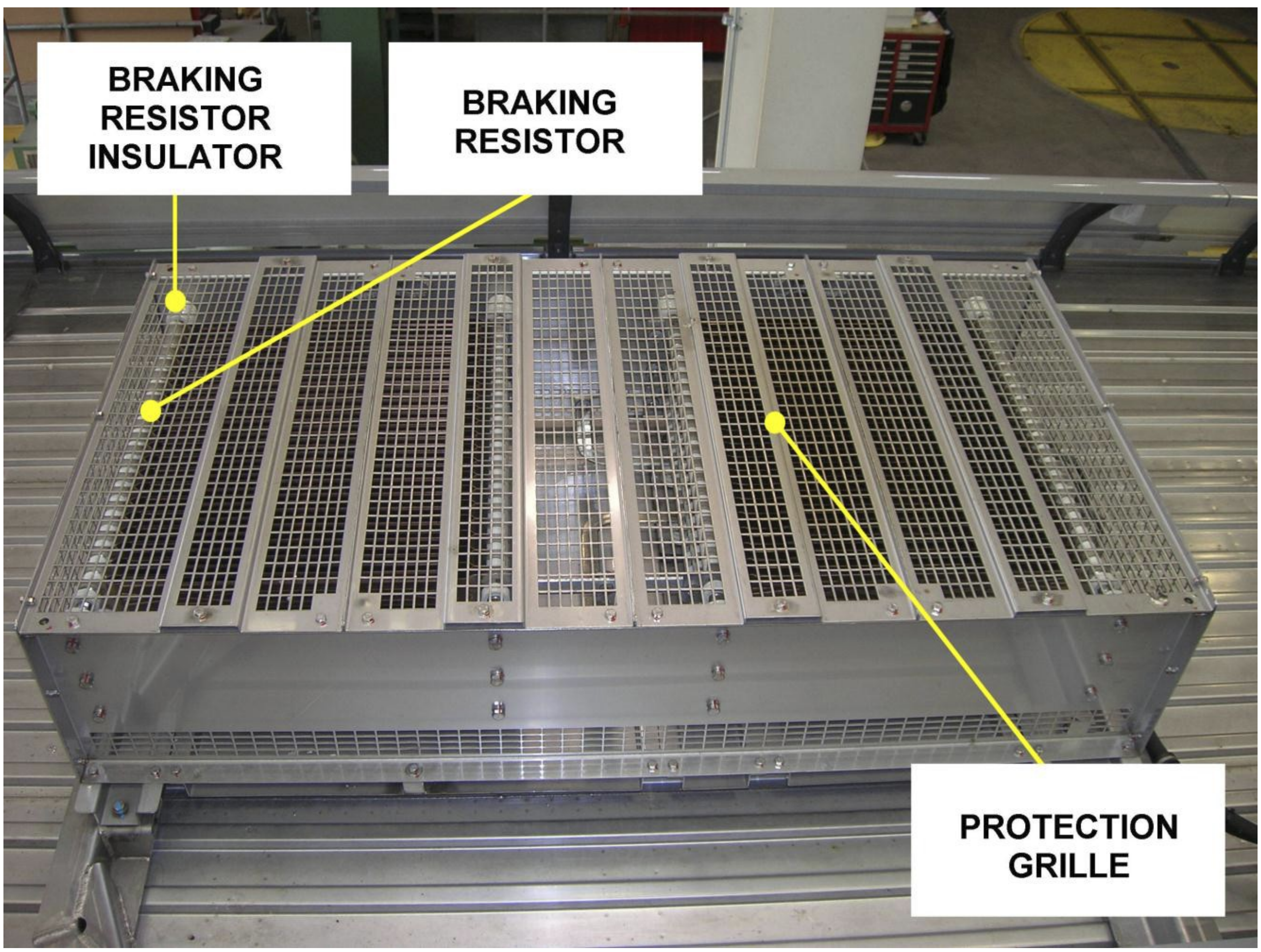
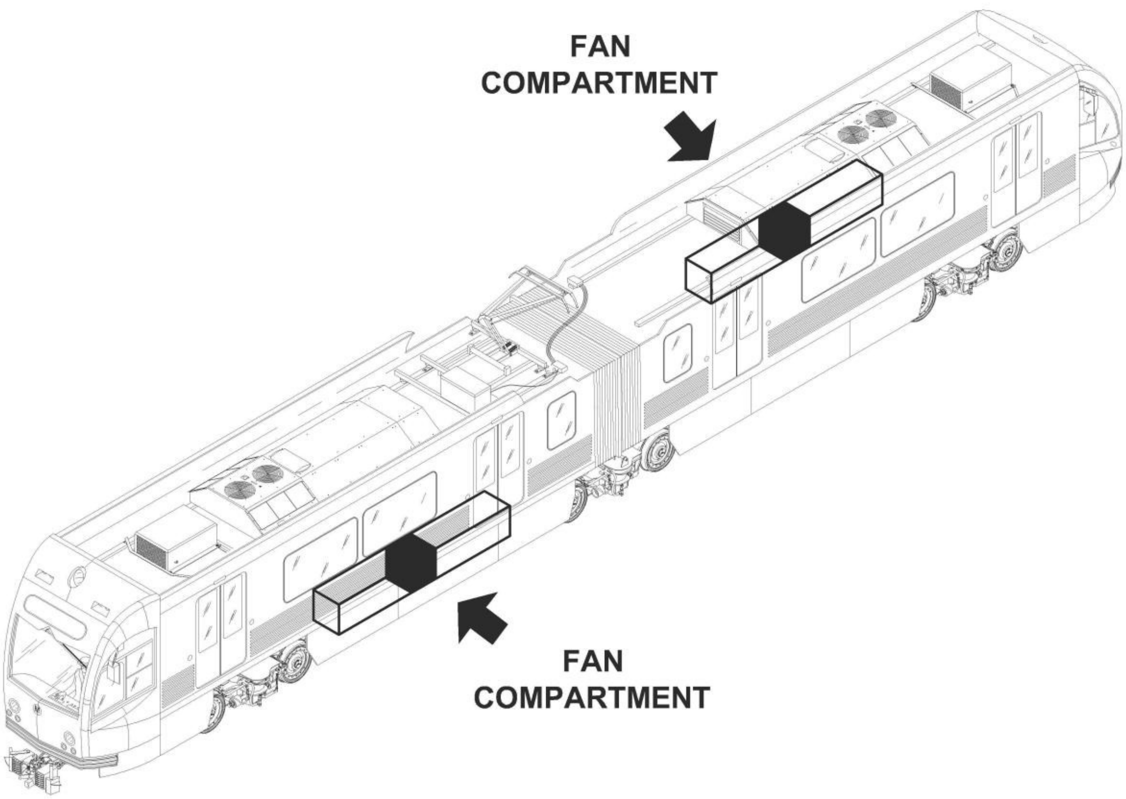


Figure 2 - BRAKING RESISTOR ON BOARD VEHICLE

P2550 PREVENTIVE MAINTENANCE SHEET		
		Card Code: **R-P-07-03-07-00/C-00**
System: **PROPULSION**		Sheet: **1/4**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**	
Component:		Man Hours: **0.3**
Maintenance Task: **CLEANING**		Interval/Miles: **30,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-07-00/C-00**	
System: **PROPULSION**	Sheet: **2/4**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **0.3**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT. REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVE OR OPEN MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: WHEN WORKING ON COMPONENTS ACCESSIBLE FROM THE UNDERFRAME, AND THE VEHICLE IS ON THE INSPECTION PIT, A WARNING SIGN MUST BE APPLIED EXTERNALLY FROM THE PIT TO WARN THAT MAINTENANCE PERSONNEL IS WORKING IN THE PIT.

TOOLS:
Air gun

CONSUMABLES:
Degreaser

SPARE PARTS:
N/A

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-07-00/C-00**
System: **PROPULSION**	Sheet: **3/4**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **0.3**
Maintenance Task: **CLEANING**	Interval/Miles: **30,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

3. Place both the CB 2F06 (Propulsion Motor Fan Circuit Breaker located on the LV Locker both cars) to OFF position.

INSPECTION

To perform the task proceed as follows (Refer to Figure 1):

1. Inspect Motor Fan Compartment for general condition visible damage, missing / loose hardware.

2. Clean the Motor Air inlet with air gun and clean the Fan Motor Cooling Fins with a degreaser.

3. Check the Motor Power Supply Terminal Board for missing /loose hardware, visible gasket damage / deformation and relevant Cable Bushing for correct tightness.

4. Check the Motor Power Supply Cable for visible damage / loose / missing clamp.

5. Check the Grounding Wire and relevant connections for missing / loose parts, signs of fraying / overheating.

6. Clean the Grill using the air gun, if needed.

7. Check Inverter Air Outlet Grille for damage / deformation, loose / missing hardware.

8. Note any areas / items requiring corrective maintenance.

9. Restore Electrical Power to Vehicle.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-03-07-00/C-00**		
System: **PROPULSION**		Sheet: **4/4**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**	
Component:		Man Hours: **0.3**
Maintenance Task: **CLEANING**		Interval/Miles: **30,000**

PROCEDURE (CONT'D):

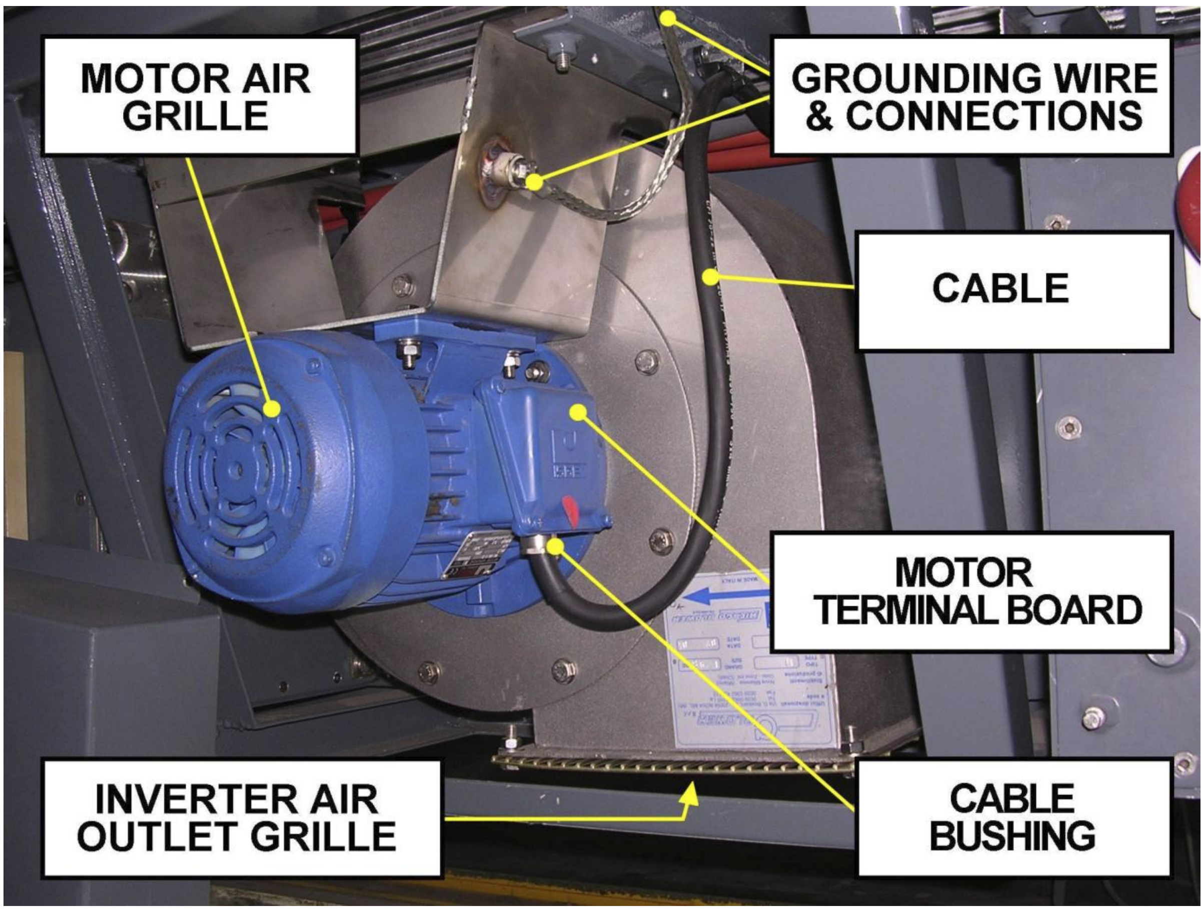
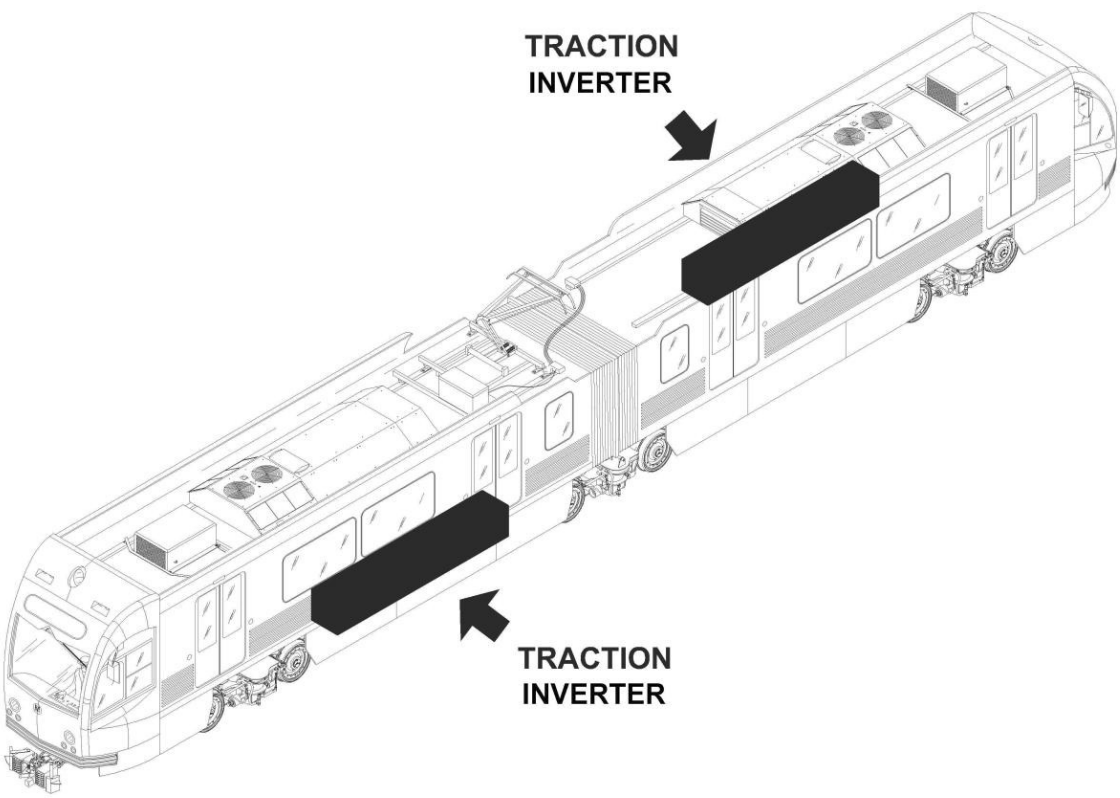


Figure 1 - TRACTION INVERTER - MOTOR FAN

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-00-00/C-01**
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **0.8**
Maintenance Task: **CLEANING**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/C-01**	
System: **PROPULSION**	Sheet: **2/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **0.8**
Maintenance Task: **CLEANING**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

**WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.**

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

**WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.**

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:
LACMTA Maintenance Shop Standard Tool Kit (19 mm Torque Wrench, 8 mm Wrench, 10 mm Wrench)
Vacuum Cleaner.

CONSUMABLES:
Cleaner / Degreaser
CRC Industrial - Precision Cleaner M3 PN 147535
Dry Compressed Air for Electronic Equipment (commercial)

SPARE PARTS:
Control Module Gasket (PN 212EE10291B)
HV Control Module Rear Box (Packing) (PN 212EE10175B)

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-00-00/C-01

System: PROPULSION		Sheet: 3/8
Subsystem/Assy: TRACTION INVERTER HV COMPONENTS	Unit:	
Component:		Man Hours: 0.8
Maintenance Task: CLEANING		Interval/Miles: 60,000

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

To perform the task proceed as follows:

TRACTION INVERTER
INSPECTION (EXTERIOR)
(Refer to Fig 1)

1. Check Traction Inverter Frame for damage / deformation.
2. Check Traction Inverter for loose /missing mounting bolts.
3. Check Bolts for proper torque of **52 ft-lb.**
4. Check all Modules Exterior Covers for damage / deformation.
5. Check the mounting Hardware and Grounding Cables of all Modules Covers for damage / loose / missing parts.
6. Check for damage / loose / missing label on all module covers.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/C-01**	
System: **PROPULSION**	Sheet: **4/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **0.8**
Maintenance Task: **CLEANING**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

CLEANING (EXTERIOR)

1. Remove dirt / dust from Traction Inverter Exterior Covers and Frame using sash brush.
2. Remove stubborn dirt using damp wiping rag and recommended cleaner.
3. Use vacuum cleaner to remove debris.
4. Record task results on the Defect Report Card for administrative and maintenance planning.

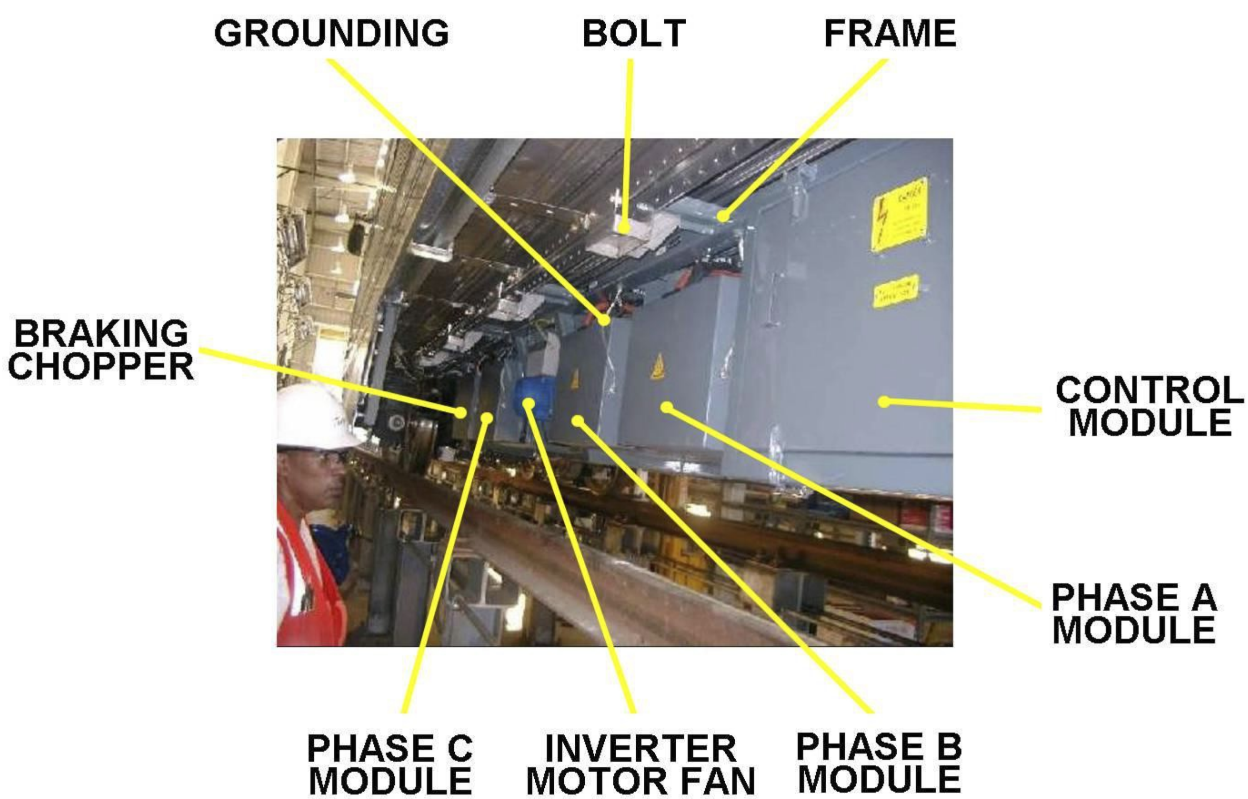


Figure 1 - TRACTION INVERTER

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-00-00/C-01

System:	Sheet:
PROPULSION	**5/8**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	

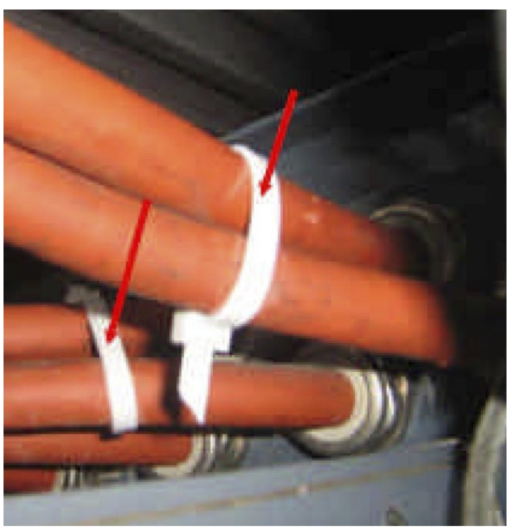
Component:	Man Hours:
	0.8

Maintenance Task:	Interval/Miles:
CLEANING	**60,000**

PROCEDURE (CONT'D):
CONTROL MODULE

INSPECTION
(EXTERIOR) (Refer to Fig 2 and 3)

1. Inspect cables and connectors for any signs of damage or over-heating.
2. Verify that all connectors are tight..
3. Check the Ties applied to each couple of P and N cables for proper position / missing as shown in Fig 2 Detail "A."



DETAIL"A"
Exterior view of the Control Module from over the IGBT module side; Two ties each couple of "P" and "N" cables

Figure 2 - CONTROL MODULE CONNECTIONS

Figure 2 - CONTROL MODULE CONNECTIONS

P2550 PREVENTIVE MAINTENANCE SHEET			
Card Code: **R-P-07-03-00-00/C-01**			
System: **PROPULSION**			Sheet: **6/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:		
Component:			Man Hours: **0.8**
Maintenance Task: **CLEANING**		Interval/Miles: **60,000**	

PROCEDURE (CONT'D):

INSPECTION
(EXTERIOR)

4. Remove the Cover of the HV Connections located on the rear of the Module.
5. Check the Gasket for damage / deformation / signs of degradation. Replace if needed.
6. Replace Gasket, as per check result, paying attention to completely remove adhesive residue, using recommended agent, before positioning the new Gasket.
7. Clean the HV Terminal Insulators using recommended agent.
8. Check the HV Terminal connections for proper torque of **52 ft-lb.**
9. Inspect the LV/MV cables and connectors for any signs of damage or overheating.
10. Verify that all connector are tightened.
11. Reinstall the HV Connections Cover.

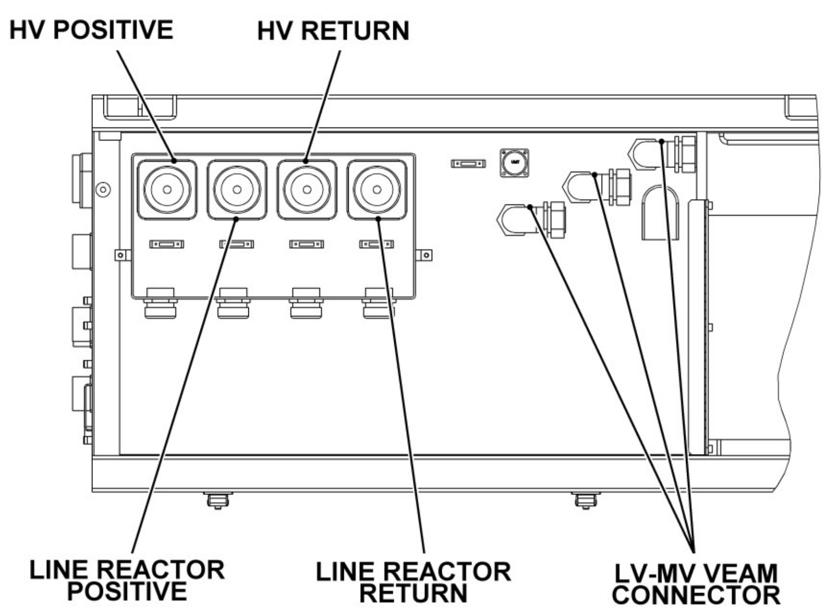


Figure 3 - CONTROL MODULE REAR SIDE CONNECTORS

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/C-01**

System:	Sheet:
PROPULSION	**7/8**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	

Component:	Man Hours:
	0.8

Maintenance Task:	Interval/Miles:
CLEANING	**60,000**

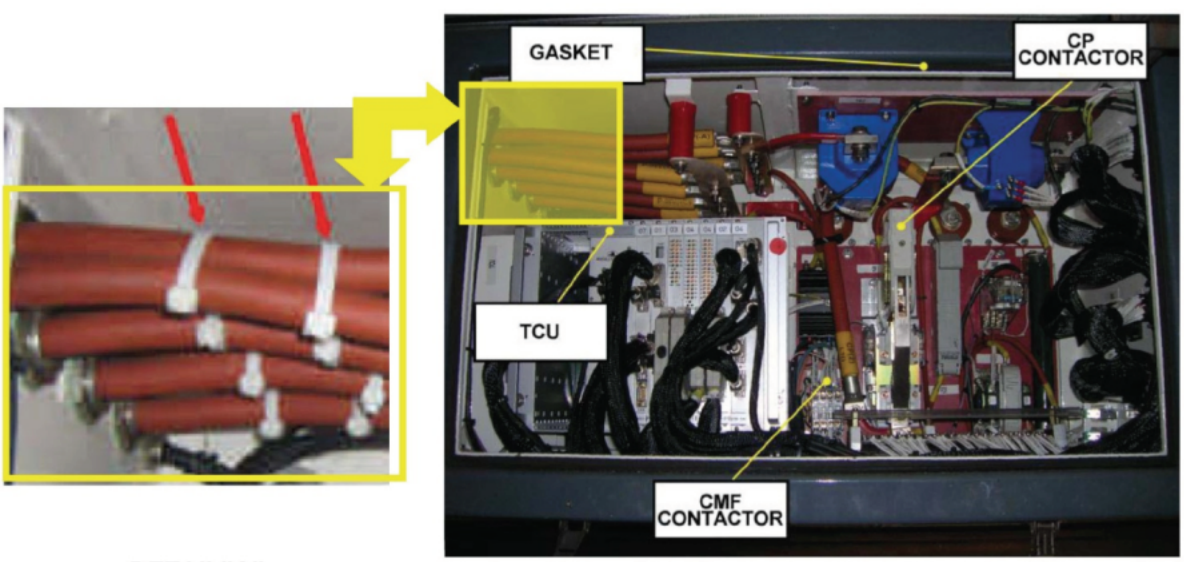
PROCEDURE (CONT'D):

CONTROL MODULE

INSPECTION

(INTERIOR) (Refer to Fig 4)

1. Remove the Control Module Cover.
2. Check Gasket for damage / deformation / signs of degradation. Replace, as needed.
3. Inspect components for installation / loose / missing parts /signs of overheating.
4. Check components connections. Tighten as needed.
5. Clean components as needed.



DETAIL"A"
Two ties each couple of "P" and "N" cables

Figure 4 - CONTROL MODULE INTERIOR AND GASKET

NOTE: Accurate Inspection of all components installed in the Control Module is scheduled at 120,000 miles (refer to Sheet R-P 07-03-00-00/I-00).

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/C-01**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **0.8**
Maintenance Task: **CLEANING**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

PHASE MODULES AND BRAKING CHOPPER MODULE INSPECTION

(Refer to Figure 5 and 6)

1. Remove the Cover of the Module.
2. Inspect the LV cables and connectors for signs of damage or over-heating.
3. Verify that all connector are tightened.
4. Remove the HV Terminal Protectors.
5. Check the HV Terminal Connections for proper torque of **52 ft-lb**.
6. Clean the HV Terminal Insulators and the heat sink using recommended agent.
7. Reinstall the HV Terminal Protectors.
8. Reinstall the Front Cover Module and Grounding Cable. Tighten relevant fixing screws.
9. Repeat steps 1 through 8 for each Module (Phase A,B,C and Chopper).
10. Once completed, restore Electrical Power.

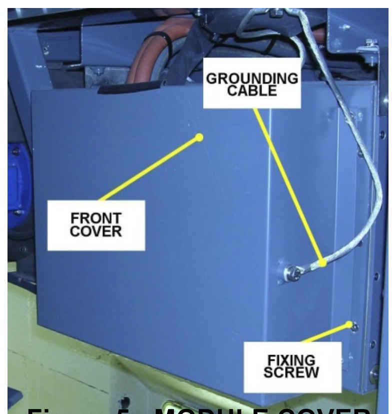


Figure 5 - MODULE COVER

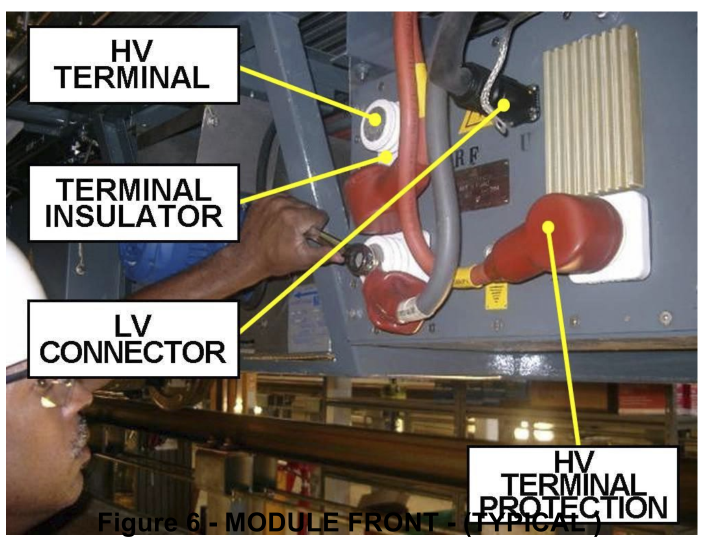


Figure 6 - MODULE FRONT - (TYPICAL)

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-01-00/I-00

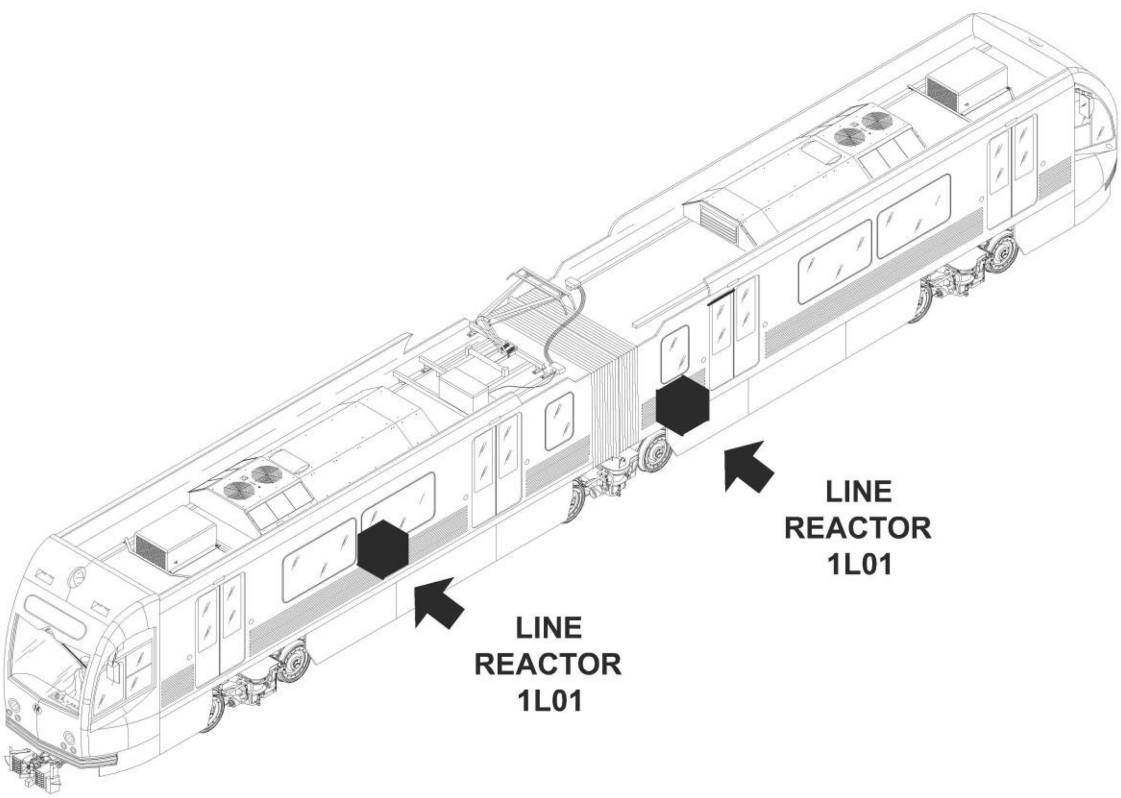
System:	Sheet:
PROPULSION	**1/6**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**LINE REACTOR (1L01)**

Component:	Man Hours:
	0.6

Maintenance Task:	Interval/Miles:
INSPECTION	**60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-01-00/I-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**
Component:	Man Hours: **0.6**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit
High Pressure Water Gun

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

Junction Box Gasket (PN TDB)

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-01-00/I-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**
Component:	Man Hours: **0.6**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

To perform the task proceed as follows (Refer to Fig 1 through 2):

1. Remove Junction Box Grounding Cable first and then remove Junction Box Cover by loosening relevant hardware. Retain hardware for later use.
2. Check the Box Cover Gasket for damage / deformation / signs of degradation. Replace as needed.
3. Check the inside of the Junction Box and next to the Cable Bushings for traces of dirt.
4. Clean the HV.
5. Check the HV Insulators for damage / signs of degradation. Replace as needed.
6. Check the HV Terminal connections for proper torque. Torque of **52 ft-lb.**
7. Check Cables Bushings for damage / deformation, defects and tightness.
8. Clean and inspect Cables for damage / missing clamp and burns.
9. Check, on Junction Box exterior, the Grounding Cable and relevant connection for damage, loose / missing part. Replace and / or tighten as per check result..
10. Reinstall the Junction Box Cover and Grounding Cable and tighten the relevant hardware.
11. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-03-01-00/I-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**	
Component:		Man Hours: **0.6**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

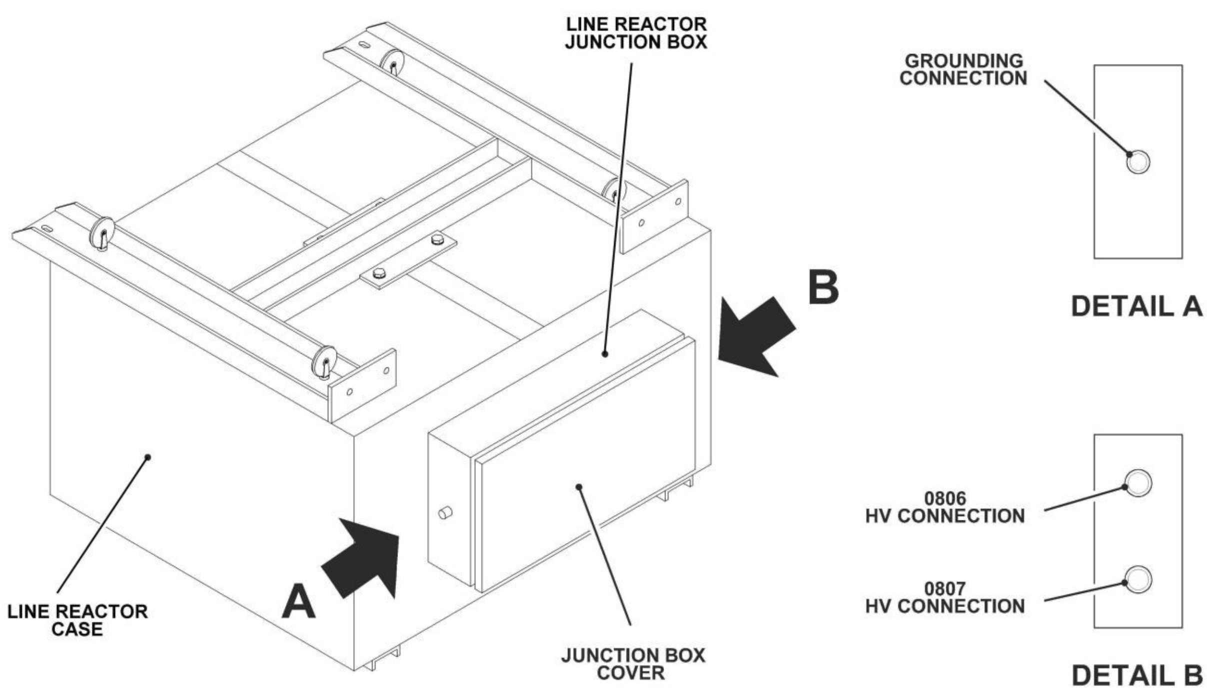


Figure 1 - LINE REACTOR 1L01

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-01-00/I-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**
Component:	Man Hours: **0.6**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

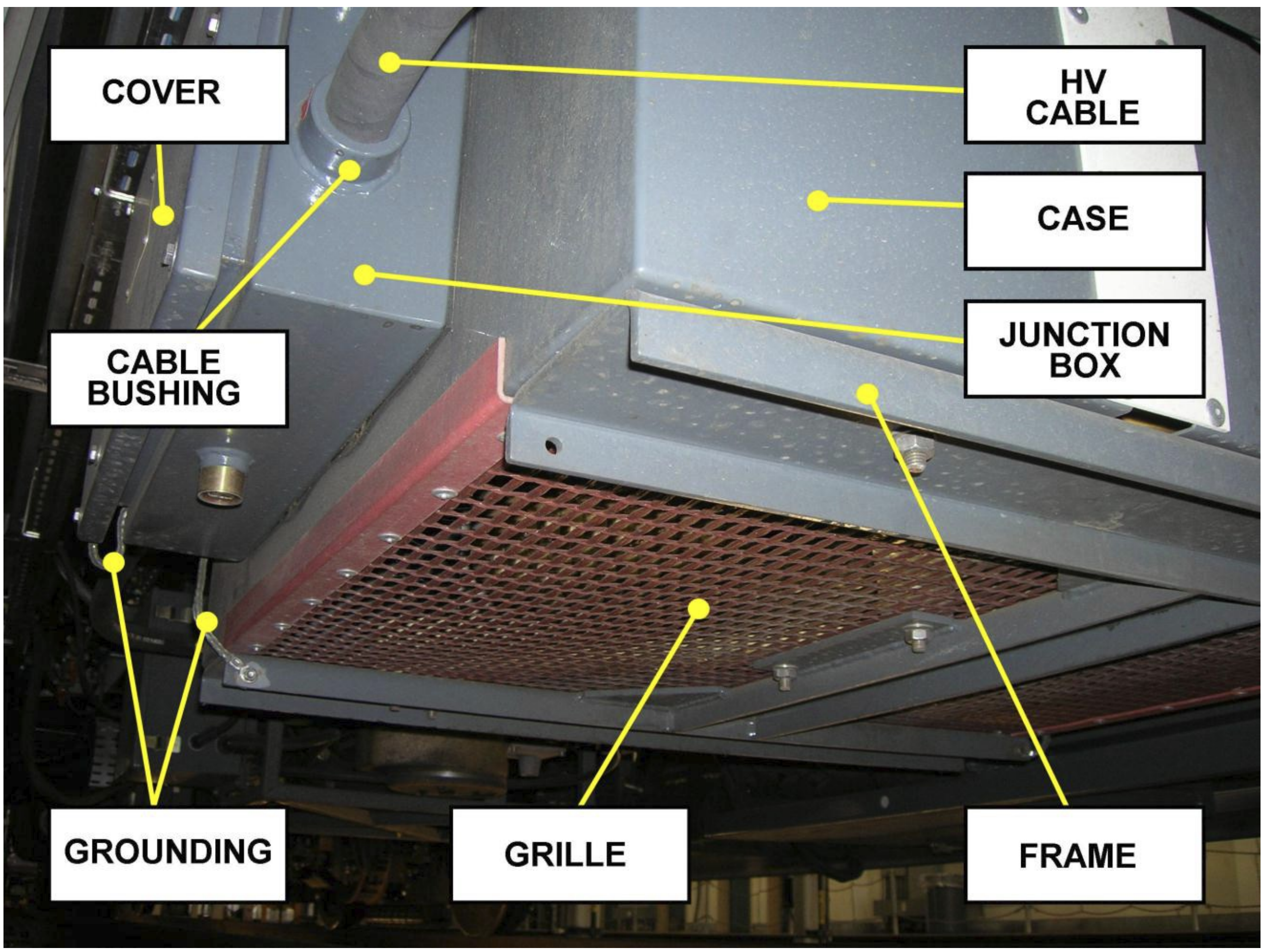


Figure 2 - LINE REACTOR

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-03-01-00/I-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**	
Component:		Man Hours: **0.6**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

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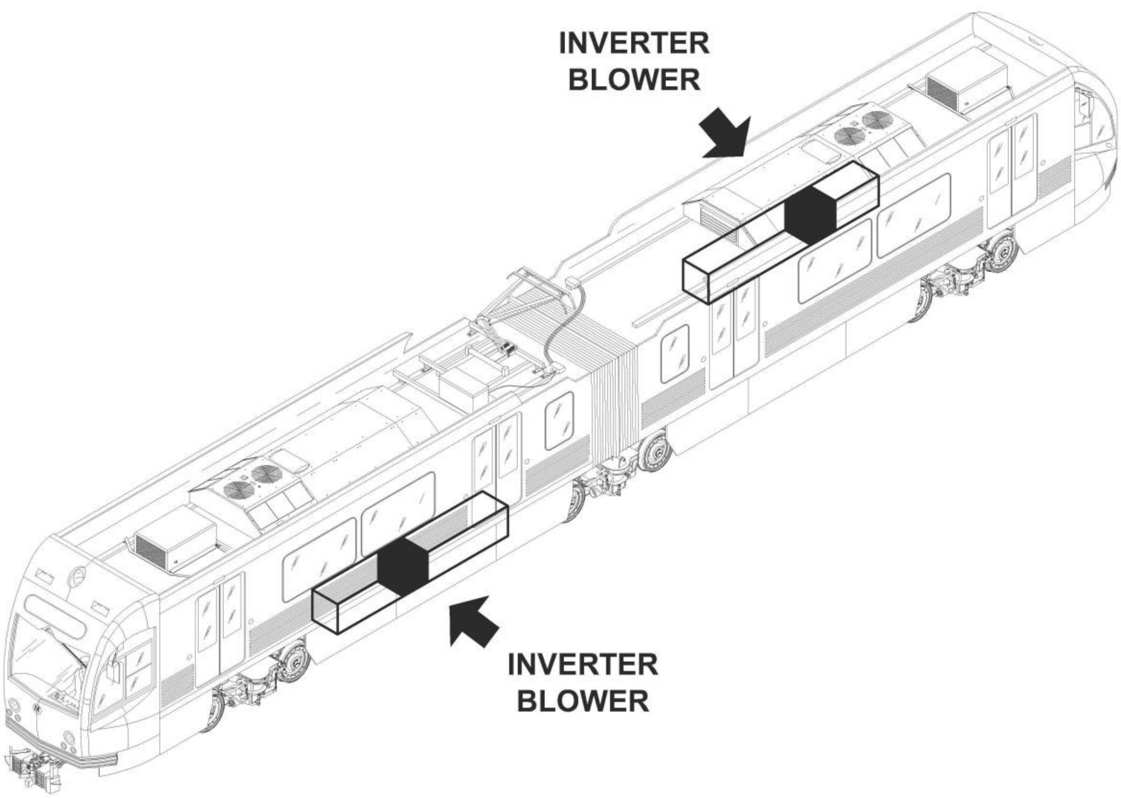
P2550 PREVENTIVE MAINTENANCE SHEET			
Card Code: **R-P-07-03-07-00/I-00**			
System: **PROPULSION**			Sheet: **1/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**		
Component:			Man Hours: **0.7**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-07-00/I-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **0.7**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Dial Indicator
13 mm Wrench and Socket

CONSUMABLES:

Cleaner

SPARE PARTS:

Fan Weldment Packing (P/N 212EE10048B)

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-07-00/I-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **0.7**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

3. Place both the CB 2F06 (Propulsion Motor Fan Circuit Breaker located on the LV Locker both cars) to OFF position.

INSPECTION

To perform the task proceed as follows (Refer to fig 1 through 3):

1. Inspect Motor Fan Compartment for general condition, visible damage, missing / loose hardware.

2. Check the Motor Power Supply Terminal Board for missing /loose hardware, visible gasket damage / deformation and relevant Cable Bushing for correct tightness.

3. Check the Motor Power Supply Cable for visible damage / loose / missing clamp.

4. Check the Grounding Wire and relevant connections for missing / loose parts, signs of fraying / overheating.

5. Check Inverter Air Outlet Grille for damage / deformation, loose / missing hardware.

6. Check and clean the Fan Motor Cooling Fins.

7. Note any areas / items requiring corrective maintenance.

8. Record Inspection results on the Defect Report Card for administrative and maintenance planning.

P2550 PREVENTIVE MAINTENANCE SHEET			
Card Code: **R-P-07-03-07-00/I-00**			
System: **PROPULSION**			Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**		
Component:			Man Hours: **0.7**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

PROCEDURE (CONT'D):

INVERTER FAN COMPARTMENT INSPECTION

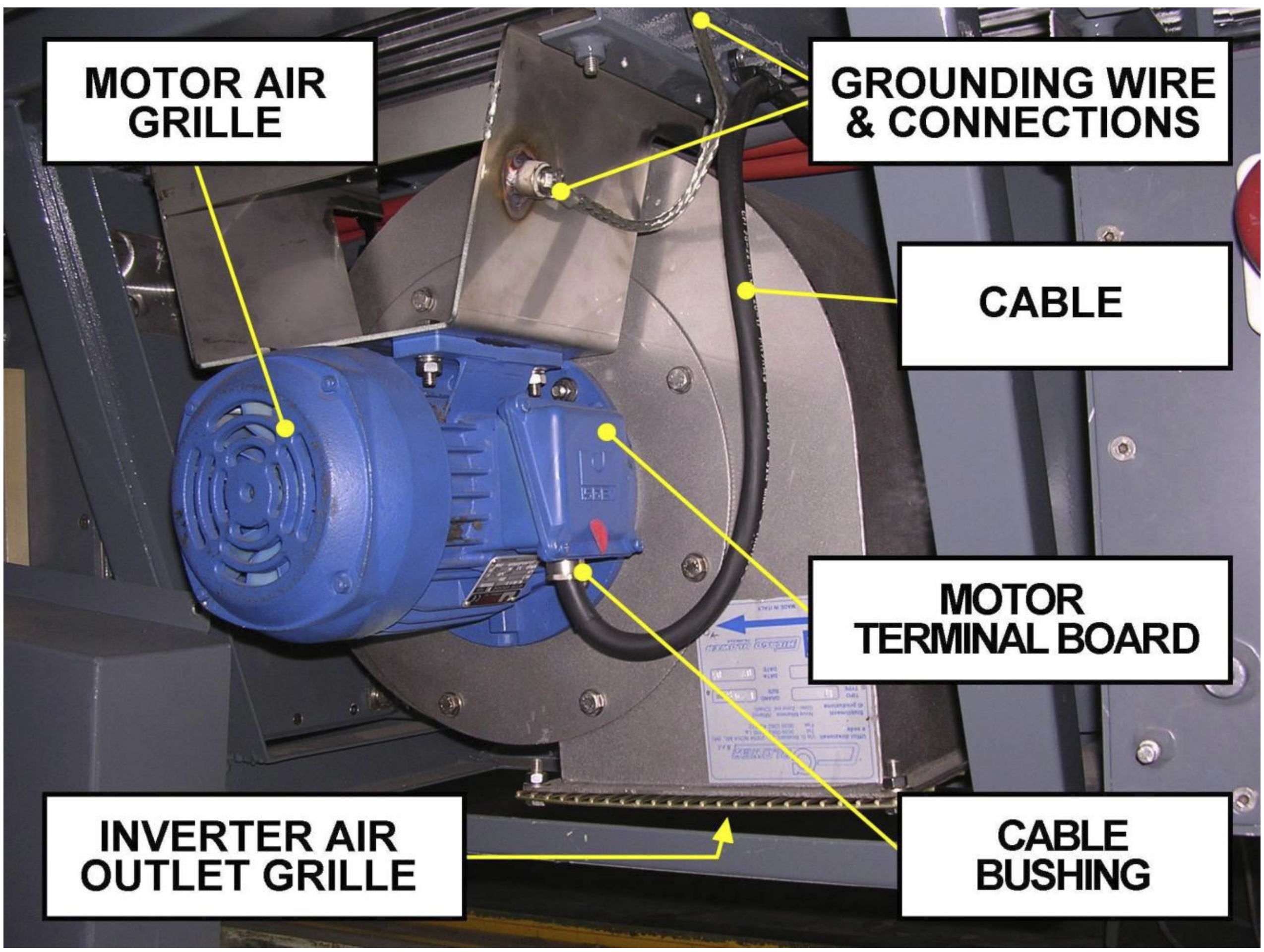


Figure 1 - TRACTION INVERTER - MOTOR FAN COMPARTMENT

P2550 PREVENTIVE MAINTENANCE SHEET		
		Card Code: **R-P-07-03-07-00/I-00**
System: **PROPULSION**		Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**	
Component:		Man Hours: **0.7**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

INVERTER FAN UNIT INSPECTION

1. Remove the Inverter Fan Air Outlet Grille by loosening relevant Hardware. Retain the Hardware for later use
2. Clean the Fan Blade Assembly with the Fan in place.
3. Check the Fan Blade Assembly by hand for:
   - excessive play
   - abnormal noise
   - rubbing
4. If any excessive play, abnormal noise, or rubbing is noticed, it is required to:
   a. remove the Fan Unit according to Sheet R-P-07-03-07-00R-00
   b. verify that Fan tolerances as indicated below:
5. Reinstall the Inverter Fan Air Outlet Grille and tighten the relevant hardware.

TOLERANCES CHECKING

NOTE: It is assumed that, after removal according to Sheet indicated above, the Inverter Fan Unit is in the following status:

a) Located in suitable position to perform accurate Inspection.
b) Inverter Fan Unit Grounding Wire disconnected from Fan Unit.
c) Motor Power Supply Terminal Board Cover removed.
d) Motor Power Supply Cable with relevant Bushing disconnected from Motor Terminal Board.

1. Check for correct clearance of **0.1969 in. (5 mm)** between Outer Diameter of Air Inlet Profiled Coupling and Inner Diameter of the Air Inlet Fan Weldment.

   NOTE: Measurement should be taken at 3, 6, 9, and 12 o-clock positions and each value should be noted.

2. Inspect Fan Hub to Motor Shaft location. The Fan Hub should be flush with the ends of the Motor Shaft. With one hand on the Fan Hub carefully push in and pull out on the Hub checking for wear.

   NOTE: If excessive movement can be felt, measure the distance between the edge of the Air Inlet Profiled Coupling and the External Plane of the Fan Weldment with a Dial Indicator. The change in distance is the Bearing End Play and must not exceed **0.010 in.**, if greater replace Inverter Fan Unit.

   NOTE: After the completion of the Tolerances Checking, it is advised to replace the Fan Weldment Gasket before to reinstall the Fan Unit.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-07-00/I-00**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **0.7**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

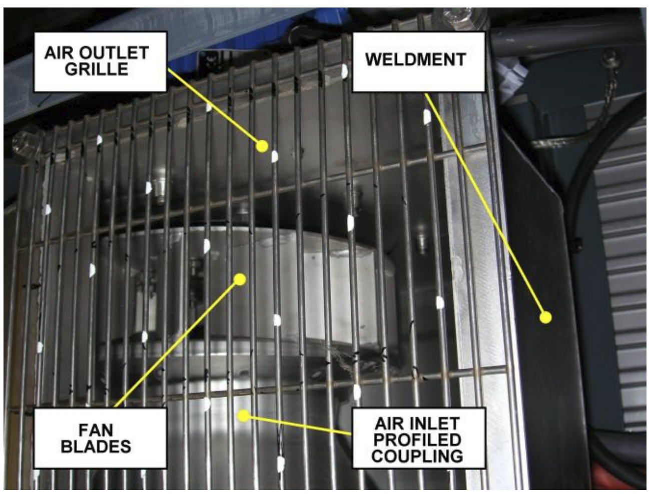


Figure 2 - FAN UNIT VIEW FROM AIR OUTLET GRILLE

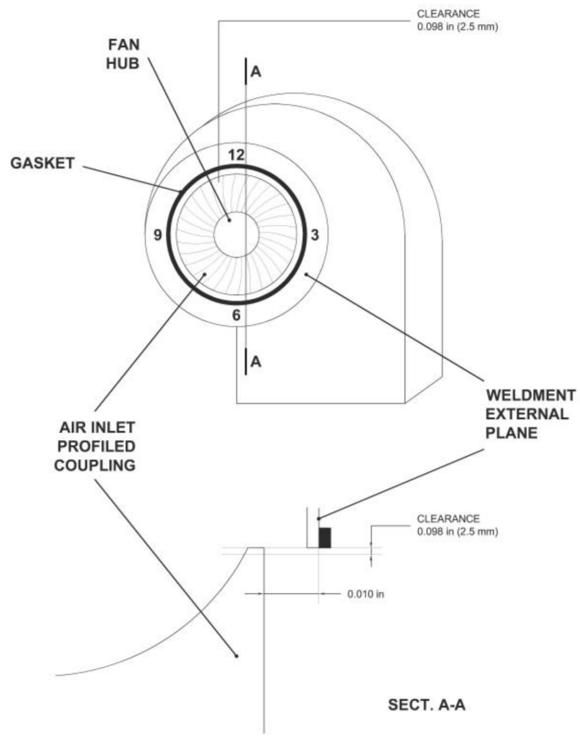


Figure 3 - FAN UNIT INSPECTION

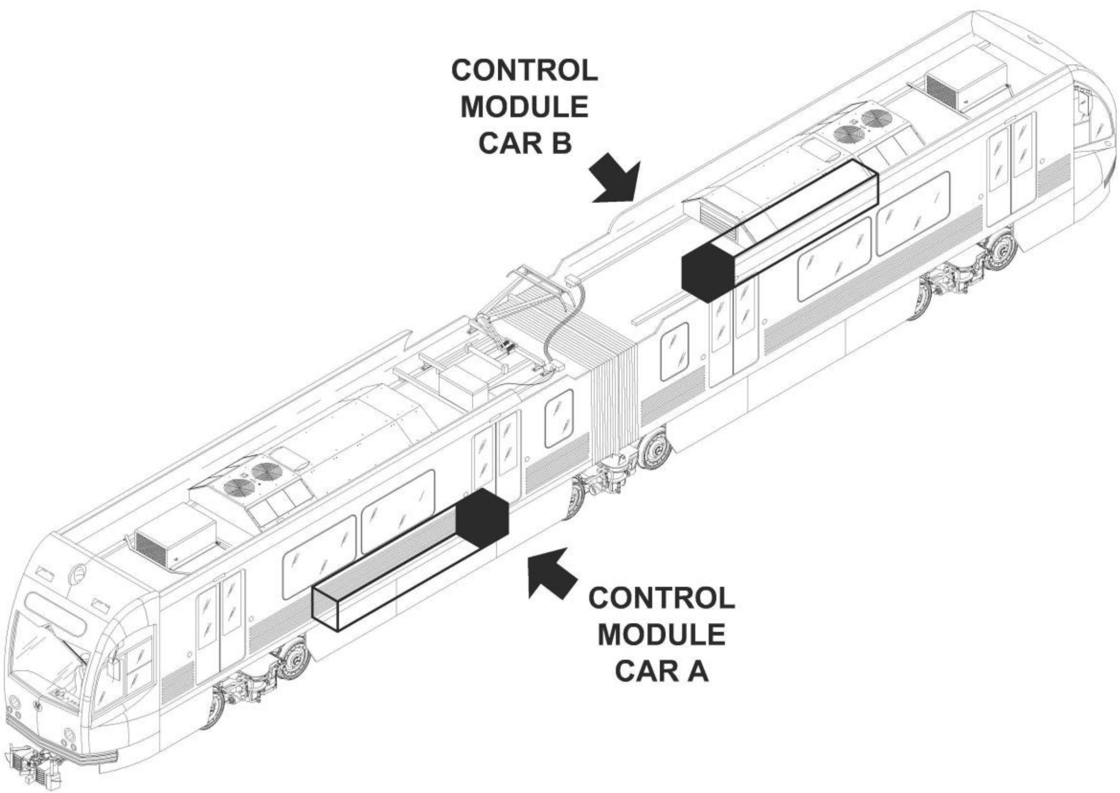
FINAL OPERATIONS

1. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-08-00/I-00**
System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **CONTACTOR MOTOR FAN (CMF)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-08-00/I-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **CONTACTOR MOTOR FAN (CMF)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

**WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.**

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

**WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.**

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:
LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

CRC 2000 Contact Cleaner		
CRC Industrial - Precision Cleaner M3	PN	147535

SPARE PARTS:

Three Phases Contactor Motor Fan 380 VAC	P/N	211VK01330B011020

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-08-00/I-00

System:	Sheet:
PROPULSION	**3/6**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**CONTACTOR MOTOR FAN (CMF)**

Component:	Man Hours:
	0.5

Maintenance Task:	Interval/Miles:
INSPECTION	**60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

3. Place both the CB 2F06 (Propulsion Motor fan Circuit Breaker, located on the LV Locker both cars) to OFF position.

INSPECTION

To perform the task proceed as follows: (Refer to Fig 1 through 3)

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.

2. Gain access to CMF contactor by removing the Grounding Cable, Safety Latches and Cover from the Control Module.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1

3. Inspect CMF Contactor for damage, signs of arcing, or overheating.

4. Replace, as per inspection result, according to Sheet R-C-07-03-08-00/ R-00.

5. Clean the Insulator Plate using the recommended agent.

6. Check the CMF Contactor for mechanical parts for smooth movement.

7. Check the connections of the Auxiliary and Main Circuits for tightness and/or burns, and tighten or replace, as necessary.

8. Inspect the CCF Contactor for loose hardware. Tighten, as per check result.

9. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

10. Reconnect the Grounding Cable.

11. Record task results on the Defect Report Card for administrative and maintenance planning.

12. Once completed, proceed as follows:

   a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.
   b. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-08-00/I-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **CONTACTOR MOTOR FAN (CMF)**	
Component:		Man Hours: **0.5**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

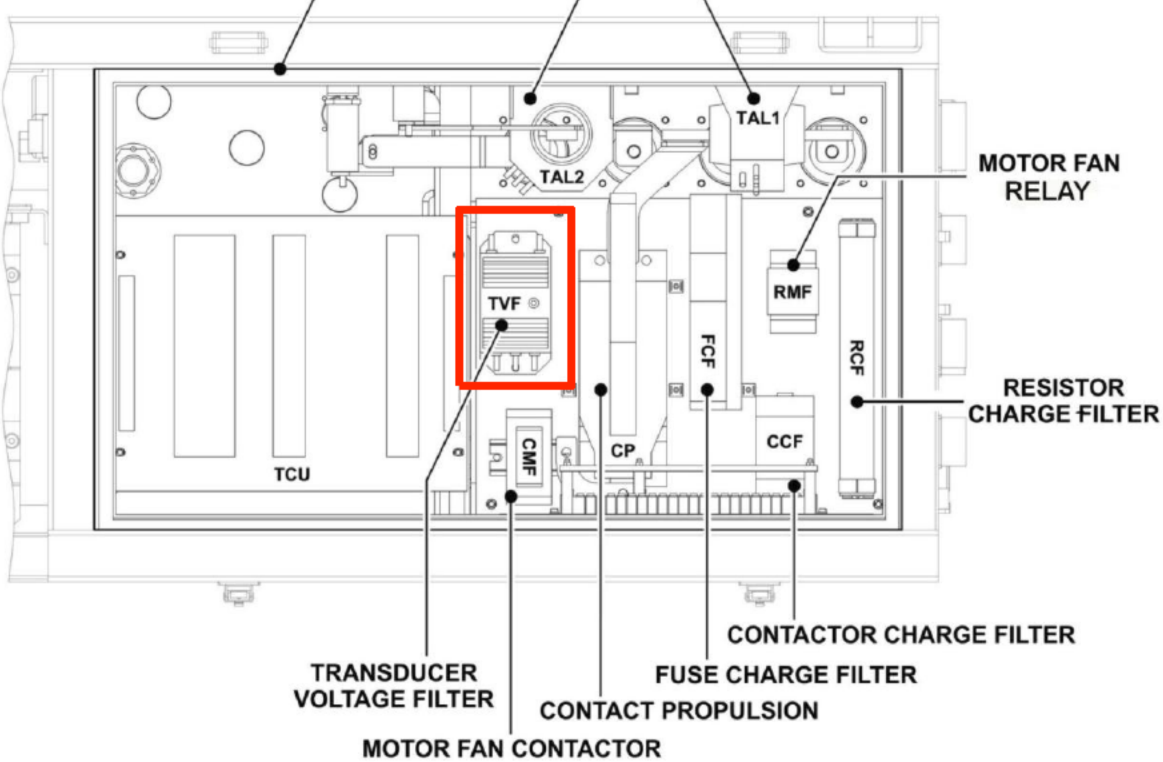
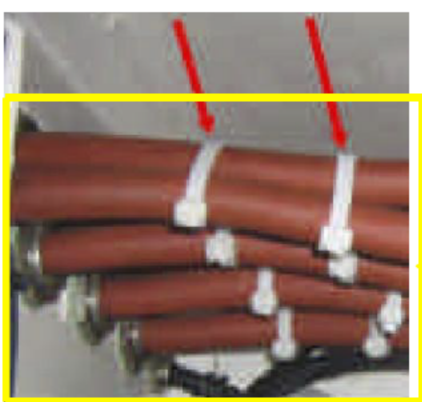


Figure 1 - CONTROL MODULE

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-08-00/I-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **CONTACTOR MOTOR FAN (CMF)**
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):



DETAIL"A"
Two ties each couple of
"P" and "N" cables

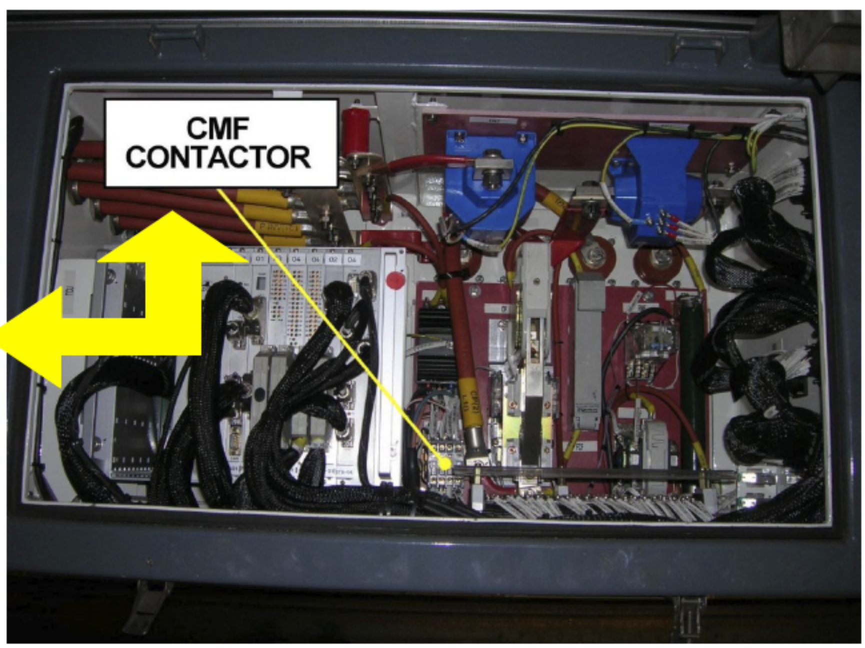


Figure 2 - CONTROL MODULE INTERIOR

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-03-08-00/I-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **CONTACTOR MOTOR FAN (CMF)**	
Component:		Man Hours: **0.5**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

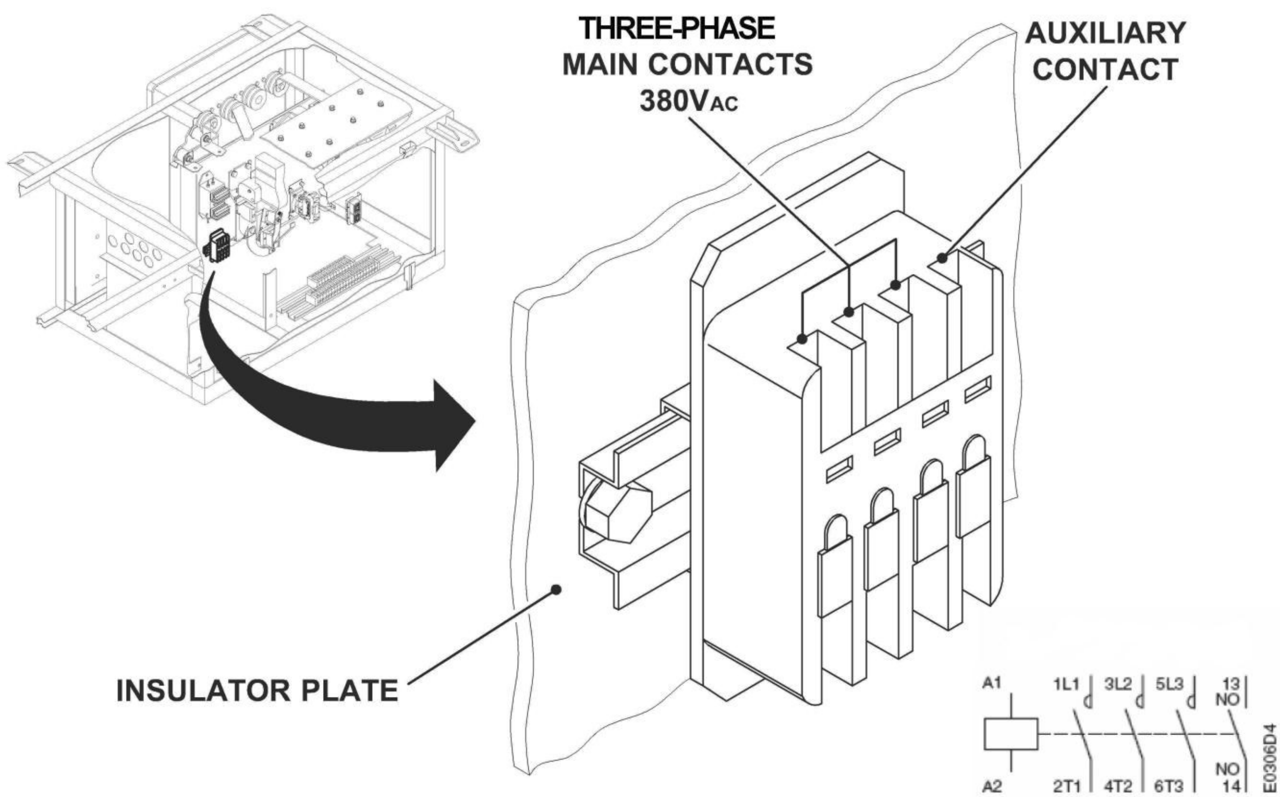
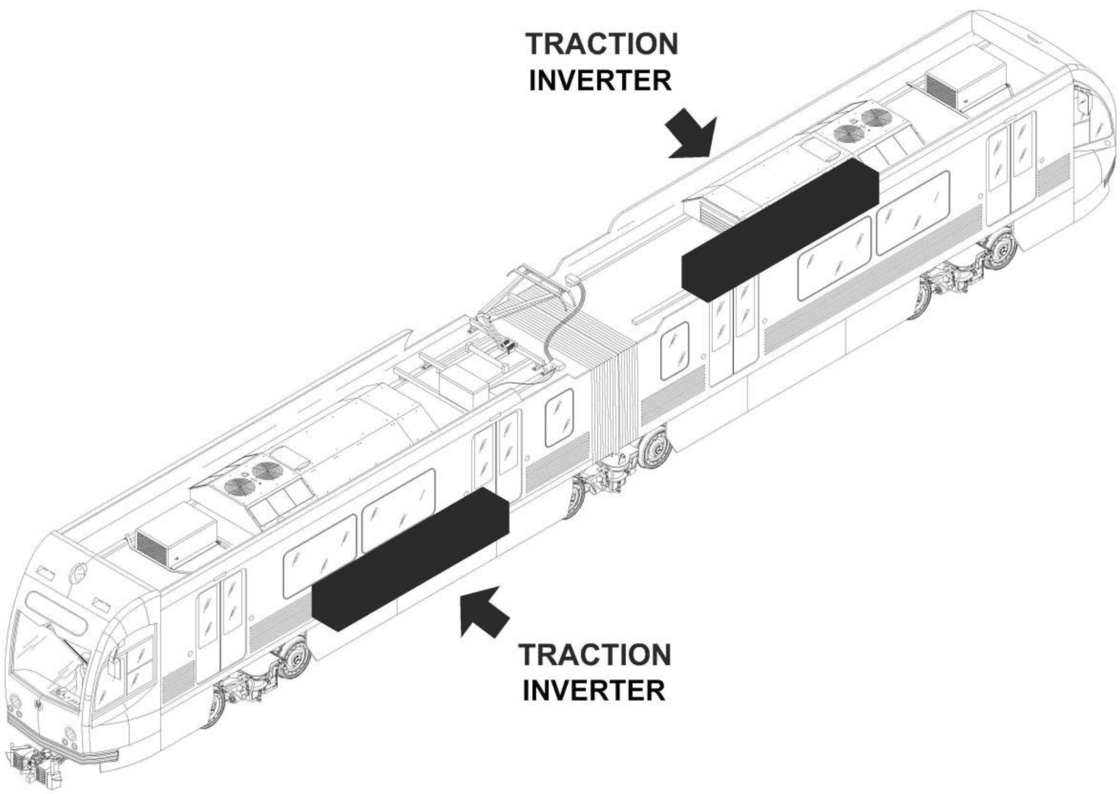


Figure 3 - MOTOR FAN CONTACTOR

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-00-00/I-00**
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **2**
Maintenance Task: **INSPECTION**	Interval/Miles: **120,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/I-00**	
System: **PROPULSION**	Sheet: **2/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **2**
Maintenance Task: **INSPECTION**	Interval/Miles: **120,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

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WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit
19 mm Torque Wrench, 8 mm Wrench, 10 mm Wrench

Vacuum Cleaner

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-03-00-00/I-00

System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **2**
Maintenance Task: **INSPECTION**	Interval/Miles: **120,000**

CONSUMABLES:

Cleaner / Degreaser
CRC Industrial - Precision Cleaner M3 PN 147535
Dry Compressed Air for Electronic Equipment (commercial)

SPARE PARTS:

Control Module Gasket	(PN 212EE10291B)
HV Control Module	
Rear Box (Packing)	(PN 212EE10175B)
CP Contactor	(PN 211VK00732B04)
CCF Contactor	(PN 211VK01326B02)
CMF Contactor	(PN 211VK01330B011020)
FCF Fuse10A	(PN 211VF00021B07)
RCF Resistor RSS260	(PN 211NR50041B160491)
TAL 1 Current Transducer	(PN 211ET22501B02)
TAL 2 Current Transducer	(PN 211ET22501B02)
TVF Voltage Transducer	(PN 211ET22613B)
RMF Relay	(PN 211EK23922B01)
VUBTA Connector	(PN 211VU01323B0202)
VUBTB Connector	(PN 211VU01317B0202)
VUMOT Connector	(PN 211VU01317B0202)
VUDIA Connector	(PN 211VU01317B0202)
VUBUS Connector	(PN 211VU01317B0202)
VUBAT Connector	(PN 211VU01424B0102)
VUMT Connector	(PN 211VU01424B0103)
Contact Size 16	(PN 211VU01315B105)
Contact Size 16	(PN 211VU01315B104)
Contact Size 12	(PN 211VU01315B108)
Contact Size 12	(PN 211VU01315B110)

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/I-00**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:	
Component:		Man Hours: **2**
Maintenance Task: **INSPECTION**		Interval/Miles: **120,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it. Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

CONTROL MODULE

INSPECTION

(INTERIOR) (Refer to Figures 1 through 2)

1. Check the mechanical parts on the following items for smooth movement:
   a. CP Contactor.
   b. CMF Contactor.
   c. CCF Contactor.
   d. TAL1 transducer.
   e. TAL2 transducer.
   f. RFM resistor.
   g. RCF resistor.
   h. FCF fuse.
   i. TVF transducer.

2. Replace Contactor, as per check result

3. Check Main and Auxiliary Contacts for installation / loose / missing parts / signs of overheating

4. Check components connections. Tighten as needed.

5. Check the Ties applied to each couple of “P” and “N” cables for proper installation as shown in Fig 2 Detail “A” Damaged / missing ties should be replaced

6. Clean components using recommended agents.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-00-00/I-00**
System: **PROPULSION**	Sheet: **5/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **2**
Maintenance Task: **INSPECTION**	Interval/Miles: **120,000**

PROCEDURE (CONT'D):

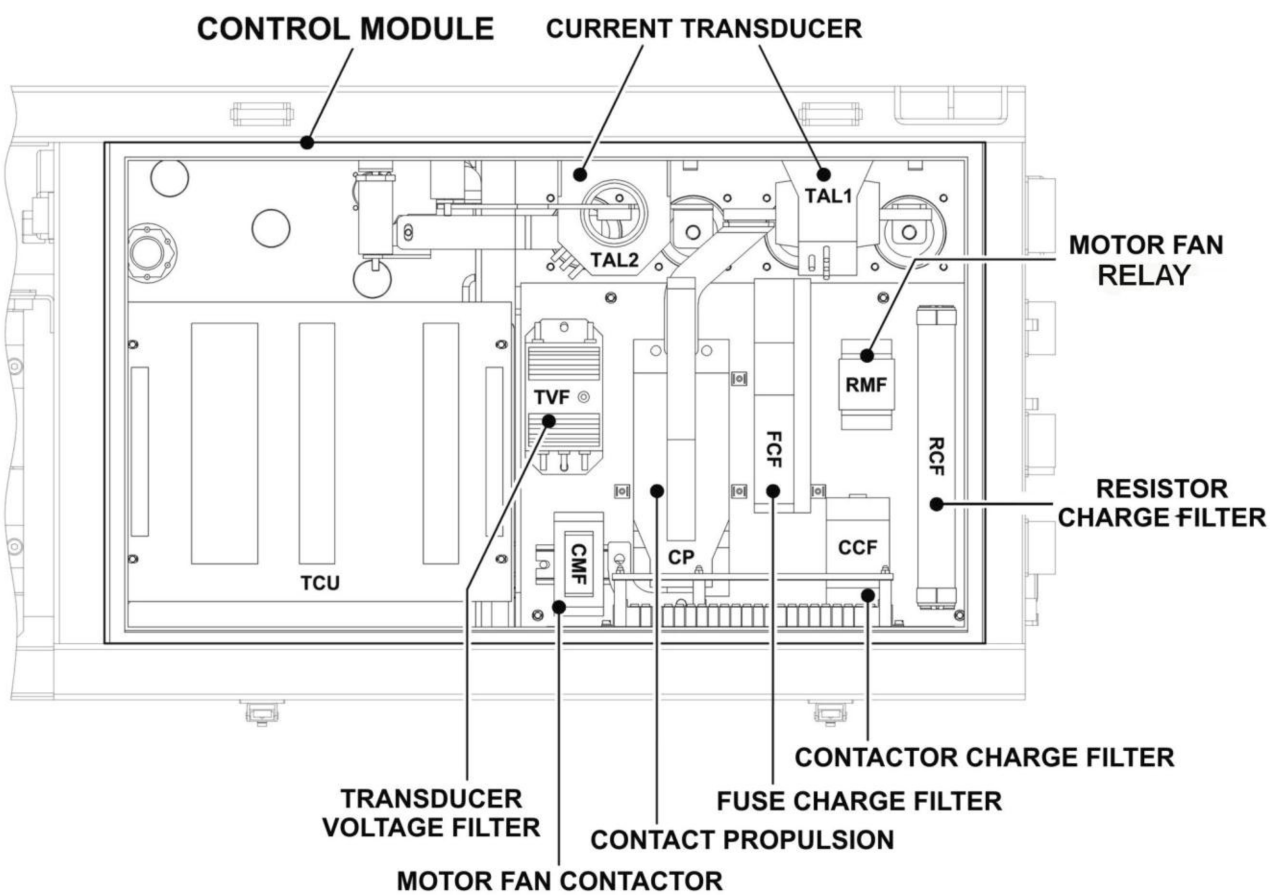


Figure 1 - CONTROL MODULE COMPONENTS

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-03-00-00/I-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **2**
Maintenance Task: **INSPECTION**	Interval/Miles: **120,000**

PROCEDURE (CONT'D):

DETAIL"A"
Two ties each couple of
"P" and "N" cables

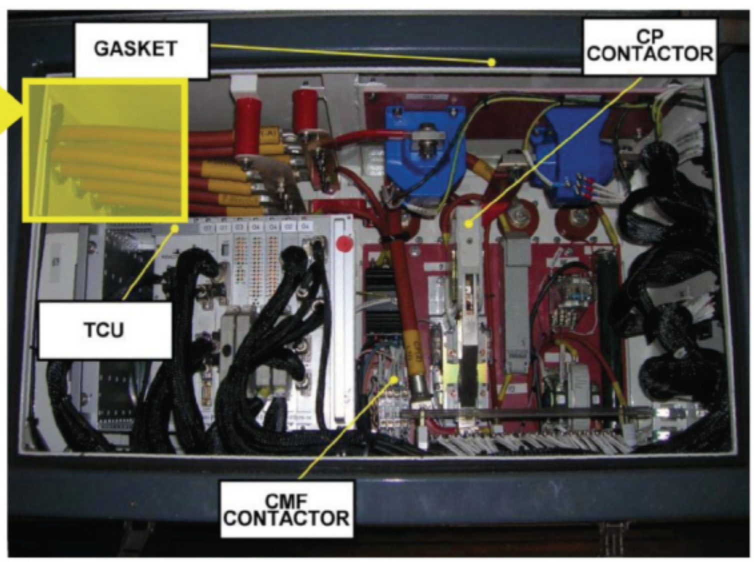


Figure 2 - CONTROL MODULE INTERIOR AND GASKET

PHASE MODULES AND BRAKING CHOPPER MODULE INSPECTION

(Refer to Figure 3 and 4)

1. Remove the Cover of the Module
2. Check that the LV and HV cables are positioned , wired and secured with relevant ties as shown in Figures 8 and 9
3. Reinstall the Module Front Cover and Grounding Cable. Tighten relevant fixing screws.
4. Repeat steps 1 through 3 for each Module. (Phase A,B, C and Chopper).
5. Once completed, restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-03-00-00/I-00**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:
Component:	Man Hours: **2**
Maintenance Task: **INSPECTION**	Interval/Miles: **120,000**

PROCEDURE (CONT'D):

NOTE : The wiring must have the geometry as shown in the following Figure 3.
Also in the front of the module the cables must not have turns routing.

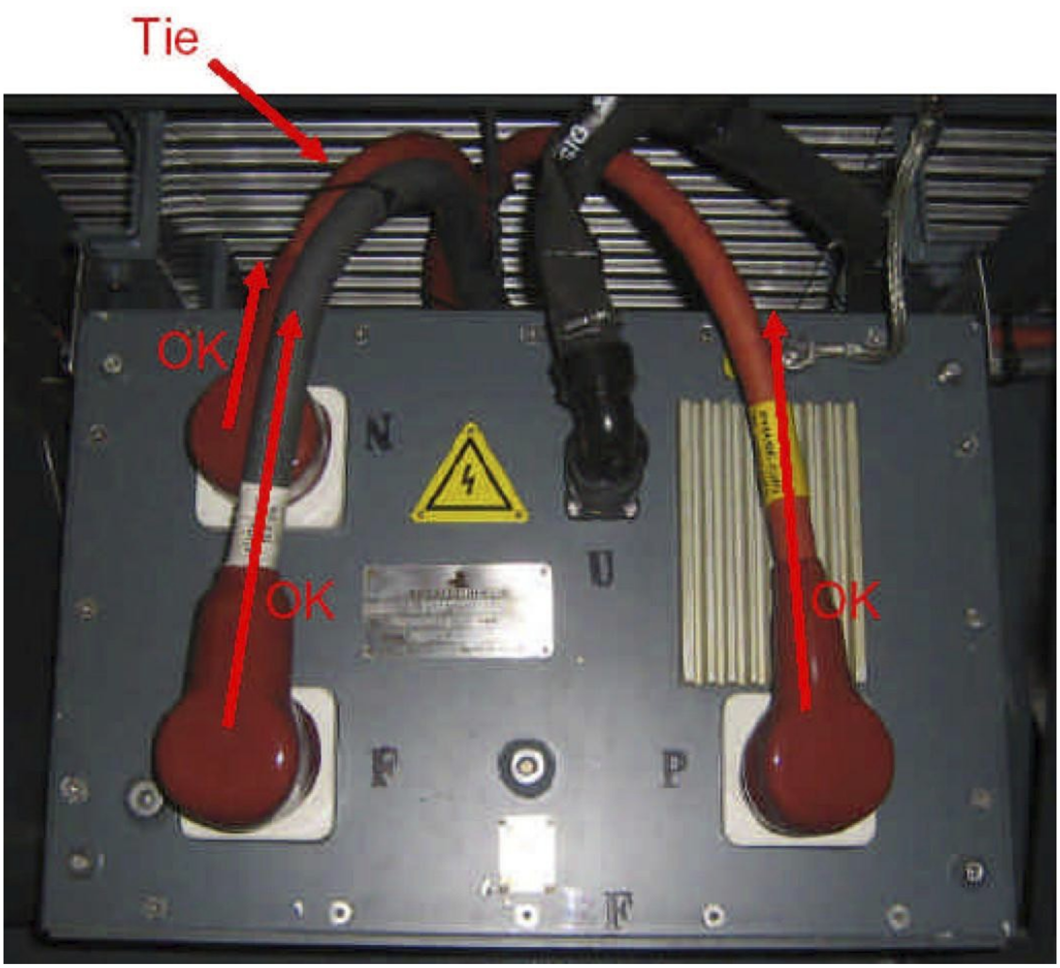


Figure 3 - FRONT VIEW - MODULE PROPERLY WIRED

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-03-00-00/I-00**		
System: **PROPULSION**		Sheet: **8/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit:	
Component:		Man Hours: **2**
Maintenance Task: **INSPECTION**		Interval/Miles: **120,000**

PROCEDURE (CONT'D):

NOTE : The cables have to keep a perpendicular routing respect to the floor/rail. This means also that all the cables must have and keep a constant distance from the IGBT module front panel.

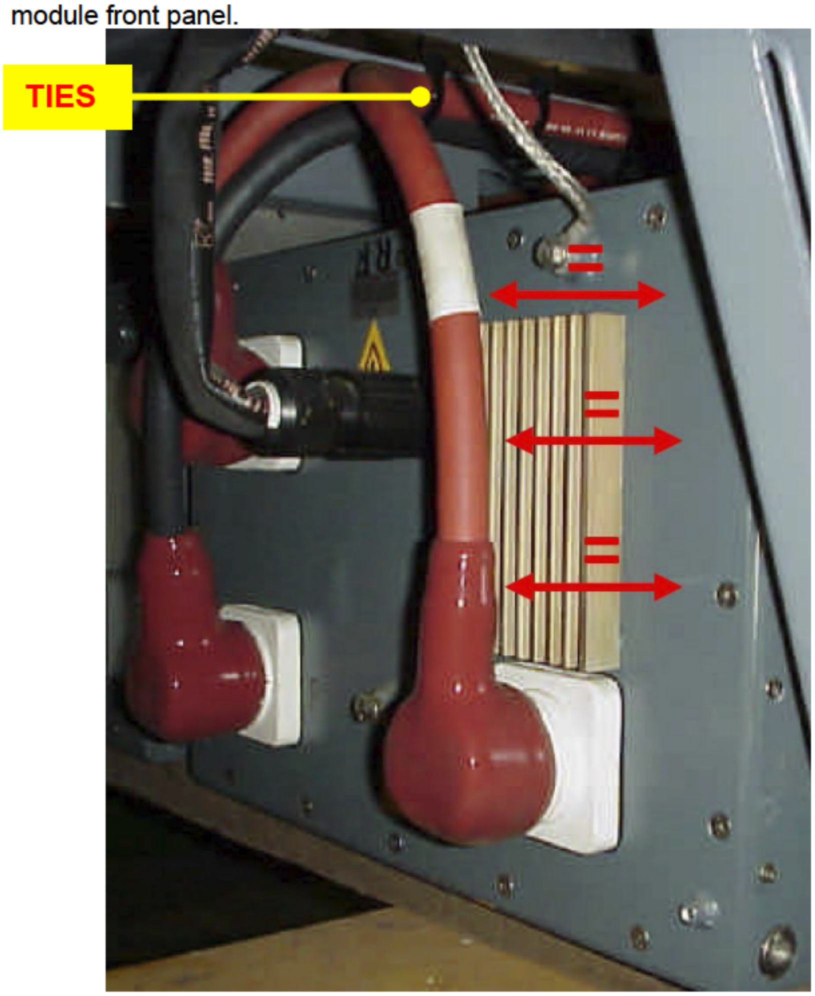
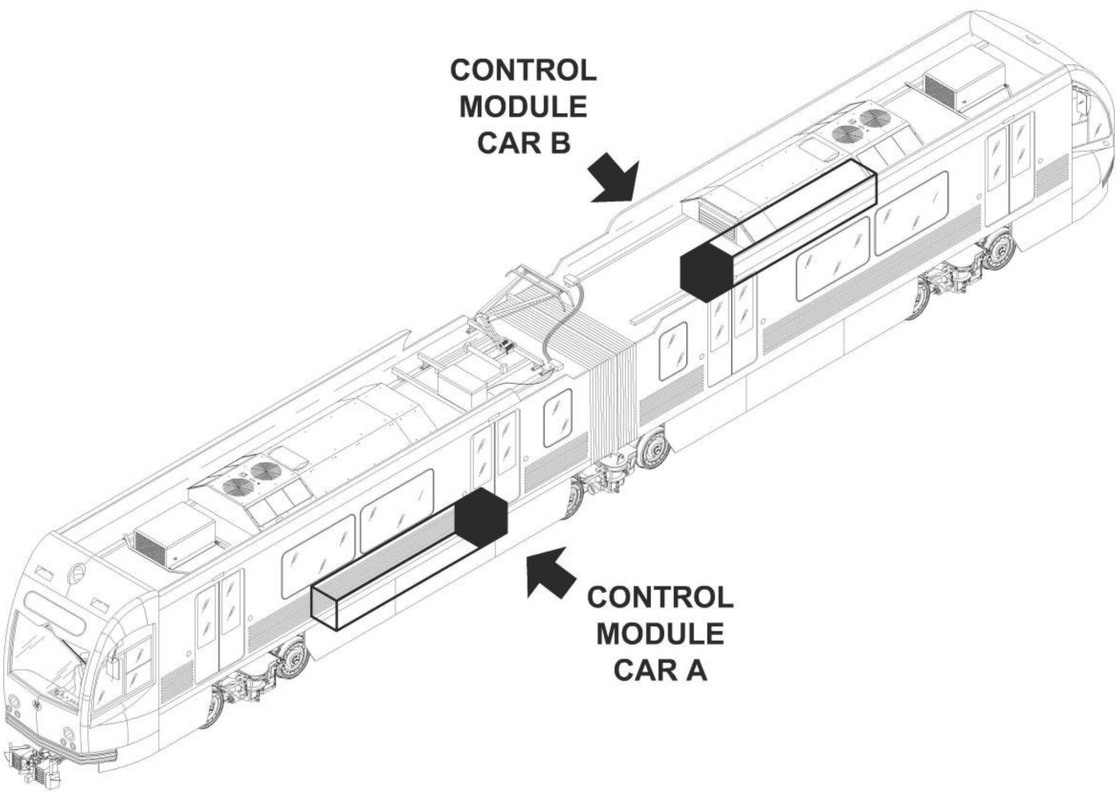


FIGURE 4 - MODULE - FRONT - DETAIL
CABLES PERPENDICULAR ROUTING AND CONSTANT DISTANCE FROM THE IGBT MODULE FRONT PANEL

P2550 PREVENTIVE MAINTENANCE SHEET

		Card Code: **R-P-07-04-00-00/I-00**
System: **PROPULSION**		Sheet: **1/6**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit:	
Component:		Man Hours: **0.16**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-04-00-00/I-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit:
Component:	Man Hours: **0.16**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

CRC Industrial - Precision Cleaner M3	PN	147535
Dry Compressed Air for Electronic Equipment	(commercial)	

SPARE PARTS:

N/A

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-04-00-00/I-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit:
Component:	Man Hours: **0.16**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

To perform the task proceed as follows (Refer to Fig 1 through 3):

1. Gain access to TCU by removing the Grounding Cable, Safety Latches and Cover from the Control Module.

WARNING **BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1**

2. Inspect TCU for damage / missing / loose parts / circuit boards.
3. Inspect connectors for sign of damage and for over-heating.
4. Check that all circuits are tighted.
5. Note any items requiring corrective maintenance.
6. Clean TCU components using recommended agents.
7. Reinstall and secure the Control Module Cover. Reconnect the Grounding Cable.
8. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-04-00-00/I-00**			
System: **PROPULSION**			Sheet: **4/6**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit:		
Component:			Man Hours: **0.16**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

PROCEDURE (CONT'D):

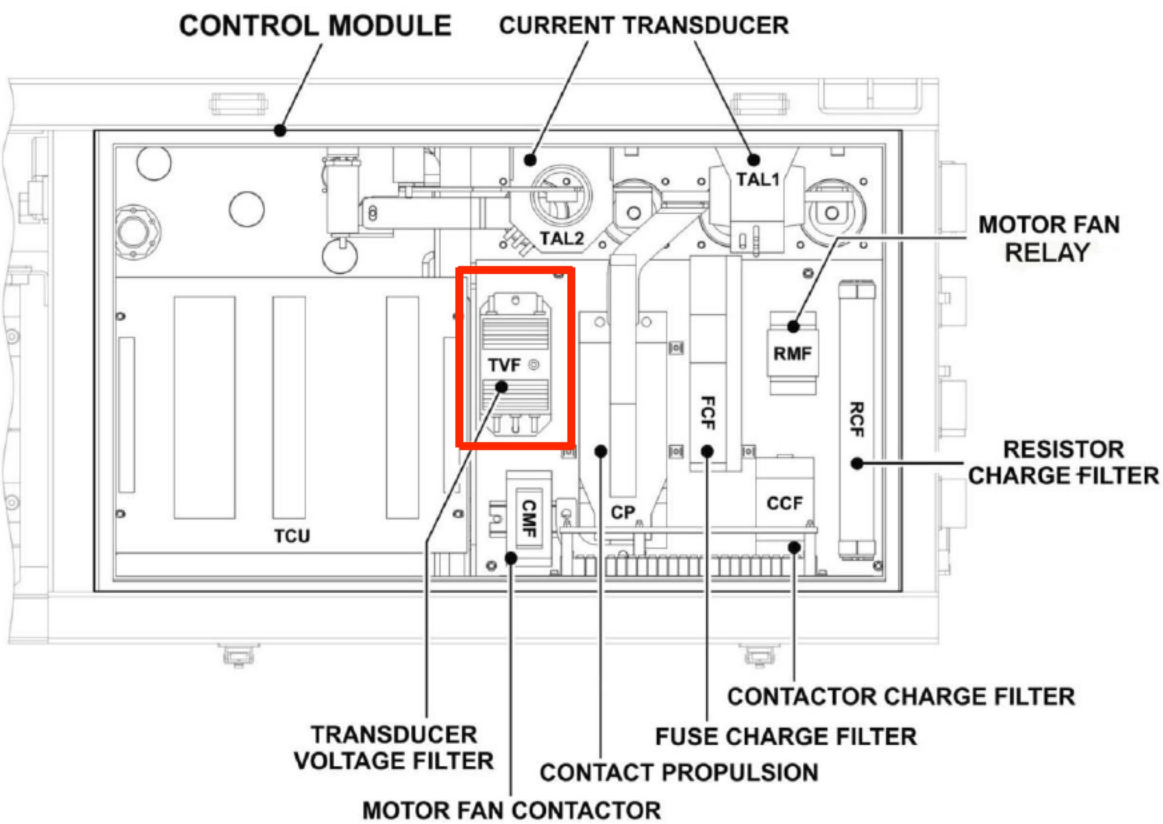
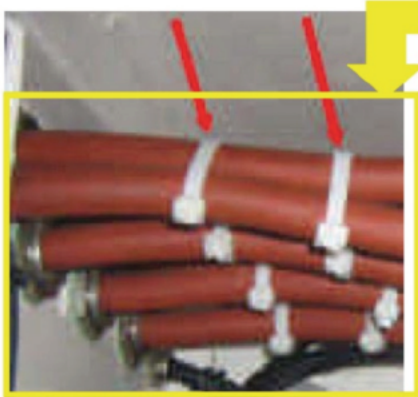


Figure 1 - CONTROL MODULE

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-04-00-00/I-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit:
Component:	Man Hours: **0.16**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):



DETAIL"A"
Two ties each couple of
"P" and "N" cables

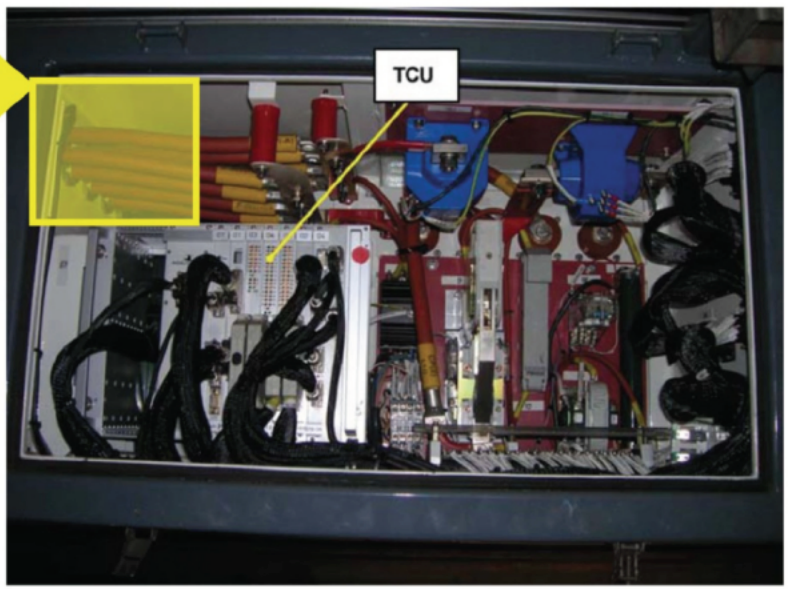


Figure 2 - CONTROL MODULE INTERIOR AND TCU

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-04-00-00/I-00**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit:
Component:	Man Hours: **0.16**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

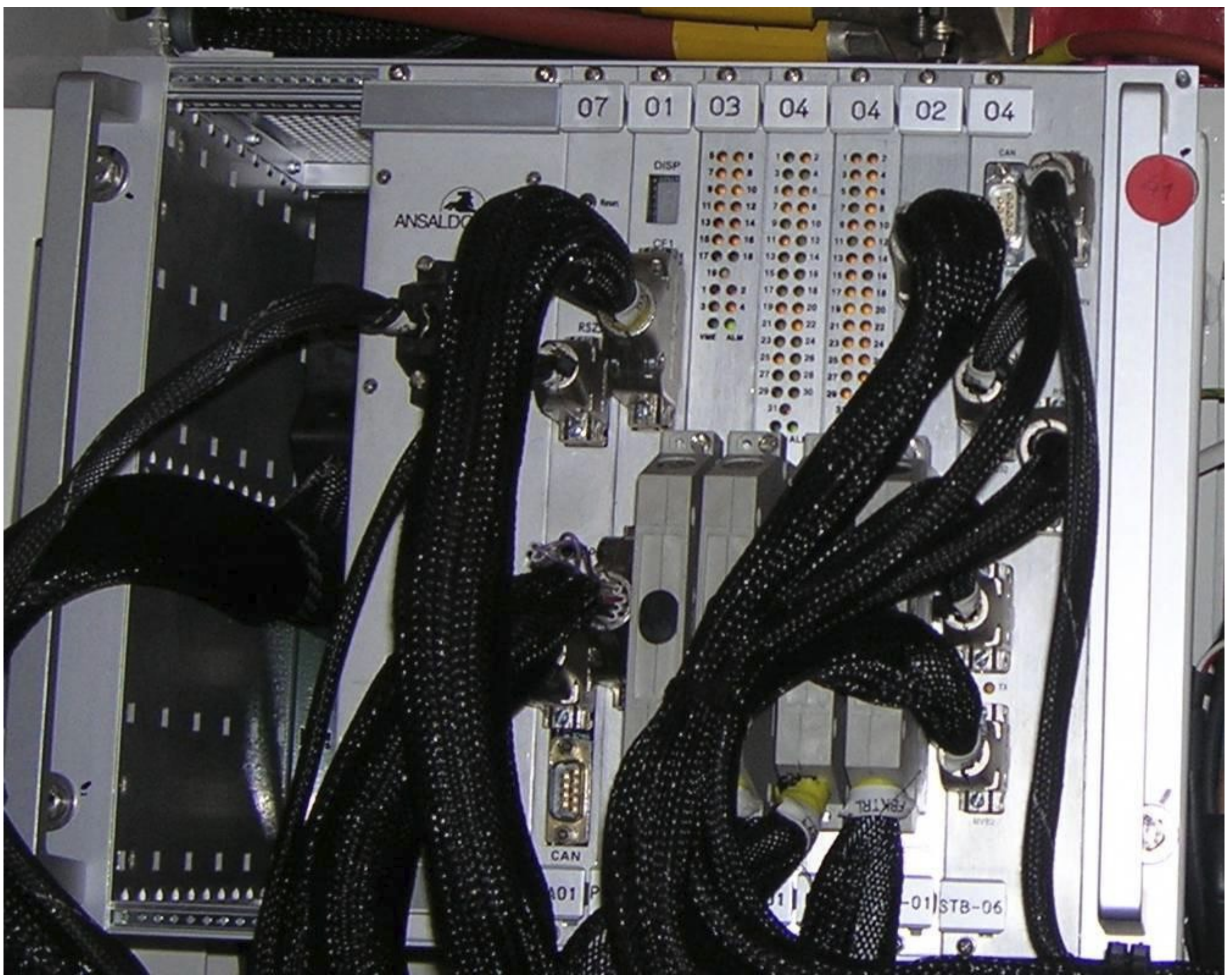
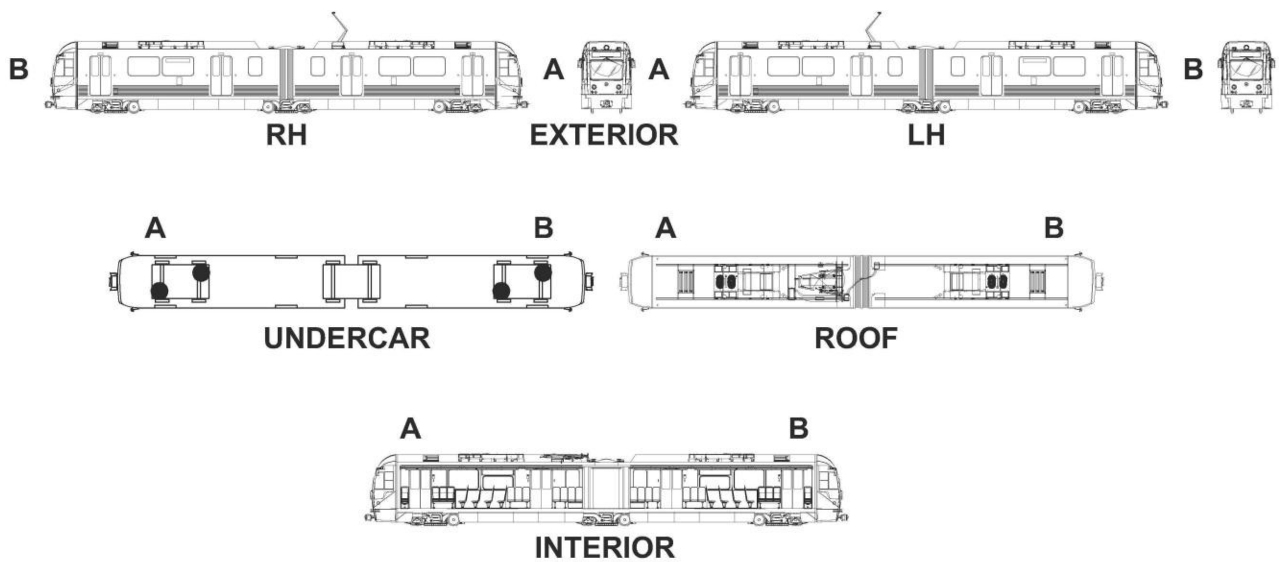


Figure 3 - TCU - CONNECTORS

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-05-01-00/I-00**
System: **PROPULSION**	Sheet: **1/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-01-00/I-00**		
System: **PROPULSION**		Sheet: **2/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**	
Component:		Man Hours: **1**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: **ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.**

WARNING: **ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.**
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: **BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.**

WARNING: **HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS**
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: **WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.**

WARNING: **BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.**

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE TRACTION MOTOR BEARING LUBRICATION GREASE FITTING AND VALVE. ONLY USE THE RECOMMENDED TYPE OF GREASE.

P2550 PREVENTIVE MAINTENANCE SHEET

		Card Code: **R-P-07-05-01-00/I-00**
System: **PROPULSION**		Sheet: **3/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**	
Component:		Man Hours: **1**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

SAFETY PRECAUTIONS (CONT'D):

CAUTION: BEFORE TIGHTENING TRACTION MOTOR MOUNTING HARDWARE TO DESIGN VALUE:

1) INSTALL NEW SAFETY WASHERS.
2) REMOVE ANY TRACE OF PREVIOUS MARKER LINE ON NUT AND SCREW HEAD.

CAUTION: AFTER TIGHTENING TRACTION MOTOR MOUNTING HARDWARE TO DESIGN VALUE:

1) BEND SAFETY WASHERS BY MEANS OF FLAT HEAD SCREWDRIVER AND HAMMER PAYING ATTENTION TO NOT DAMAGE THE WASHER, NUT AND /OR SCREWS HEAD.
2) MARK NUT AND SCREW HEAD, USING MARKER PEN, WITH A CONTINUOUS LINE.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

Torque Wrench 120 through 320 ft-lb

Grease Gun with extension

CONSUMABLES:

Grease Esso Beacon EP 2 (P/N 211MX40043B) QTY =1,1 lb

SPARE PARTS:

Sensor Housing / Cover Gasket (P/N TBD)

Traction Motor Support Safety Washer (P/N AA0403R) QTY = 4

Traction Motor Collar Safety Washer (P/N AA04040) QTY = 4

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-01-00/I-00**	
System: **PROPULSION**	Sheet: **4/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.
3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

To perform the task for each Traction Motor proceed as follows (Refer to Figures 1 through 4):

NOTE: Perform the task for each Traction Motor.

1. Check the Traction Motor for any signs of damag, missing parts and/or overheating. Repair/replace as needed.
2. Check the Traction Motor Grounding Cable and relevant Terminals connections for visible damage, missing / loose parts, signs of burns.
3. Check the Traction Motor Bare Copper Strap and relevant connections to Traction Motor for visible damage, missing / loose parts, signs of over-heating.
4. Inspect the following items for damage / missing /loose parts and / or clamps or signs of overheating:
   a) Traction Motor Power Supply Connection Box at Motor Cable Connections End.
   b) Traction Motor Power Supply Cables from Motor Cable Connections End to Quick Disconnect Box Cables.
   c) Traction Motor Power Supply Connections at Quick Disconnect Box.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-05-01-00/I-00**
System: **PROPULSION**	Sheet: **5/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

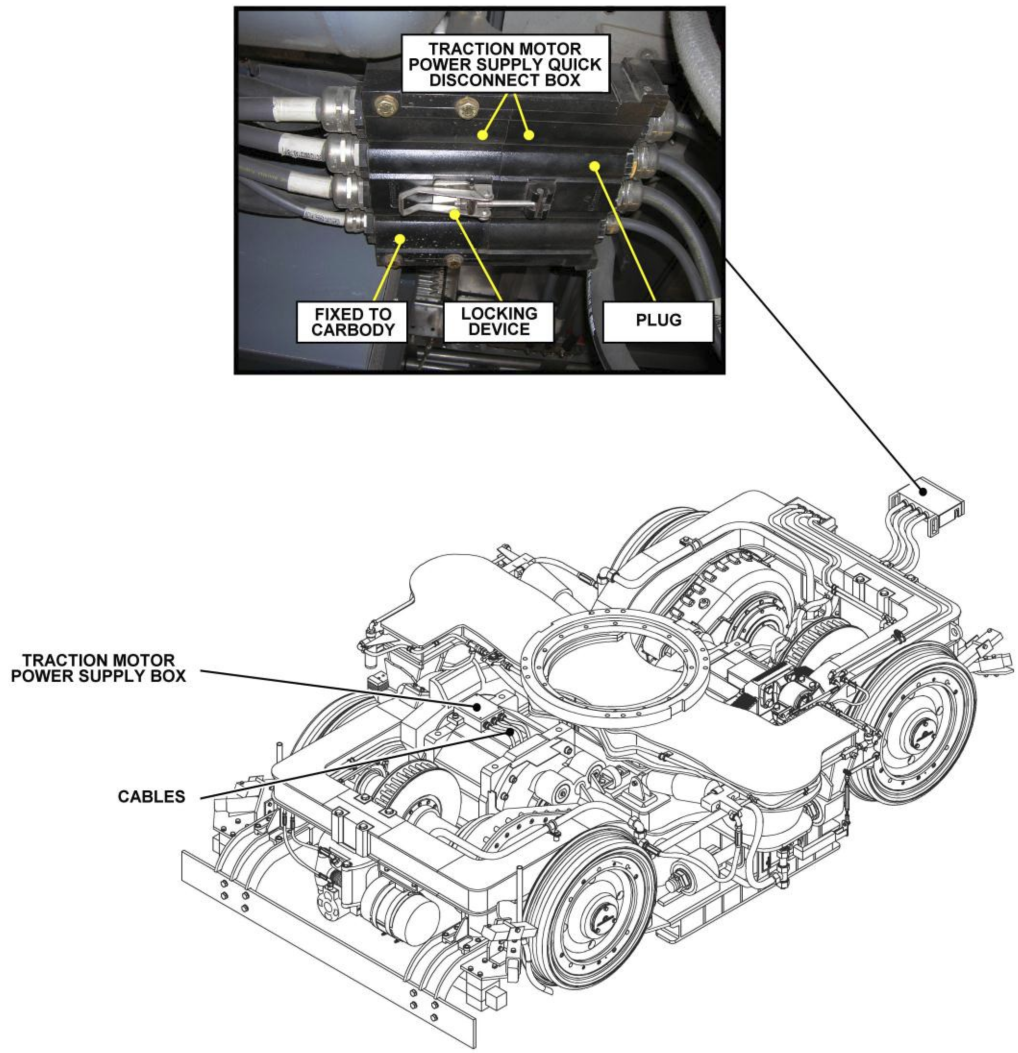


Figure 1 - TRACTION MOTOR POWER SUPPLY & CABLES INSPECTION

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-01-00/I-00**	
System: **PROPULSION**	Sheet: **6/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

5. Check, at Motor Cable Connections End side, the Safety Washers of the Motor Support Collar Screws and the Motor (Support) Safety Nose for correct installation, damage or missing.

6. Check the Marker Lines for correct alignment on the Nut and the Screw Head of the following Traction Motor Mounting Hardware:

a) At Motor Cable Connections End side: 1) Motor Support Collar Screws and (Collar) Nut.
2) Motor (Support) Safety Nose.

b) At Gear Drive End side: Motor Supports Screws.

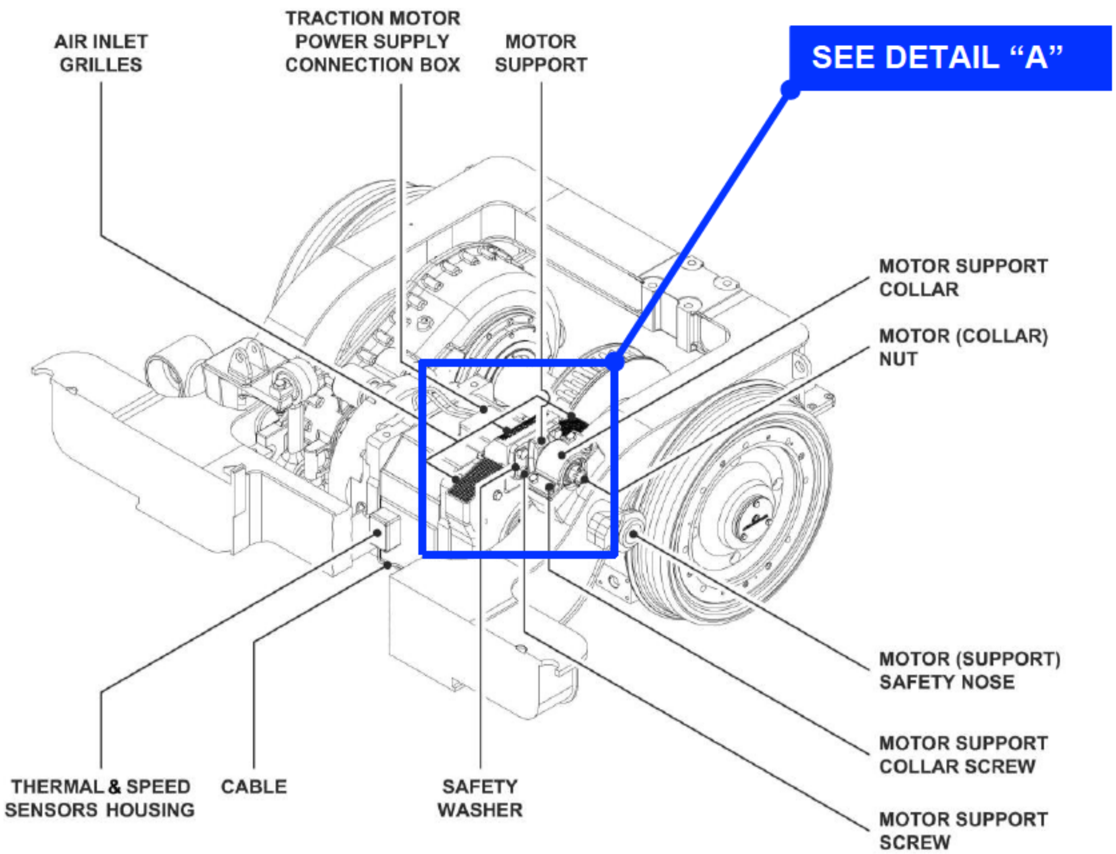


Figure 2 - TRACTION MOTOR INSPECTION AT CABLE CONNECTION END

P2550 PREVENTIVE MAINTENANCE SHEET			
Card Code: **R-P-07-05-01-00/I-00**			
System: **PROPULSION**		Sheet: **7/12**	
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**		
Component:		Man Hours: **1**	
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

PROCEDURE (CONT'D):

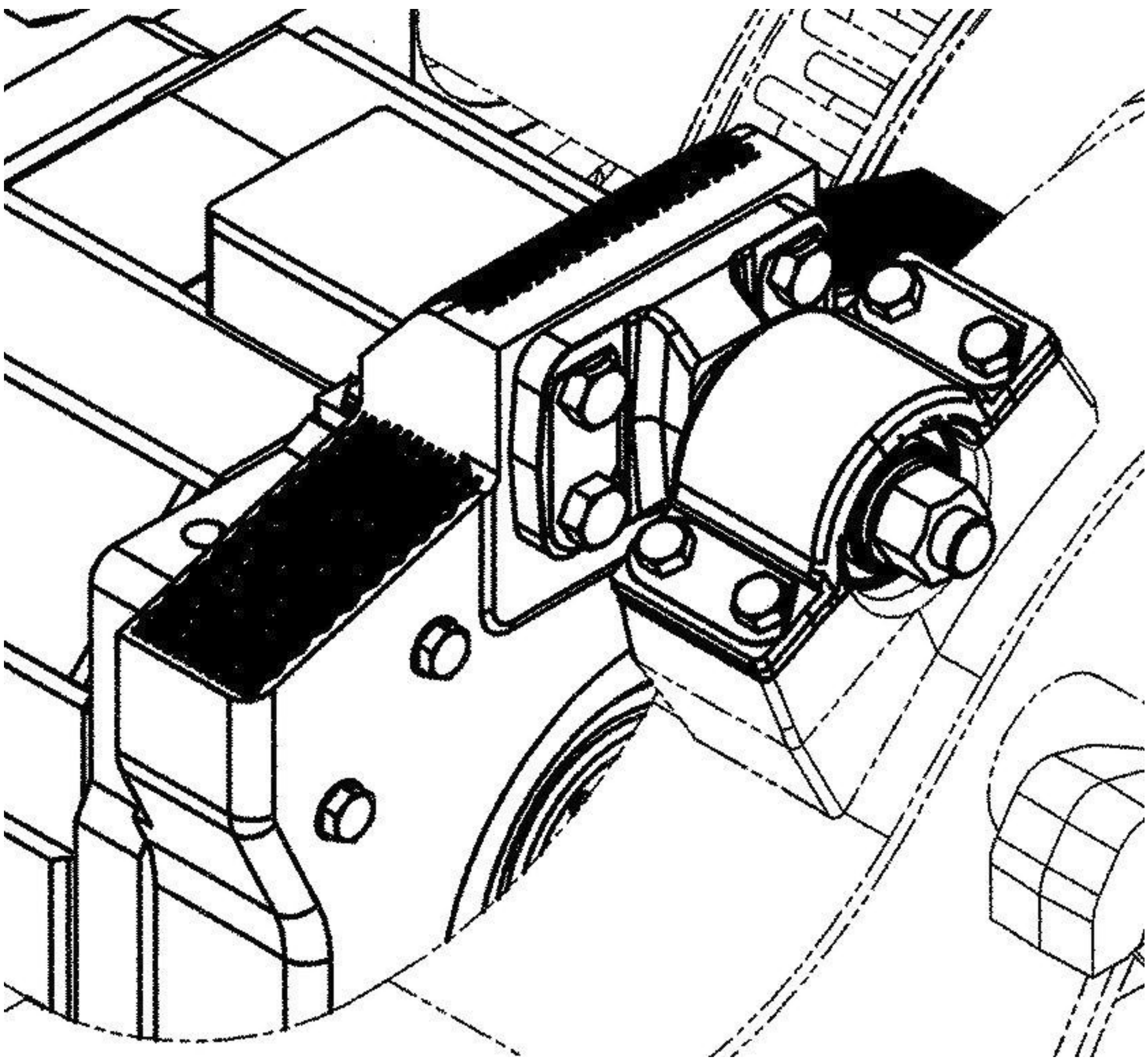


Figure 2 - TRACTION MOTOR INSPECTION - DETAIL "A"

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-01-00/I-00**	
System: **PROPULSION**	Sheet: **8/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

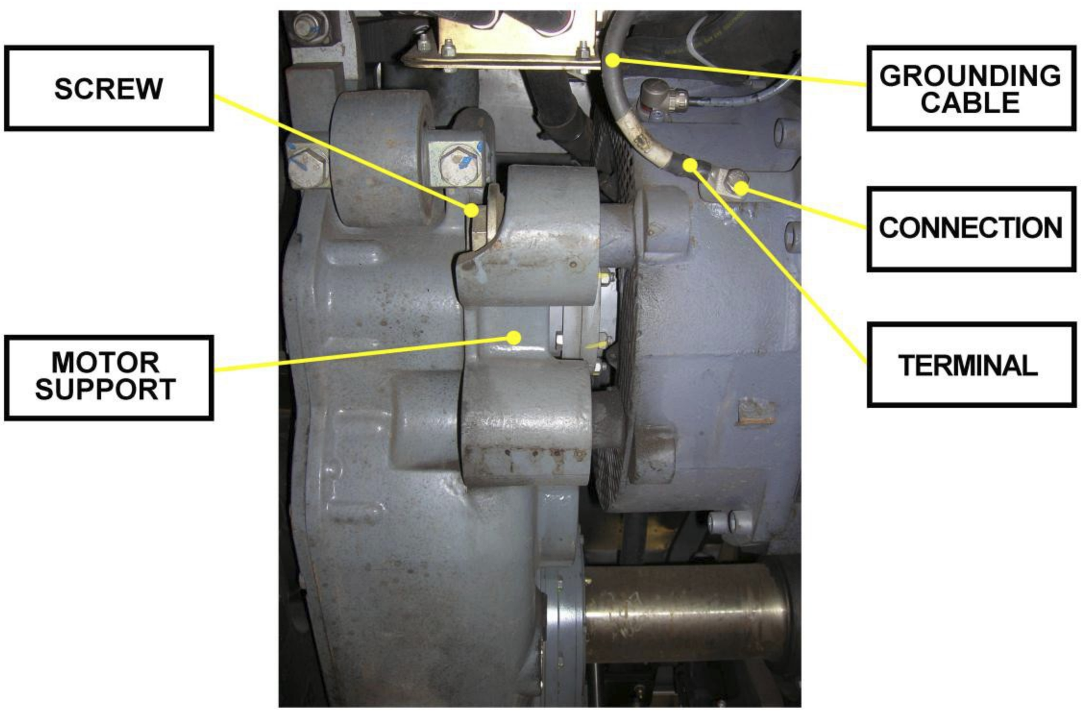


Figure 3 - TRACTION MOTOR INSPECTION AT GEAR DRIVE END

NOTE: The Safety Washers and the Marker Lines of the Traction Motor Mounting Hardware must be in proper positions / alignments respectively.
If not, it is MANDATORY to check Traction Motor Mounting Hardware for design torque as follows:

- (At Motor Cable Connections End side): Motor Support Screws =288 ft-lb (+/- 5%).
  Motor Collar Screws = 144 ft-lb (+/- 5%).
  Motor (Collar) Nut = 302 ft-lb (+/- 5%).
- (At Gear Drive End side): Motor Supports Screws = 288 ft-lb (+/- 5%).

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-01-00/I-00**	
System: **PROPULSION**	Sheet: **9/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

CAUTION: BEFORE TIGHTENING TRACTION MOTOR MOUNTING HARDWARE TO DESIGN VALUE:
1) INSTALL NEW SAFETY WASHERS.
2) REMOVE ANY TRACE OF PREVIOUS MARKER LINE ON NUT AND SCREW HEAD.

CAUTION: AFTER TIGHTENING TRACTION MOTOR MOUNTING HARDWARE TO DESIGN VALUE:
1) BEND SAFETY WASHERS BY MEANS OF FLAT HEAD SCREWDRIVER AND HAMMER PAYING ATTENTION TO NOT DAMAGE THE WASHER, NUT AND /OR SCREWS HEAD.
2) MARK NUT AND SCREW HEAD, USING MARKER PEN, WITH A CONTINUOUS LINE.

5. Check Traction Motor Air Inlet and Outlet Grilles for damage / missing parts / dirt obstruction. Clean using a degreaser cleaner and lint free rag.

6. Check (Thermal & Speed) Sensor Housing, Cover and Cable for damage / missing / loose parts / signs of burns.

7. Remove the Cover of the (Thermal & Speed) Sensor Housing by loosening relevant hardware. Retain it for later use.

8. Remove and discard Cover Gasket. Replace Cover Gasket with a new one.

9. Check (Thermal & Speed) Sensor Components and Terminal connections inside the Housing for damage / missing / loose parts / signs of burns/ overheating. Replace / repair as per check result.

10. Reinstall the Cover of the (Thermal & Speed) Sensor Housing by tightening relevant hardware.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: R-P-07-05-01-00/I-00		
System: PROPULSION		Sheet: 10/12
Subsystem/Assy: TRACTION MOTOR	Unit: TRACTION MOTOR	
Component:		Man Hours: 1
Maintenance Task: INSPECTION		Interval/Miles: 60,000

PROCEDURE (CONT'D):

BEARINGS LUBRICATION
(Refer to Figure 4)

To perform the task proceed as follows:

NOTE: Perform the task for each Traction Motor.

1. Clean the area around the Bearing Grease Fitting Inlet, at the Motor Cable Connections End, using recommended agent.
2. Remove Grease Fitting Inlet Cap.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE TRACTION MOTOR BEARING LUBRICATION VALVE. ONLY USE THE RECOMMENDED TYPE OF GREASE.

3. Remove Grease Fitting Outlet Cap to allow any excess grease to vent out of the Bearing Valve.
4. Connect a Grease Gun, provided with suitable extension, to the Grease Fitting Inlet.

NOTE: When using a Grease Gun or similar Lubrication Device, release a small amount of grease and wipe the tip of the applicator with a clean rag or paper towel before servicing the Bearings, to remove any contaminant.

5. Inject one ounce of recommended grease into the Inlet Fitting.

NOTE: Excess grease (if any) will flow from the open Bearing Grease Outlet. Remove grease excess using cleaning rag.

6. Reinstall Bearing Grease Fitting Inlet and Outlet Caps.
7. Repeat steps 1 through 6 for the Bearing on the Motor Gear Drive End.

8. Restore Electrical Power.
9. Record inspection results on the Defect Report Card for administrative and maintenance planning.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-05-01-00/I-00**
System: **PROPULSION**	Sheet: **11/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**
Component:	Man Hours: **1**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

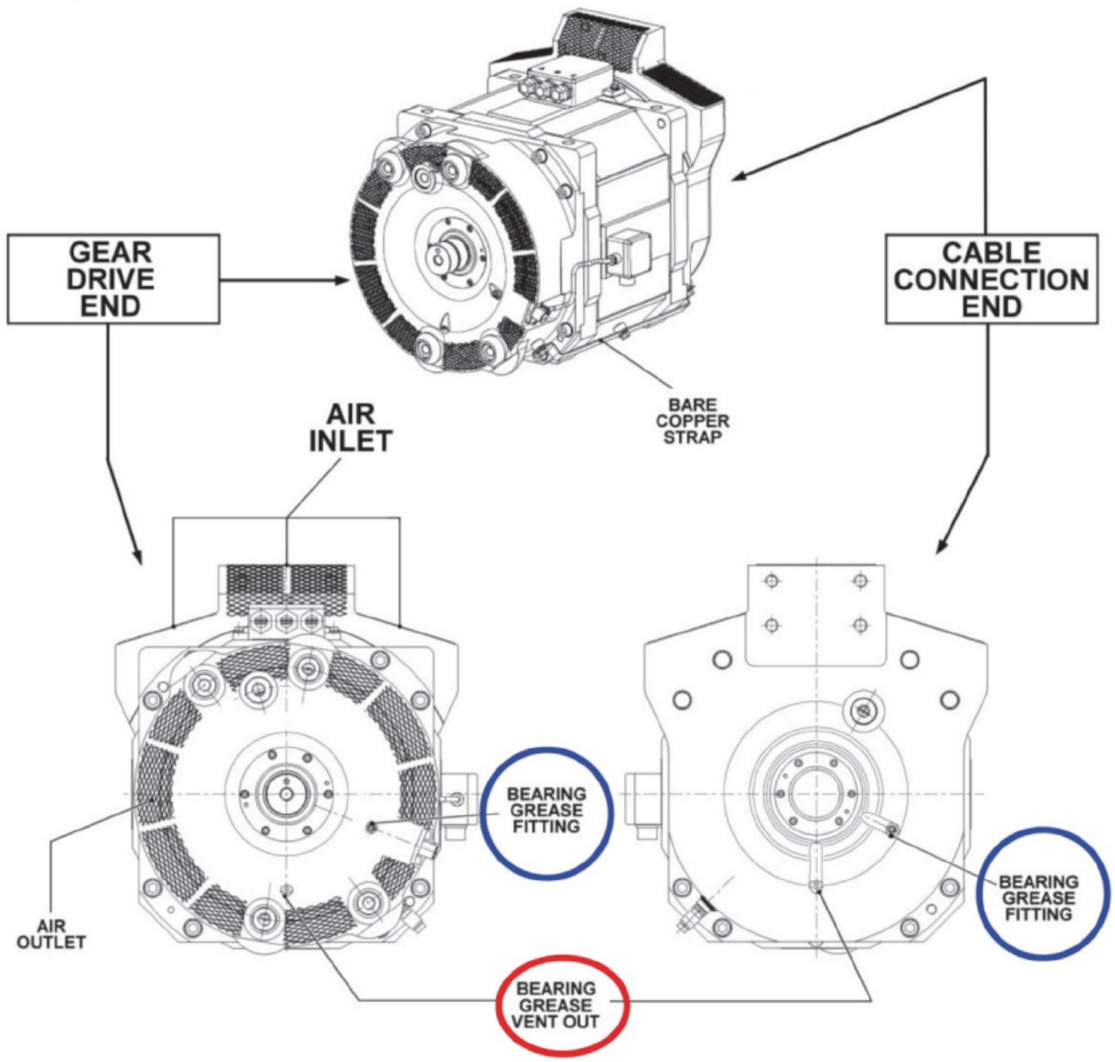


Figure 4 - TRACTION MOTORS - LUBRICATION

P2550 PREVENTIVE MAINTENANCE SHEET			
Card Code: **R-P-07-05-01-00/I-00**			
System: **PROPULSION**			Sheet: **12/12**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTOR**		
Component:			Man Hours: **1**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

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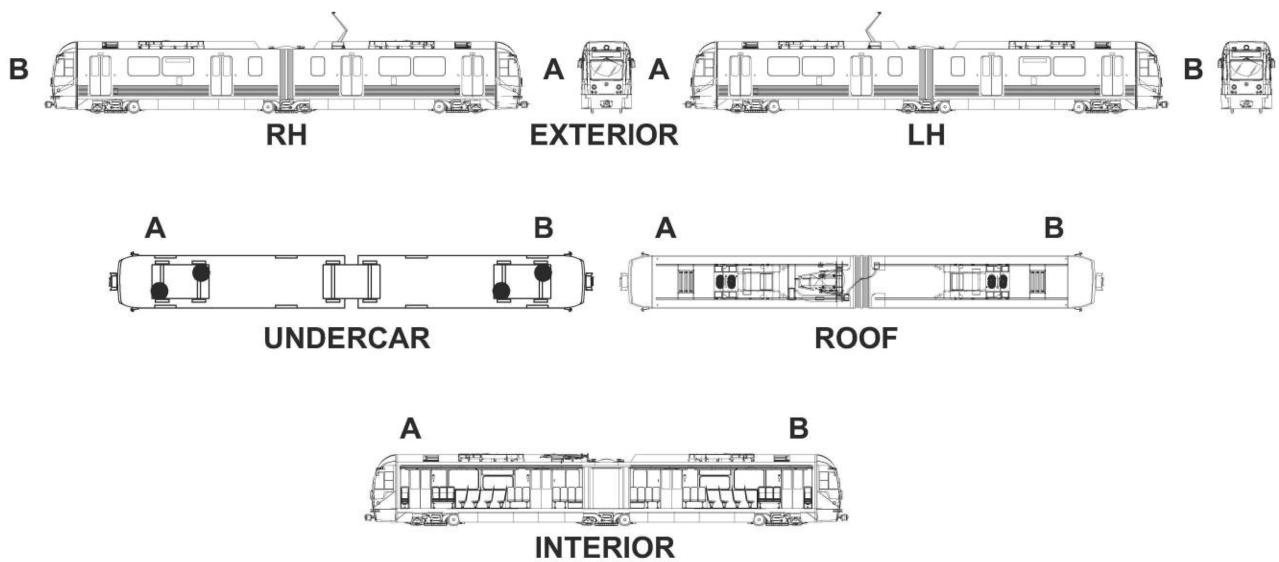
P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-02-00/I-00**	
System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.66**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-02-00/I-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.66**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

CRC 2000 Contact Cleaner

SPARE PARTS:

Traction Motors Speed Sensor	(P/N 211VT01355B)
O-ring	(P/N TBD)

P2550 PREVENTIVE MAINTENANCE SHEET

			Card Code: **R-P-07-05-02-00/I-00**
System: **PROPULSION**			Sheet: **3/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**		
Component:			Man Hours: **1.66**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.
3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

(Refer to Figures 1through 3)

To perform the task proceed as follows:

NOTE: Perform the task for each Traction Motor.

1. Inspect the Traction Motor Speed Sensor Device for visible damage / loose / missing hardware.
2. Inspect Speed Sensor Cable from Speed Sensor Device to (Thermal & Speed) Sensor Housing for damage, missing, loose clamp, signs of burns.
3. Remove the Speed Sensor from Traction Motor by loosening the relevant fixing screws.
4. Inspect the (Sensor) Sensing End for visible damage /grooving.
5. Remove the O-ring and discard. Replace with a new one.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-05-02-00/I-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**	
Component:		Man Hours: **1.66**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

6. Measure, the dimension between the Sensing End and the Sensor Assembly Plate.

NOTE: The dimension should never be less than 1.1378 inches or over 1.1417 inches. Replace Speed Sensor, as per check result, as follows:

a) Disconnect relevant Terminals located inside the (Thermal & Speed) Sensor Housing.

b) Reconnect the new Sensor Terminals, paying attention to respect the Wiring Diagram Color Codes shown in the Label inside the Cover.

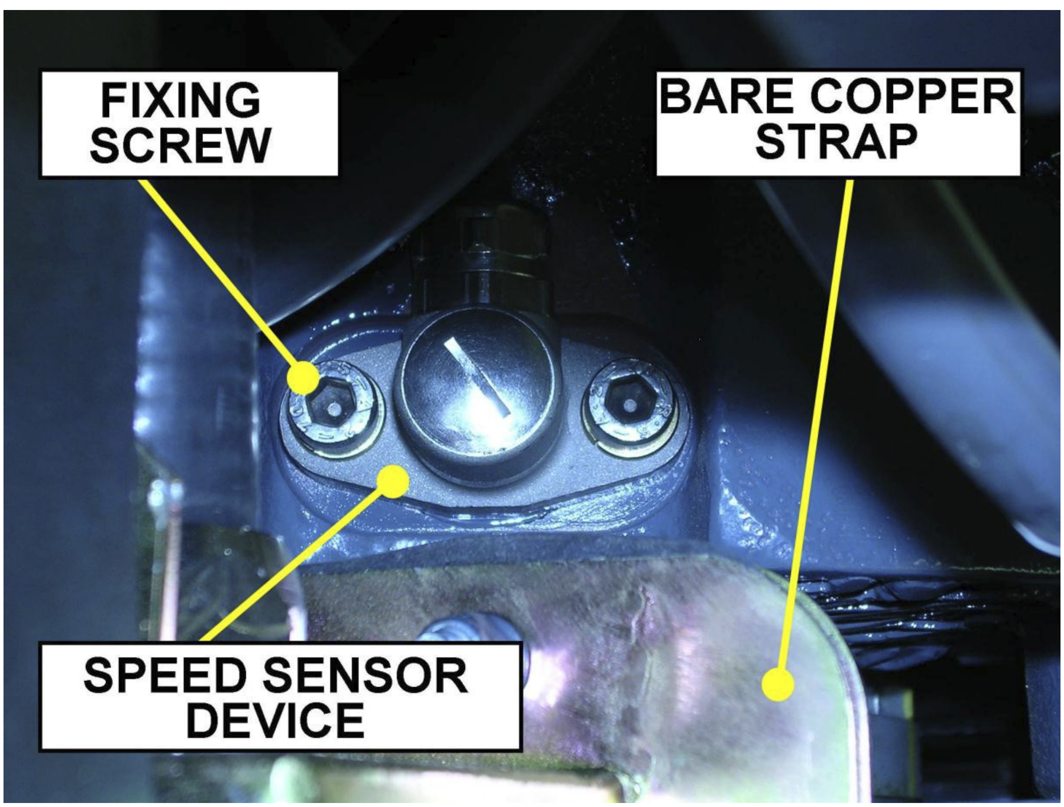


Figure 1 - TRACTION MOTOR SPEED SENSOR

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-05-02-00/I-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.66**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

7. Clean the Traction Motor Speed Sensor Assy, Sensing End and Cable using a cleaner and lint free-rag.

8. Thoroughly clean the Speed Sensor mating surface on the Traction Motor using recommended cleaner and lint free-rag.

9. Reinstall the Speed Sensor by tightening the Fixing Screws to **20 ft-lb**.

10. Restore the Electrical Power.

11. Record Inspection results on the Defect Report Card for administrative and maintenance planning.

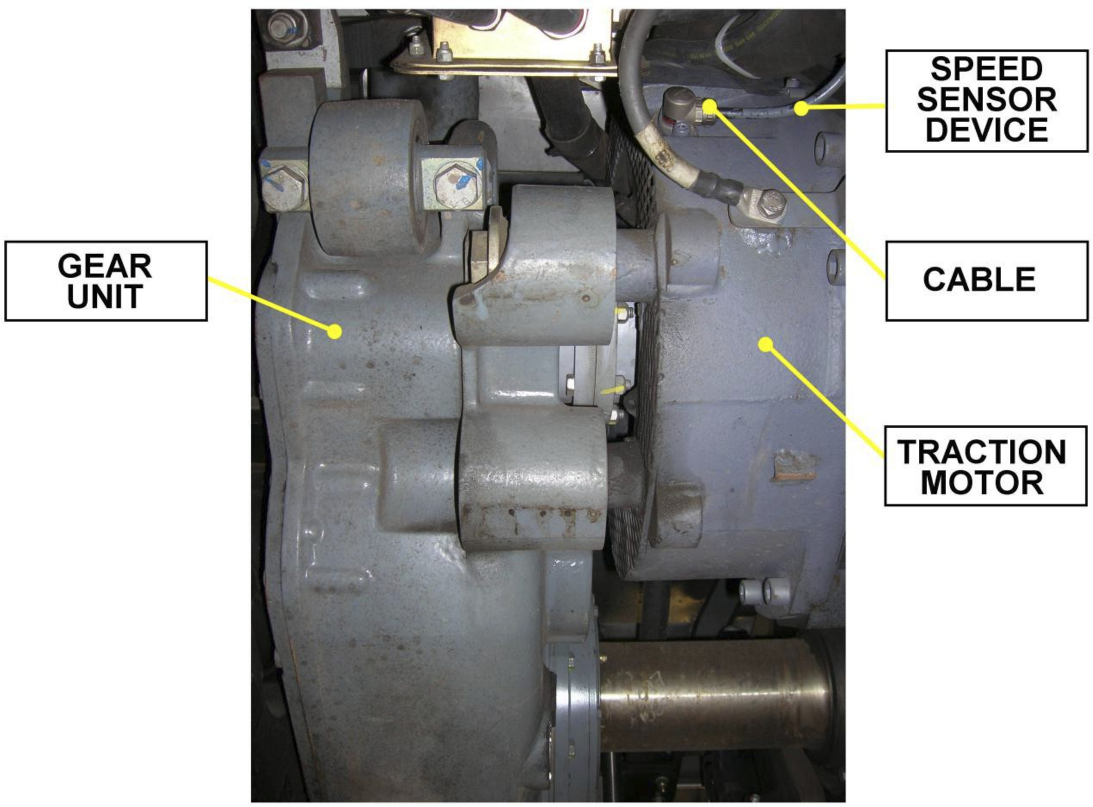


Figure 2 - TRACTION MOTOR SPEED SENSOR LOCATION

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-05-02-00/I-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**	
Component:		Man Hours: **1.66**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

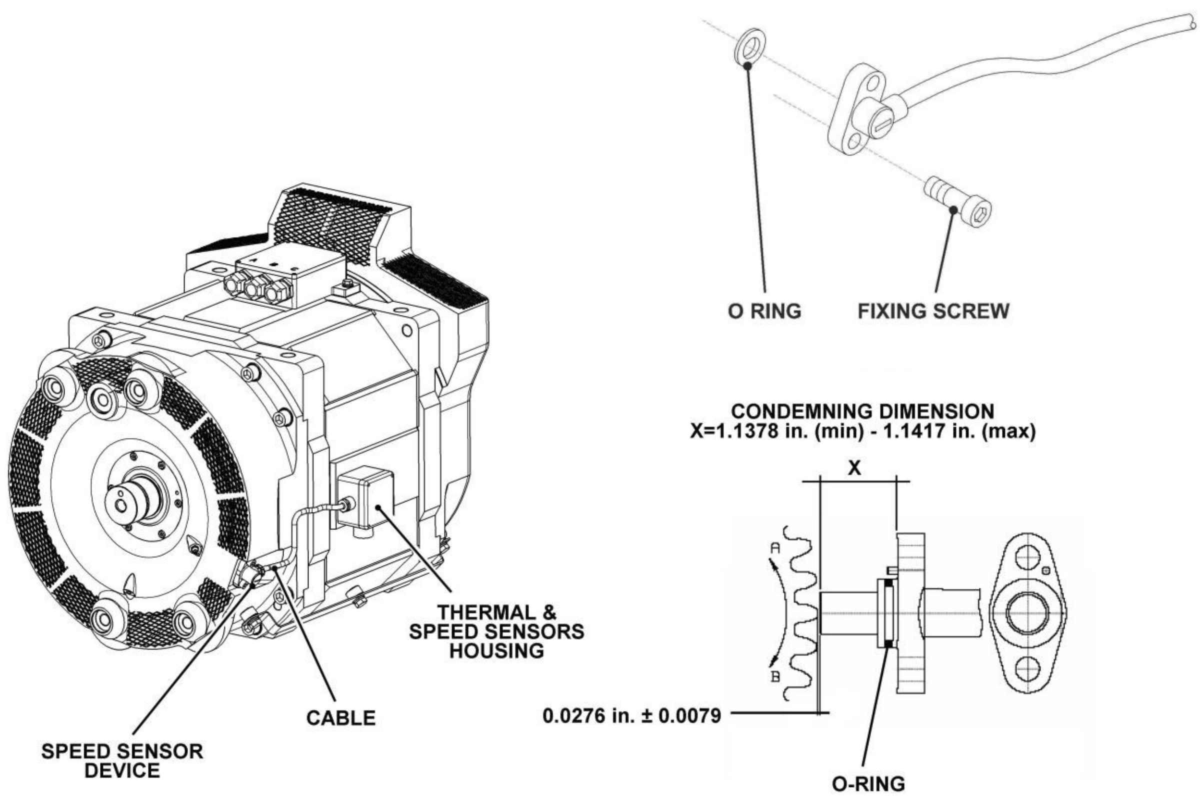


Figure 3 - TRACTION MOTOR SPEED SENSOR CHECK

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-06-01-00/I-00

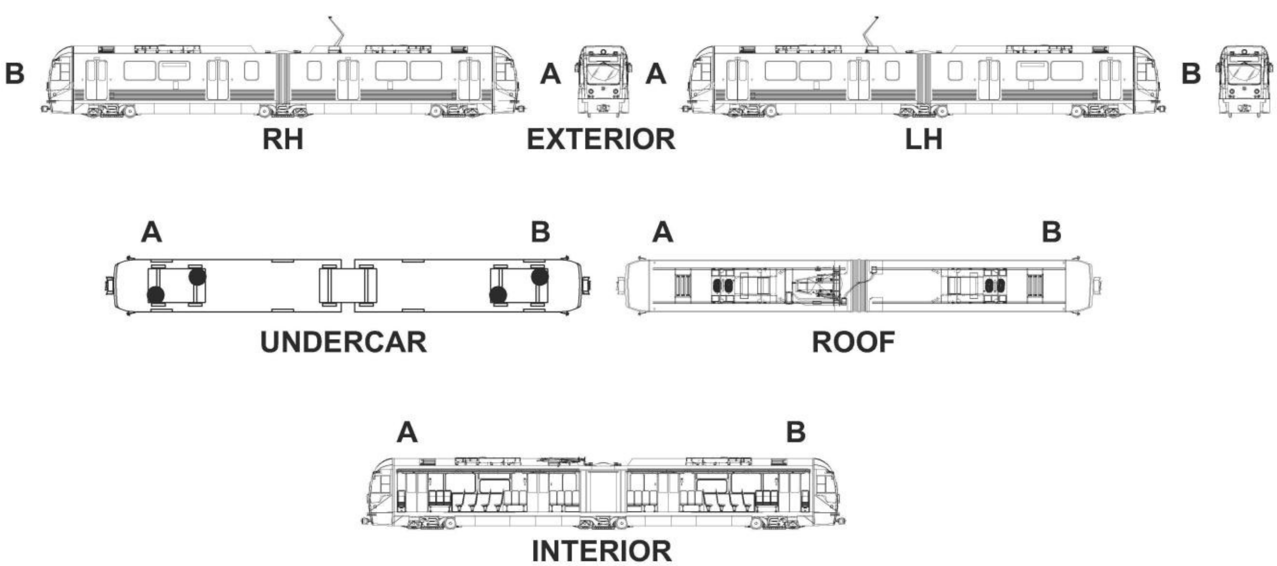
System:	Sheet:
PROPULSION	**1/8**

Subsystem/Assy:	Unit:
GEARBOX ASSY	**GEARBOX**

Component:	Man Hours:
	0.2

Maintenance Task:	Interval/Miles:
INSPECTION	**10,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/I-00**			
System: **PROPULSION**			Sheet: **2/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**		
Component:			Man Hours: **0.2**
Maintenance Task: **INSPECTION**		Interval/Miles: **10,000**	

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: BEFORE BEGINNING ANY WORK UNDER THE TRUCK, MAKE SURE THE TRACTION MOTOR NEAR THE GEARBOX IS DE-ENERGIZED. BEFORE BEGINNING ANY WORK ON THE DRIVE UNITS, MAKE SURE THAT NEITHER THE VEHICLE NOR THE TRUCK OR THE WHEEL SET CAN MOVE.

CAUTION: INSPECTION OF THE GEARBOX OIL LEVEL MUST BE PERFORMED:
A) WITH VEHICLE ON LEVEL TRACK.
B) AFTER THE VEHICLE HAS BEEN IN STATIONARY MODE FOR AT LEAST 20 MINUTES.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX.

TOOLS:
LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

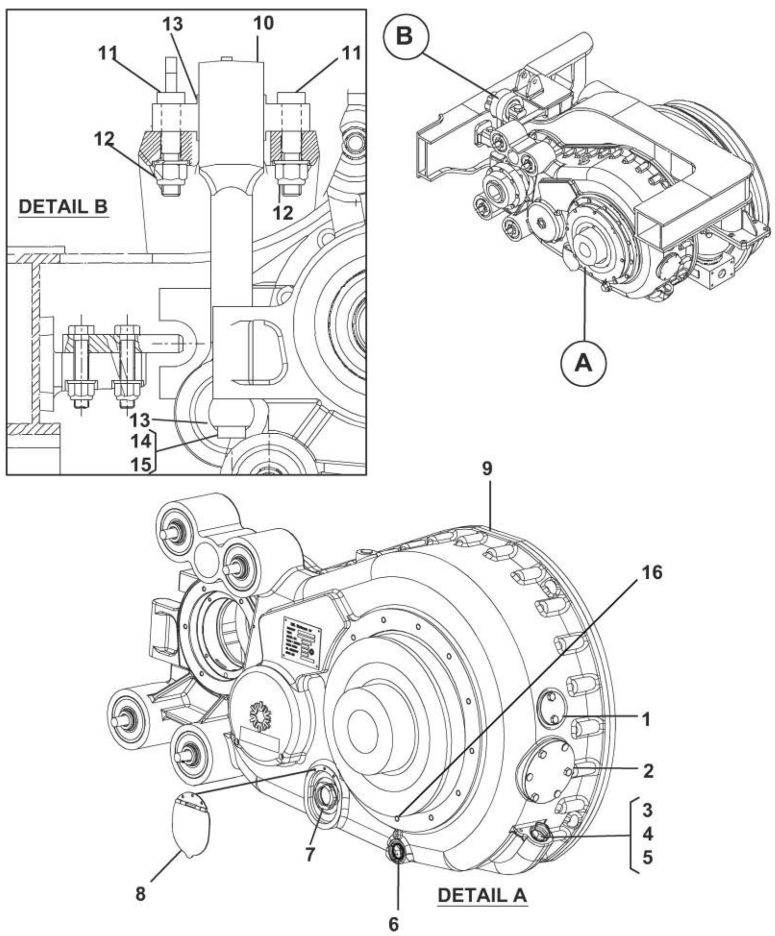
OIL: Mobilube SHC 75W90-LS or equivalent
GREASE: Mobilux EP2
CLEANING AGENTS:
Solvent naphtha
Pentex 2000 / Fa. Pentol AG
Aral 4005
MPA / Fa. Herberts, D-42202 Wuppertal
Rivolta MTX
Loctite 7061 or 7063 FOR THREADS
THREADLOCKING: Loctite 243, Loctite 518
MATERIALS: Safety Wires

SPARE PARTS:
Plastic plug Kapsto GPN300 F2

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:	**R-P-07-06-01-00/I-00**
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **0.2**
Maintenance Task: **INSPECTION**	Interval/Miles: **10,000**

PROCEDURE:



1. SPEED SENSOR COVER
2. INSPECTION COVER
3. SAFETY WIRE
4. OIL FILL PLUG
5. COPPER RING
6. OIL DRAIN PLUG
7. OIL GAUGE GLASS
8. SPRING COVER
9. COUPLING HALVES CONNECTION
10. REACTION ROD
11. BOLT
12. NUT
13. ULTRABUSH
14. BOLT
15. SAFETY WIRE
16. WATER DRAIN BORE

Figure 1 - GEARBOX

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/I-00**	
System: **PROPULSION**	Sheet: **4/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **0.2**
Maintenance Task: **INSPECTION**	Interval/Miles: **10,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.
3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released "and on Indicator Panel "A" "Park / Friction Brake" ON).
4.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

This inspection consists of the following maintenance activities:

1. Check for Gearbox Oil Leakage.
2. Check for Gearbox Oil Level.
3. Check for Gearbox Water Bores In Labyrinth Covers.
4. Check tooth contact pattern of the gearwheel output shaft.
5. Gearbox Suspension Inspection.
6. Motor Suspension inspection.

1. **Check for Gearbox Oil Leakage** (refer to figure 1)
   - **a.** Locate Gearbox Unit Assembly (Motor Trucks).
   - **b.** Inspect Gear Unit for oil leakage on the following items:
     - Speed Sensor Cover (1)
     - Inspection Cover (2)
     - Oil Fill Plug (4)
     - Oil Drain Plug (6)
     - Oil Gauge Glass (7)
     - Coupling Halves connection (9)
   - **c.** Record Inspection results on the Defect Report card for administrative and maintenance planning.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/I-00**	
System: **PROPULSION**	Sheet: **5/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **0.2**
Maintenance Task: **INSPECTION**	Interval/Miles: **10,000**

PROCEDURE (CONT'D):

2. Check for Gearbox Oil Level (refer to figure 1)

CAUTION: INSPECTION OF THE GEARBOX OIL LEVEL MUST BE PERFORMED:
A) WITH VEHICLE ON LEVEL TRACK.
B) AFTER THE VEHICLE HAS BEEN IN STATIONARY MODE FOR AT LEAST 20 MINUTES.

a. Check that the oil level is in the red circle, which is on the Oil Gauge Glass (7). This indicates that the oil level is between the minimum and maximum allowable levels.

b. If the oil level is below the minimum then add oil.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX.

c. Clean the Oil Fill Cap (4) with cleaning agents.

d. Fill oil (Mobilube SHC 75W90-LS type or equivalent) until the level is more or less in the middle of the red circle.

CAUTION: TOO MUCH OIL IN THE GEARBOX IS JUST AS HARMFUL AS TOO LITTLE OIL. FOR THIS REASON, THE CORRECT OIL LEVEL MUST BE ADJUSTED BY DRAINING AND/OR FILLING.

e. When the oil is in the middle of the red circle, install the Oil Fill Cap (4) in the housing with a new Copper Ring (5) and tighten to 58.8 ft lb (80 Nm).

f. Secure the Oil Fill Cap (4) with a new Safety Wire (3).

3. Check for Gearbox Water Bores In Labyrinth Covers (refer to figure 1)

a. Check the water-draining bore of each of the outermost labyrinth chambers for dirt, contamination obstruction.

b. If any dirt or obstructions are noted, in any of the bores, then remove with an appropriate tool.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/I-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **0.2**
Maintenance Task: **INSPECTION**	Interval/Miles: **10,000**

PROCEDURE (CONT'D):

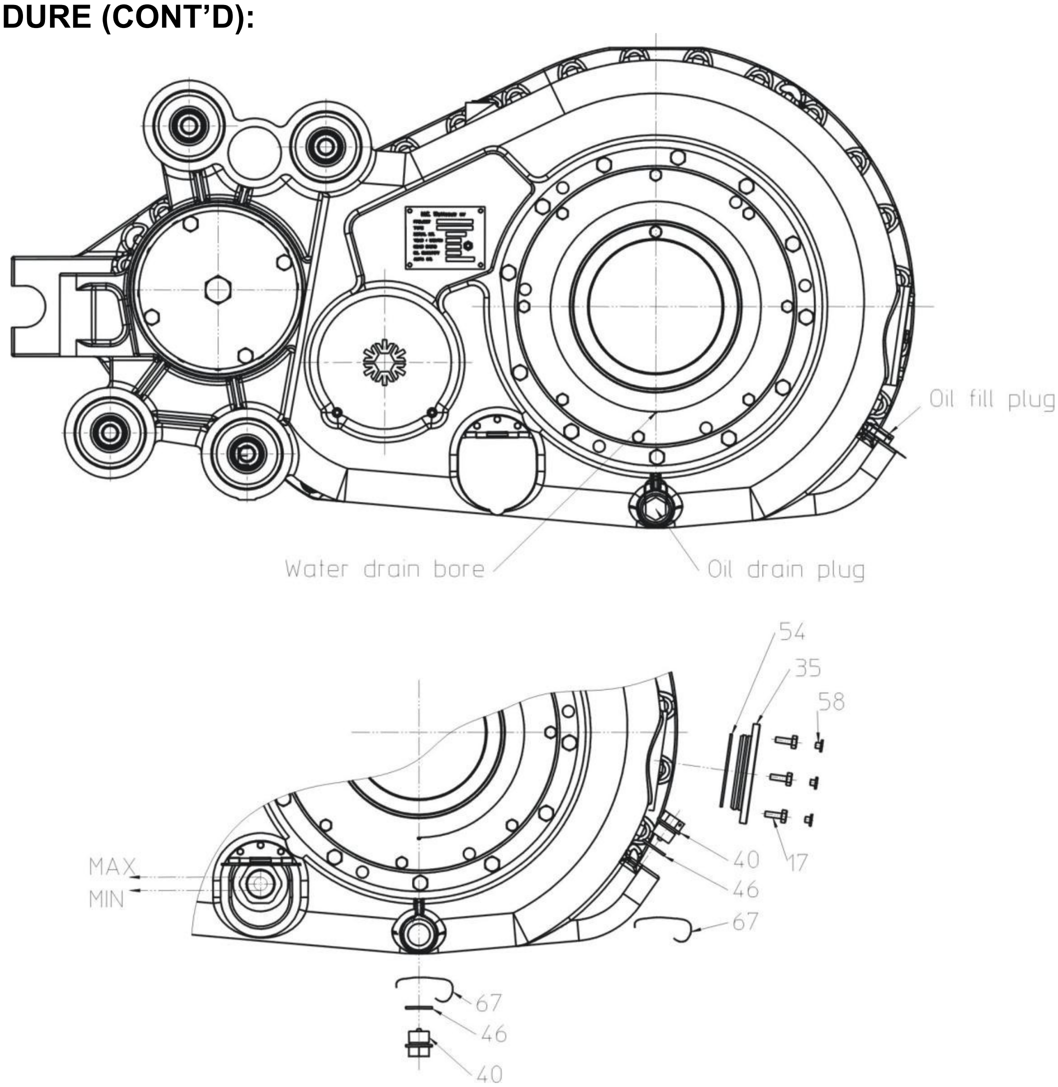


Figure 2 - GEAR UNIT

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-06-01-00/I-00**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **0.2**
Maintenance Task: **INSPECTION**	Interval/Miles: **10,000**

PROCEDURE (CONT'D):

4. Gearbox Suspension Inspection (refer to figure 1)

To perform Gearbox Suspension Inspection Procedure proceed as follows:

- **a.** Note any areas/ items requiring corrective maintenance.
- **b.** Check Bolts (11) and Nuts (12) condition.
- **c.** Tighten Nuts (12) to 288 ft lb (390 Nm).
- **d.** Clean the Ultrabushes (13) with glycerine-spiritus-mixture.
- **e.** Inspect ultrabush rubber surfaces for cracks. Cracks must not be deeper than 0.12 in (3 mm); otherwise the two Ultrabushes (13) must be replaced.
- **f.** Record Inspection results on the Defect Report card for administrative and maintenance planning.

5. Motor Suspension Inspection

To perform Motor Suspension Inspection Procedure proceed as follows (refer to figure 1):

- **a.** Clean the bottom Ultrabushes (4) with glycerine-spiritus-mixture.
- **b.** Note any areas/ items requiring corrective maintenance.
- **c.** Inspect the ultrabush rubber surfaces for cracks. Cracks must not be deeper than **0.12 in (3 mm)**; otherwise the Ultrabushes (13) must be replaced.
- **d.** Check Bolts (14) and Safety Wire (15) condition.
- **e.** Check motor suspension parts for damage, corrosion and rust. Damaged parts must be replaced.
- **f.** Inspect for missing/loose hardware and safety wire.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/I-00**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **0.2**
Maintenance Task: **INSPECTION**	Interval/Miles: **10,000**

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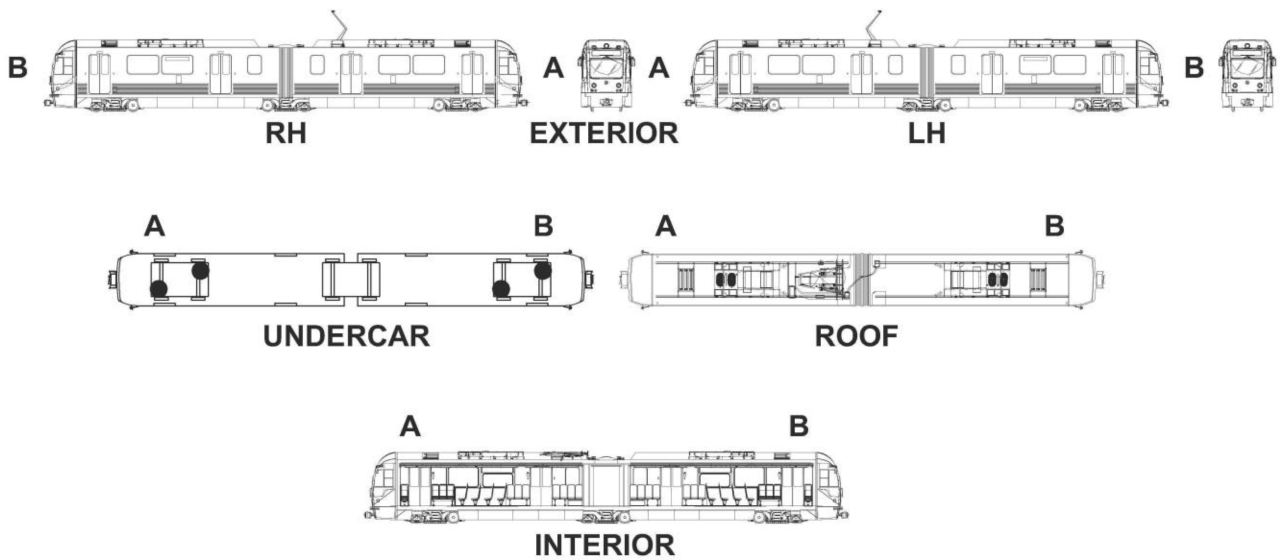
P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **10,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **2/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **10,000**

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: BEFORE BEGINNING ANY WORK UNDER THE TRUCK, MAKE SURE THE TRACTION MOTOR NEAR THE GEARBOX IS DE-ENERGIZED. BEFORE BEGINNING ANY WORK ON THE DRIVE UNITS, MAKE SURE THAT NEITHER THE VEHICLE NOR THE TRUCK OR THE WHEEL SET CAN MOVE.

WARNING: THE DRAINED OIL MAY BE VERY HOT.

CAUTION: THE FIRST OIL CHANGE MUST BE PERFORMED ONLY ONE TIME ON EACH GEARBOX WHEN THE FIRST OF THE FOLLOWING RUN-IN SERVICE CONDITIONS OCCUR AFTER START UP:"

1-MAX 400H"

2-MAX 10000 MILES.

CAUTION: OIL CHANGE SHOULD BE CARRIED OUT WHEN THE GEAR IS WARM (I.E. IMMEDIATELY AFTER RETURN FROM SERVICE), BECAUSE WARM OIL DRAINS MORE EASILY AND DIRT PARTICLES ARE RINSED OUT WITH THE OIL.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX. ONLY USE THE SPECIFIED TYPE OF OIL.

CAUTION: THE GEARBOX MUST NOT OPERATE WITHOUT OIL.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

OIL: Mobilube SHC 75W90-LS

CLEANING AGENTS:

Solvent naphtha	Pentex 2000 / Fa. Pentol AG	Aral 4005
MPA / Fa. Herberts, D-42202 Wuppertal	Rivolta MTX	

ITEMS:
Retaining Wire

SPARE PARTS:

Copper Ring (DIN7603-Cu-A27x32)

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-06-01-00/S-00**		
System: **PROPULSION**		Sheet: **3/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **10,000**

PROCEDURE:

PRELIMINARY OPERATIONS:

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.
3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

OIL CHANGE

(refer to fig. 1 through 3)

To perform First Oil change proceed as follows:

1. Cut through the Retaining Wire (67) of the magnetic Oil Drain Cap (40) and remove the Wire.
2. Clean the area around the magnetic Oil Drain Cap (40) using recommended agent.
3. Unscrew the magnetic Oil Drain Cap (40) and remove the Copper Ring (46).
4. Collect the Oil in a container.
5. Examine the magnetic Oil Drain Cap (40) for dirt. Fine dust is normal. If metal chips are found then, the Gearbox should be inspected more closely.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**			
System: **PROPULSION**			Sheet: **4/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**		
Component:			Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **10,000**	

PROCEDURE (CONT'D):

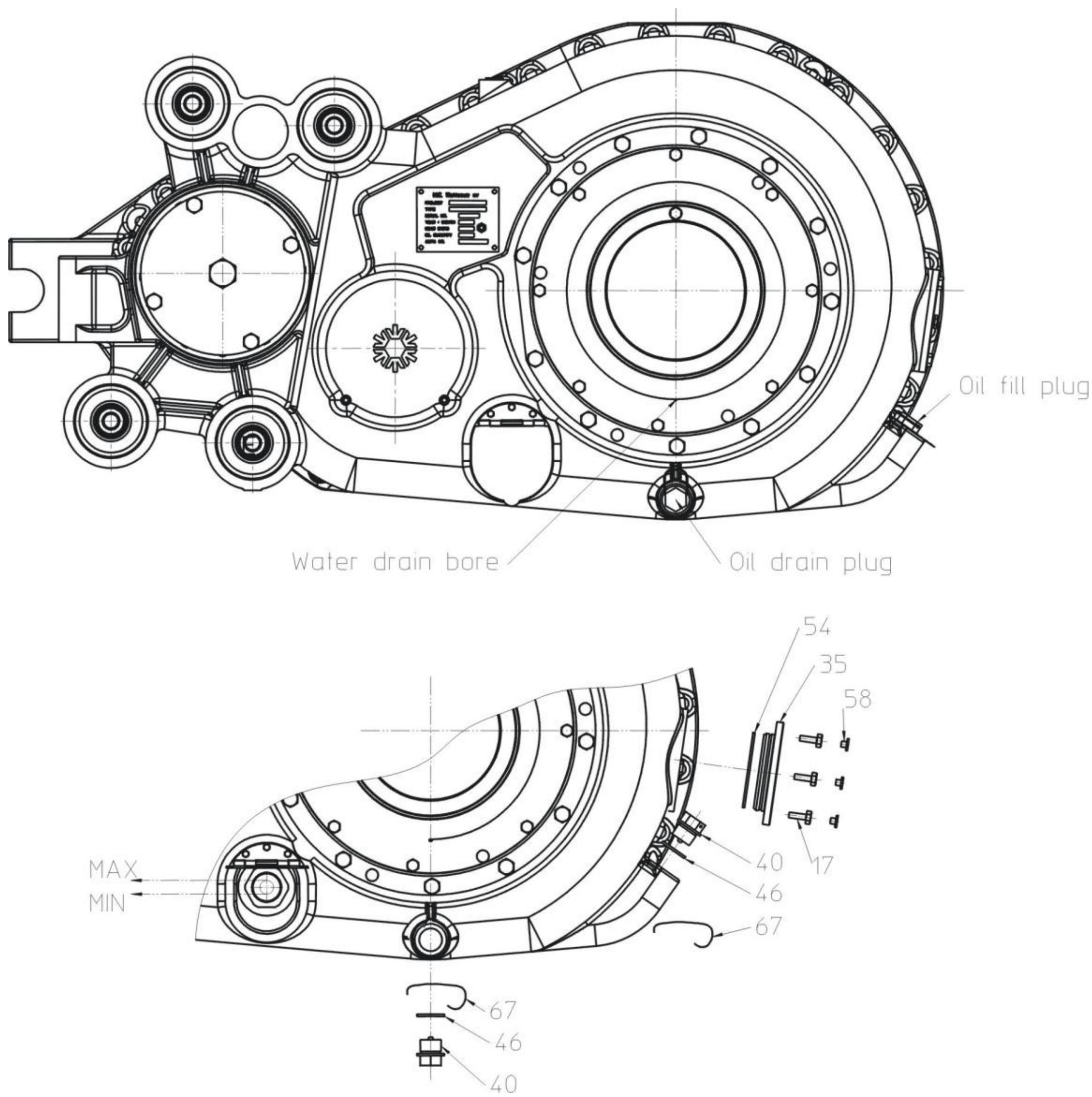


Figure 1 - GEAR UNIT - OIL CHANGE/REFILL

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **5/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **10,000**

PROCEDURE (CONT'D):

6. Clean the magnetic Oil Drain Cap (40) using recommended agent.
7. Fit the magnetic Oil Drain Cap (40) with a new Copper Ring (46) and screw it into the Housing with a tightening torque of **58.8 ft-lb** (80 Nm.)
8. Secure the magnetic Oil Drain Cap (40) with Retaining Wire (67).
9. Cut through the Retaining Wire (67) of the Oil Fill Cap (40) and remove the Wire.
10. Clean the area around the magnetic Oil Fill Cap (40) using recommended agent.
11. Unscrew the Oil Fill Cap (40) and remove the Copper Ring (46).
12. Examine the magnetic Oil Fill Cap (40) for dirt. Fine dust is normal. If metal chips are found then, the Gearbox should be inspected more closely.
13. Clean the Oil Fill Cap (40) using recommended agent.
14. Pour in 5.0 liter of oil (0.5 liter oil rests in the gearbox after draining), there is now a total of 5.5 liter oil in the Gearbox.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX.
ONLY USE THE SPECIFIED TYPE OF OIL.

CAUTION: THE GEARBOX MUST NOT OPERATE WITHOUT OIL.

15. Check the Oil Level. Therefore, take a closer look at the Oil Gauge Glass. The Oil Level has to be at the maximum, this means at the top of the Red Circle on the Oil Gauge Glass.

NOTE: After driving, the fixed Oil Capture Device is filled up again and the Oil Level has to stay between the Minimum and the Maximum, marked by a Red Circle on the Oil Gauge Glass.

NOTE: Too much Oil in the Gearbox is just as harmful as too little oil.

16. Restore Power.
17. Record task results on the Defect Report Card for administrative and maintenance planning.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **10,000**

PROCEDURE (CONT'D):

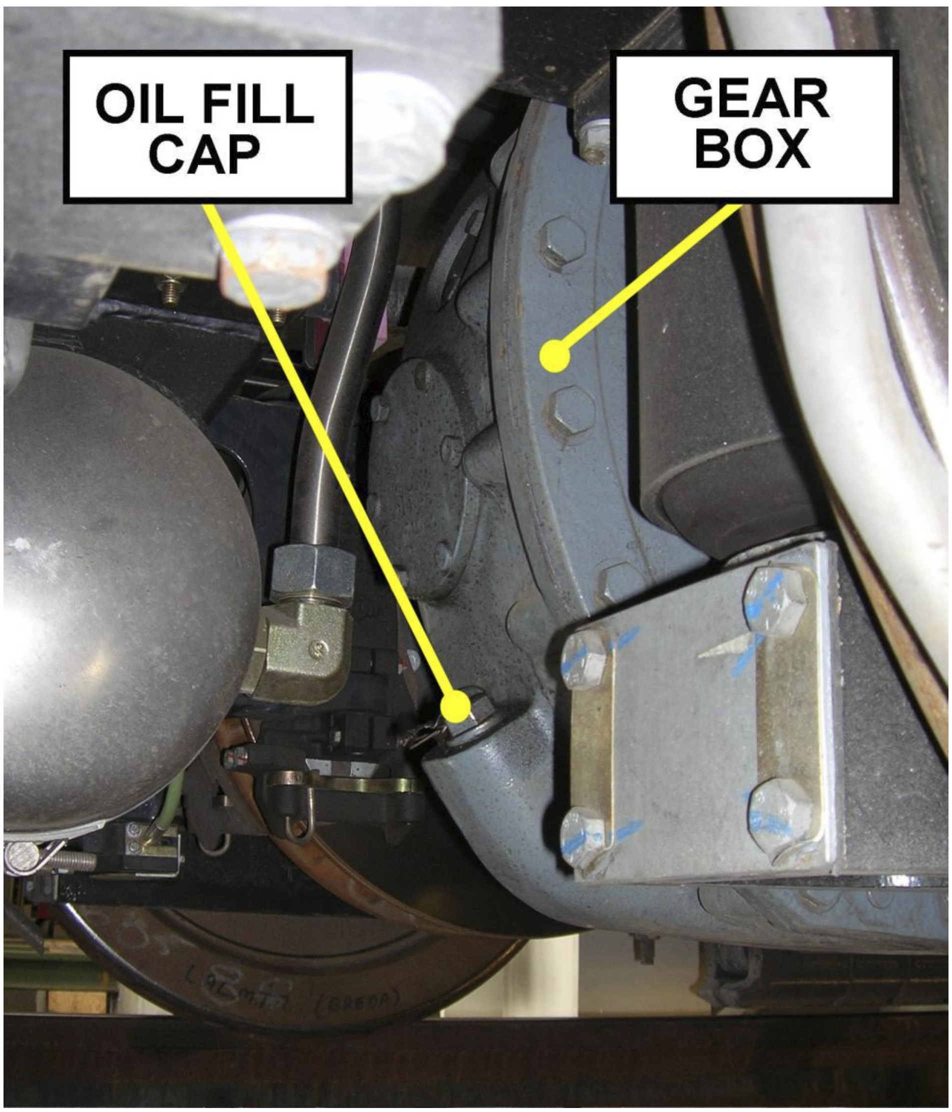


Figure 2 - GEAR UNIT - FILL OIL CAP

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **10,000**

PROCEDURE (CONT'D):

Figure 3 - GEAR UNIT - RED CIRCLE ON THE OIL GAUGE GLASS

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **10,000**

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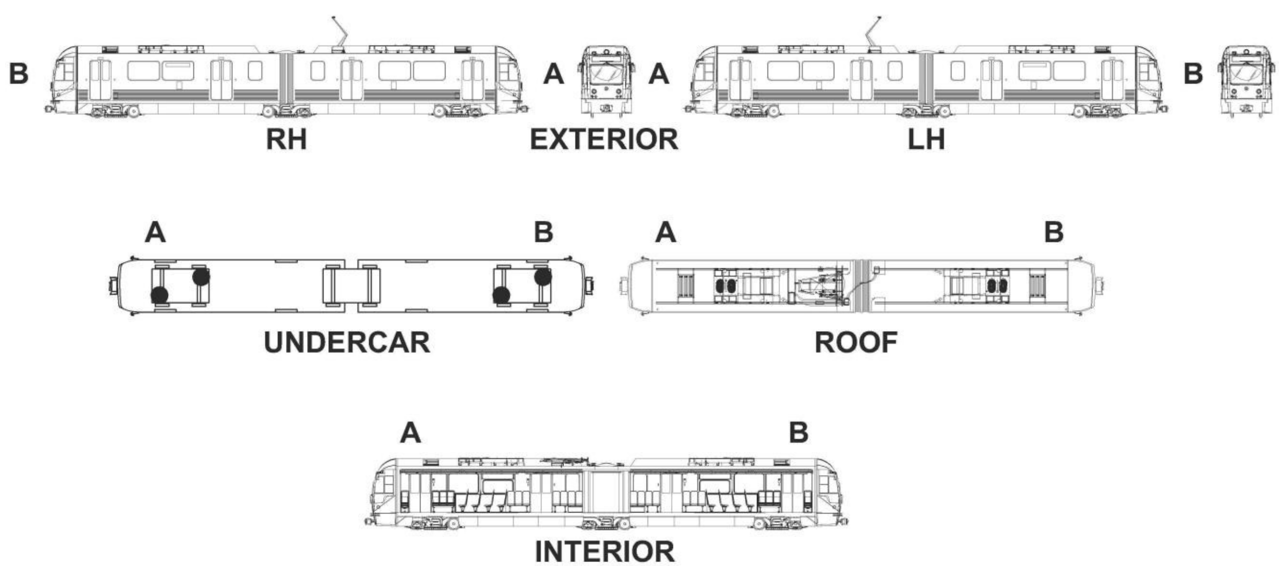
P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-01**	
System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **30,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-01**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **30,000**

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: BEFORE BEGINNING ANY WORK UNDER THE TRUCK, MAKE SURE THE TRACTION MOTOR NEAR THE GEARBOX IS DE-ENERGIZED. BEFORE BEGINNING ANY WORK ON THE DRIVE UNITS, MAKE SURE THAT NEITHER THE VEHICLE NOR THE TRUCK OR THE WHEEL SET CAN MOVE.

WARNING: THE DRAINED OIL MAY BE VERY HOT.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

CAUTION: OIL DRAINING FOR EXAMINATION SHOULD BE CARRIED OUT WHEN THE GEAR IS WARM (I.E. IMMEDIATELY AFTER RETURN FROM SERVICE), BECAUSE WARM OIL DRAINS MORE EASILY AND DIRT PARTICLES ARE RINSED OUT WITH THE OIL.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX. ONLY USE THE SPECIFIED TYPE OF OIL.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Hand Pump

CONSUMABLES:

OIL: Mobilube SHC 75W90-LS
CLEANING AGENTS:
Solvent naphtha
Pentex 2000 / Fa. Pentol AG
Aral 4005
MPA / Fa. Herberts, D-42202 Wuppertal
Rivolta MTX

SPARE PARTS:

Copper Ring (DIN7603-Cu-A27x32)

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-01**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **30,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

SERVICE

(refer to Figure 1 and 2)

Oil Examination

NOTE: Perform the task for all Gear Boxes of the First Vehicle.

NOTE: The final interval of Oil Change can be determined on the basis of the results of the oil Analysis.

To perform the task proceed as follows:

1. Cut through the Retaining Wire (67) of the Oil Fill Cap (40) and remove the Wire.

2. Clean the area around the Oil Fill Cap (40); using recommended agent.

3. Unscrew the Oil Fill Cap (40) and remove the Copper Ring (46).

4. Take a sample of 6.1 cubic inches from the Oil in the Gearbox using suitable hand pump.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX. ONLY USE THE SPECIFIED TYPE OF OIL.

5. Clean the Oil Fill Cap (40) using recommended agent.

6. Fill new Oil in the Gearbox with the same quantity as the sample.

7. Insert the Oil Fill Cap (40) in the Housing with a New Copper Ring (46) and tighten to **58.8 ft-lb**.(80 Nm.).

8. Secure the Oil Fill Cap (40) with the Retaining Wire (67).

9. Make available for Test Examination the sample of oil that was drained.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-06-01-00/S-01**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **30,000**

PROCEDURE (CONT'D):

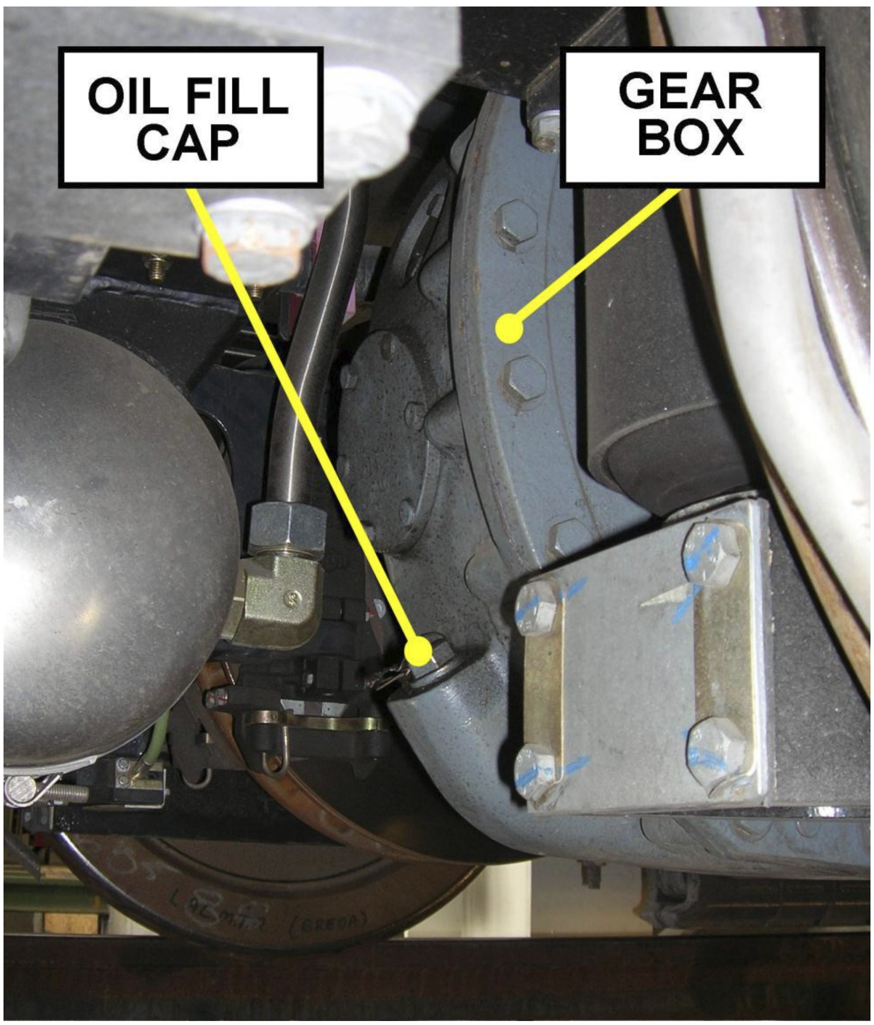


Figure 1 - GEAR UNIT - FILL OIL CAP

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-01**

System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):

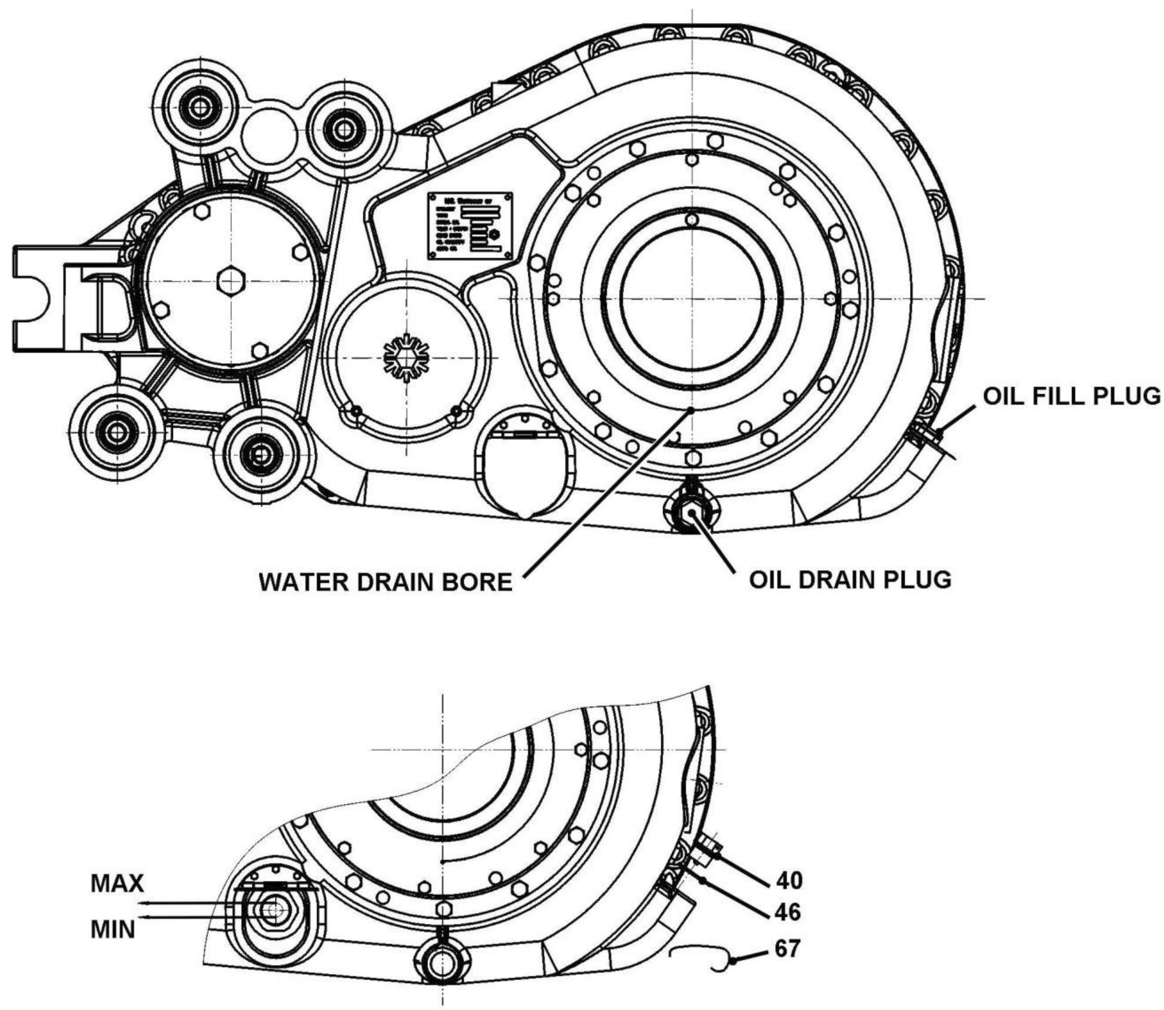


Figure 2 - GEAR UNIT - OIL EXAMINE

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-01**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **30,000**

PROCEDURE (CONT'D):

10. Add to each Oil sample the following Label filled with relevant data.

LACMTA P2550 LRV	
Reference Number Sample	
Date Of Sample Taking	
Serial Number Gearbox	
Running Distance Examined Gearbox	
Vehicle Number.	

11. Send the sample of the Oil to.

MC Watteeuw NV
attn. Engineering Department
Kampveldstraat
51 8020
Oostkamp Belgium -
Europe

12. Restore the Electrical Power.

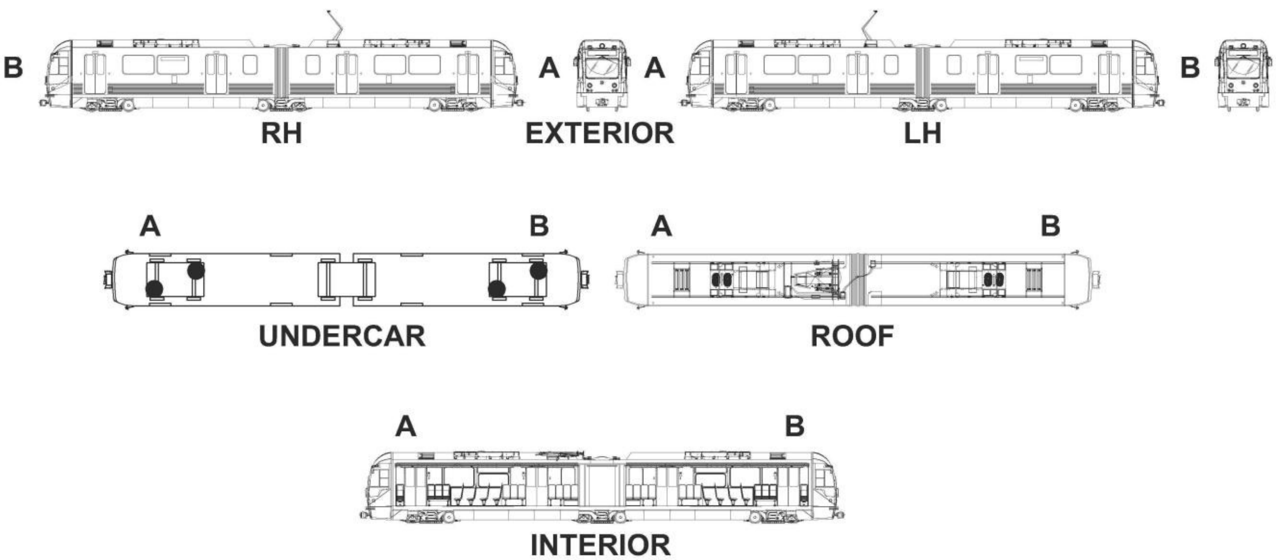
13. Record Inspection results on the Defect Report Card for administrative and maintenance planning.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-06-01-00/S-02

System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-06-01-00/S-02

System:	Sheet:
PROPULSION	**2/8**

Subsystem/Assy:	Unit:
GEARBOX ASSY	**GEARBOX**

Component:	Man Hours:
	1

Maintenance Task:	Interval/Miles:
SERVICE	**60,000**

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: BEFORE BEGINNING ANY WORK UNDER THE TRUCK, MAKE SURE THE TRACTION MOTOR NEAR THE GEARBOX IS DE-ENERGIZED. BEFORE BEGINNING ANY WORK ON THE DRIVE UNITS, MAKE SURE THAT NEITHER THE VEHICLE NOR THE TRUCK OR THE WHEEL SET CAN MOVE.

WARNING: THE DRAINED OIL MAY BE VERY HOT.

CAUTION: OIL CHANGE SHOULD BE CARRIED OUT WHEN THE GEAR IS WARM (I.E. IMMEDIATELY AFTER RETURN FROM SERVICE), BECAUSE WARM OIL DRAINS MORE EASILY AND DIRT PARTICLES ARE RINSED OUT WITH THE OIL.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX. ONLY USE THE SPECIFIED TYPE OF OIL.

CAUTION: THE GEARBOX MUST NOT OPERATE WITHOUT OIL..

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

OIL: Mobilube SHC 75W90-LS or equivalent

CLEANING AGENTS:
Solvent naphtha
Pentex 2000 / Fa. Pentol AG
Aral 4005
MPA / Fa. Herberts, D-42202 Wuppertal
Rivolta MTX

ITEMS:
Retaining Wire

SPARE PARTS:

Copper Ring (DIN7603-Cu-A27x32)

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-06-01-00/S-02**
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS:

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

OIL CHANGE

(refer to fig. 1 through 3)

To perform Oil change proceed as follows:

1. Clean the area around the magnetic Oil Drain Cap (40) and remove Drain Cap (40) and the Copper Ring (46).

2. Examine the magnetic Oil Drain Cap (40) for dirt. Fine dust is normal. If metal chips are found then inform your supervisor (the Gearbox should be inspected more closely).

3. Clean the magnetic Oil Drain Cap (40) and install the magnetic Oil Drain Cap (40) with a new Copper Ring (46), torque to **58.8 ft-lb** (80 Nm).

4. Install Safety Wire and Drain Cap.

5. Clean the area around the magnetic Oil Fill Cap (40) and remove the Oil Fill Cap (40) and the Copper Ring (46).

6. Examine the magnetic Oil Fill Cap (40) for dirt. Fine dust is normal. If metal chips are found then, the Gearbox should be inspected more closely.

7. Clean the Oil Fill Cap (40).

8. Pour in 5.0 liter of oil (0.5 liter oil rests in the gearbox after draining), there is now a total of 5.5 liter oil in the Gearbox.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX.
ONLY USE THE SPECIFIED TYPE OF OIL.

CAUTION: THE GEARBOX MUST NOT OPERATE WITHOUT OIL.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-01-00/S-02**			
System: **PROPULSION**			Sheet: **4/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**		
Component:			Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **60,000**	

PROCEDURE (CONT'D):

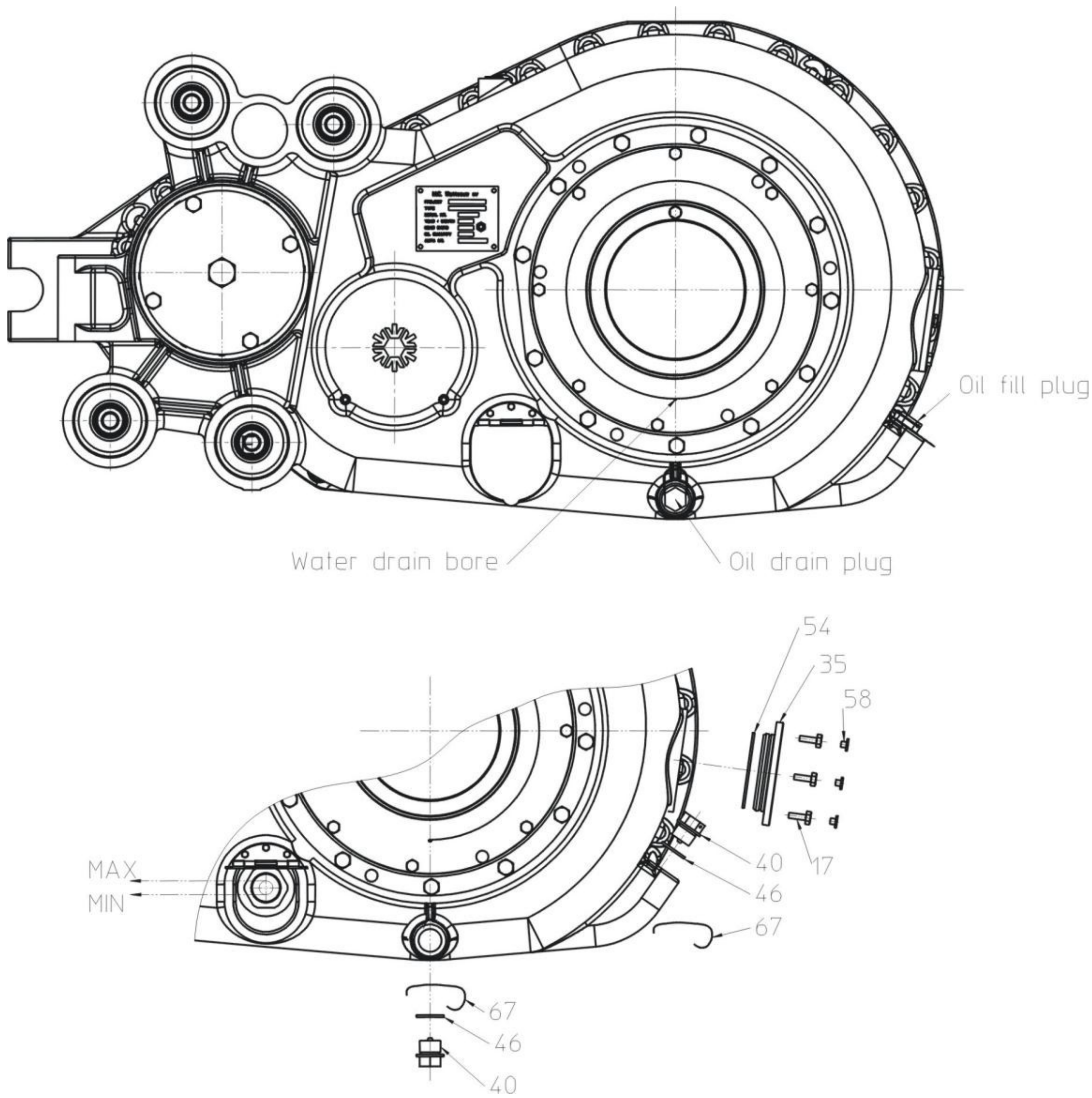


Figure 1 - GEAR UNIT - OIL CHANGE/REFILL

P2550 PREVENTIVE MAINTENANCE SHEET

		Card Code: **R-P-07-06-01-00/S-02**
System: **PROPULSION**		Sheet: **5/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

9. Check the Oil Level. Therefore, take a closer look at the Oil Gauge Glass. The Oil Level has to be at the maximum, this means at the top of the Red Circle on the Oil Gauge Glass.

NOTE: After driving, the fixed Oil Capture Device is filled up again and the Oil Level has to stay between the Minimum and the Maximum, marked by a Red Circle on the Oil Gauge Glass.

NOTE: Too much Oil in the Gearbox is just as harmful as too little oil.

10. Install Filling Cap with a new Copper Ring and torque to **58.8 ft-lb** with Safety Wire..

11. Restore Power.

OIL EXAMINATION

NOTE: This task should be performed ONLY FOR VEHLICLE UNDER MTA MONITORING

1. Take a sample of 6.1 cubic inches from the Oil drained from Gearbox using suitable Hand Pump.
2. Make available for Test Examination the sample of oil that was drained.
3. Add to each Oil sample the following Label filled with relevant data.

LACMTA P2550 LRV	
Reference Number Sample	
Date Of Sample Taking	
Serial Number Gearbox	
Running Distance Examined Gearbox	
Vehicle Number.	

4. Send the sample of the Oil to:

MC Watteeuw NV
attn. Engineering Department
Kampveldstraat 51 8020
Oostkamp Belgium - Europe

5. Record tasks results on the Defect Report Card for administrative and maintenance planning.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-06-01-00/S-02**		
System: **PROPULSION**		Sheet: **6/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

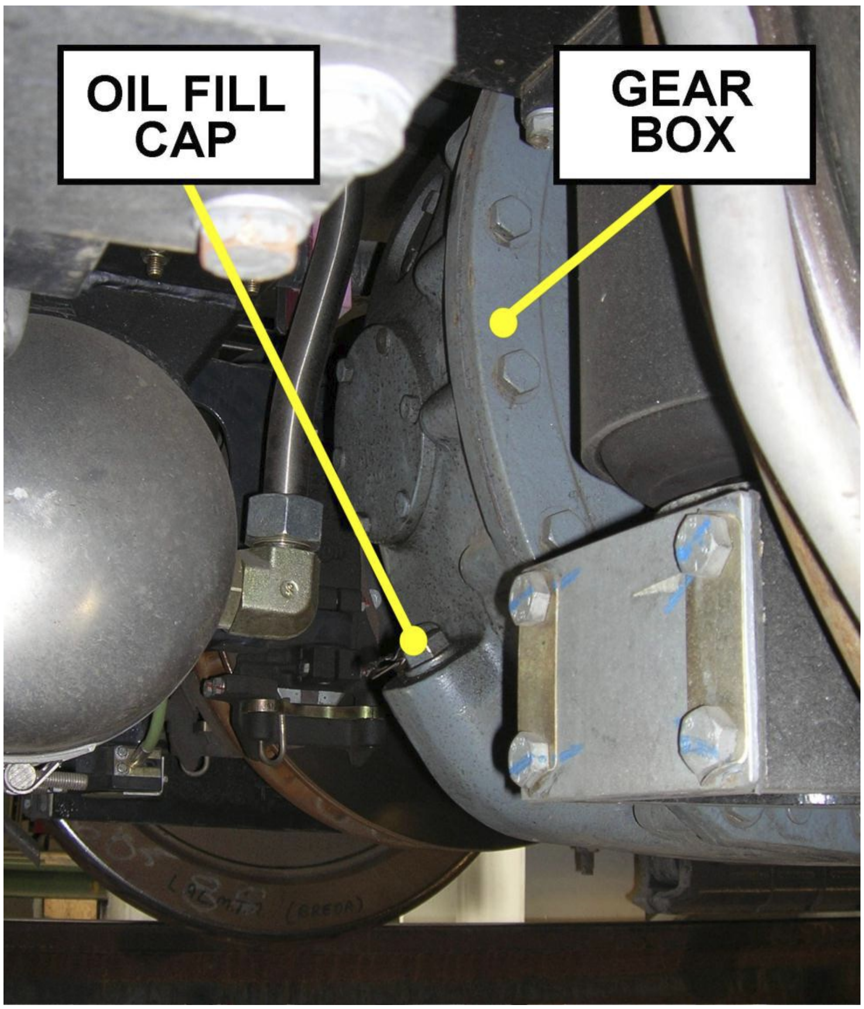


Figure 2 - GEAR UNIT - FILL OIL CAP

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-06-01-00/S-02**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

Figure 3 - GEAR UNIT - RED CIRCLE ON THE OIL GAUGE GLASS.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-06-01-00/S-02**		
System: **PROPULSION**		Sheet: **8/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **60,000**

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P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-06-02-00/S-00

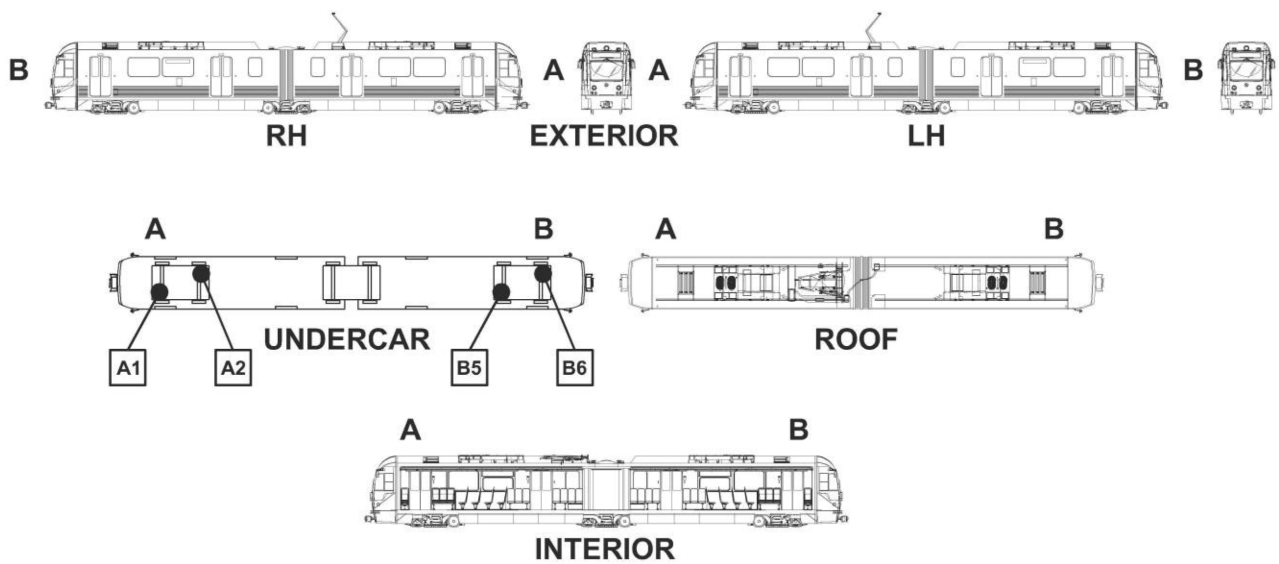
System:	Sheet:
PROPULSION	**1/6**

Subsystem/Assy:	Unit:
GEARBOX ASSY	**COUPLING**

Component:	Man Hours:
	1

Maintenance Task:	Interval/Miles:
SERVICE	**120,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-02-00/S-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **COUPLING**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **120,000**

SAFETY PRECAUTIONS:

WARNING: BEFORE BEGINNING ANY WORK UNDER THE TRUCK, MAKE SURE THE TRACTION MOTOR NEAR THE GEARBOX IS DE-ENERGIZED.

BEFORE BEGINNING ANY WORK ON THE DRIVE UNITS, MAKE SURE THAT NEITHER THE VEHICLE NOR THE TRUCK OR THE WHEEL SET CAN MOVE.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE HALF COUPLING.

ONLY USE THE RECOMMENDED TYPE OF GREASE.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

Grease Gun

CONSUMABLES:

Grease Type:Texaco Coupling Grease, as needed

SPARE PARTS:

Sealing Ring (A10 X 14 DIN 7603-Cu) (P/N M5351014003) QTY =8

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-06-02-00/S-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **COUPLING**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **120,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

SERVICE

Grease Examination

To perform the task proceed as follows:

(Refer to Figures 1and 2):

NOTE: Perform the task only for 2 Couplings per Vehicle according to the following Table.

COUPLING IDENTIFICATION		GREASE EXAMINATION
MOTOR TRUCK	AXLE	MILES
A	A1	120,000
B	B5	120,000
A	A2	240,000
B	B56	240,000

NOTE: The final interval of grease change can be determined on the basis of the results of the grease analysis.

1. Locate the Coupling selected for Grease Examination

2. Clean the area around the two (2) Half Coupling Screw Plugs at Coupling Gear Unit Side; using recommended agent.

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-06-02-00/S-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **COUPLING**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **120,000**

PROCEDURE (CONT'D):

3. Remove the two (2) Half Coupling Screw Plugs (at Coupling Gear Unit Side).

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE HALF COUPLING.
ONLY USE THE RECOMMENDED TYPE OF GREASE.

4. Remove the Sealing Rings from Screw Plugs and discard.

5. Connect a Grease Gun, provided with suitable extension, to the Half Coupling Upper Filler Hole.

NOTE: When using a Grease Gun or similar Lubrication Device, release a small amount of grease and wipe the tip of the applicator with a clean rag or paper towel before servicing the Coupling, to remove any contaminant.

6. Position under the Half Coupling Lower Filler Hole a suitable Test Tube (Cubic inch Graduated) (min capacity 1 cubic inch).

7. Inject recommended grease into the Upper Filler Hole in quantity suitable to eject from the Lower Filler Hole 0.6 cubic inch (minimum quantity) of grease.

NOTE: Remove grease excess using cleaning rag.

8. Apply the relevant Cap to the Test Tube to prevent grease contamination and record onto the Test Tube Label the selected Half Coupling identification according to the previous Coupling identification.

9. Clean accurately both the Half Coupling Screw Plugs using recommended agent.

10. Install new and clean Sealing Rings on relevant Screw Plugs.

11. Tighten Screw Plugs to **30 ft-lb.**

12. Repeat steps 1 through 11 for the other Half Coupling at Traction Motor Gear Unit Side.

13. Make available for Test Examination both Half Coupling Grease Samples.

14. Record task results on the Defect Report Card for administrative and maintenance planning.

15. Restore Electrical Power.

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-06-02-00/S-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **COUPLING**
Component:	Man Hours: **1**
Maintenance Task: **SERVICE**	Interval/Miles: **120,000**

PROCEDURE (CONT'D):

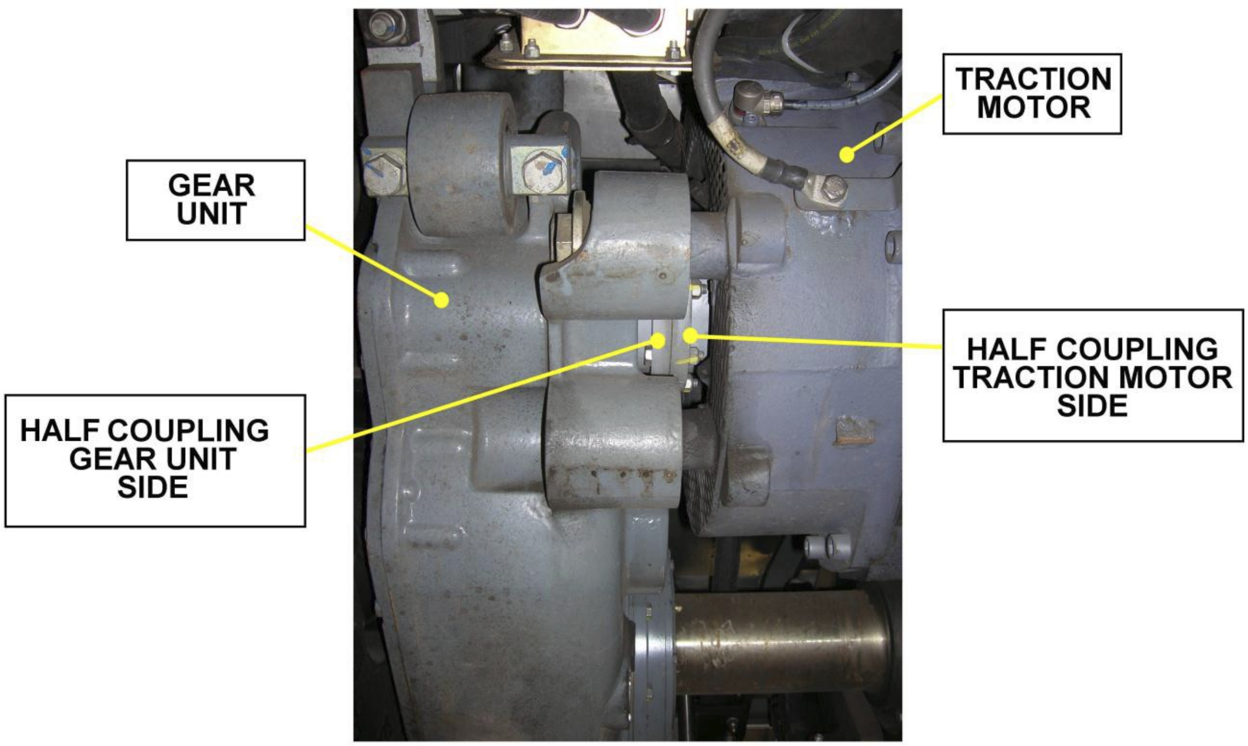


Figure 1 - COUPLING LOCATION

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-06-02-00/S-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **COUPLING**	
Component:		Man Hours: **1**
Maintenance Task: **SERVICE**		Interval/Miles: **120,000**

PROCEDURE (CONT'D):

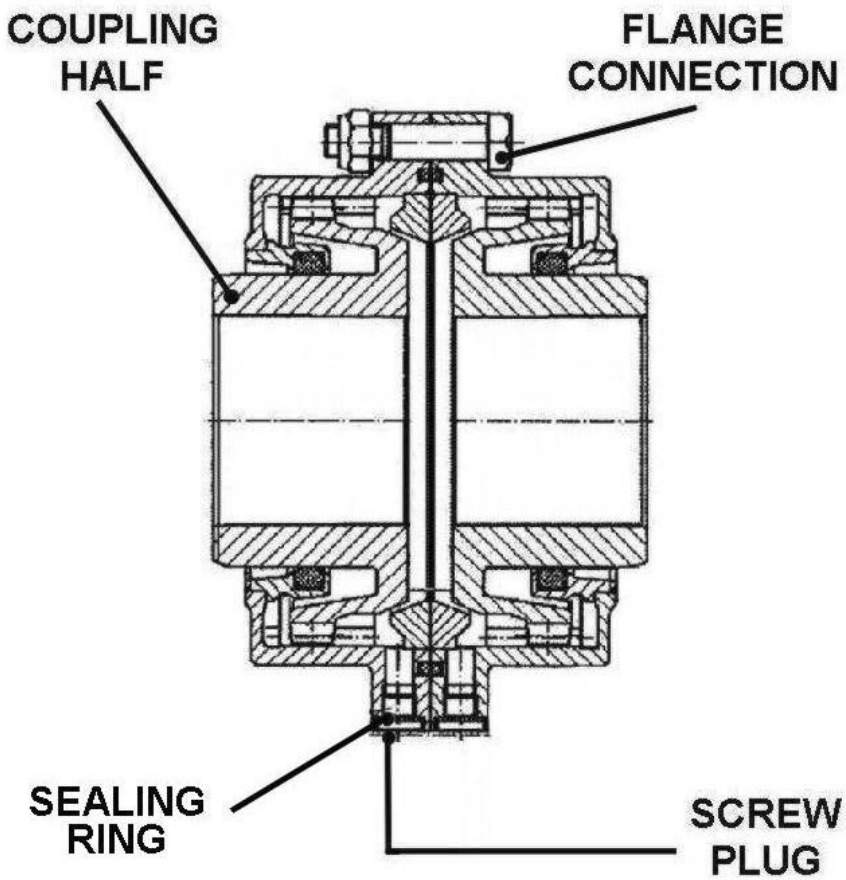
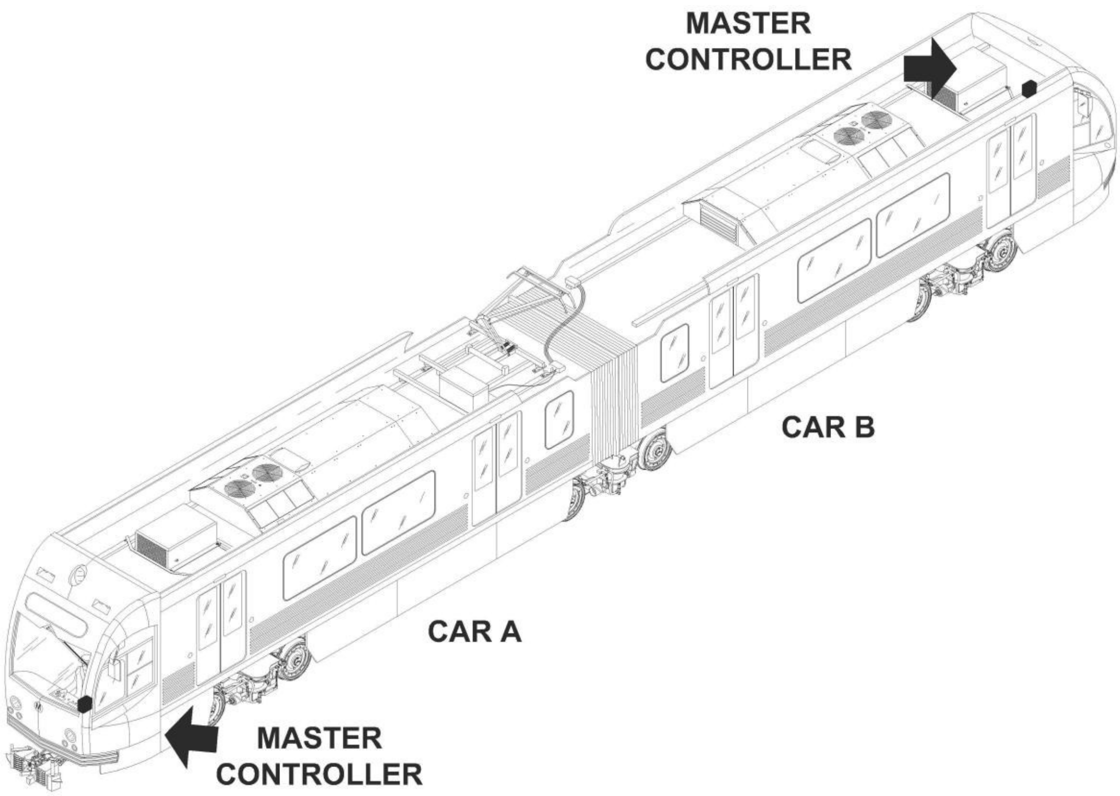


Figure 2 - COUPLING -

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-08-00-00/I-00**
System: **PROPULSION**	Sheet: **1/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

LOCATION:



P2550 PREVENTIVE MAINTENANCE SHEET

Card Code:
R-P-07-08-00-00/I-00

System:	Sheet:
PROPULSION	**2/10**

Subsystem/Assy:	Unit:
MASTER CONTROLLER	

Component:	Man Hours:
	0.5

Maintenance Task:	Interval/Miles:
INSPECTION	**60,000**

SAFETY PRECAUTIONS:

WARNING: **CONTACT WITH ENERGIZED ELECTRICAL PARTS CAN CAUSE PERSONAL INJURY. TO AVOID ACCIDENTS, KEEP HANDS, TOOLS (ETC.) AWAY FROM ANY ELECTRICAL PARTS, IF THE CIRCUIT NEEDS TO BE ENERGIZED FOR TESTING PURPOSES. IN ANY OTHER CASE, DE-ENERGIZE THE CIRCUIT.**

CAUTION: FOR THE INSTALLATION OF THE MICROSWITCHES EQUIPPED WITH ACTION ROLL PAY ATTENTION TO PLACE THE ROLLERS IN THE SAME POSITION PREVIOUSLY NOTED.

CAUTION: BE SURE THAT NO LUBRICANT GETS ON ANY OF THE MASTER CONTROLLER MICROSWITCH CONTACTS.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Small set of screw wrench.
Socket wrench.
Elbowed wrench.
Digital Multimeter.
Vacuum Cleaner.

CONSUMABLES:

GREASE TYPE:
Exxon BEACOM EP2 or equivalent, as needed
Exxon Multipurpose Grease MOLY or equivalent, as needed

SPARE PARTS:

MICROSWITCHES:

Type	with Roller	PN	S826A
Type	with Roller	PN	S847W2
Type	without Roller	PN	S800C

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-08-00-00/I-00**
System: **PROPULSION**	Sheet: **3/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Open the 3F18, 3F05 and 3F20 Circuit Breakers and place a tag on them.

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

INSPECTION

To perform the task proceed as follows (refer to Figures 1through 3):

1. Remove the Master Controller from the Cab Console and disconnect both the Power Supply Cable, Encoder Cable and the Ground Cable.

2. Check the Cams for damage / missing loose parts and correct positions.

3. Inspect the Master Controller components for visible damage / missing /loose parts.

4. Move the Master Controller Handle to verify that it can be moved freely and that it is momentarily retained by the notches in the seven traction/braking positions (SCEB, HRSB, FSB, Min Braking, COAST, Min Power, Max Power).

5. Move the Transfer Switch and the Reverser Switch to verify that they can be moved freely and that they are retained by the notches in the three relevant positions (ON, LOCAL, OFF and FWD, NEUTRAL, REVERSE).

6. Verify all the mechanical interlocks for the Reverser Switch and the Transfer Switch and the Master Controller Handle.

7. Check wiring for loose terminals, connections and signs of burns.

8. Check grounding cable, terminal and relevant connection for visible damage / missing /loose parts /signs of overheating.

9. Check each Microswitch for damage /missing loose parts /signs of overheating, repair/replace as needed.

CAUTION: FOR THE INSTALLATION OF THE MICROSWITCHES EQUIPPED WITH ROLLER PAY ATTENTION TO PLACE THE ROLLER IN THE SAME POSITION PREVIOUSLY NOTED.

10. Check master controller adjustment for correct energize dead man switch.

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-08-00-00/I-00**	
System: **PROPULSION**	Sheet: **4/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

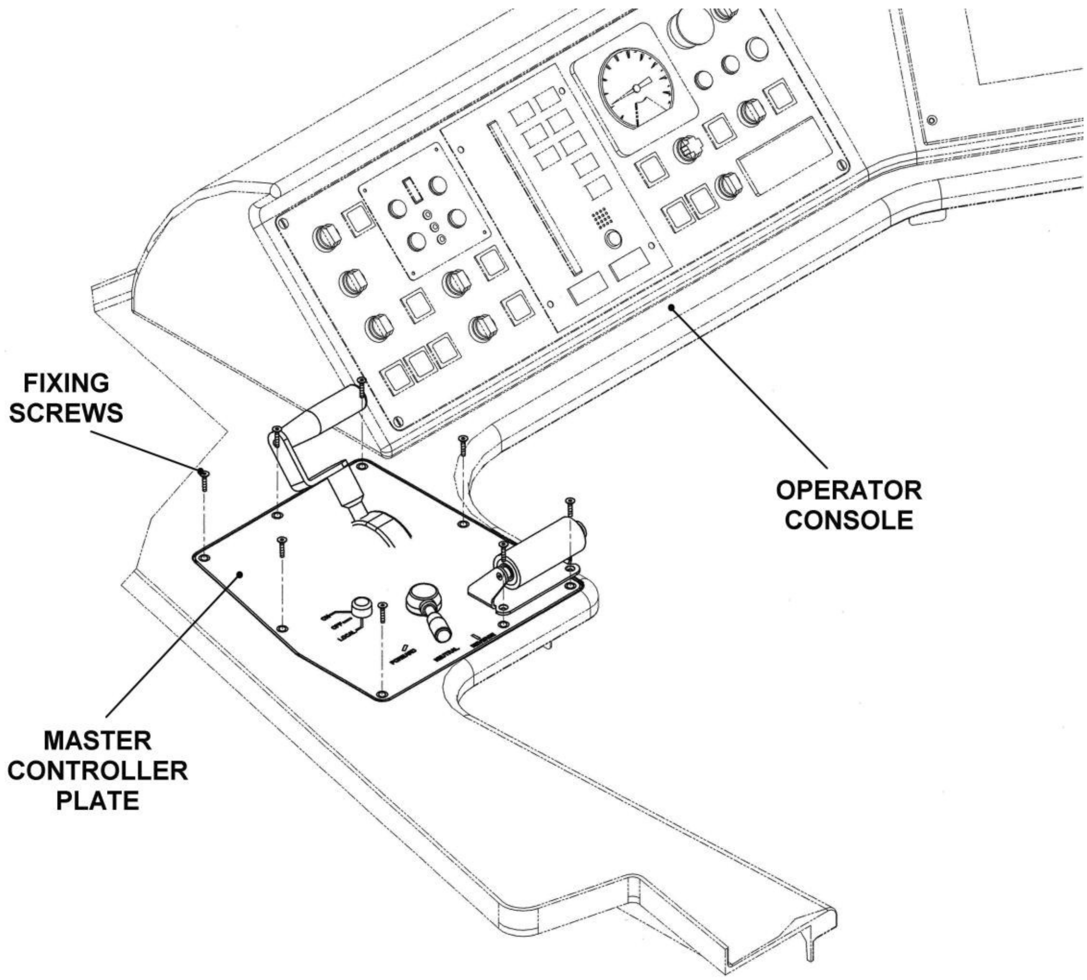


Figure 1 - MASTER CONTROLLER - REMOVAL

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-08-00-00/I-00**
System: **PROPULSION**	Sheet: **5/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

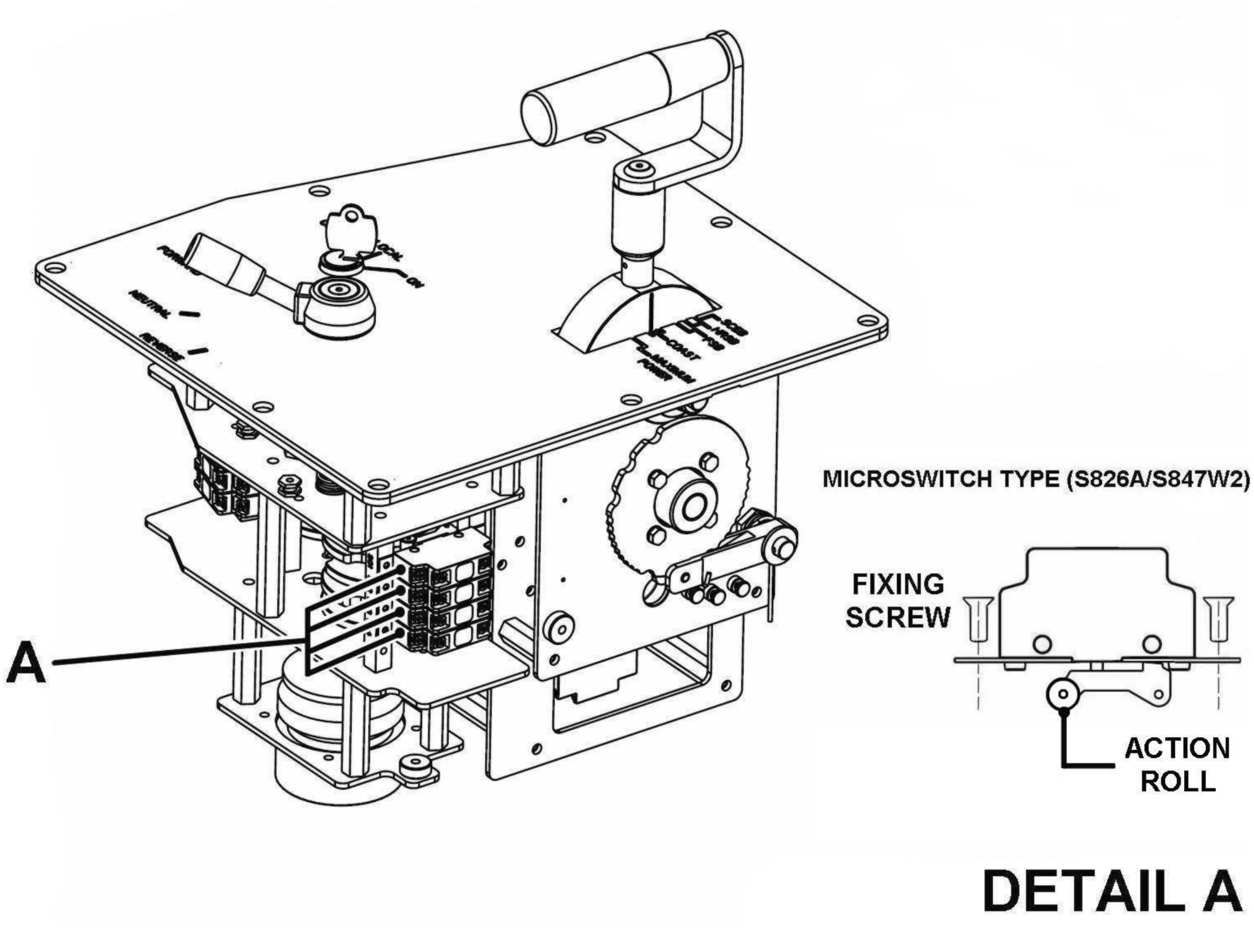


Figure 2 - MC - MICROSWITCHES WITH ROLLER

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-08-00-00/I-00**		
System: **PROPULSION**		Sheet: **6/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:	
Component:		Man Hours: **0.5**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

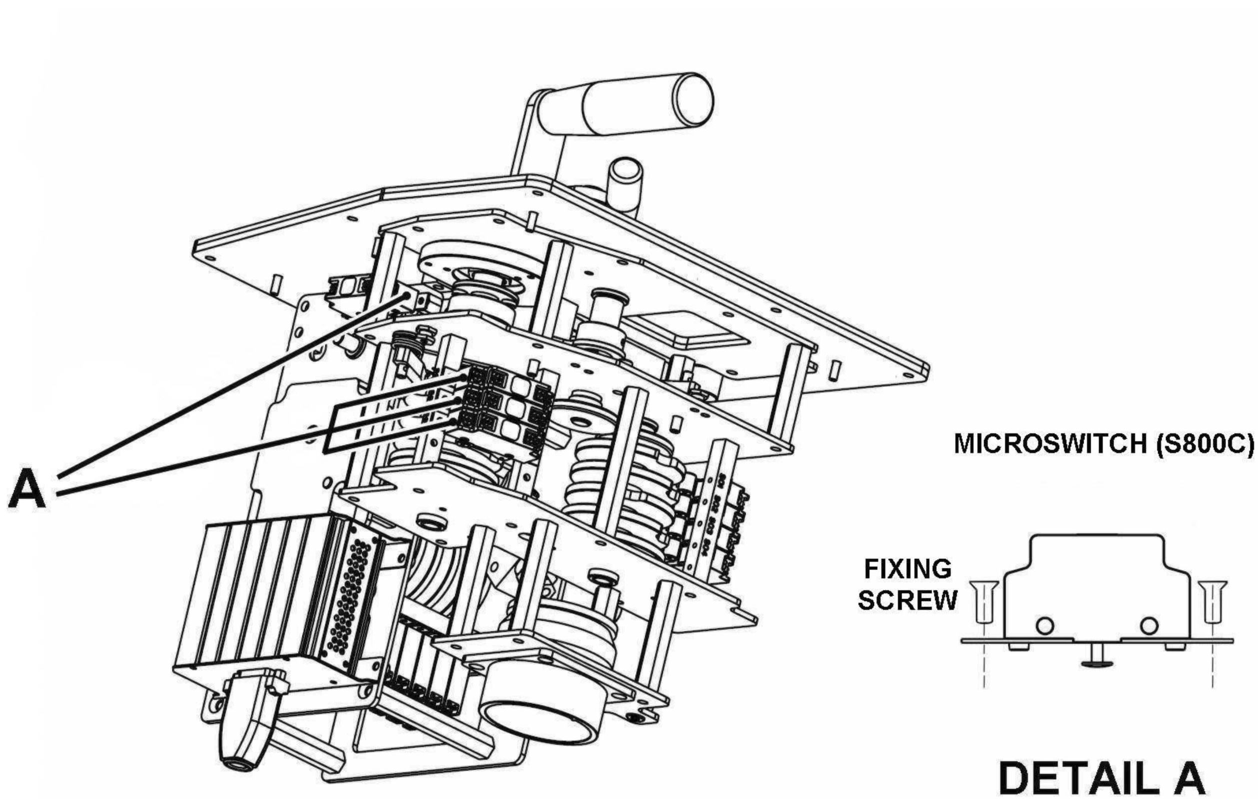


Figure 3 - MC - MICROSWITCHES WITHOUT ROLLER -

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-08-00-00/I-00**
System: **PROPULSION**	Sheet: **7/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

LUBRICATION

(Refer to Figure 4)

To perform the task proceed as follows:

CAUTION: BE SURE THAT NO LUBRICANT GETS ON ANY OF THE MASTER CONTROLLER MICROSWITCH CONTACTS.

1. Clean the Microswitches and the mechanical parts.

2. Lubricate the mechanical (movable) items such as gears position indicators etc.

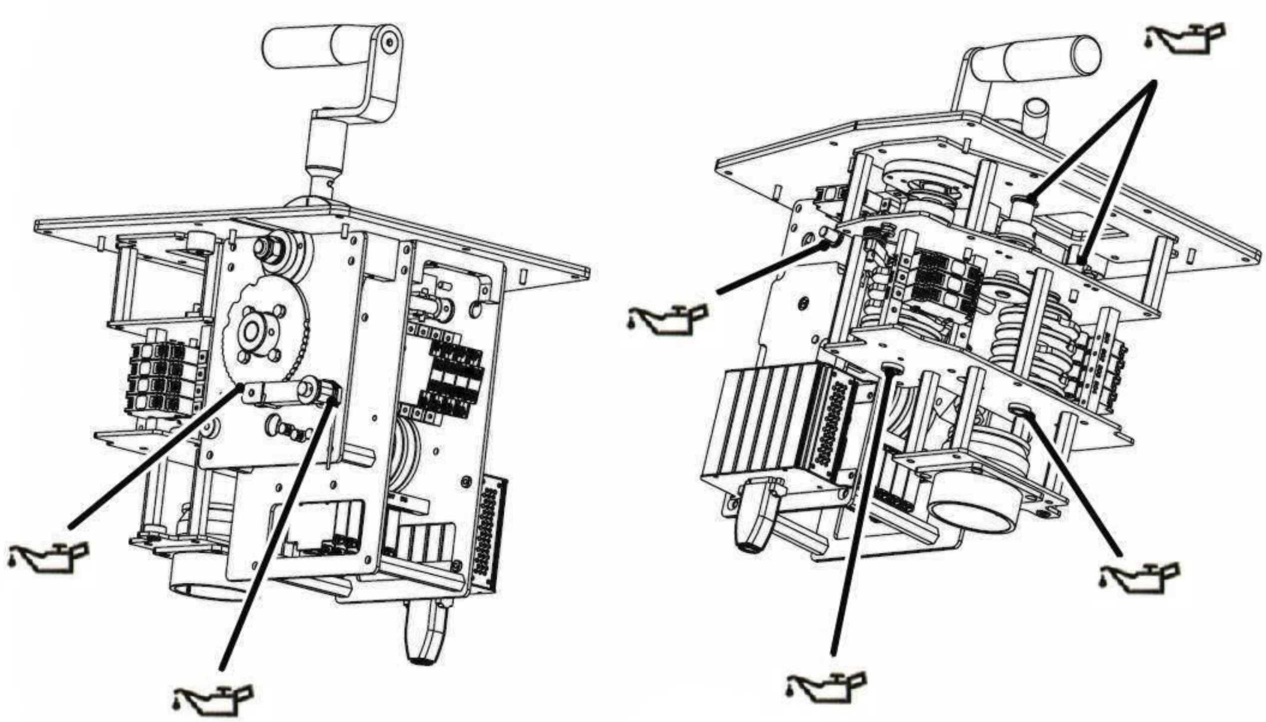


Figure 4 - MASTER CONTROLLER - LUBRICATION CHART

P2550 PREVENTIVE MAINTENANCE SHEET		
Card Code: **R-P-07-08-00-00/I-00**		
System: **PROPULSION**		Sheet: **8/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:	
Component:		Man Hours: **0.5**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

PROCEDURE (CONT'D):

ADJUSTMENT

To perform the task proceed as follows (Refer to Figures 5 and 6):

1. Place the Transfer switch in "ON" position.

2. Place the Master Control Handle in "COAST" position.

4. Apply an External Power Supply 37.5 VDC to the Encoder through the Encoder Connector pins 15 (+) and 1 (-).

5. Connect a Digital Multi Meter to output signal (pin 8 (-) and pin 13 (+)) of Encoder Connector.

6. Rotate the Adjustment Screw, using flat head screwdriver, to obtain 12 mA (+/- 0.3 mA) on Multi Meter Display.

7. Put the Master Controller in “FSB” and verify that the output is 4 +/- 0.3 mA.

8. Put the Master Controller in “MAX POWER” and verify that the output is 20 +/- 0.5 mA

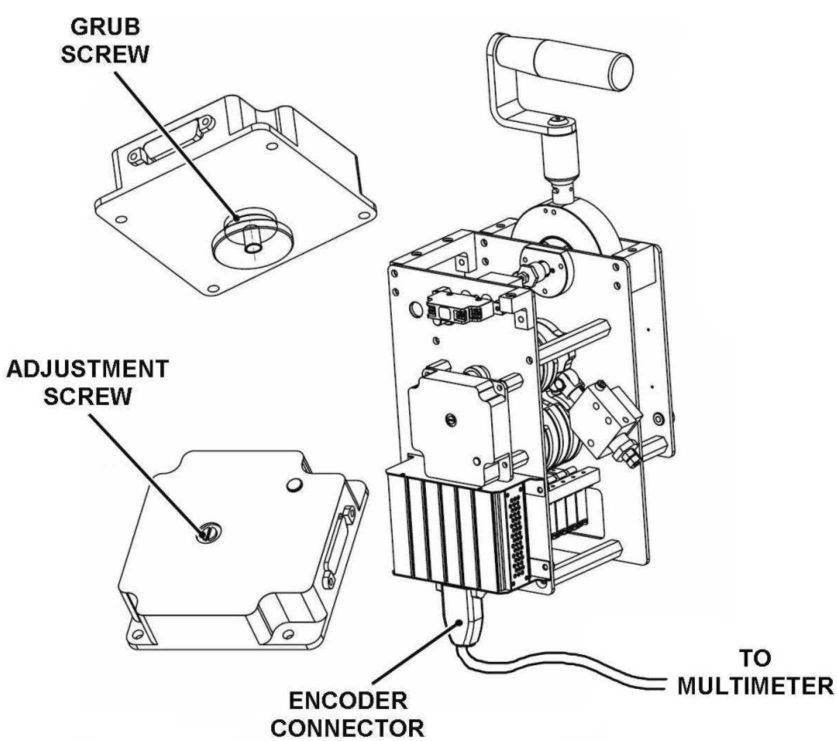


Figure 5 - MASTER CONTROLLER - ADJUSTMENT

P2550 PREVENTIVE MAINTENANCE SHEET

	Card Code: **R-P-07-08-00-00/I-00**
System: **PROPULSION**	Sheet: **9/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:
Component:	Man Hours: **0.5**
Maintenance Task: **INSPECTION**	Interval/Miles: **60,000**

PROCEDURE (CONT'D):

9. Set the Master Controller Handle to FSB position and Transfer Switch to OFF position.

10. Remove the external Power Supply 37.5 VDC.

FINAL OPERATIONS

1. Reinstall the Master Controller on its position, paying attention to not damage components / connections and reconnect the Electric Cables.

2. Restore Electrical Power.

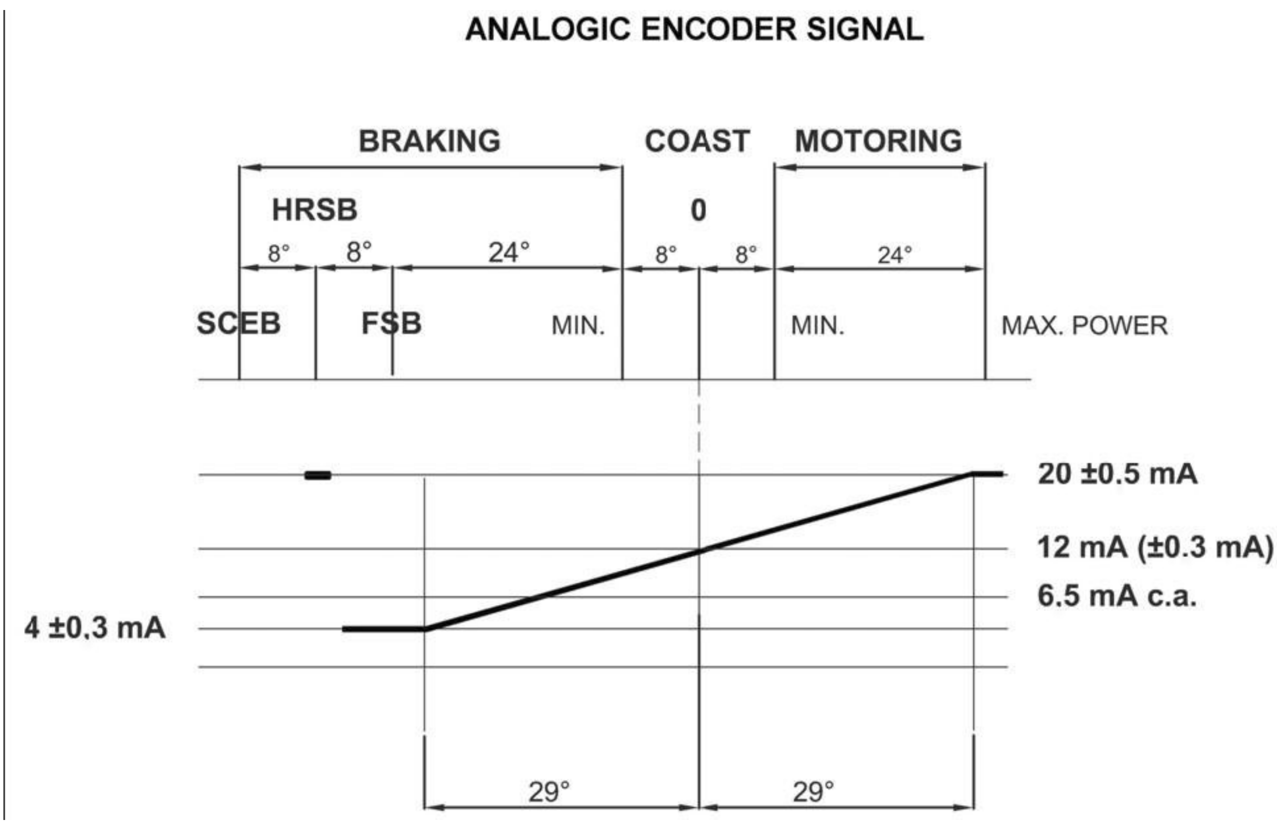


Figure 6 - MASTER CONTROLLER - RATE REFERENCE

P2550 PREVENTIVE MAINTENANCE SHEET

Card Code: **R-P-07-08-00-00/I-00**		
System: **PROPULSION**		Sheet: **10/10**
Subsystem/Assy: **MASTER CONTROLLER**	Unit:	
Component:		Man Hours: **0.5**
Maintenance Task: **INSPECTION**		Interval/Miles: **60,000**

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07-III-05 RUNNING -CORRECTIVE MAINTENANCE

07-III-05.01 Running -Corrective Maintenance Sheets (R-CMS)

Each R-CMS provides the following data consistent with Corrective Maintenance Analysis (CMA), AB Design Documentation and Vehicle Systems Functional Tree:

- **R-CM Sheet Code**
- **SYSTEM, SUBSYSTEM /ASSEMBLY, UNIT, Component** (Names)
- **SYSTEM, SUBSYSTEM /ASSEMBLY, UNIT, Component** (Location)
- **Maintenance Task,**

The following definitions are applicable to the R-CM Tasks

Inspection:	Maintenance procedures such as those required to ascertain the serviceability of a Part, Assembly, System or the specific interrelationship of Parts that perform a functional operation.
Leveling:	Procedure to adjust the distance between the Vehicle Floor to the Top Of Rail and the designated Vehicle Height
Replacement:	Provides the Components / Assemblies and Subassemblies removal & installation in a logical sequential order.
Re-Profiling:	Provides the procedure to maintain the safe and proper "wheel profile".
Repair:	Provides detailed procedures for the repair of a specific Equipment / Component
Service:	Operation performed to replenish Sand, Windshield Wiper Washer Fluid, HVAC Coolant, Gear and Compressor Oil, and Vehicle Lubrication.

- **Man Hours,** needed to perform the Task
- **SPARE PARTS,** needed to perform the Task

Each

R-CMS provides also:

- **SAFETY PRECAUTIONS,** to be followed to safely accomplish the Task
- **TOOLS,** including Special Tools and Test Equipment, needed to accomplish the Task
- **CONSUMABLES,** required to accomplish the Task and consistent with those used by MTA
- **PROCEDURE,** consisting of Preliminary Operations and Procedural Steps, to be followed while performing Maintenance Tasks
- **Illustrations and Pictures** are inserted in the text to facilitate the understanding of the topics and/or to explain step-by-step procedure

Each R-CM Sheet refers to one Task and consists of several pages where Safety Precautions and Maintenance Instructions to perform safely the Task are provided by Procedural Steps in conjunction with Illustrations and Pictures.

07-III-05.01.01 Running- Corrective Maintenance Sheet (R-CMS) Form

The R-CMS Form (refer to Figure 07-III-05.1) consists of several fields containing the following data/ information:

RUNNING -CORRECTIVE MAINTENANCE SHEET (R-CMS) Form			
ITEM #	**TITLE**	**CONTENT**	**EXPLANATORY NOTES**
1	**Card code**	**Sheet code**	The Sheet Code is an alphanumerical code that identifies each R-CM Sheet. **THE SHEET CODE IS EXPLICIT** The Sheet Code consists of letters **R-C** followed by an 11 digit code number as follows: **R-C-**nn-mm-zz-ww/Y-kk **R = Running** **C= Corrective** **nn** may vary from 02 to 19, identifying the System/ Manual Section number. **mm-zz-ww** each one may vary from 00 to 99, according to AB System Functional Tree, allowing the identification of the Assembly/Unit/Component **Y** Maintenance Task Code. It may be one of the following: **I** = **I**nspection **LL** =**L**eveling **R** = **R**eplacement **RP**= **R**e-**P**rofiling **RR** = **R**epair **S** = **S**ervice **SP** = **S**afety **P**recautions **kk** It may vary from 00 to 99. It is a progressive number allowing the univocal identification of R-CMS **NOTE:** The code R-C-nn-00-00-00-R-kk identifies a Typical Replacement Procedure The Typical Replacement Procedure is provided for the following items: Board, Circuit Breaker, Diode, Indicator Lamp, Main Contactor,Switch & Relays..
2	**System**	**System name**	This field indicates the System to which the Assembly/Unit/Component belongs.
3	**Subsystem/ Assembly**	**Subsystem/ Assembly name**	This field indicates the Subsystem/Assembly to which the Unit/Component belongs.
4	**Unit**	**Unit name**	This field indicates the Unit to which the Component belongs.
5	**Component**	**Component name**	This field indicates the Component the Maintenance Task is referring to
6	**Maintenance Task**	**Maintenance Task name**	This field indicates the Maintenance Task to be performed.
7	**Man Hours**	**Number**	The Man Hour field indicates the time needed to perform the corresponding Maintenance Task. with the basic assumption that the Vehicle is staged on an Inspection Pit/Jacking tracks with the required Consumables, Tools and Materials available.

RUNNING -CORRECTIVE MAINTENANCE SHEET (R-CMS) Form (cont'd)			
ITEM #	**TITLE**	**CONTENT**	**EXPLANATORY NOTES**
8	**Sheet**	**Pages numbering**	This field indicates the progressive R-CMS sheet page number.
9	**LOCATION**	**Illustration**	This field indicates the On Board Location of the Equipment to be maintained The following Graphic Symbols are used for: Assembly/Unit/Component for System/Subsystem/Vehicle as a Whole
10	**R**	**Letter**	This field indicates that the Sheet pertains to Running Maintenance
11	**C**	**Letter**	This field indicates that the Sheet pertains to Corrective Maintenance
12	**nn**	**Number**	This field indicates the System/Manual Section number to which the Sheet pertains. It may vary from 01 to 19
13	**rr**	**Number**	This field indicates the Sheet Revision number
14	**Page ##**	**Page ##**	This field indicates the RMSM Section Page number
15	**-#**	**Number**	This field indicates the RMSM Section Revision number
16	**SAFETY PRECAUTIONS**	**Text**	This field presents the General and/or specific Safety Precautions to be followed to safely accomplish the relevant Maintenance Tasks.
17	**TOOLS**	**Text**	This field lists the description and the P/N of the Standard tools, Special Tools and Test Equipment needed to accomplish the Maintenance Task. Refer to the TTE Manual for the TE and Special Tools detailed descriptions and tools maintenance.
18	**CONSUMABLES**	**Text**	This field lists the Consumables Materials (consistent with those used by MTA with the related P/N.) needed to accomplish the Maintenance Task. Cleaning agents are included
19	**SPARE PARTS**	**Text**	This field lists the Description and PN of Spare Parts (consistent with Illustrated Parts Catalog) needed to accomplish the Maintenance Task.
20	**PROCEDURE**	**Text**	The Procedure field provides Preliminary Operations and Procedural step by step Instructions to be followed while performing the Maintenance Task. Illustrations and Pictures are inserted in the text to facilitate the understanding of the topics and/or to explain step-by-step procedure.

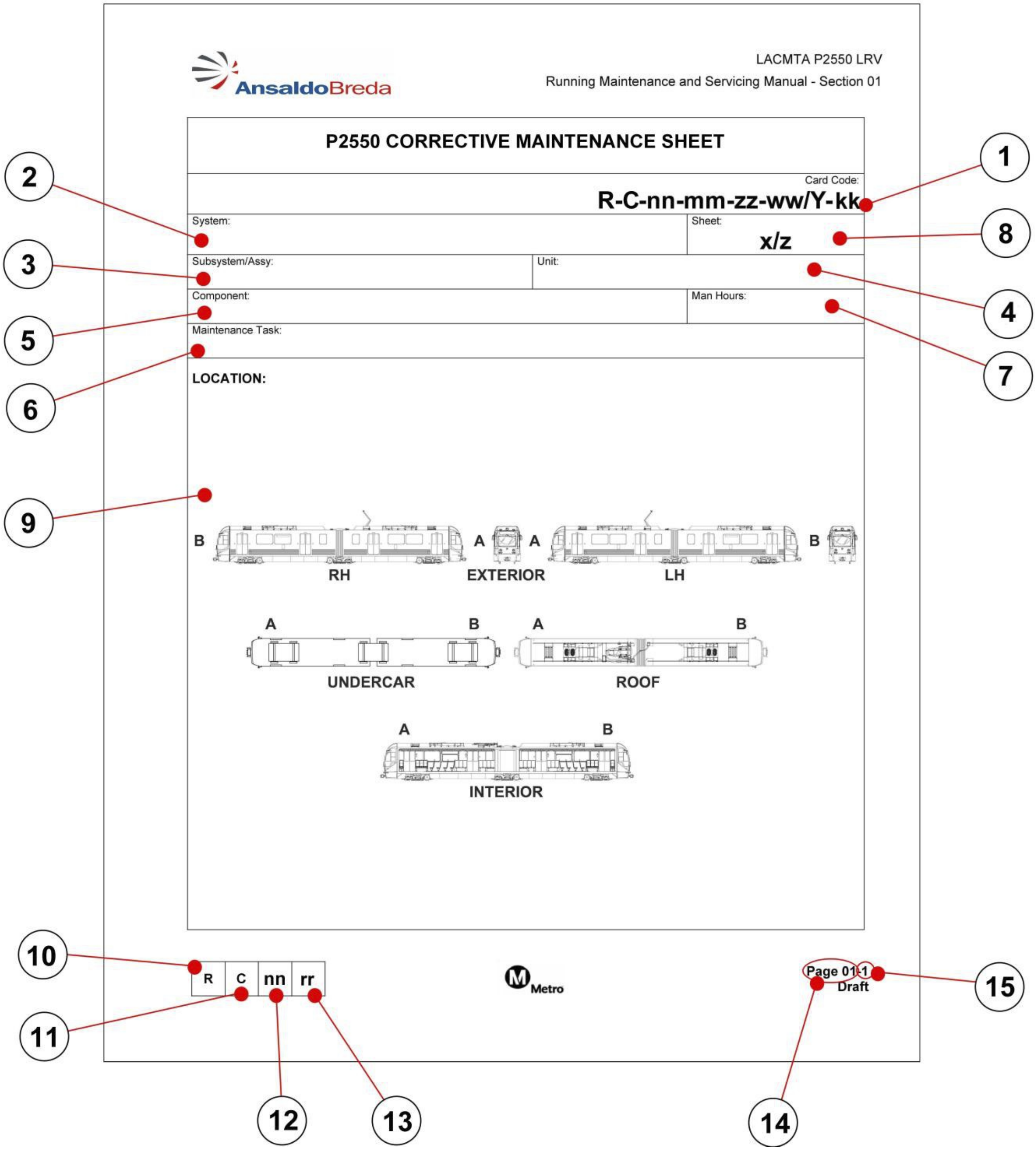
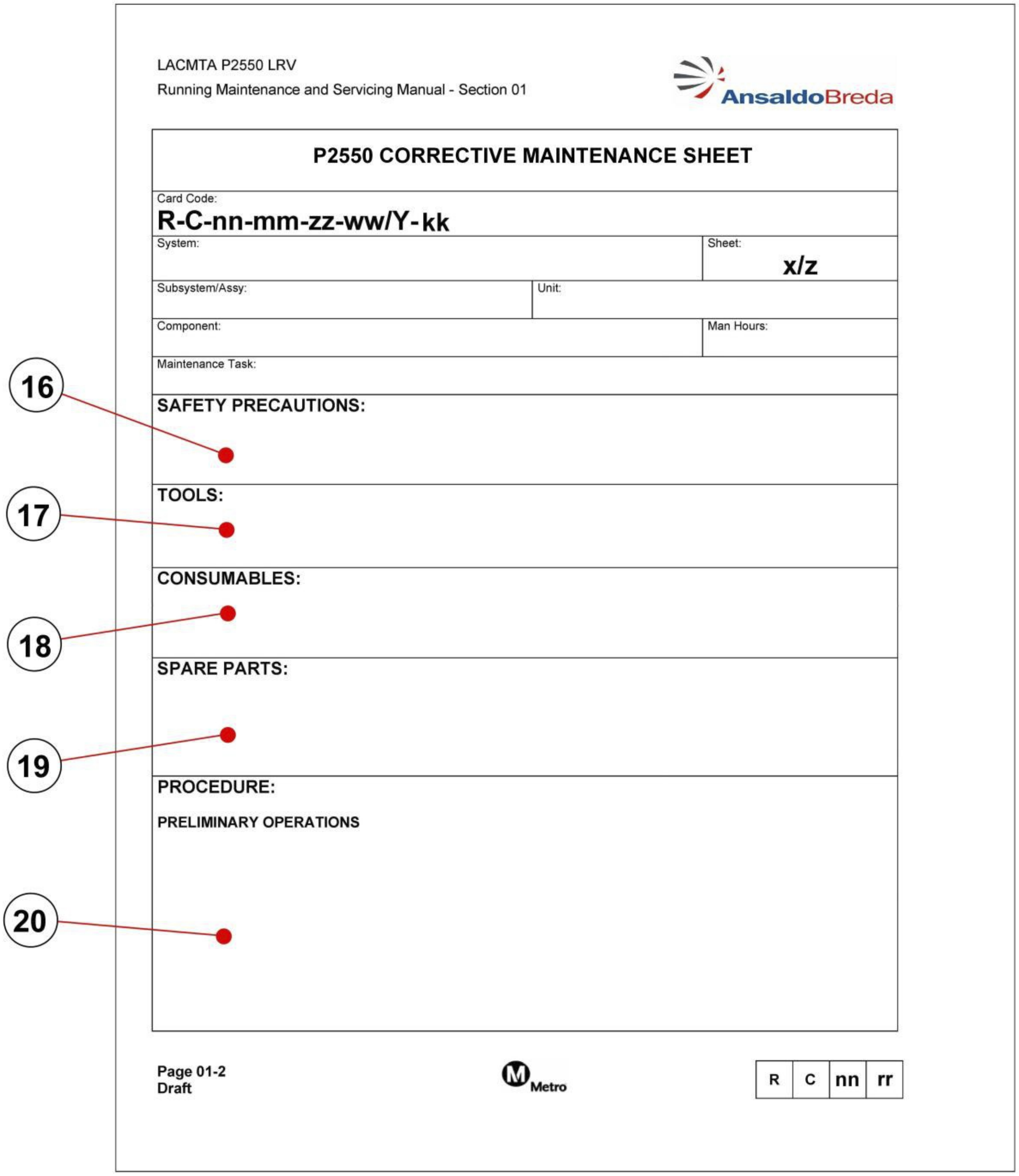


Figure 07-III-05.1 R-CMS Form
(Sheet 1 of 2)



LACMTA P2550 LRV
Running Maintenance and Servicing Manual - Section 01

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P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: R-C-nn-mm-zz-ww/Y-kk		
System:		Sheet: x/z
Subsystem/Assy:	Unit:	
Component:		Man Hours:
Maintenance Task:		
SAFETY PRECAUTIONS:		
TOOLS:		
CONSUMABLES:		
SPARE PARTS:		
PROCEDURE: PRELIMINARY OPERATIONS		

Page 01-2
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**Figure 07-III-05.1 R-CMS Form
(Sheet 2 of 2)**

07-III-05.01.02 How to Use the R-CM Sheets

To optimize the job organization it is suggested to proceed as follows:

1. Before Task Execution

a) Read accurately the Sheet to fully knowledge the provided Data /Instructions

b) Particularly read

- The Safety Precautions to perform safely the Task
- The Preliminary Operations to set the Vehicle in safety conditions according to MTA Maintenance Shop Regulations
- The Tools, Consumables and Spare Parts listed in each Sheet and needed to accomplish the Task, to have all of them available next the location of the Equipment to be maintained before to start the activities

2. During Task Execution

a) Follow accurately the prescribed Safety Precautions and Maintenance Procedural Steps

b) Note any Areas/Items of the Assembly/Unit/Component under Corrective Maintenance Process requiring further Corrective Maintenance

c) Gather as much information about the Equipment as is practical

(i e knowledge about the malfunction in terms of correctly operating and incorrectly operating equipment processes) to increase your equipment knowledge.

3. At every Task Completion

a) Follow carefully the prescribed Safety Precautions before restoring the Electrical Power to Vehicle.

b) Check the correct operation and/or functions of the Subsystem to which the maintained Equipment pertains.

c) It is suggested to perform this check on the IDU “A “as follows:

NOTE: Through the IDU you can check if all Systems are exchanging data by MVB or LonWorks Bus and the Trainlines Status.

The IDU Display also shows in real time the Status of all Vehicle Systems.

Reading the IDU Fault List it is possible to immediately detect a fault

Using the IDU in the Operating Mode the Fault Indications are generic,

Using the IDU in Maintenance Mode the same Fault has a detailed description.

For more in depth troubleshooting use the PTU connected to the relevant system that requires further troubleshooting.

1. On IDU "A" access to the Maintenance Menu first and then to the "Faults" Screen by selecting, in sequence, the relevant icons
2. Check, On IDU "A" through the list of the Current Active Faults shown in the "Faults" Screen, for Fault Codes related to the Subsystem to which the maintained Equipment pertains.

   Refer to Section 18 of RMSM for Fault Signals Details
3. As per "Fault" Codes check results proceed as follows:

➢ **No Faults are listed in the "Faults" Screen**

a) Key OFF the Vehicle

b) Record Service and Test results on the Defect Report Card for administrative and maintenance planning.

➢ **Fault Codes are listed in the "Faults" Screen**

a) Investigate/troubleshoot the Equipment previously maintained first and then the System/Subsystem/Assembly/Unit for Fault Probable Causes

b) Gather as much information about the failure symptoms as is practical. Refer to Section 18 of RMSM for Fault Signals Details

c) Try to identify the malfunction in terms of correctly operating and incorrectly operating equipment processes.

d) Identify which equipment signals or parameters will best help you to localize the failure.

e) Identify the source of the problem.

f) Repair or replace the defective component.

g) Verify that the repair is effective in eliminating all of the failure symptoms.

h) Evaluate whether or not the defective component was the root cause of the failure.

i) Once the Fault Codes are not found in the "Faults" Screen perform steps from 3-a through 3-b (previous subparagraph **"No Faults are listed in the "Faults" Screen)**

07-III-05.01.03 Running- Corrective Maintenance Sheet (R-CMS) List

The “ Propulsion System “ Running- Corrective Maintenance Sheets (R-CMS) List is provided in the following
Table 07-III-05.1

The R-CM Sheets are listed by Subsystem / Assembly / Unit / Component and sequenced by Sheet Codes and Tasks to be performed

Table 07-III-05.1 Running Corrective Maintenance Sheets List

SYSTEM 07 PROPULSION				
SUBSYSTEM / ASSY	**UNIT**	**COMPONENT**	**TASK**	**SHEET CODE**
PRECHARGE SYSTEM	CONTACTOR PROPULSION (CP)		REPLACEMENT	R-C-07-01-01-00/R-00
PRECHARGE SYSTEM	CONTACTOR CHARGE FILTER (CCF)		REPLACEMENT	R-C-07-01-02-00/R-00
PRECHARGE SYSTEM	RESISTOR (RCF)		REPLACEMENT	R-C-07-01-03-00/R-00
PRECHARGE SYSTEM	FUSE (FCF)		REPLACEMENT	R-C-07-01-04-00/R-00
RETURN CURRENT SYSTEM		GROUNDING CONTACT	REPLACEMENT	R-C-07-02-00-00/R-00
TRACTION INVERTER HV COMPONENTS	LINE REACTOR (1L01)		REPLACEMENT	R-C-07-03-01-00/R-00
TRACTION INVERTER HV COMPONENTS	LINE VOLTAGE TRANSDUCER		REPLACEMENT	R-C-07-03-02-00/R-00
TRACTION INVERTER HV COMPONENTS	LINE CURRENT TRANSDUCER		REPLACEMENT	R-C-07-03-03-00/R-00
TRACTION INVERTER HV COMPONENTS	IGBT PHASE MODULE IGBT CHOPPER MODULE		REPLACEMENT	R-C-07-03-04-00/R-00
TRACTION INVERTER HV COMPONENTS	BRAKING RESISTOR		REPLACEMENT	R-C-07-03-06-00/R-00
TRACTION INVERTER HV COMPONENTS	INVERTER COOLING MOTOR FAN		REPLACEMENT	R-C-07-03-07-00/R-00
TRACTION INVERTER HV COMPONENTS	MOTOR FAN CONTACTOR		REPLACEMENT	R-C-07-03-08-00/R-00
TRACTION CONTROL UNIT (TCU)	BOARDS		REPLACEMENT	R-C-07-04-01-00/R-00
TRACTION MOTOR	TRACTION MOTORS (01M 01-02)		REPLACEMENT	R-C-07-05-01-00/R-00
TRACTION MOTOR	ACTIVE SPEED SENSOR		REPLACEMENT	R-C-07-05-02-00/R-00
TRACTION MOTOR	THERMAL SENSOR ASSEMBLY		REPLACEMENT	R-C-07-05-03-00/R-00
GEARBOX ASSY	GEARBOX		SERVICE	R-C-07-06-01-00/S-00
MASTER CONTROLLER	MASTER CONTROLLER (3A01)		REPLACEMENT	R-C-07-08-01-00/R-00
MASTER CONTROLLER	MICROSWITCHES		REPLACEMENT	R-C-07-08-02-00/R-00
MASTER CONTROLLER	RATE REFERENCE ENCODER (3U01)		REPLACEMENT	R-C-07-08-03-00/R-00

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07-III-05.01.04 Running- Corrective Maintenance Sheets (R-CMS)

PROPULSION

Running - Corrective Maintenance Sheets

R-CMS

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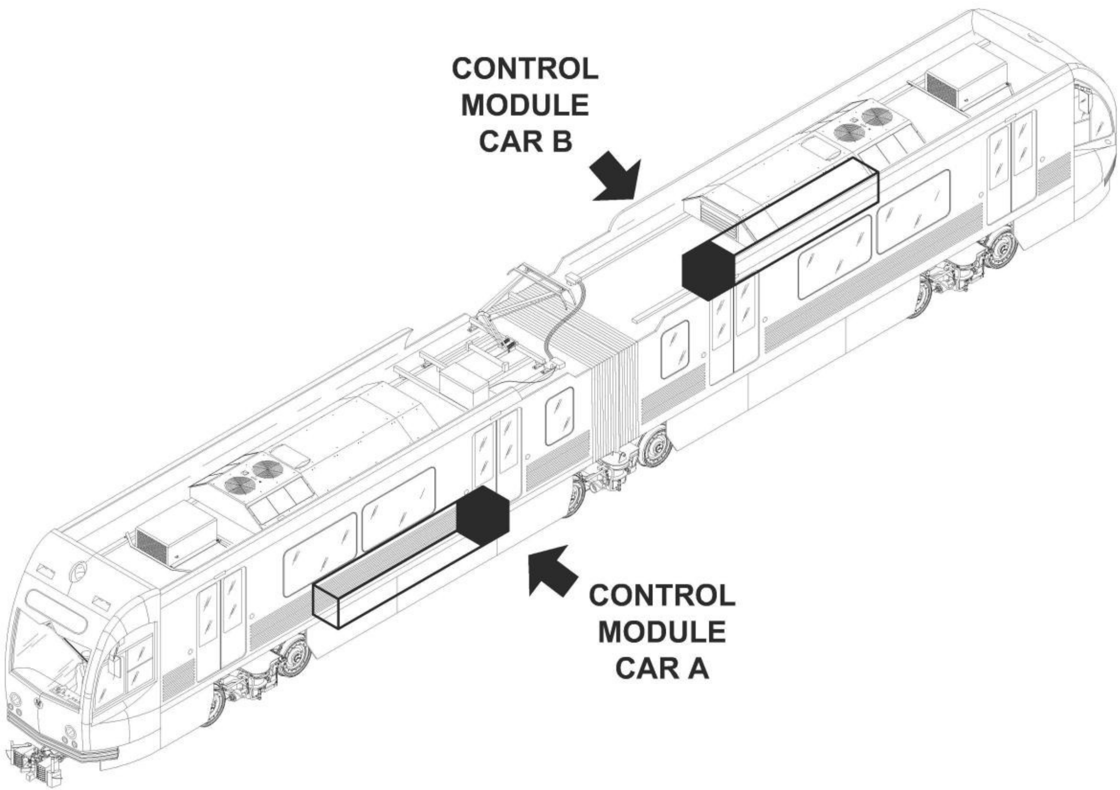
P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-01-01-00/R-00**
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-01-00/R-00

System: PROPULSION	Sheet: 2/8
Subsystem/Assy: PRECHARGE SYSTEM	Unit: CONTACTOR PROPULSION (CP)
Component:	Man Hours: 1.5

Maintenance Task:
REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

CRC 2000 Contact Cleaner
CRC Industrial - Precision Cleaner M3 PN 147535

SPARE PARTS:

CP CONTACTOR Type LTHS320 P/N 211VK00732B04

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-01-01-00/R-00**
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it. Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.
2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to CP Contactor.

WARNING BEFORE PERFORMING MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER. SEE FIGURE 1

3. Disconnect Electrical Connections from CP Contactor.
4. Remove the CP Contactor by removing fixing Screws, Washers and Nuts.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-01-00/R-00**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

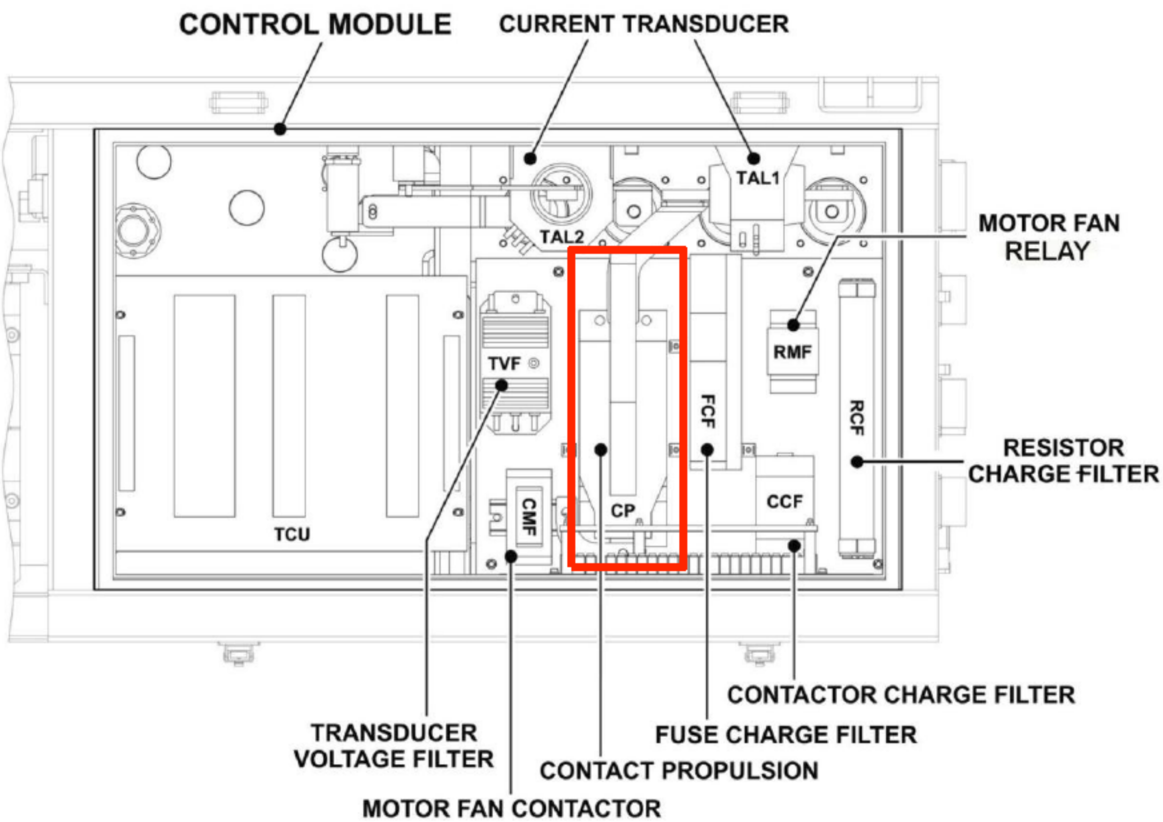


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-01-00/R-00**

System: **PROPULSION**	Sheet: **5/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

DETAIL"A" Two ties each couple of "P" and "N" cables

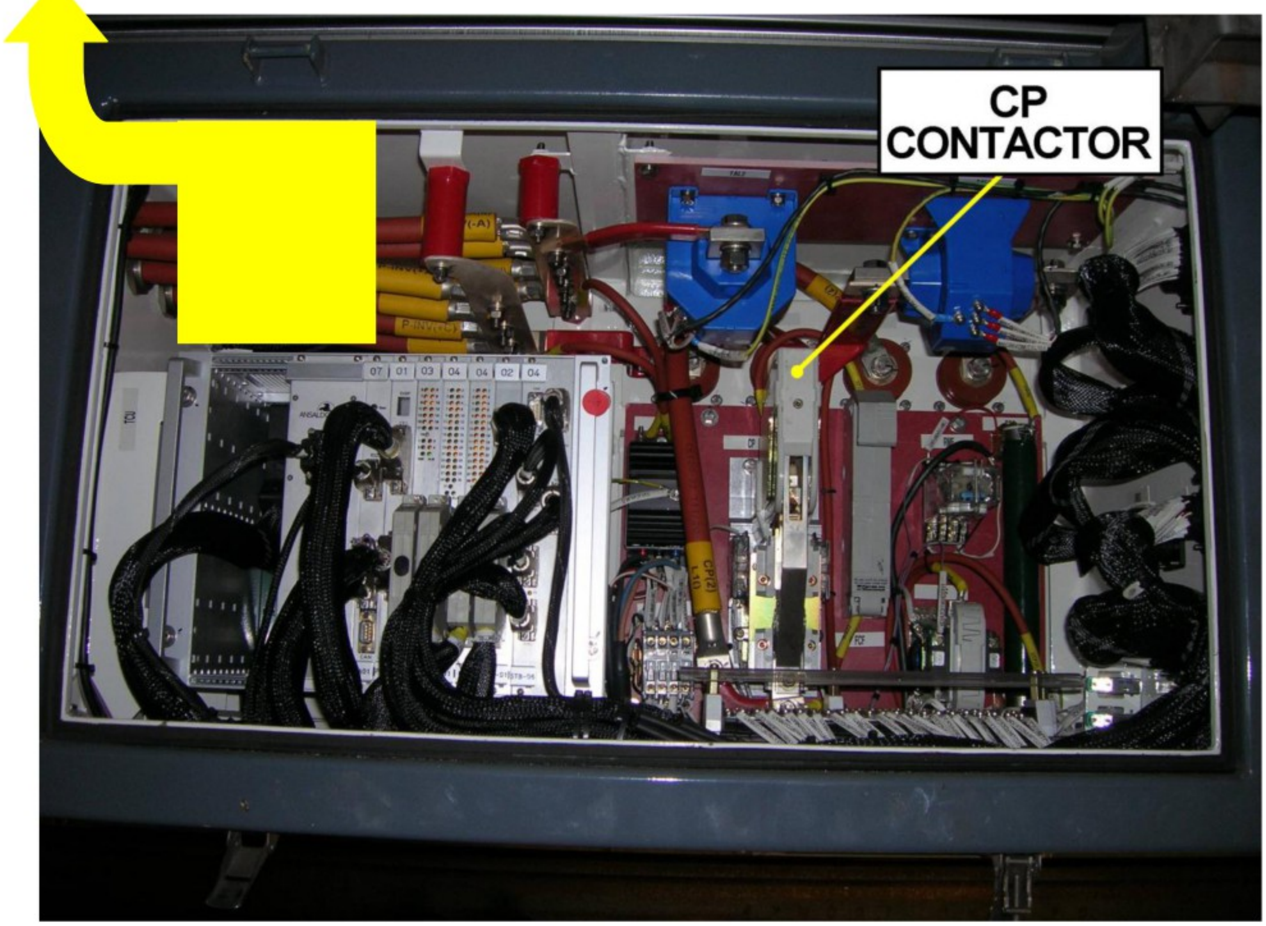


Figure 2 - CONTROL MODULE - INTERIOR

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-01-00/R-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Install the CP Contactor in its position

2 Install the fixing Screws, Washers and Nuts. Tighten as required

3. Clean the Auxiliary and Main contacts with the recommended agent and a lint-free rag.

4. Connect the Electrical Connections to CP Contactor.

5. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

6. Reconnect the Grounding Cable

7. Record task results on the Defect Report Card for administrative and maintenance planning.

8. Once completed, proceed as follows:

a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

b. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS(**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-01-01-00/R-00**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

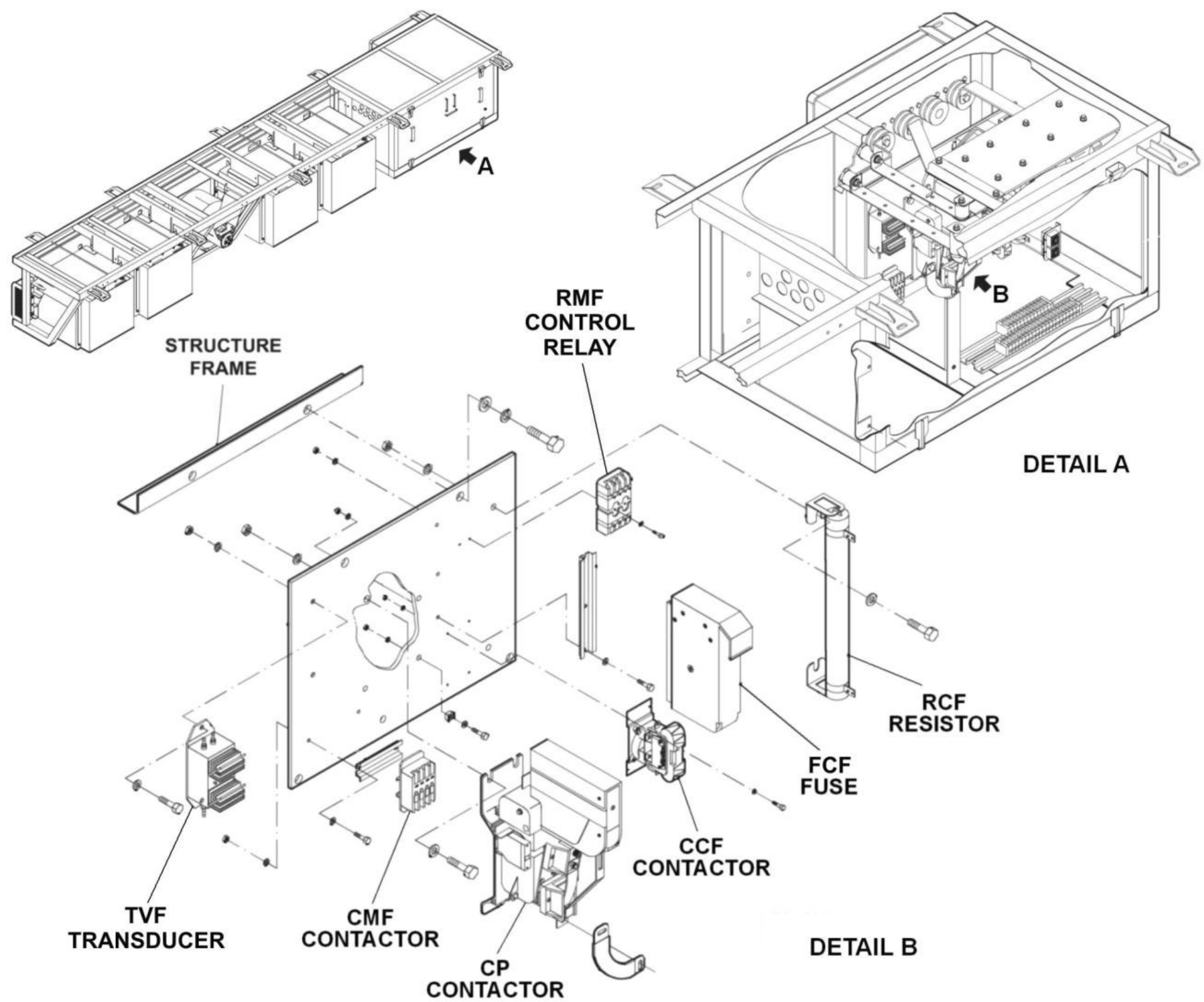


Figure 3 - CONTROL MODULE - CP CONTACTOR REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-01-00/R-00**		
System: **CAR BODY**		Sheet: **8/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR PROPULSION (CP)**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

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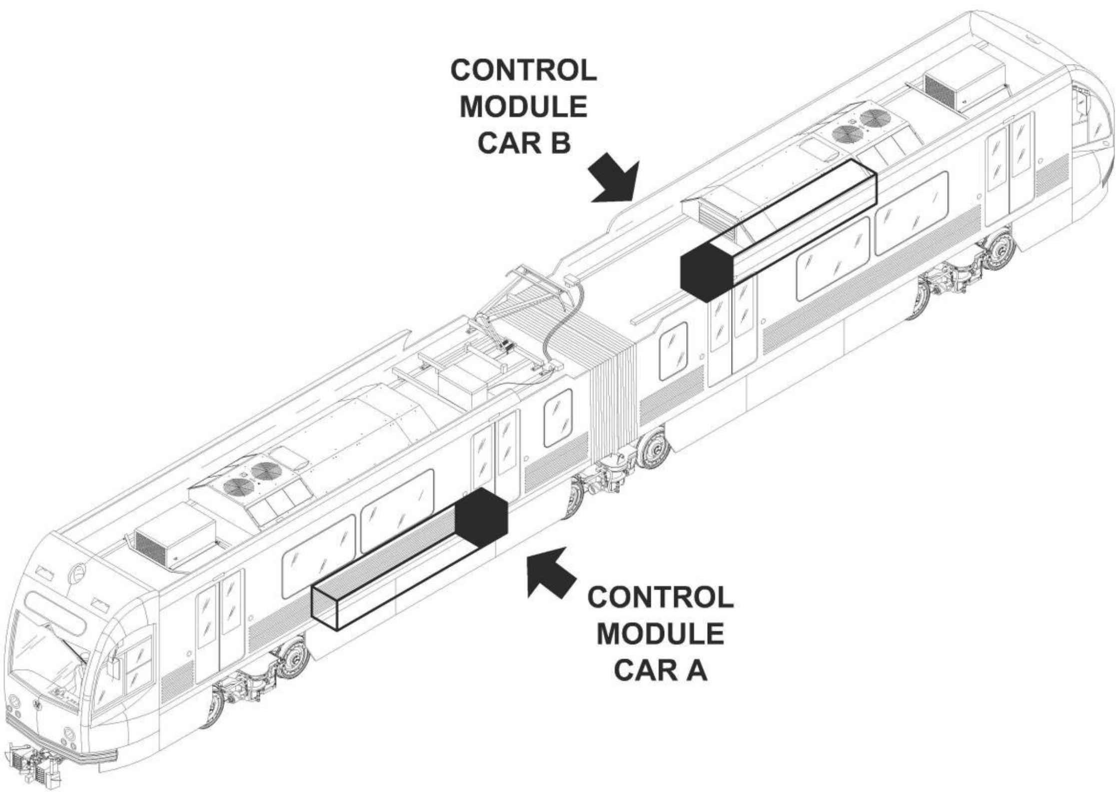
P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-02-00/R-00**		
System: **PROPULSION**		Sheet: **1/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**	
Component:		Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-02-00/R-00**		
System: **PROPULSION**		Sheet: **2/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**	
Component:		Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**		

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

CRC 2000 Contact Cleaner		
CRC Industrial - Precision Cleaner M3	PN	147535

SPARE PARTS:

CONTACTOR CHARGE FILTER (CCF) Type LTC100	P/N	211VK01326B02

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-02-00/R-00**	
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.
2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to CCF Contactor.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER. SEE FIGURE 1.

3. Disconnect Electrical Connections from CCF Contactor.
4. Remove the CCF Contactor by removing fixing Screws, Washers and Nuts.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-02-00/R-00**	
System: **PROPULSION**	Sheet: **4/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

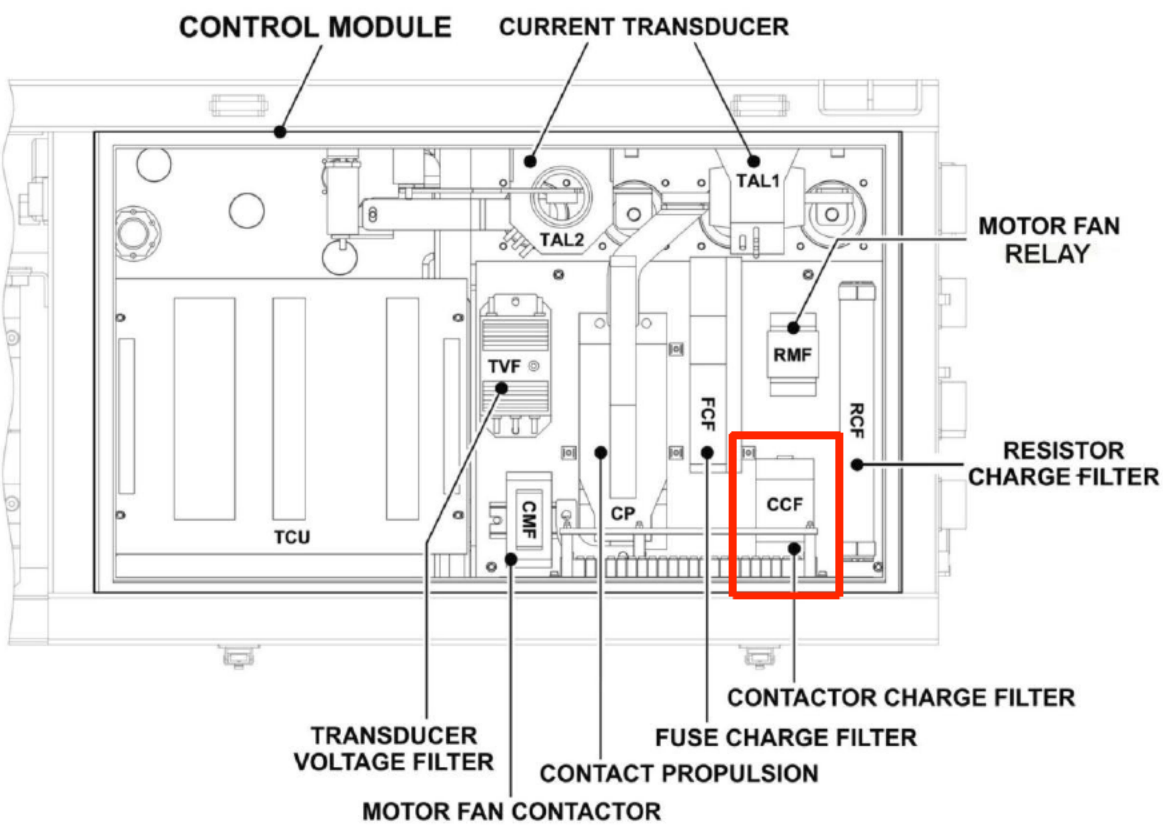


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-02-00/R-00**

System:	Sheet:
PROPULSION	**5/8**

Subsystem/Assy:	Unit:
PRECHARGE SYSTEM	**CONTACTOR CHARGE FILTER (CCF)**

Component:	Man Hours:
	1.25

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

DETAIL "A" Two ties each couple of "P" and "N" cables

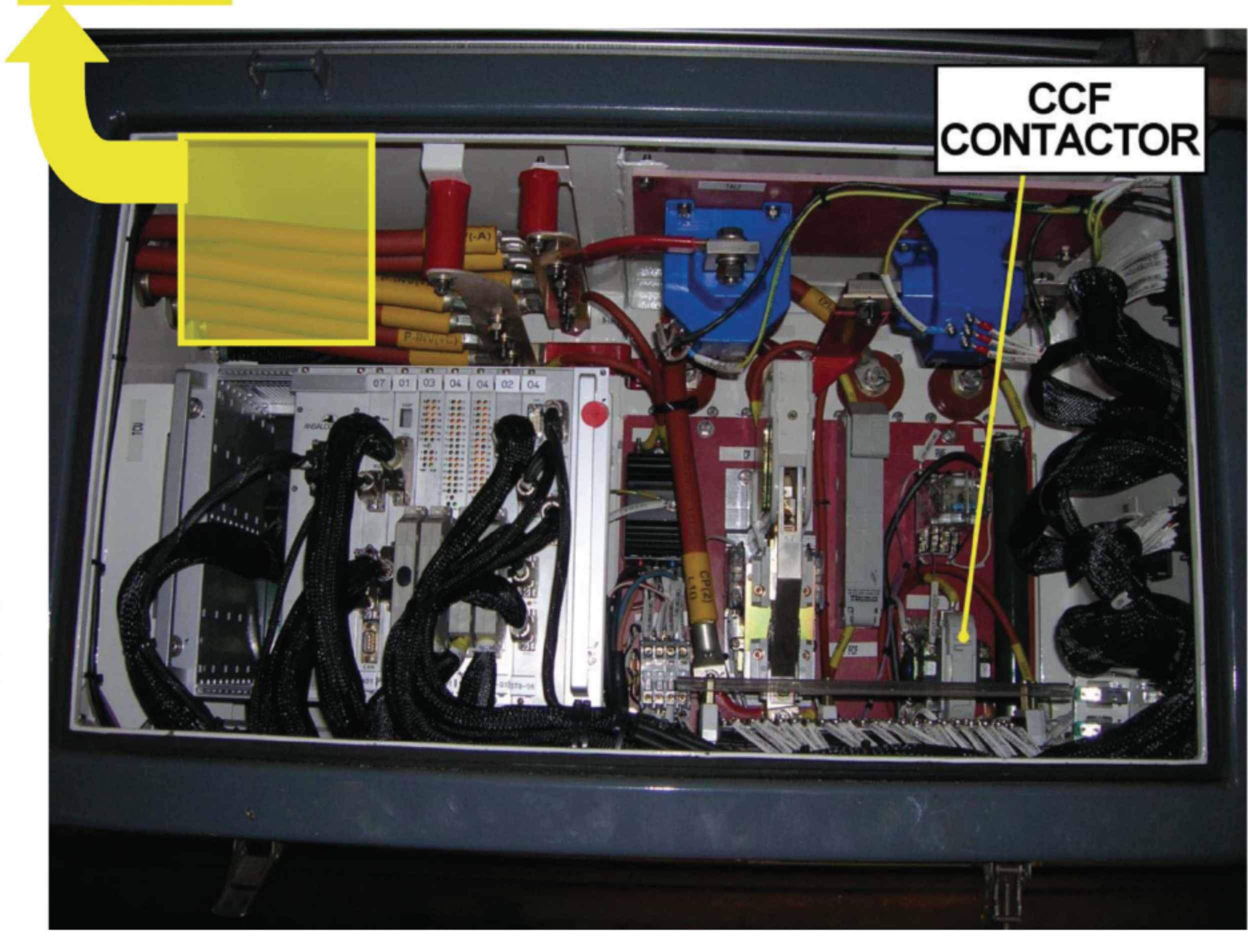


Figure 2 - CONTROL MODULE - INTERIOR

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-02-00/R-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Install the CCF Contactor in its position.

2. Install the fixing Screws, Washers and Nuts.Tighten as required.

3. Clean the Auxiliary and Main contacts with the recommended agent and a lint-free rag.

4. Connect the Electrical Connections to CCF Contactor.

5. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

6. Reconnect the Grounding Cable.

7. Record task results on the Defect Report Card for administrative and maintenance planning.

8. Once completed, proceed as follows:

a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

b. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-01-02-00/R-00**
System: **PROPULSION**		Sheet: **7/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**	
Component:		Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

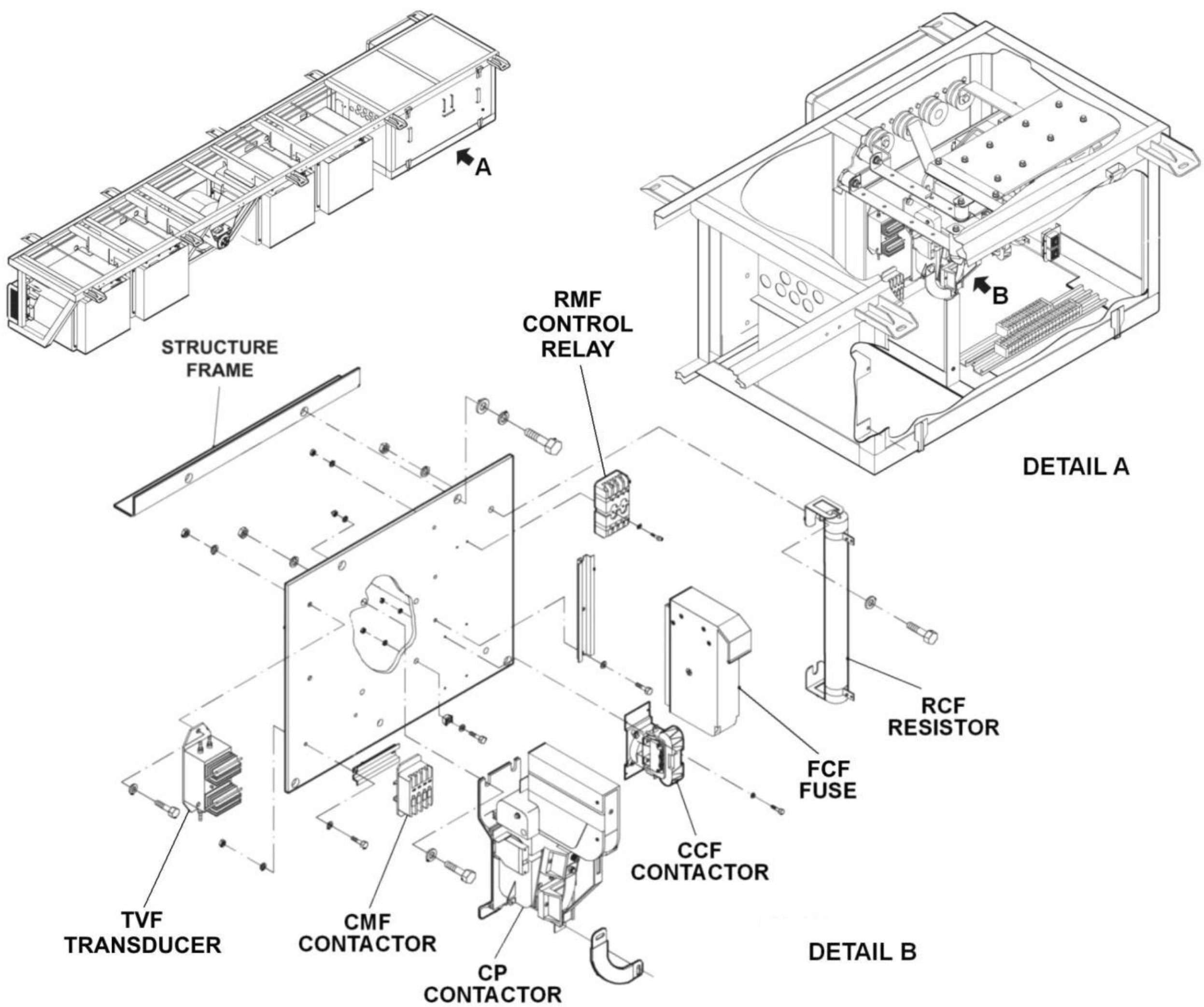


Figure 3 - CONTROL MODULE - CCF CONTACTOR REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-02-00/R-00**		
System: **CAR BODY**		Sheet: **8/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **CONTACTOR CHARGE FILTER (CCF)**	
Component:		Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**		

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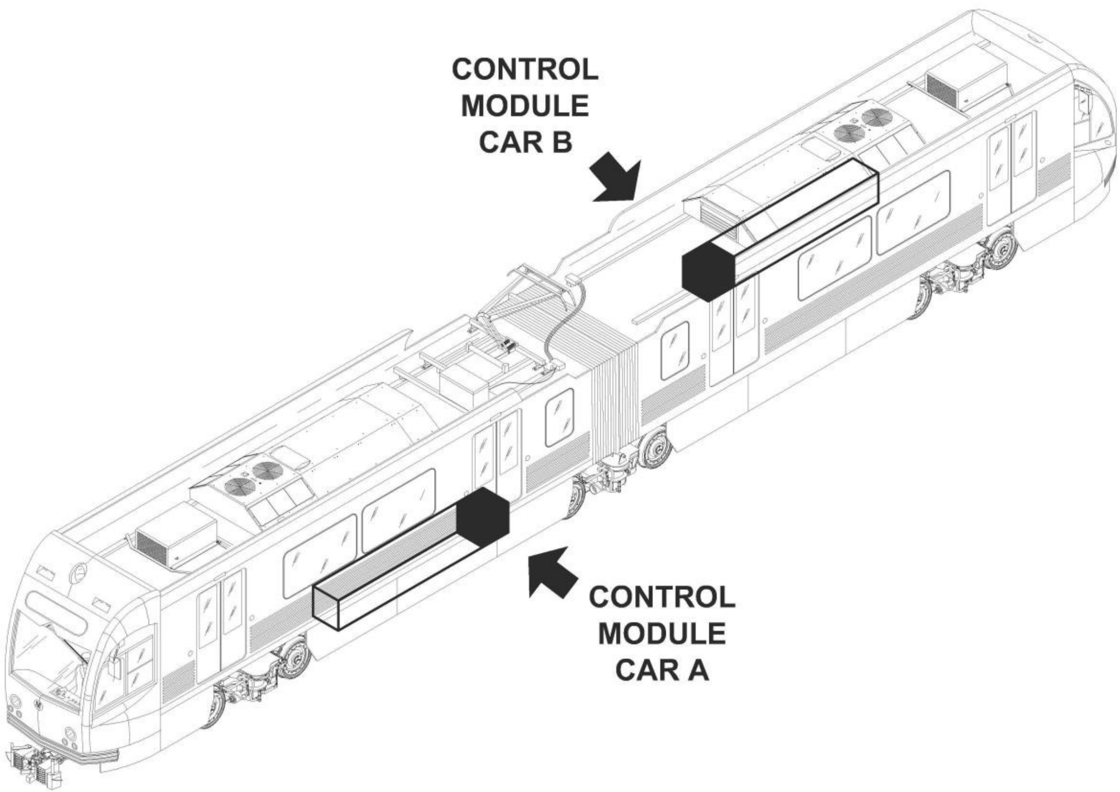
P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-03-00/R-00**		
System: **PROPULSION**		Sheet: **1/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **RESISTOR (RCF)**	
Component:		Man Hours: **0.5**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-03-00/R-00**	
System: **PROPULSION**	Sheet: **2/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **RESISTOR (RCF)**
Component:	Man Hours: **0.5**
Maintenance Task: **REPLACEMENT**	

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP, SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

CRC 2000 Contact Cleaner		
CRC Industrial - Precision Cleaner M3	PN	147535

SPARE PARTS:

RESISTOR (RCF) Type RSS260	P/N	211NR50041B160491
SUPPORT	P/N	211NR50064B0305
SUPPORT	P/N	211NR50064B0405

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-03-00/R-00

System:	Sheet:
PROPULSION	**3/8**

Subsystem/Assy:	Unit:
PRECHARGE SYSTEM	**RESISTOR (RCF)**

Component:	Man Hours:
	0.5

Maintenance Task:
REPLACEMENT

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.
2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to RCF Resistor.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1.

3. Disconnect Electrical Connections from RCF Resistor.
4. Remove the RCF Resistor with related Supports by removing fixing Screws, Washers and Nuts.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-03-00/R-00**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **RESISTOR (RCF)**	
Component:		Man Hours: **0.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

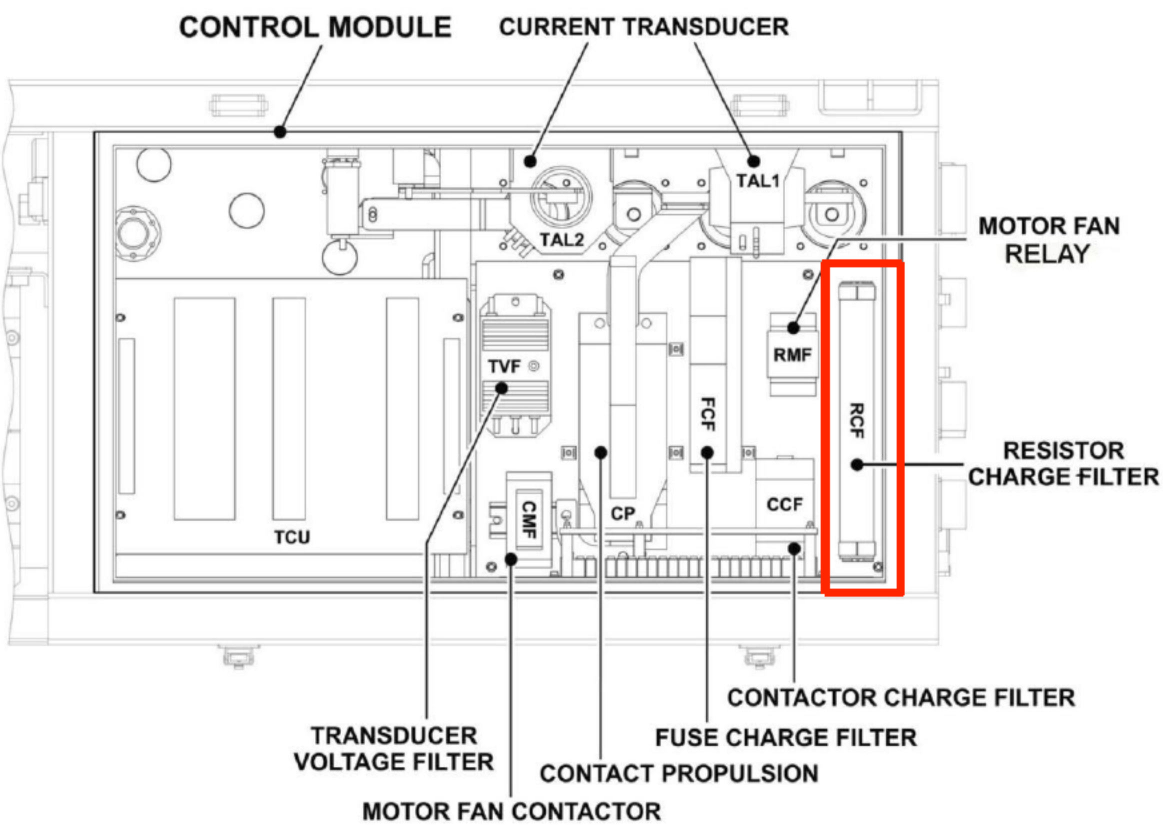


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-03-00/R-00**	
System: **PROPULSION**	Sheet: **5/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **RESISTOR (RCF)**
Component:	Man Hours: **0.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

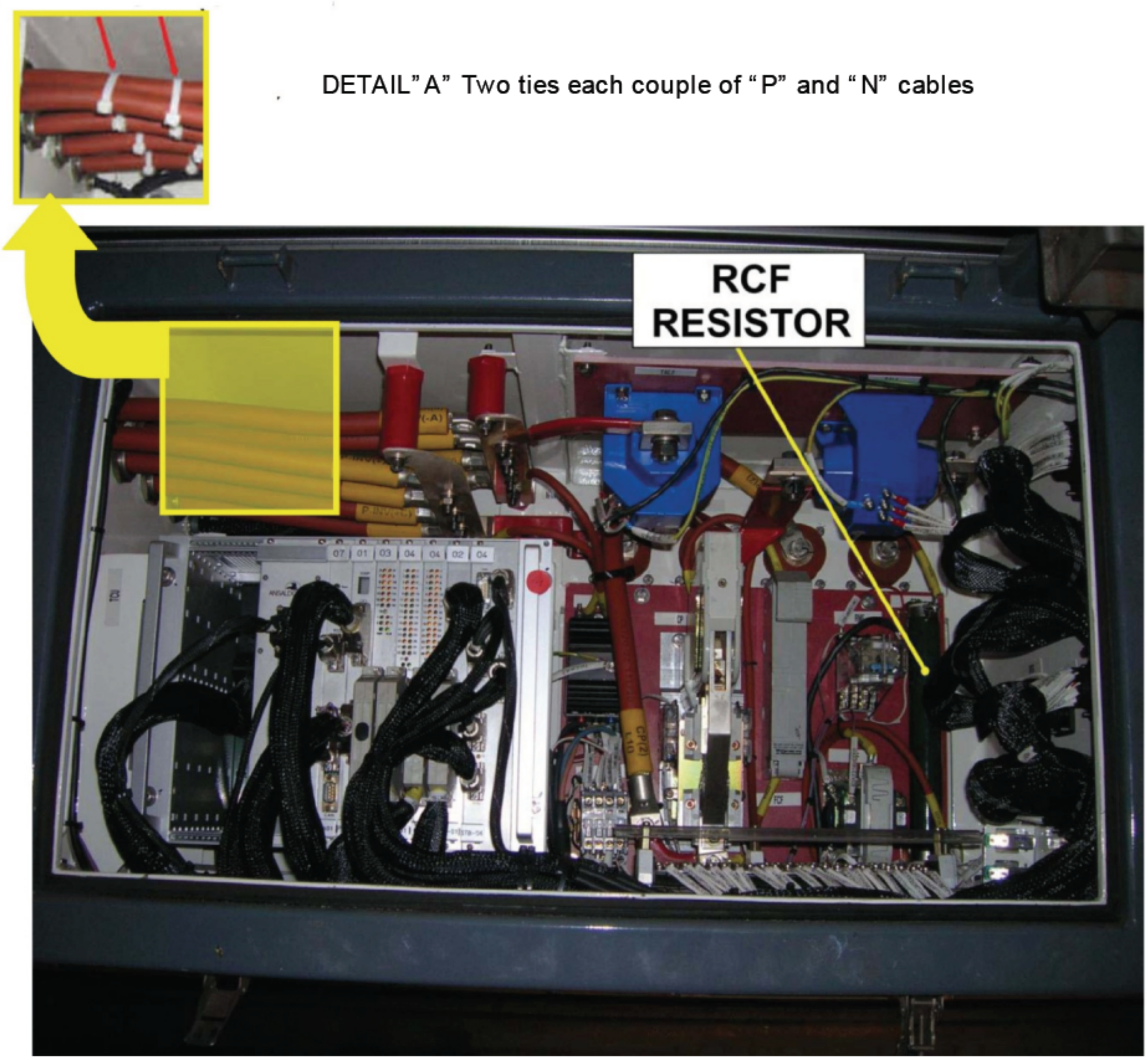


Figure 2 - CONTROL MODULE - INTERIOR

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-03-00/R-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **RESISTOR (RCF)**
Component:	Man Hours: **0.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Install the RCF Resistor with related Supports in its position.

2 Install the fixing Screws, Washers and Nuts. Tighten as required.

3. Clean the contacts with the recommended agent and a lint-free rag.

4. Connect the Electrical Connections to RCF Resistor.

5. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

6. Reconnect the Grounding Cable.

7. Record task results on the Defect Report Card for administrative and maintenance planning.

8. Once completed, proceed as follows:

a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

b. Restore Electrical Power.

<u>**NOTE:**</u> At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS(**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-03-00/R-00

System: PROPULSION	Sheet: 7/8
Subsystem/Assy: PRECHARGE SYSTEM	Unit: RESISTOR (RCF)
Component:	Man Hours: 0.5

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

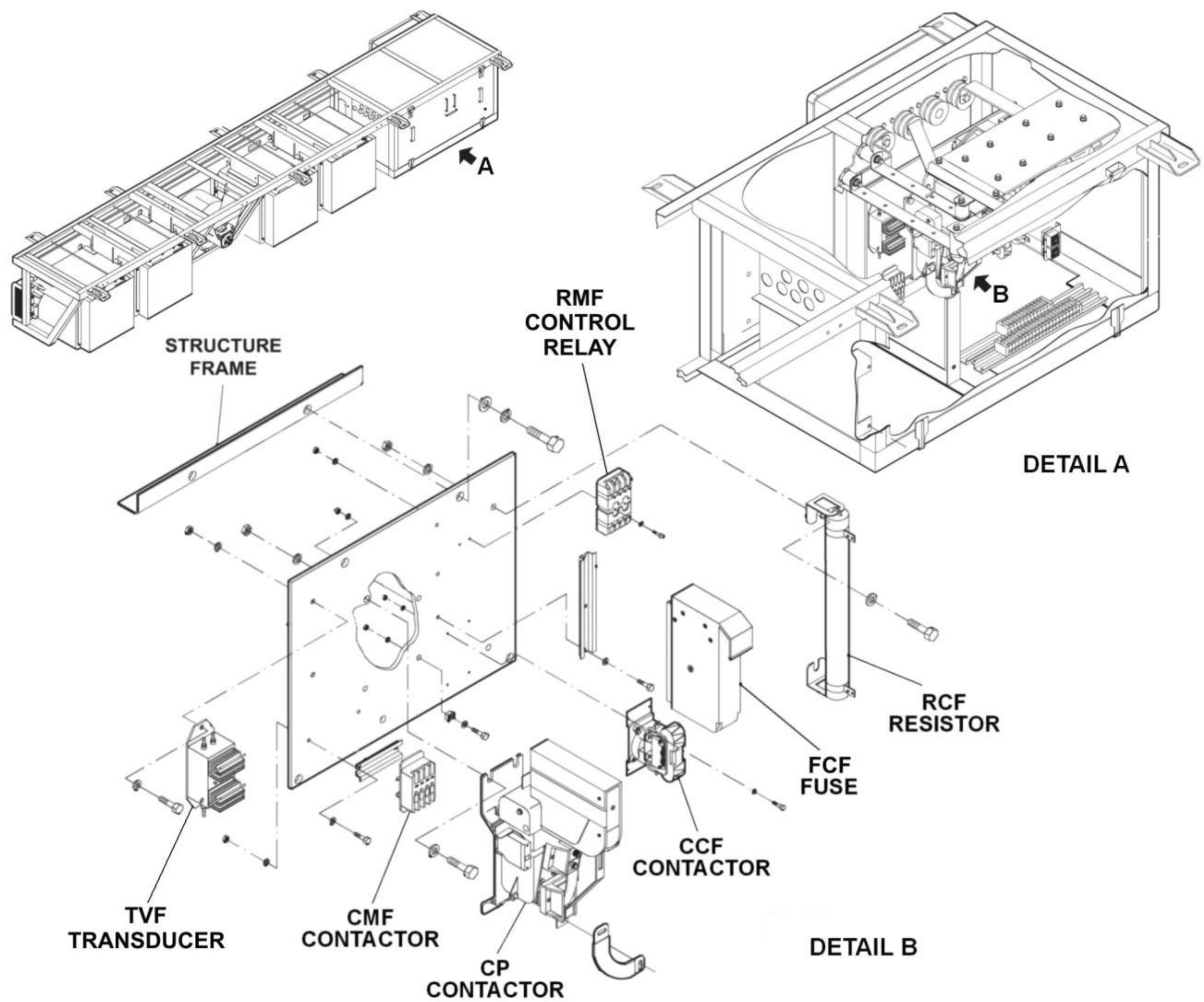


Figure 3 - CONTROL MODULE - RCF RESISTOR REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-03-00/R-00**		
System: **CAR BODY**		Sheet: **8/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **RESISTOR (RCF)**	
Component:		Man Hours: **0.5**
Maintenance Task: **REPLACEMENT**		

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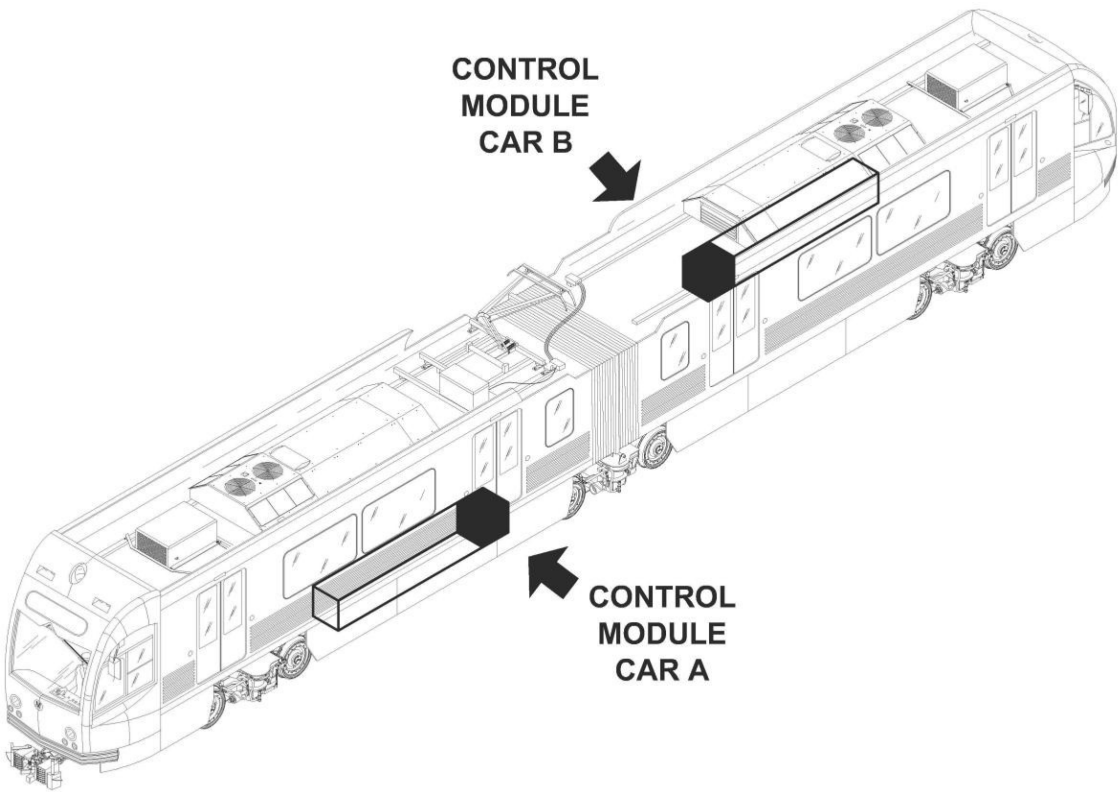
P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-04-00/R-00**		
System: **PROPULSION**		Sheet: **1/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **FUSE (FCF)**	
Component:		Man Hours: **0.25**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-04-00/R-00

System:
PROPULSION

Sheet:
2/8

Subsystem/Assy:
PRECHARGE SYSTEM

Unit:
FUSE (FCF)

Component:

Man Hours:
0.25

Maintenance Task:
REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

CRC 2000 Contact Cleaner
CRC Industrial - Precision Cleaner M3 PN 147535

SPARE PARTS:

FUSE (RCF) Type 10 A	P/N	211VF00021B07
FUSE HOLDER	P/N	211VQ00023B02

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-04-00/R-00

System: **PROPULSION**		Sheet: **3/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **FUSE (FCF)**	
Component:		Man Hours: **0.25**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.
2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to FCF Fuse.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1.

3. Disconnect Electrical Connections from FCF Fuse.
4. Remove the FCF Fuse from the related Fuse Holder.
5. Inspect the Fuse Holder for damage / overheating Replace as per Inspection Results.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-01-04-00/R-00**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **FUSE (FCF)**	
Component:		Man Hours: **0.25**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

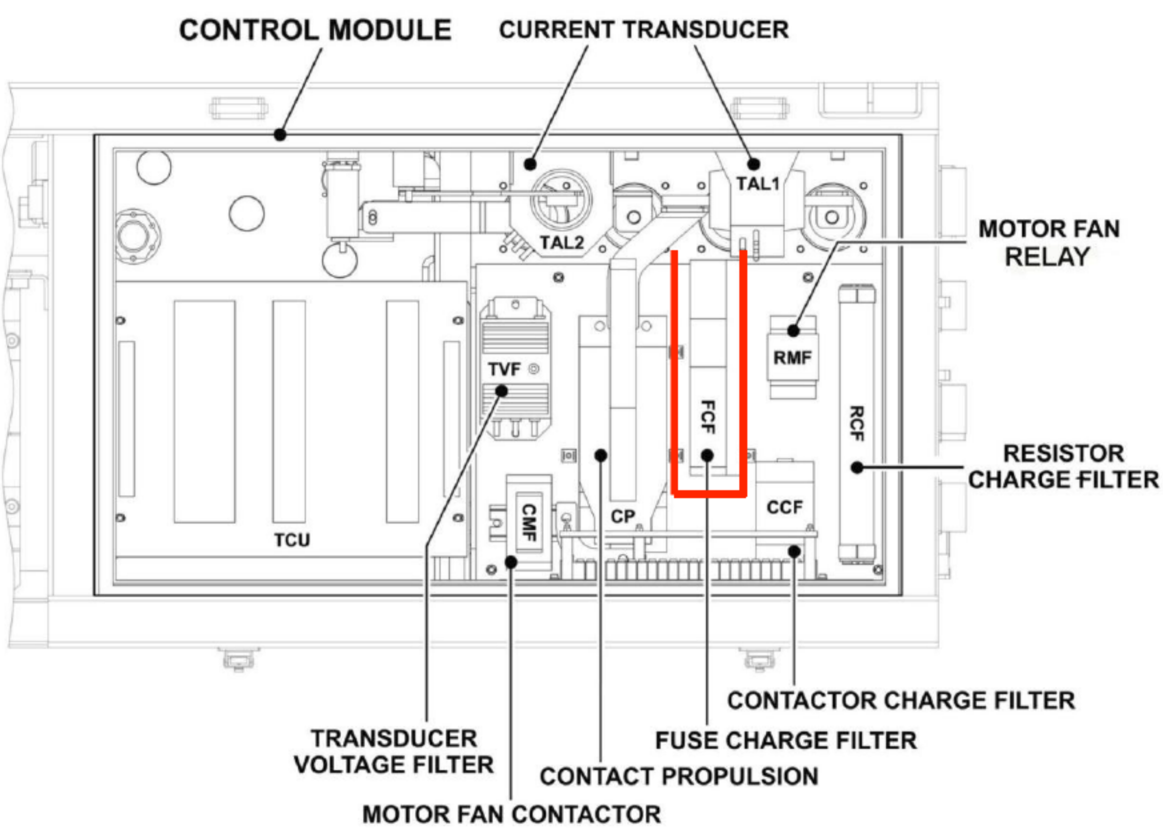


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-04-00/R-00

System:	Sheet:
PROPULSION	**5/8**

Subsystem/Assy:	Unit:
PRECHARGE SYSTEM	**FUSE (FCF)**

Component:	Man Hours:
	0.25

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

DETAIL" A" Two ties each couple of " P" and " N" cables

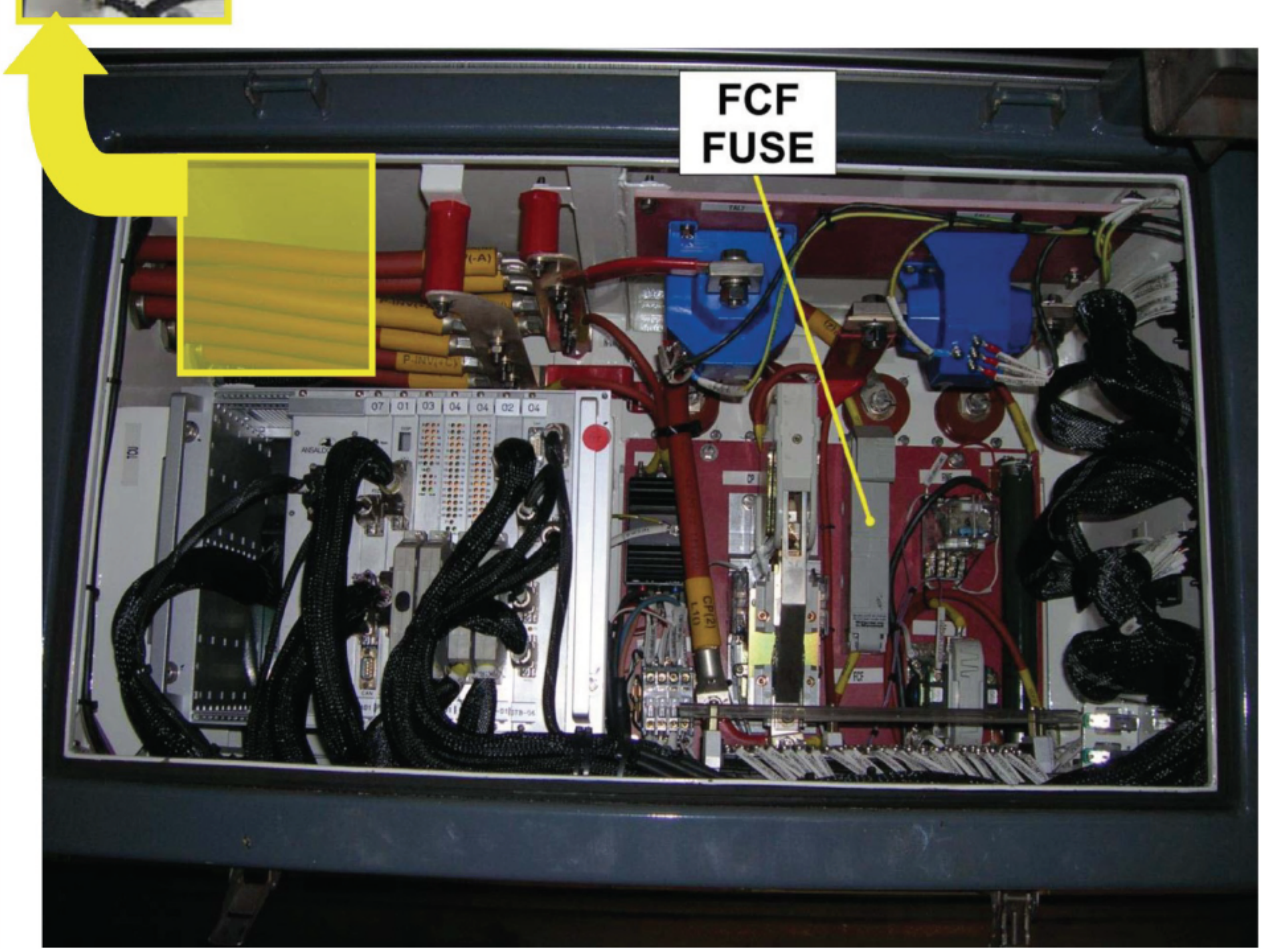


Figure 2 - CONTROL MODULE - INTERIOR

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-04-00/R-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **FUSE (FCF)**
Component:	Man Hours: **0.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Clean the Fuse Holder contacts with the recommended agent and a lint-free rag.

2. Install the "new" FCF Fuse in related Fuse Holder.

3. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

4. Reconnect the Grounding Cable.

5. Record task results on the Defect Report Card for administrative and maintenance planning.

6. Once completed, proceed as follows:

a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

b. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS(**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-01-04-00/R-00

System:	Sheet:
PROPULSION	**7/8**

Subsystem/Assy:	Unit:
PRECHARGE SYSTEM	**FUSE (FCF)**

Component:	Man Hours:
	0.25

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

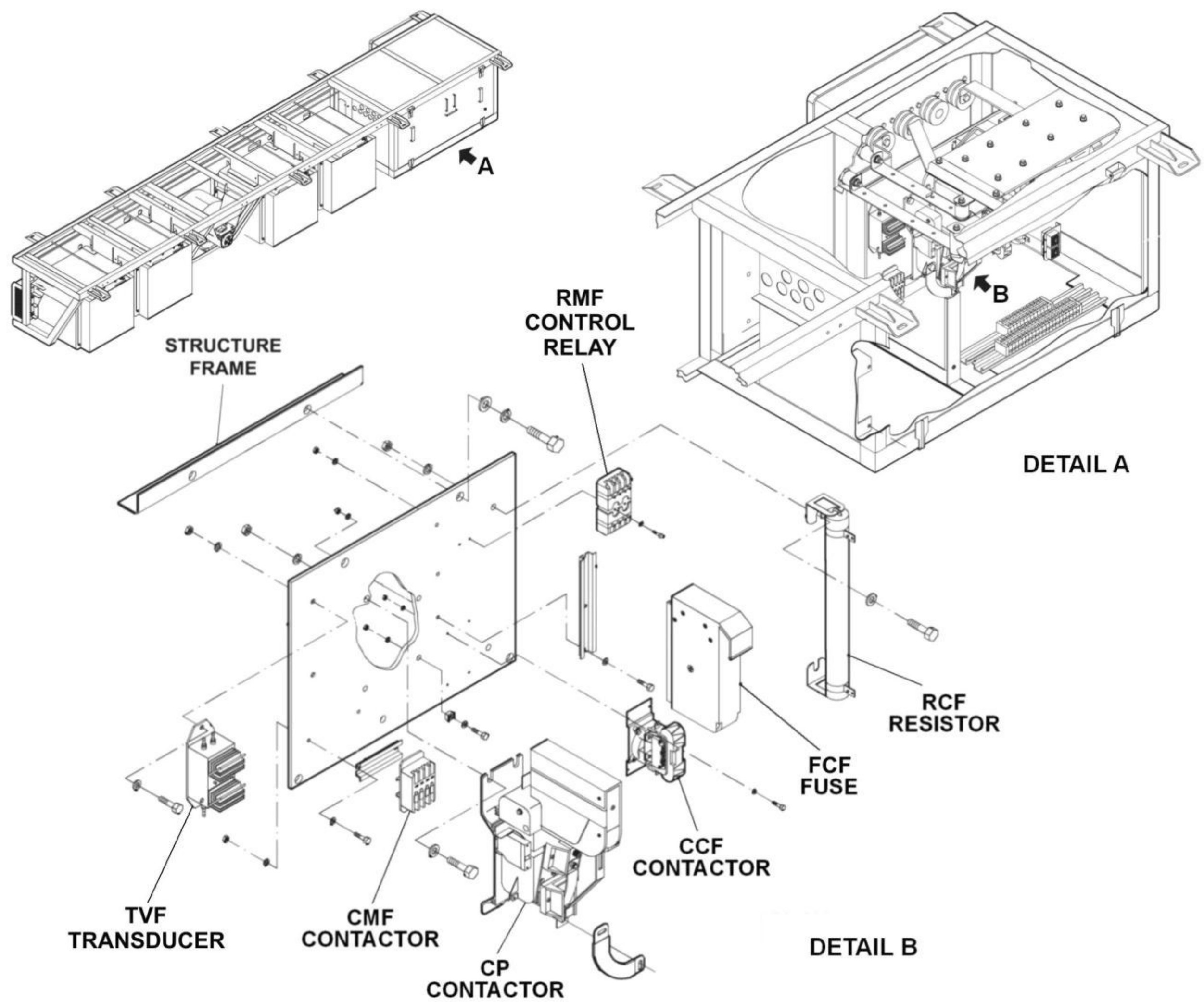


Figure 3 - CONTROL MODULE - FCF FUSE REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-01-04-00/R-00**		
System: **CAR BODY**		Sheet: **8/8**
Subsystem/Assy: **PRECHARGE SYSTEM**	Unit: **FUSE (FCF)**	
Component:		Man Hours: **0.25**
Maintenance Task: **REPLACEMENT**		

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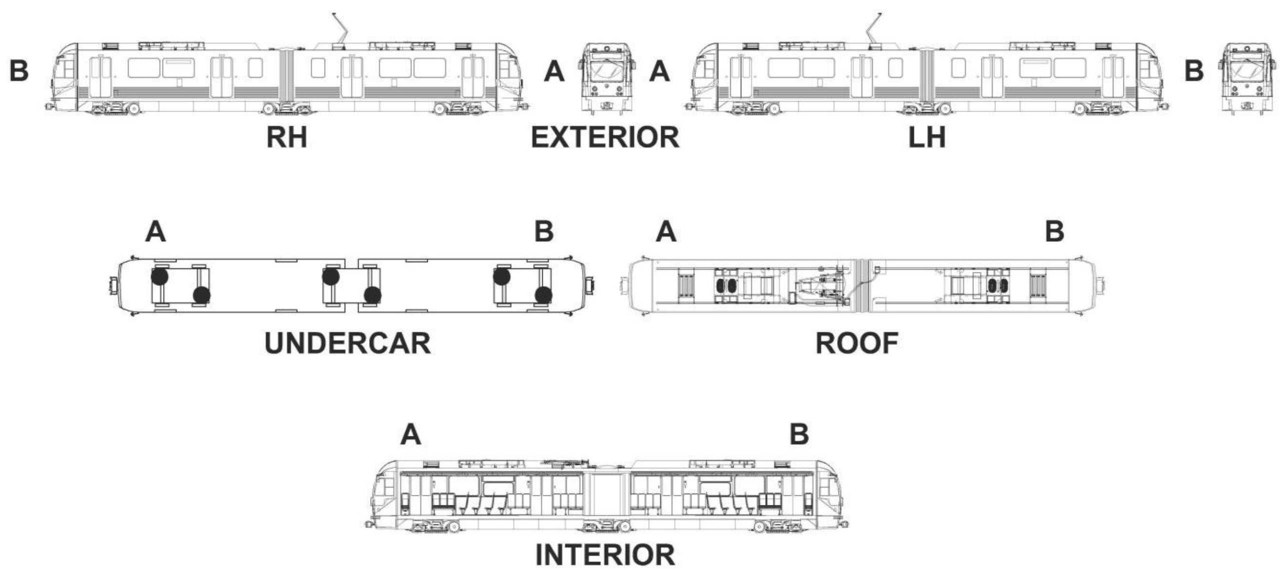
P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-02-00-00/R-00**	
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-02-00-00/R-00**		
System: **PROPULSION**		Sheet: **2/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUNDING CONTACT**		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

SAFETY PRECAUTIONS:

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP, SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

CAUTION IT IS IMPERATIVE THAT NO OIL, GREASE OR DIRT IS LEFT ON THE GROUND / RETURN CURRENT BRUSHES. RESIDUE OF ANY KIND WILL CAUSE FAILURE TO THE GROUNDING CONTACT. CLEAN GROUND / RETURN CURRENT BRUSHES WITH A CLEAN CLOTH USING WHITE ALCOHOL SPIRITS ONLY.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:

Cleaner / Degreaser, as needed.
White Alcohol Spirits as needed.
Anti-Oxidant Joint Compound Korp - Shield, as needed (P/N AA00FFX).

SPARE PARTS:

Ground / Return Brushes	PN 06.21.0076.13
Housing LH	PN 06.50.0151.00
Housing RH	PN 06.50.0151.01
Housing LH Gasket	PN tbd
Housing RH Gasket	PN tbd

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-02-00-00/R-00**		
System: **PROPULSION**		Sheet: **3/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUNDING CONTACT**		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To remove the Return Current / Grounding Brushes proceed as follows (Refer to figures 3 and 4)
:

1. Remove Brush Housings Cover by loosening relevant attaching parts. Retain Cover and attaching parts for later use.
2. Remove Cover Gasket and discard.
3. Slide Out the Pressure Device from the slot in the Brush Guide to disengage the Brush Terminals.
4. Remove the Brush from Brush Guide.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-02-00-00/R-00**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUNDING CONTACT**		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

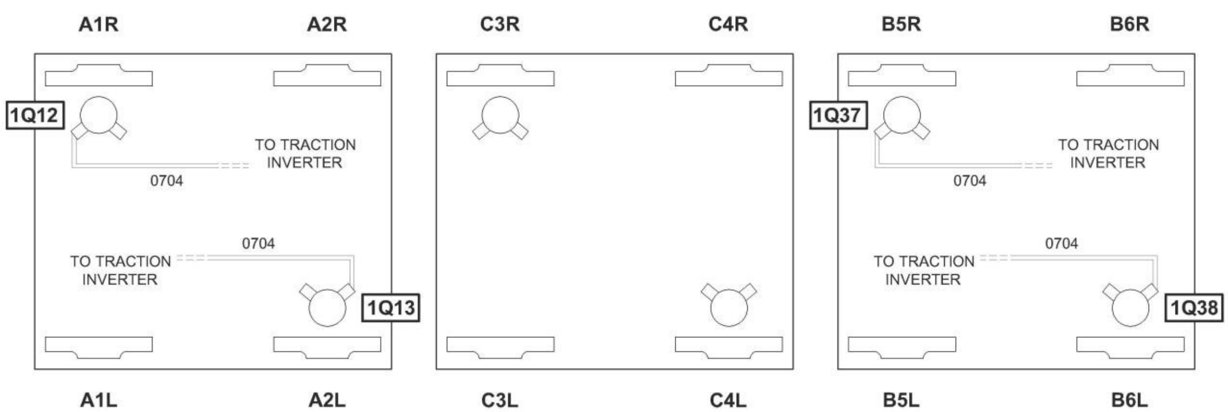


Figure 1 - RETURN CURRENT BRUSHES - LOCATION AND CONNECTIONS

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-02-00-00/R-00

System: PROPULSION	Sheet: 5/8
Subsystem/Assy: RETURN CURRENT SYSTEM	Unit:
Component: GROUNDING CONTACT	Man Hours: 1
Maintenance Task: REPLACEMENT	

PROCEDURE (CONT'D):

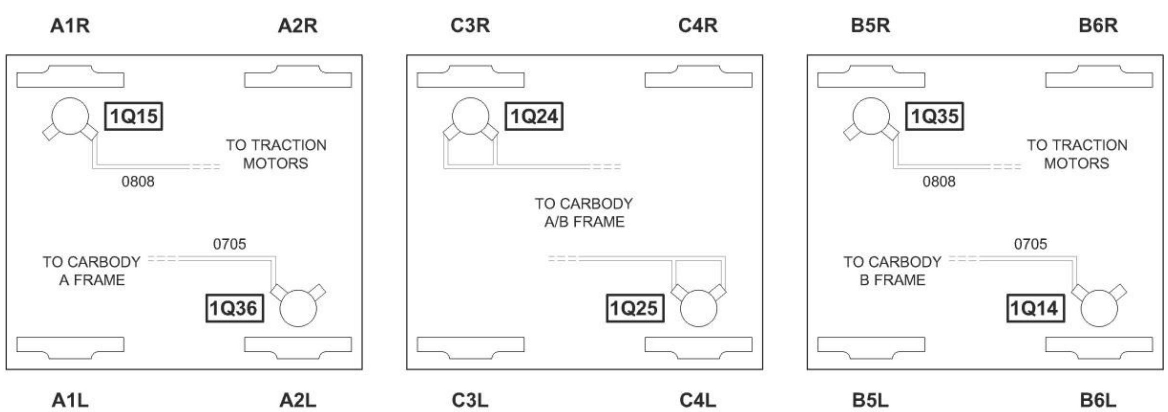


Figure 2 - GROUND BRUSHES - LOCATION AND CONNECTIONS

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-02-00-00/R-00**		
System: **PROPULSION**		Sheet: **6/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUNDING CONTACT**		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

INSTALLATION

To install the Return Current / Grounding Brushes proceed as follows (Refer to figures 3 and 4):

CAUTION: IT IS IMPERATIVE THAT NO OIL, GREASE OR DIRT IS LEFT ON THE GROUND RING / CURRENT RETURN BRUSHES.

RESIDUE OF ANY KIND WILL CAUSE FAILURE TO THE GROUNDING CONTACT.

CLEAN GROUND RING / CURRENT RETURN BRUSHES WITH A CLEAN CLOTH USING WHITE ALCOHOL SPIRITS ONLY.

1. Install the Brush into the Brush Guide.
2. Slide the Pressure Device into the slot in the Brush Guide until it "clicks" into place.
3. Check Pressure Devices for good tension.
4. Clean both mating surfaces for the Cover Gasket using recommended agent
5. Install new Cover Gasket.
6. Install Brush Housing Cover and Gasket, then install Screws, Washers and Lock-washers. Torque Screws to **11 ft-lb**.
7. Record inspection results on the Defect Report Card for administrative and maintenance planning.
8. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS(**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-02-00-00/R-00**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:
Component: **GROUNDING CONTACT**	Man Hours: **1**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

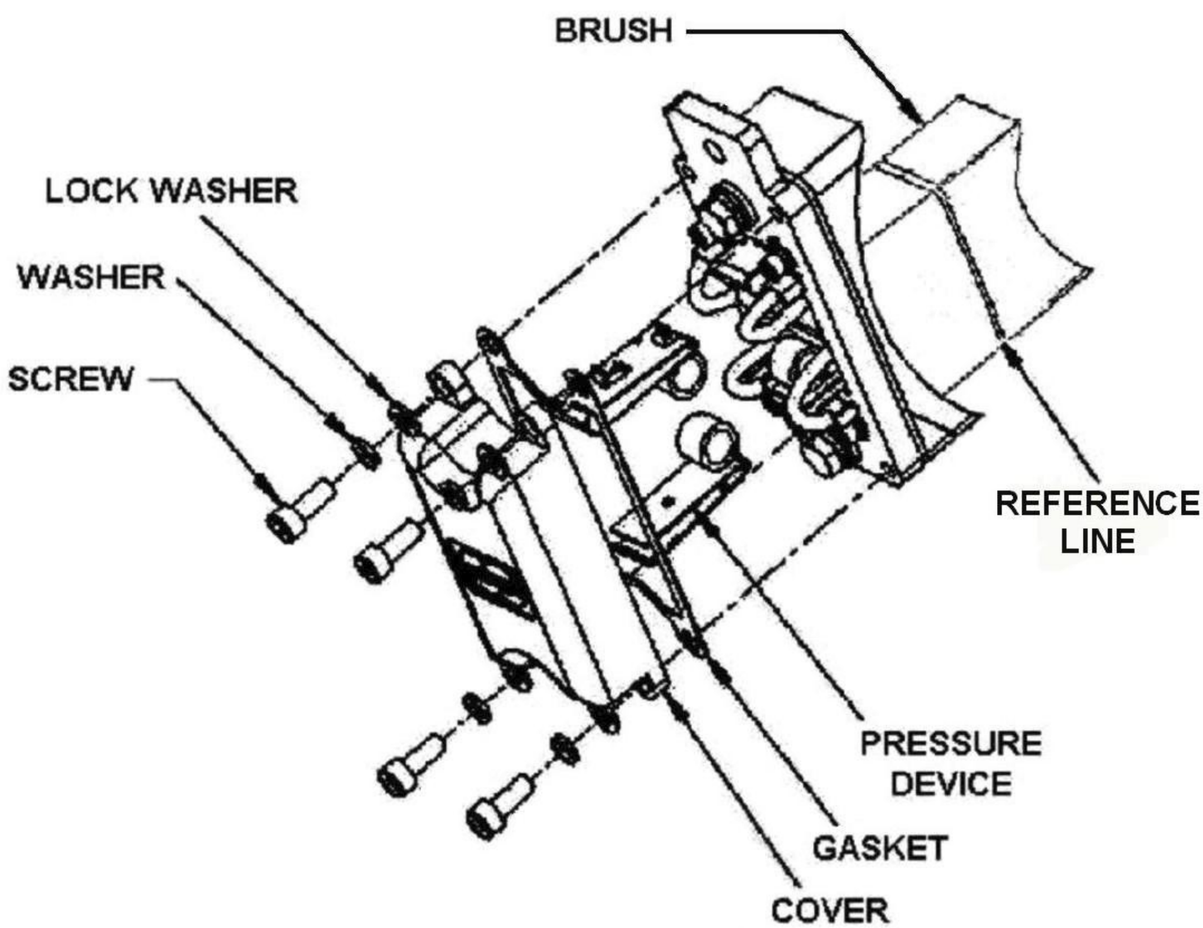


Figure 3 - GROUND / RETURN CURRENT BRUSHES - MAIN COMPONENTS

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-02-00-00/R-00**		
System: **PROPULSION**		Sheet: **8/8**
Subsystem/Assy: **RETURN CURRENT SYSTEM**	Unit:	
Component: **GROUNDING CONTACT**		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

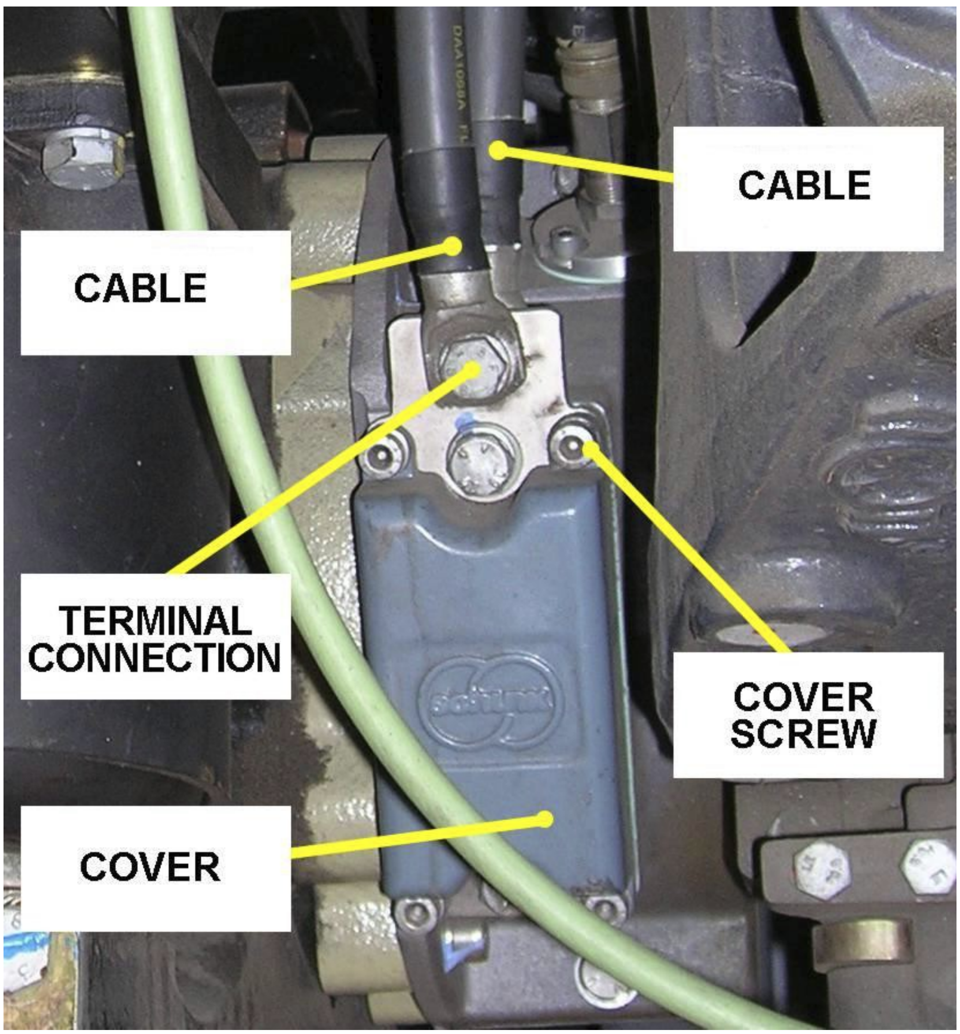


Figure 4 - GROUND / RETURN CURRENT BRUSH HOUSING

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-01-00/R-00

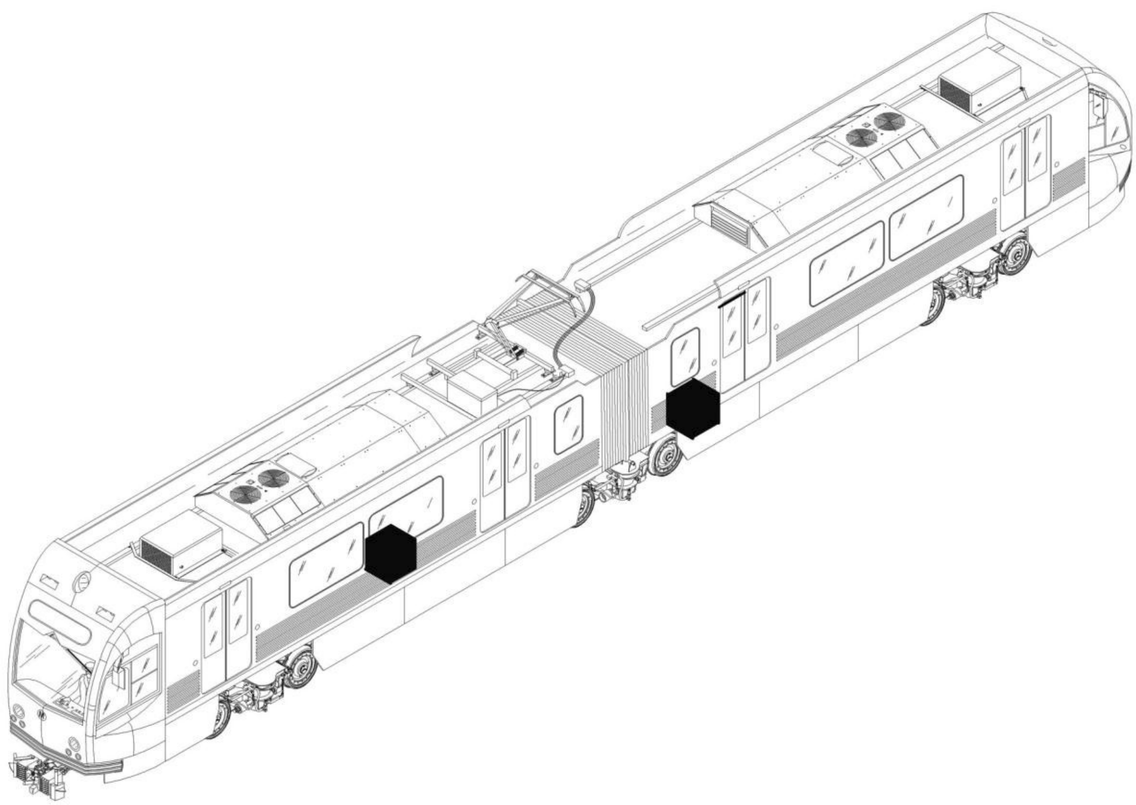
System:	Sheet:
PROPULSION	**1/8**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**LINE REACTOR (1L01)**

Component:	Man Hours:
	4.0

Maintenance Task:
REPLACEMENT

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-01-00/R-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**
Component:	Man Hours: **4.0**
Maintenance Task: **REPLACEMENT**	

SAFETY PRECAUTIONS:

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: HEAVY OBJECT - LINE REACTOR WEIGHS 529 LB. SUPPORT LINE REACTOR WITH SUITABLE LIFTING DEVICE. FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit
Module Support Hydraulic Device

CONSUMABLES:

NA

SPARE PARTS:

Line Reactor P/N AA03F8M (I54087)

P2550 CORRECTIVE MAINTENANCE SHEET

		Card Code: **R-C-07-03-01-00/R-00**
System: **PROPULSION**		Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**	
Component:		Man Hours: **4.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:
PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figure 1):

1. Remove Skirts according to Sheet R-C-02-05-00-00 / R-00 to gain access to the Line Reactor.
2. Disconnect the Junction Box Grounding Cable first and then remove the Junction Box Cover by loosening relevant hardware.
3. Disconnect the HV Cables from Terminals.
4. Secure and protect the HV Cables Terminals and Connector using suitable Clamps and Protection Caps.
5. Place the Module Support Hydraulic Device under the Line Reactor.
6. Remove the fixing Screws (2, 6), Washers (3, 7) and Nuts (4, 8).

NOTE: Now the Line Reactor is free. It remains in position because it is supported by the Supports. To lower it a first movement (shift) in the lateral direction is needed to allow the disengagement from its Supports.

WARNING: **HEAVY OBJECT - LINE REACTOR WEIGHS 529 LB. SUPPORT LINE REACTOR WITH SUITABLE LIFTING DEVICE. FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-01-00/R-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**	
Component:		Man Hours: **4.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

7. Lower and remove the Line Reactor (1) with the Shims (5) using the Module Support Hydraulic Device.

8. Make available the removed Line Reactor for Maintenance.

INSTALLATION

To perform the task proceed as follows (Refer to Figure 1):

1. Position the Line Reactor (1) to be installed on the Module Support Hydraulic Device, ready for on Vehicle installation.

2. Carefully raise the Line Reactor using Module Support Hydraulic Device.

3. Place the Line Reactor (1) with the Shims (5) on the Supports in order to match the Underframe Structure fixing holes with the Line Reactor fixing holes.

4. Install the fixing Screws (2, 6), Washers (3, 7) and Nuts (4, 8).

5. Connect the HV Cables to Terminals of Junction Box.

6. Install the Junction Box Cover by means of relevant hardware first and then reconnect the Junction Box Grounding Cable.

7. Install Skirts according to Sheet R-C-02-05-00-00 / R-00.

8. Record inspection results on the Defect Report Card for administrative and maintenance planning.

9 Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS(**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-01-00/R-00**	
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**
Component:	Man Hours: **4.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

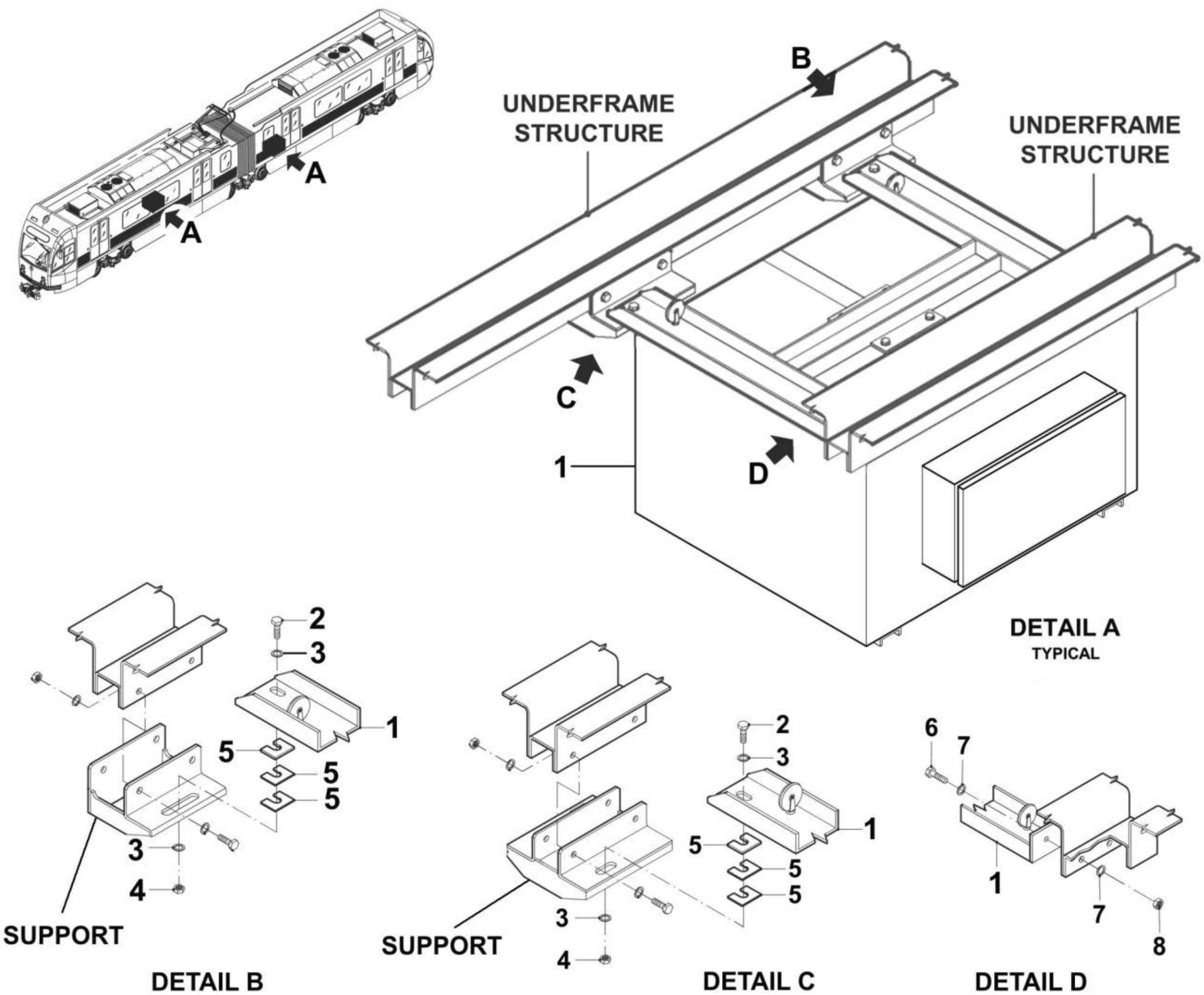


Figure 1 - LINE REACTOR REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-01-00/R-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE REACTOR (1L01)**	
Component:		Man Hours: **4.0**
Maintenance Task: **REPLACEMENT**		

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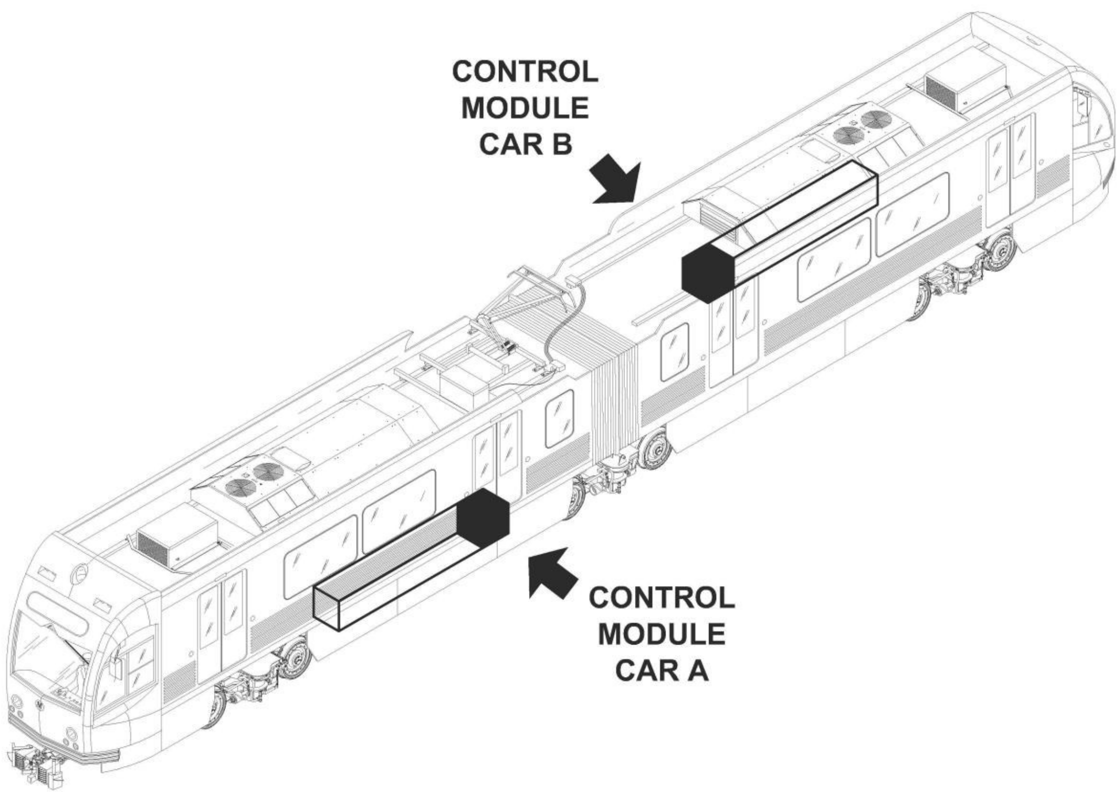
P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-02-00/R-00

System:		Sheet:
PROPULSION		**1/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE VOLTAGE TRANSDUCER**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-02-00/R-00

System:
PROPULSION

Sheet:
2/6

Subsystem/Assy:
TRACTION INVERTER HV COMPONENTS

Unit:
LINE VOLTAGE TRANSDUCER

Component:

Man Hours:
1.5

Maintenance Task:
REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:
LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:
CRC 2000 Contact Cleaner
CRC Industrial - Precision Cleaner M3 PN 147535

SPARE PARTS:

TRANSDUCER (TVF) P/N 211ET22613B

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:	**R-C-07-03-02-00/R-00**
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE VOLTAGE TRANSDUCER**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it. Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.

2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to the TVF Line Voltage Transducer.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1.

3. Disconnect Electrical Connections from TVF Line Voltage Transducer.

4. Remove the TVF Line Voltage Transducer by removing fixing Screws, Washers and Nuts.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-02-00/R-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE VOLTAGE TRANSDUCER**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

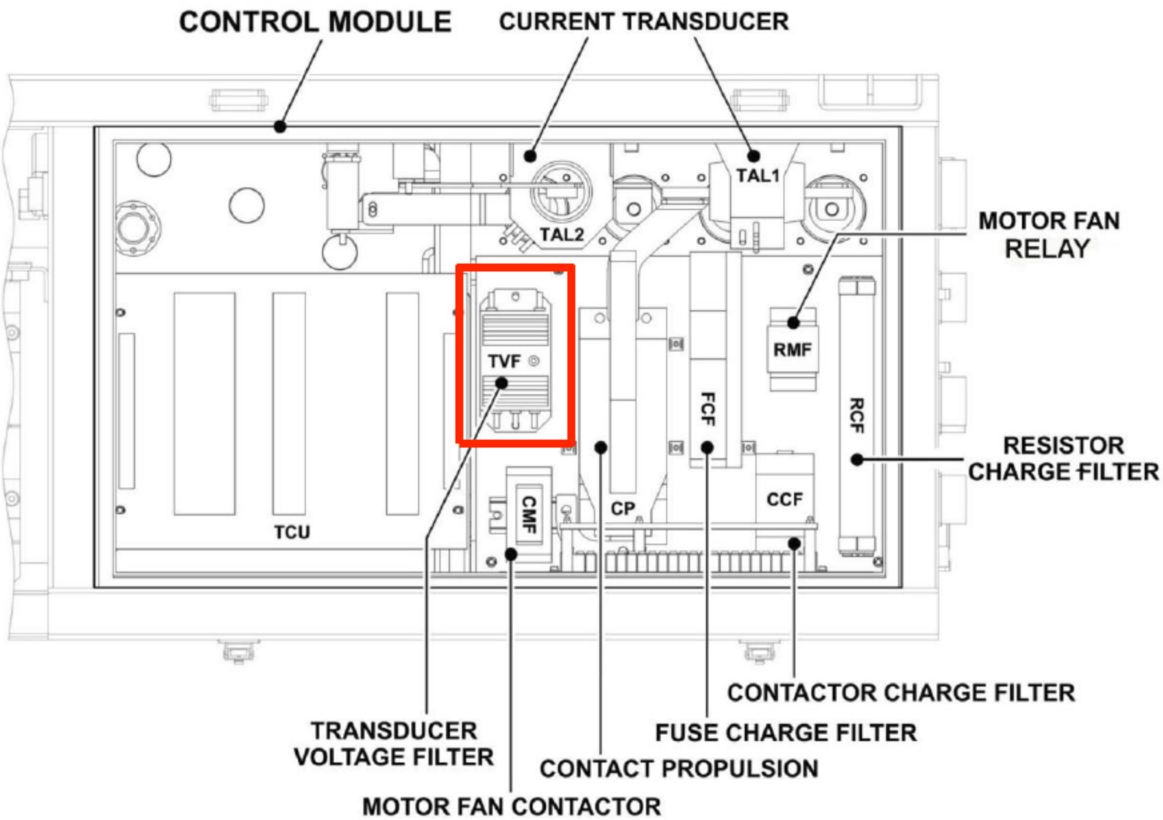


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-03-02-00/R-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE VOLTAGE TRANSDUCER**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Install the TVF Line Voltage Transducer in its position.

2 Install the fixing Screws, Washers and Nuts. Tighten as required.

3. Clean the contacts with the recommended agent and a lint-free rag.

4. Connect the Electrical Connections to TVF Line Voltage Transducer.

5. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

6. Reconnect the Grounding Cable.

7. Record task results on the Defect Report Card for administrative and maintenance planning.

8. Once completed, proceed as follows:

   a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

   b. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-02-00/R-00**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE VOLTAGE TRANSDUCER**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

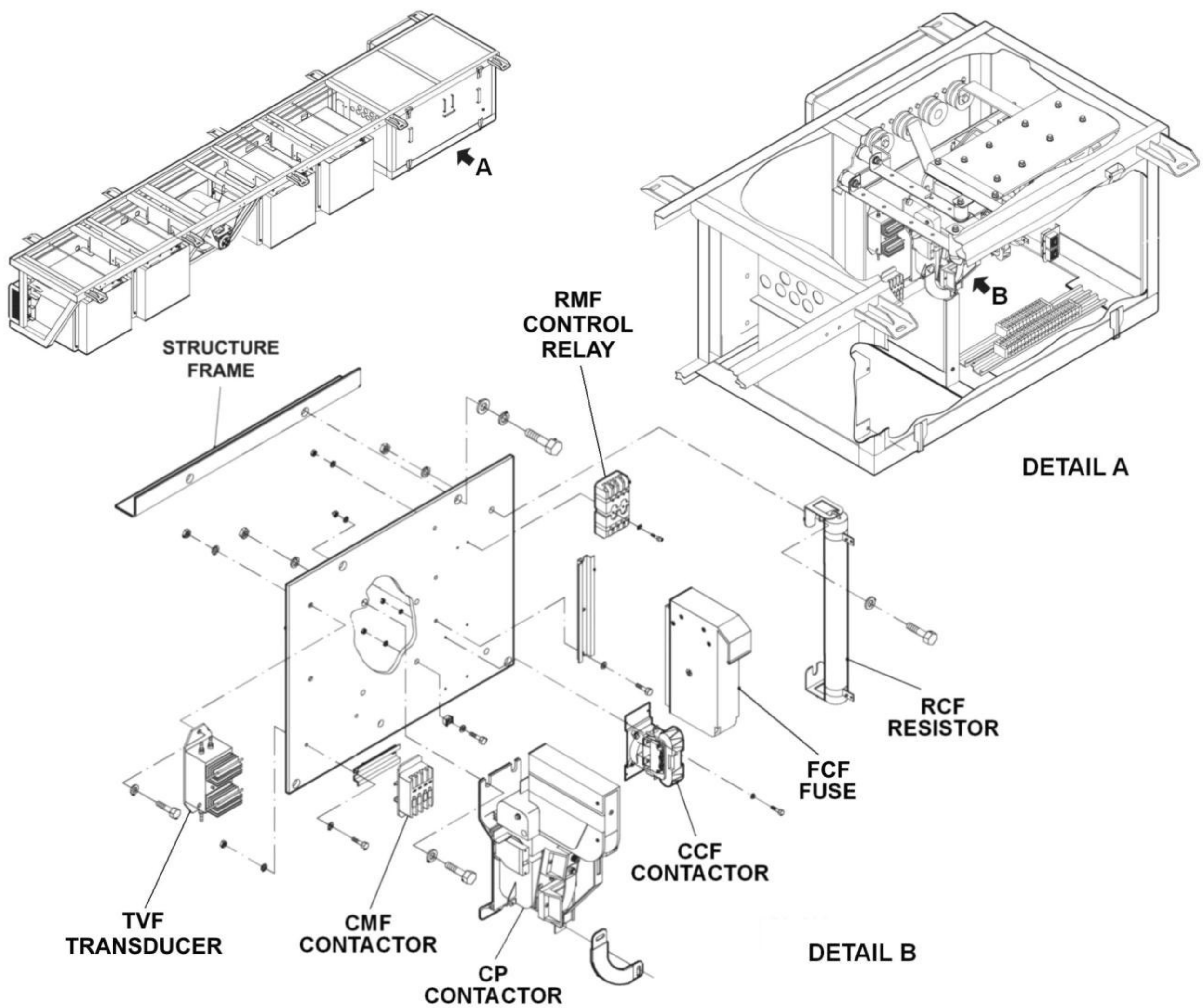


Figure 3 - CONTROL MODULE - TVF LINE VOLTAGE TRANSDUCER REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-03-00/R-00

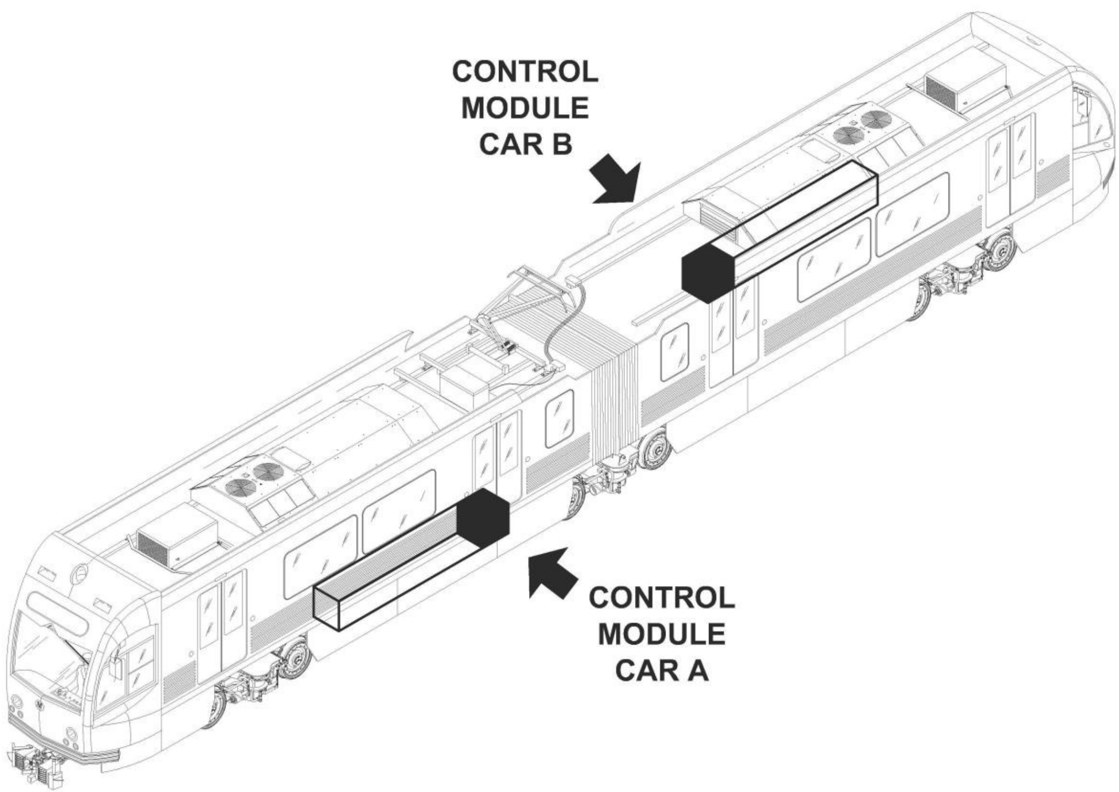
System:	Sheet:
PROPULSION	**1/6**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**LINE CURRENT TRANSDUCER**

Component:	Man Hours:
	1.5

Maintenance Task:	
REPLACEMENT	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-03-00/R-00

System:	Sheet:
PROPULSION	**2/6**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**LINE CURRENT TRANSDUCER**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

**WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.**

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

**WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.**

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

TOOLS:
LACMTA Maintenance Shop Standard Tools Kit.

CONSUMABLES:
CRC 2000 Contact Cleaner
CRC Industrial - Precision Cleaner M3 PN 147535

SPARE PARTS:

CURRENT TRANSDUCER (TAL1 & TAL2) PN 211ET22501B02

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-03-03-00/R-00**
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE CURRENT RANSDUCER**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.
2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to TAL1 and/or TAL2 Line Current Transducers.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1.

3. Disconnect Electrical Connections from TAL1 & TAL2 Line Current Transducers.
4. Remove the TAL1 and/or TAL2 Line Current Transducers by removing fixing Screws, Washers and Nuts.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-03-00/R-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE CURRENT TRANSDUCER**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

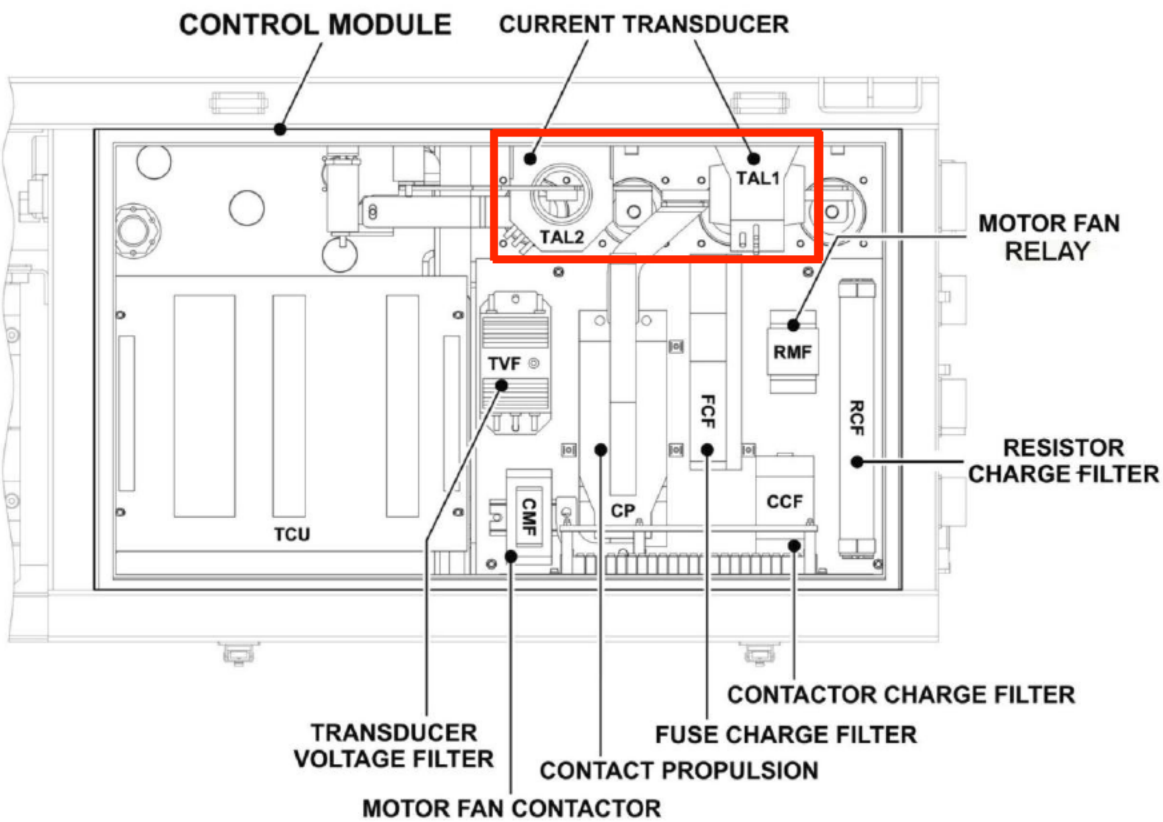


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

		Card Code: **R-C-07-03-03-00/R-00**
System: **PROPULSION**		Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE CURRENT TRANSDUCER**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Install the TAL1 and/or TAL2 Line Current Transducers in position.

2 Install the fixing Screws, Washers and Nuts. Tighten as required.

3. Clean the contacts with the recommended agent and a lint-free rag.

4. Connect the Electrical Connections to TAL1 & TAL2 Line Current Transducers.

5. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

6. Reconnect the Grounding Cable.

7. Record task results on the Defect Report Card for administrative and maintenance planning.

8. Once completed, proceed as follows:

- a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.
- b. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-03-00/R-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **LINE CURRENT TRANSDUCER**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

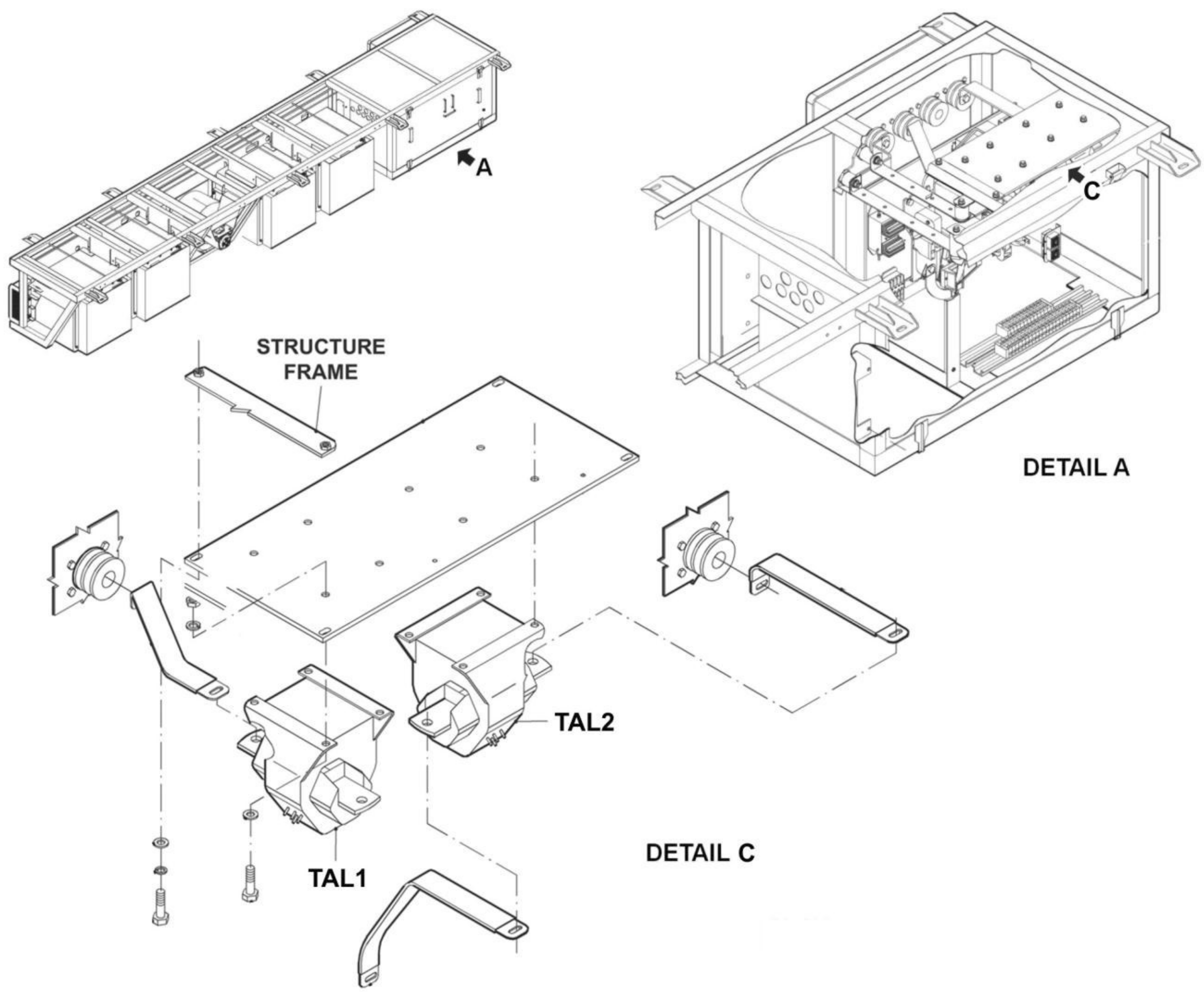
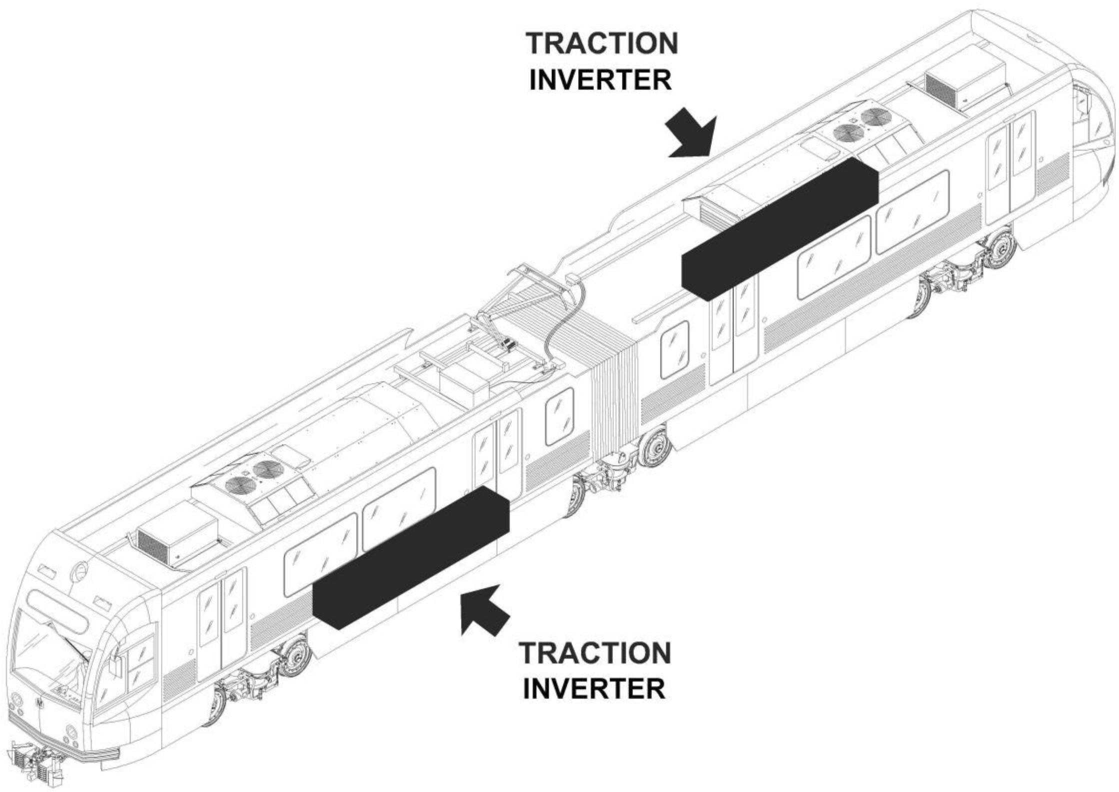


Figure 3 - CONTROL MODULE - LINE CURRENT TRANSDUCERS REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-03-04-00/R-00**
System: **PROPULSION**	Sheet: **1/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE** **IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-04-00/R-00

System: **PROPULSION**

Sheet: **2/20**

Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**

Unit: **IGBT PHASE MODULE**
IGBT CHOPPER MODULE

Component:

Man Hours: **1.5**

Maintenance Task: **REPLACEMENT**

SAFETY PRECAUTIONS:

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: HEAVY OBJECT - EACH MODULE WEIGHS 121.25 LB. SUPPORT THE MODULE WITH SUITABLE LIFTING DEVICE. FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

CAUTION: DURING MODULE SHIFTING PAY ATTENTION TO NOT DAMAGE THE HEAT SINK.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit
Module Support Hydraulic Device

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

IGBT PHASE MODULE	PN: AA03KJW	MFR PN	231EE09912B
IGBT CHOPPER MODULE	PN: AA03KJW	MFR PN	231EE09912B

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-04-00/R-00

System:	Sheet:
PROPULSION	**3/20**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**IGBT PHASE MODULE** **IGBT CHOPPER MODULE**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Place the Vehicle over the Pit (or Stand Up Rail).

2. Set the Master Controller Handle to FSB position.

3. Make sure that all Parking Brakes are applied (by checking on the IDU "Parking Brake A and B Not Released" and on Indicator Panel "A" "Park / Friction Brake" ON).

4. Remove Electrical Power from Vehicle by lowering the Pantograph.

5. Turn the Transfer Switch to OFF.

6. Set the Pantograph Control Motor Switch (5F02 CB LV Locker "A" Section) to OFF.

7. Lock out and tag out the Switch in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-04-00/R-00

System:	Sheet:
PROPULSION	**4/20**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**IGBT PHASE MODULE** **IGBT CHOPPER MODULE**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

REMOVAL
To perform the task proceed as follows:

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Traction Inverter Modules.

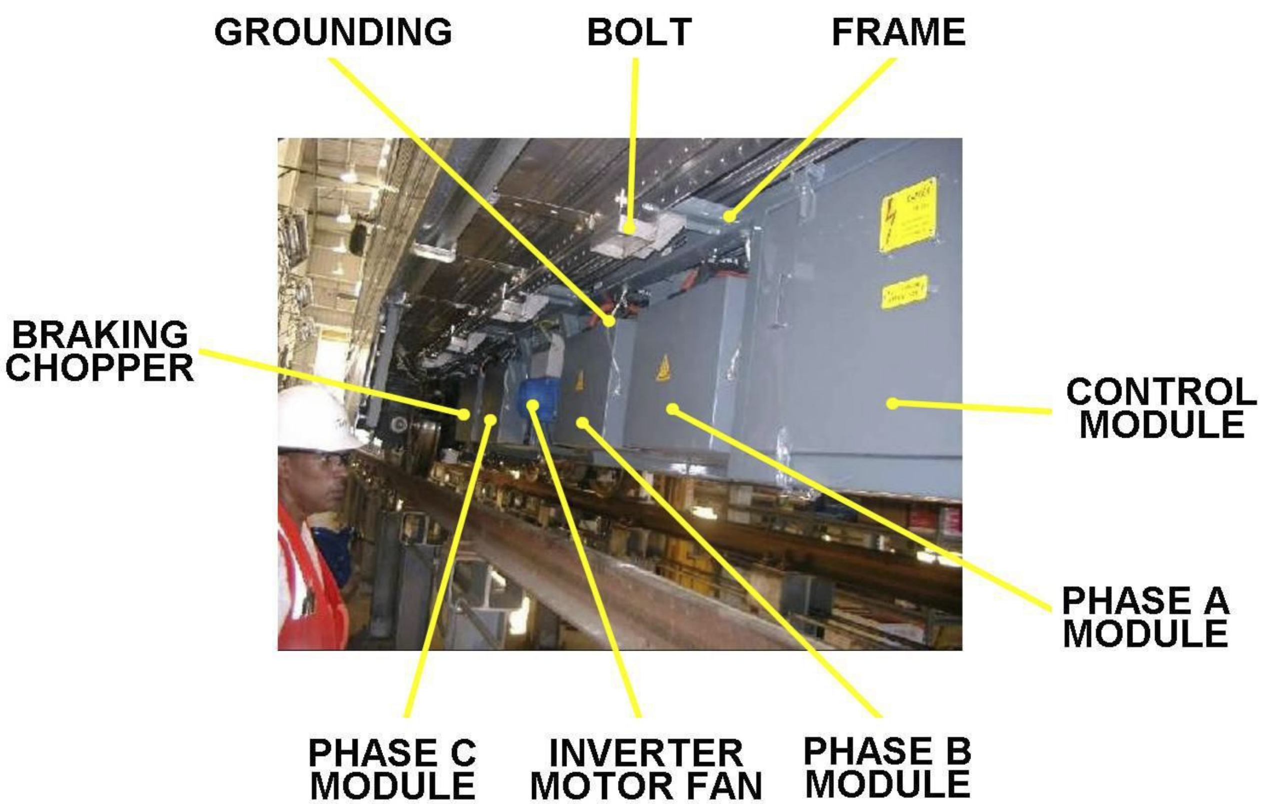


Figure 1 - TRACTION INVERTER

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-03-04-00/R-00**
System: **PROPULSION**	Sheet: **5/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

2. Disconnect the Grounding Cable and Fixing Screws**.** Retain relevant hardware for later use.

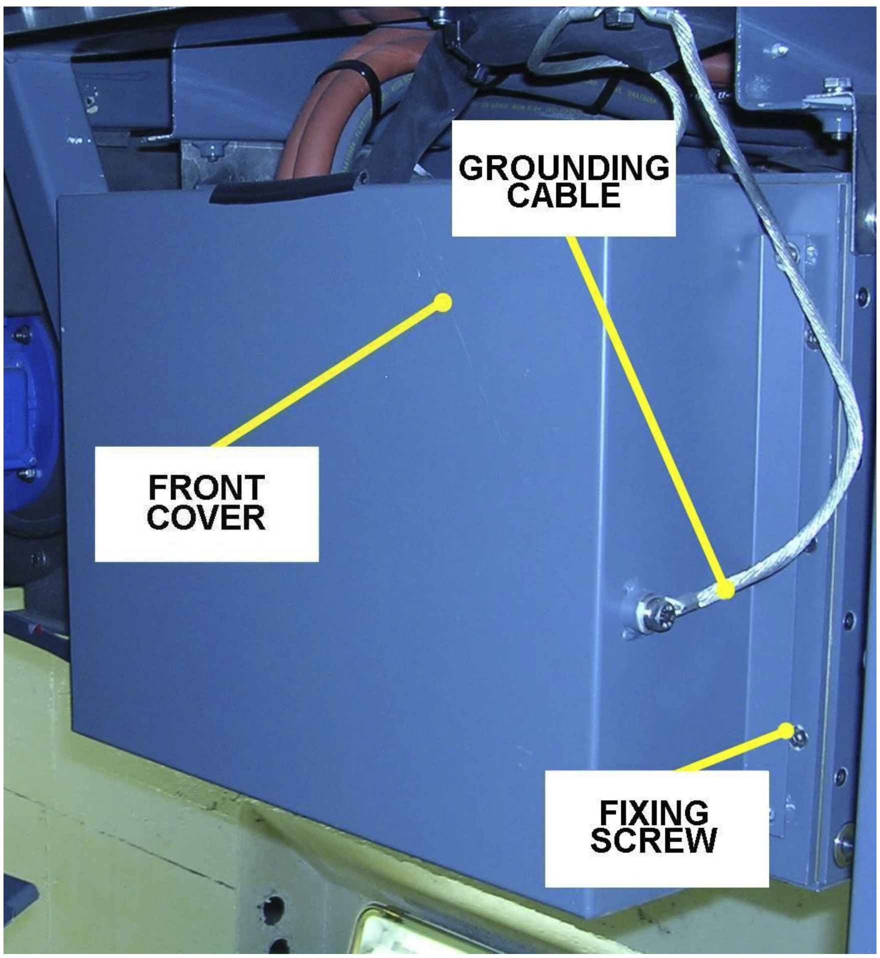


Figure 2 - MODULE FRONT COVER

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-04-00/R-00**	
System: **PROPULSION**	Sheet: **6/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

3. Remove the Front Cover.

Figure 3 - FRONT COVER

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-04-00/R-00**	
System: **PROPULSION**	Sheet: **7/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

4. Remove the HV Terminals Protectors.
5. Disconnect the HV Cables and LV Connector. Retain relevant hardware for later use.

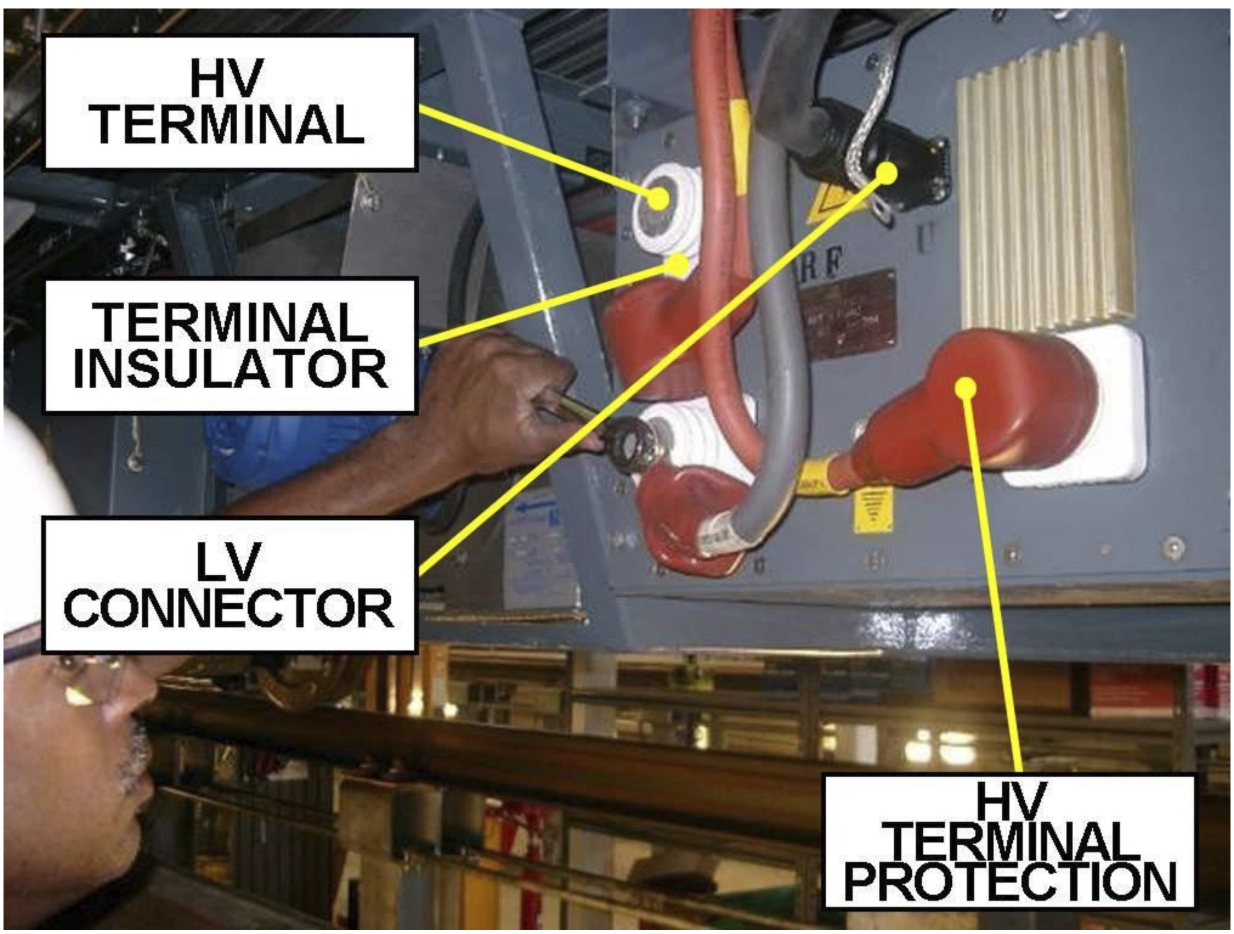


Figure 4 - MODULE ELECTRICAL CONNECTIONS (TYPICAL)

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-04-00/R-00**		
System: **PROPULSION**		Sheet: **8/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

6. Place the Module Support Hydraulic Device under the Phase Module.

Figure 5 - SUPPORTING THE MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-04-00/R-00**	
System: **PROPULSION**	Sheet: **9/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

7. Remove the 4 Side Screws (2 Left + 2 Right).

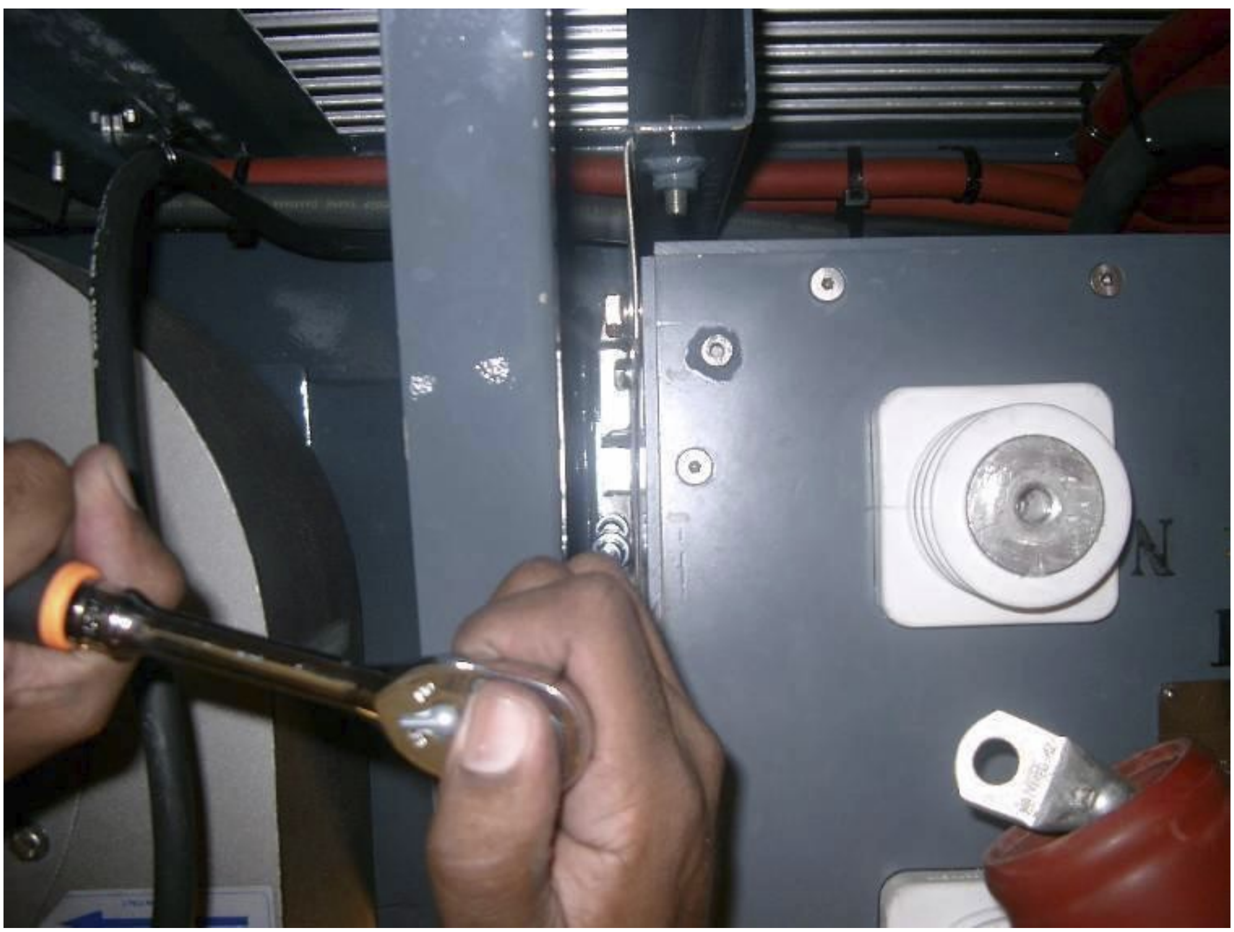


Figure 6 - MODULE LEFT SIDE SCREWS

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-04-00/R-00**		
System: **PROPULSION**		Sheet: **10/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

8. Remove the Left Upper Screw.

Figure 7 - MODULE UPPER SCREWS (LEFT)

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-04-00/R-00

System:	Sheet:
PROPULSION	**11/20**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**IGBT PHASE MODULE** **IGBT CHOPPER MODULE**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

9. Remove the Right Upper Screw.

Figure 8 - MODULE UPPER SCREWS (RIGHT)

NOTE: Now the Inverter Module is free. It remains in position because it is supported by the Upper Brackets.
To lower it a first movement (shift) in the lateral direction is needed to allow the disengagement of the Heat Sink from its Cooling Duct located in the rear side of the Module.

WARNING: **HEAVY OBJECT - EACH MODULE WEIGHS 121,25 LB.
SUPPORT THE MODULE WITH SUITABLE LIFTING DEVICE.
FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-04-00/R-00**		
System: **PROPULSION**		Sheet: **12/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

10. Disengage the Module Heat Sink from its Cooling Duct (located in the Rear Side of the Module) by shifting the Module as shown in the following 3 steps.
11. Secure the wires using tie-wraps so that they are not in the way when pulling out the IGBT (as shown in Figure 12).

CAUTION: DURING MODULE SHIFTING PAY ATTENTION TO NOT DAMAGE THE HEAT SINK.

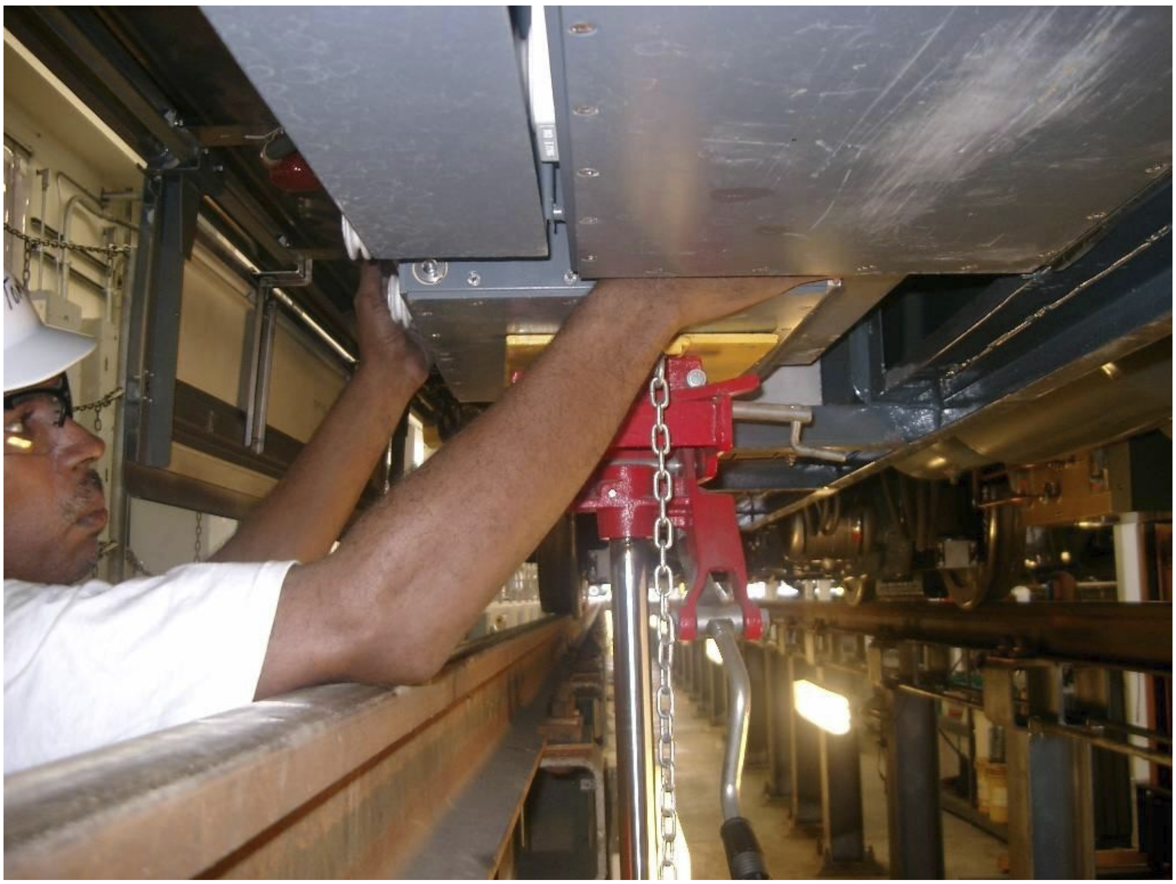


Figure 9 - SHIFTING THE MODULE (STEP 1)

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-04-00/R-00

System:	Sheet:
PROPULSION	**13/20**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**IGBT PHASE MODULE** **IGBT CHOPPER MODULE**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

Figure 10 - SHIFTING THE MODULE (STEP 2)

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-04-00/R-00**		
System: **PROPULSION**		Sheet: **14/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

Figure 11 - SHIFTING THE MODULE (STEP 3)

NOTE: In the Module position as shown in Fig 11 the Heat Sink is disengaged from the Cooling Channel.

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-03-04-00/R-00**
System: **PROPULSION**	Sheet: **15/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

11. Lower and remove the Module using the Module Support Hydraulic Device.

Figure 12 - LOWERING / RAISING THE MODULE (STEP 1)

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-04-00/R-00**		
System: **PROPULSION**		Sheet: **16/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

Figure 13 - LOWERING / RAISING THE MODULE (STEP 2)

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-04-00/R-00**	
System: **PROPULSION**	Sheet: **17/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

Figure 14 - LOWERING / RAISING THE MODULE (STEP 3)

12. Make available the removed Module for Maintenance.
13. Secure and protect the HV cables Terminals and LV connector using suitable Clamps and Protection Caps.

INSTALLATION

To perform the task proceed as follows:

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-04-00/R-00**	
System: **PROPULSION**	Sheet: **18/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

NOTE: It is assumed that:

1. The Vehicle is in Safety Conditions in accordance with LACMTA Overhaul Regulations.
2. The Module to be installed is placed on the Module Support Hydraulic Device, ready for on vehicle installation.

1. On Traction Inverter:
   a) Clean the Module Compartment using recommended agent and cleaning rags.
   b) Make free the HV Terminals, Cables and LV Connector from Clamps and Protection Caps.

2. Position the Module to be installed as shown in previous fig 14 step 3.

3. Carefully raise the Phase module using the Module Support Hydraulic Device as shown in previous fig 13 steps 2 and 1.

4. Stop the raising when the Module Brackets are about 1/3 inch higher than the Frame Upper Brackets in order to allow the Module securely sliding in to its position.

5. Carefully slide the Module for about 1/3 of its side dimension and, at the same time, lower it in order to engage the module Heat Sink with the Cooling Channel, as shown in previous fig 11 steps 3, fig 10 steps 2, and fig 9 steps 1.

CAUTION: DURING MODULE SHIFTING PAY ATTENTION TO NOT DAMAGE THE HEAT SINK.

6. Lower the Module to allow the Frame Upper Brackets to completely support it.

NOTE: Now the Module is still free but it remains in position because it is supported by the Frame Upper Brackets.

7. Install the Module Upper Screws (2), as shown in previous figs 7 and 8. Tighten to **15.5 ft-lb**.

8. Install the Module Side Screws (4), as shown in previous fig 6. Tighten to **15.5 ft-lb**.

9. Remove the Module Support Hydraulic Device.

10. Reconnect HV terminals. Thighten them by hand and proceed to next step.

11. Reconnect LV Connector.

12. Secure the LV and HV Cables with relevant ties suitably positioned in order to meet the Wiring geometry and routing shown in Figures 15 and 16. Upon completed , tighten the HV terminals to **52 ft-lb**.

13. Install HV Terminal Protectors.

14. Install the Module Cover and Grounding as shown in previous fig 3.Tighten the relevant hardware.

15. Restore the Electrical Power.

16. Record task results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.
Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section)and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-04-00/R-00**

System: **PROPULSION**	Sheet: **19/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**
Component:	Man Hours: **1.5**

Maintenance Task: **REPLACEMENT**

PROCEDURE (CONT'D):

NOTE : The wiring must have the geometry as shown in the following Figure .
Also in the front of the module the cables must not have turns routing.

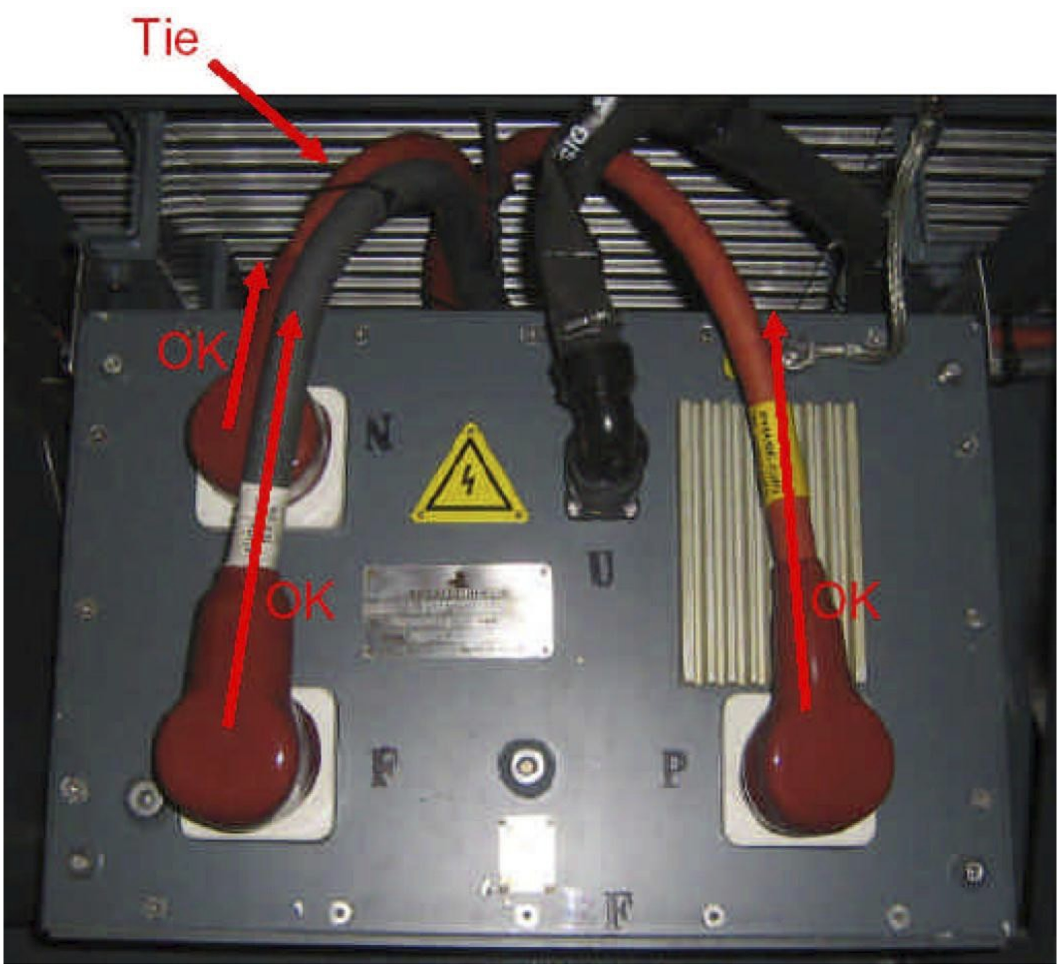


Figure 15 - FRONT VIEW - MODULE PROPERLY WIRED

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-04-00/R-00**		
System: **PROPULSION**		Sheet: **20/20**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **IGBT PHASE MODULE IGBT CHOPPER MODULE**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

NOTE : The cables have to keep a perpendicular routing respect to the floor/rail. This means also that all the cables must have and keep a constant distance from the IGBT module front panel.

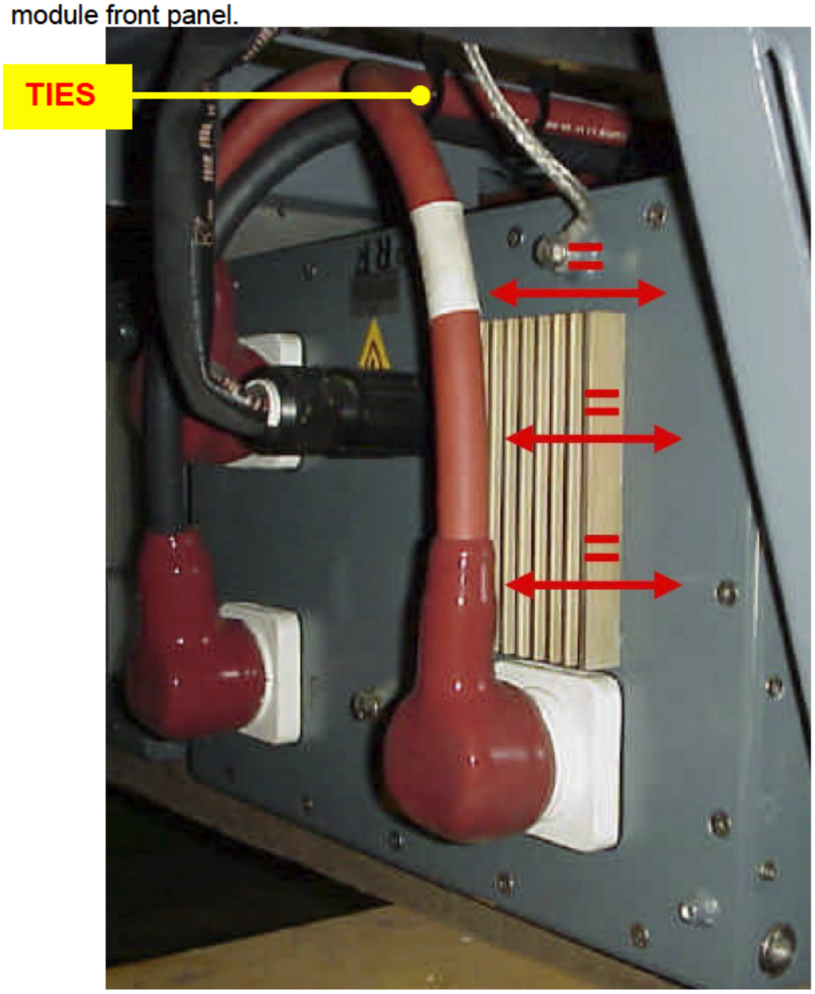
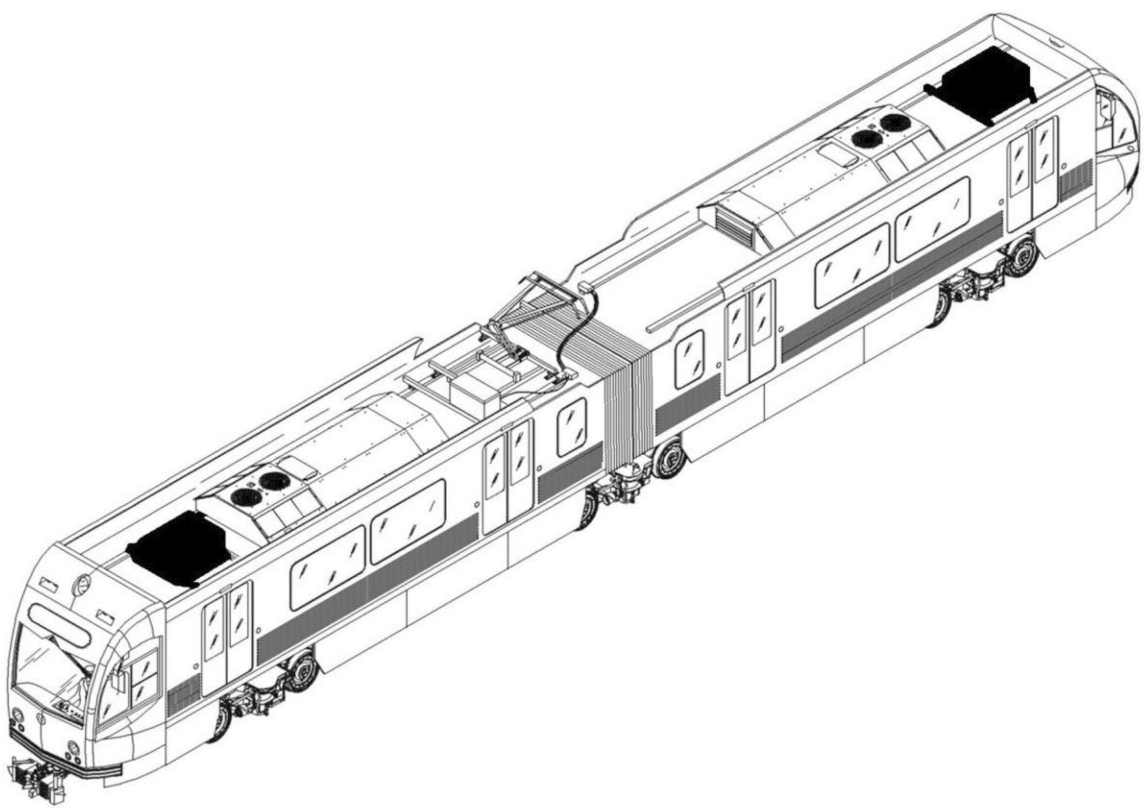


FIGURE 16 - MODULE - FRONT - DETAIL
CABLES PERPENDICULAR ROUTING AND CONSTANT DISTANCE FROM THE IGBT MODULE FRONT PANEL

P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-03-06-00/R-00**
System: **PROPULSION**		Sheet: **1/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**	
Component:		Man Hours: **3.0**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:

R-C-07-03-06-00/R-00

System:	Sheet:
PROPULSION	**2/6**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**BRAKING RESISTOR**

Component:	Man Hours:
	3.0

Maintenance Task:

REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: **BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.**

WARNING: **DANGER OF PERSONAL INJURY EXISTS DUE TO ELECTRICAL POWER.(750V) ENSURE PANTOGRAPH IS LOWERED, AND CATENARY POWER IS REMOVED AND ISOLATED PER LACMTA SAFETY RULES AND PROCEDURES.**
IF POSSIBLE, WORK SHOULD BE DONE IN AN AREA WITHOUT OVERHEAD CATENARY.

WARNING: **DANGER OF PERSONAL INJURY EXISTS DUE TO THE WORKING ON ROOF. FOLLOW SAFETY PROCEDURES FOR ACCESSING ROOF. ALWAYS WEAR A SAFETY HARNESS WHEN ACCESSING THE ROOF.**

WARNING: **ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.**
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: **BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.**

WARNING: **HEAVY OBJECT - BRAKING RESISTOR WEIGHS 320 LB. SUPPORT BRAKING RESISTOR WITH SUITABLE LIFTING DEVICE. FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

TOOLS:

LACMTA Standard Tools Kit
Lifting Device

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

Braking Resistor	P/N	AA03KDX	MFR PN:	211VR01198B02

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-06-00/R-00**	
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **3.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To remove the Braking Resistor Assy proceed as follows (Refer to Figure 1):

1. Access to Vehicle Roof "A" and "B" Car according to MTA procedures.

WARNING: DANGER OF PERSONAL INJURY EXISTS DUE TO THE WORKING ON ROOF. FOLLOW SAFETY PROCEDURES FOR ACCESSING ROOF. ALWAYS WEAR A SAFETY HARNESS WHEN ACCESSING THE ROOF.

2. Disconnect the Power Cables from the Terminals.
3. Disconnect the Ground Strap from the Braking Resistor.
4. Remove the fixing Screws (2), Washers (3, 4) and Nuts (5).
5. Hoist the Braking Resistor (1) using the eyebolts installed on the top.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-06-00/R-00**	
System: **PROPULSION**	Sheet: **4/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **3.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To install the Braking Resistor Assy proceed as follows (Refer to Figure 1):

WARNING: **HEAVY OBJECT - BRAKING RESISTOR WEIGHS 320 LB. SUPPORT BRAKING RESISTOR WITH SUITABLE LIFTING DEVICE. FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.**

1. Hoist the Braking Resistor (1)
2. Place the Braking Resistor (1) on the Supports on the Roof Vehicle in order to match the Roof Structure installation holes with the Braking Resistor fixing holes.
3. Install the fixing Screws (2), Washers (3, 4) and Nuts (5).
4. Re-connect the Braking Resistor Ground Strap.
5. Connect the Power Cables to the Terminals.
6. Restore the Electrical Power.
7. Record Task results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**.

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-03-06-00/R-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**
Component:	Man Hours: **3.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

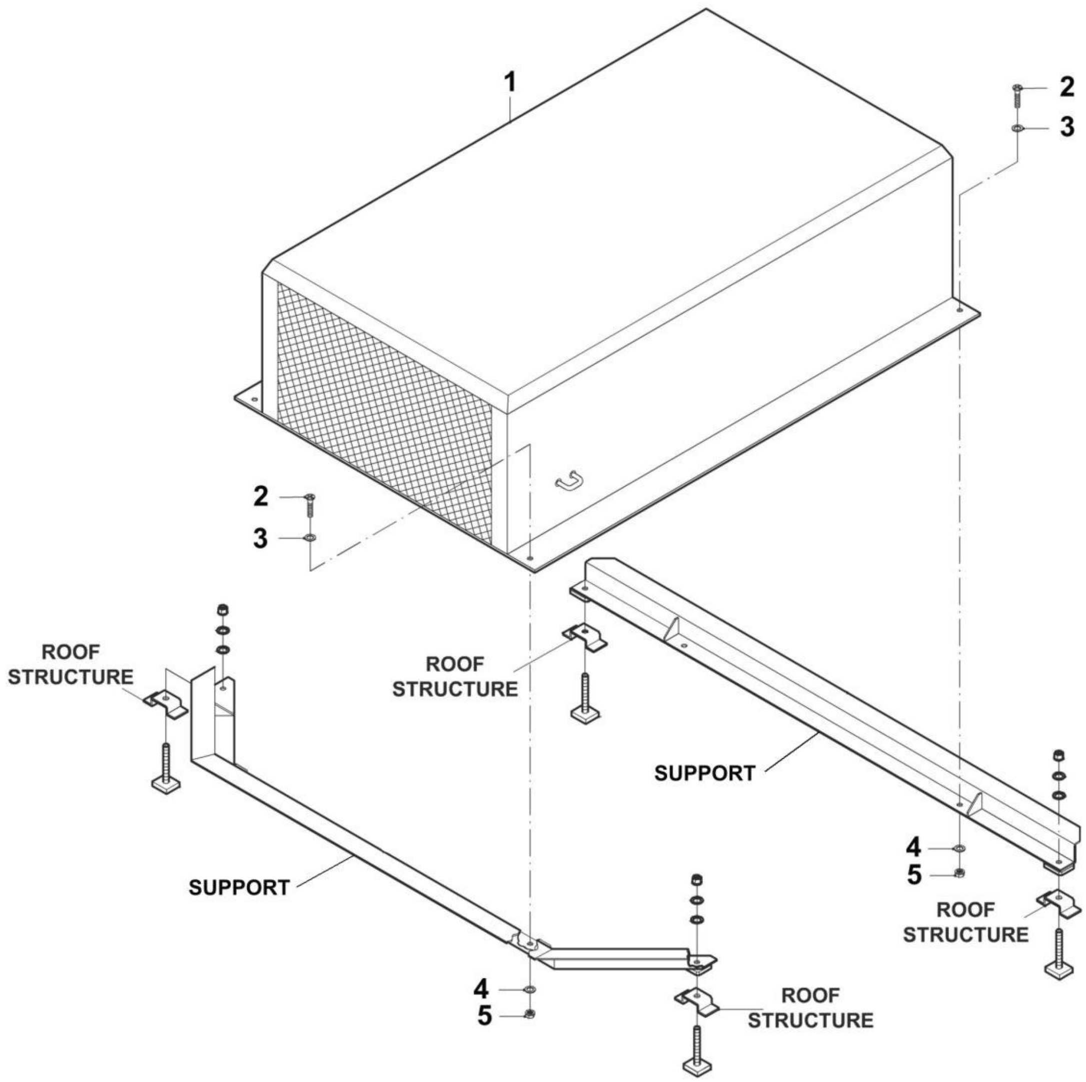


Figure 1 - BRAKING RESISTOR REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-06-00/R-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **BRAKING RESISTOR**	
Component:		Man Hours: **3.0**
Maintenance Task: **REPLACEMENT**		

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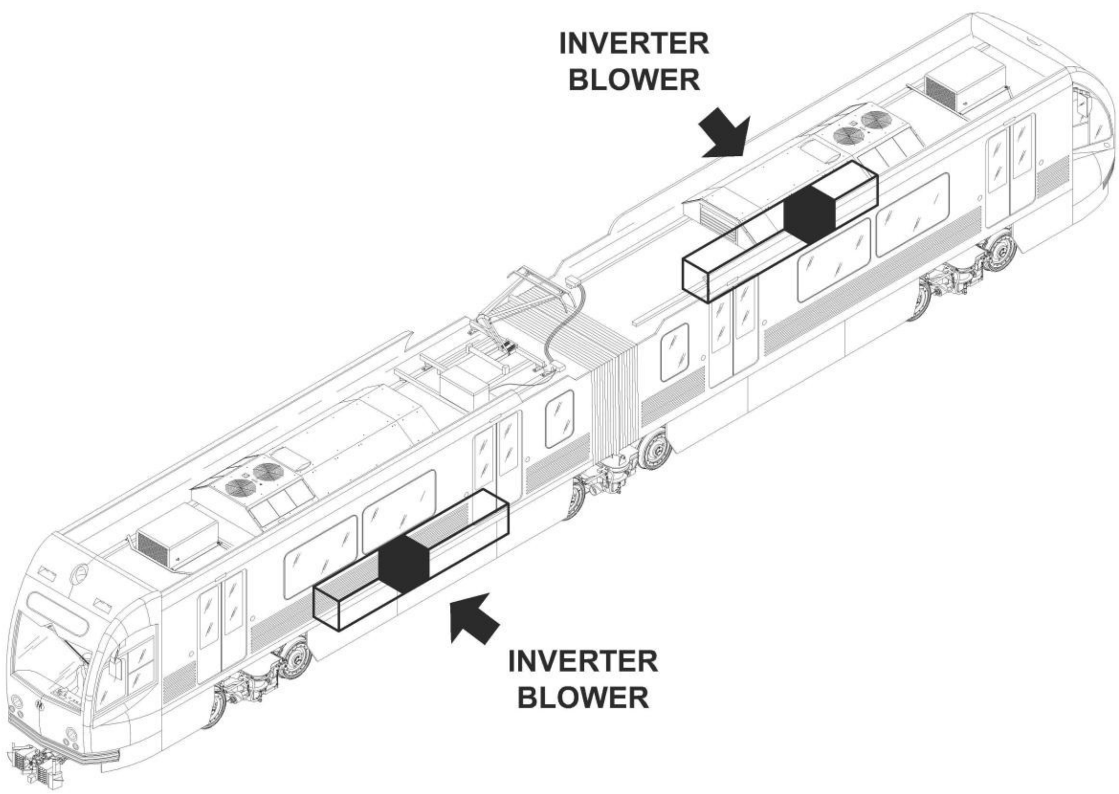
P2550 CORRECTIVE MAINTENANCE SHEET		
	Card Code: **R-C-07-03-07-00/R-00**	
System: **PROPULSION**		Sheet: **1/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-07-00/R-00**	
System: **PROPULSION**	Sheet: **2/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

**WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.**

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

**WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.**

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

WARNING: HEAVY OBJECT - COOLING FAN MODULE WEIGHS 70,55 LB. SUPPORT COOLING FAN MODULE WITH SUITABLE LIFTING DEVICE. FAILURE TO COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

WARNING: KEEP IN PLACE THE LIFTING ROPE UNTIL THE INVERTER COOLING MOTOR FAN IS SECURED TO THE FRAME.

CAUTION: DURING INVERTER COOLING MOTOR FAN SLIDING PAY ATTENTION TO NOT DAMAGE THE PACKING.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-07-00/R-00

System:	Sheet:
PROPULSION	**3/10**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**INVERTER COOLING MOTOR FAN**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

TOOLS:

LACMTA Standard Tools Kit

Support Hydraulic Device

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

Inverter Cooling Motor Fan	(P/N AA03Z7R)
Fan Weldment Packing	(P/N 212EE10048B)

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-07-00/R-00**		
System: **PROPULSION**		Sheet: **4/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

8. Place the relevant CB 2F06 (Propulsion Motor Fan Circuit Breaker located on the LV Locker both cars) to OFF position.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-07-00/R-00**	
System: **PROPULSION**	Sheet: **5/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):
(Refer to Figures 1, 2, 3)

REMOVAL

To perform the Task proceed as follows:

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Inverter Motor Fan Compartment.

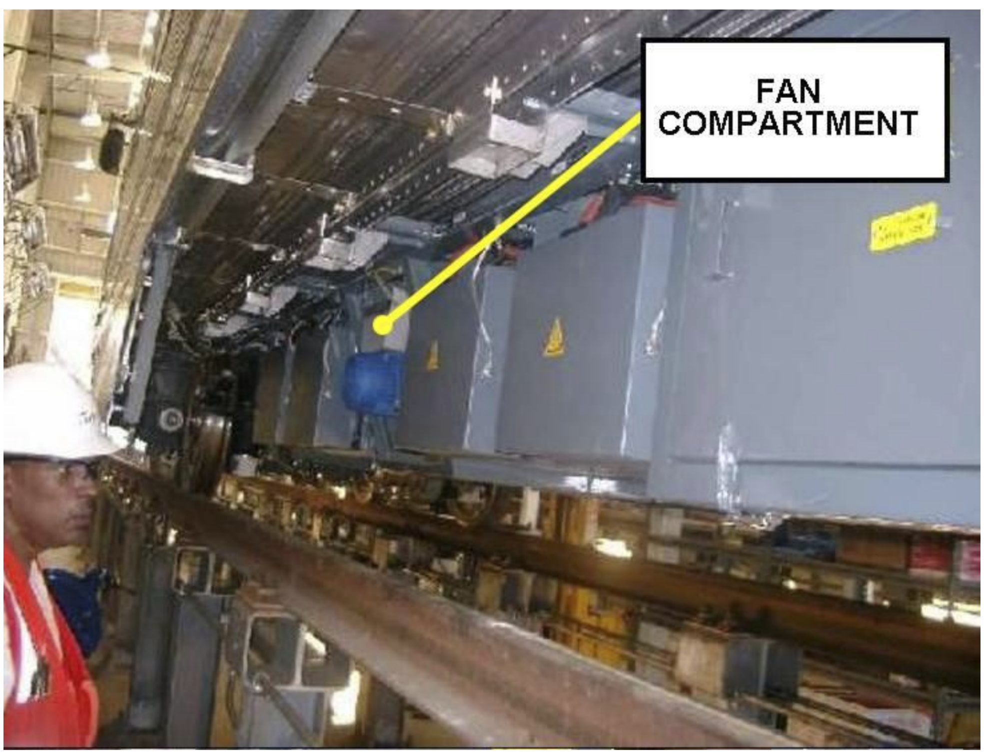


Figure 1 - TRACTION INVERTER

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-07-00/R-00**	
System: **PROPULSION**	Sheet: **6/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

2. Disconnect the Grounding Wire by loosening relevant hardware.. Retain hardware for later use. Protect Terminal by suitable Protection Cap.

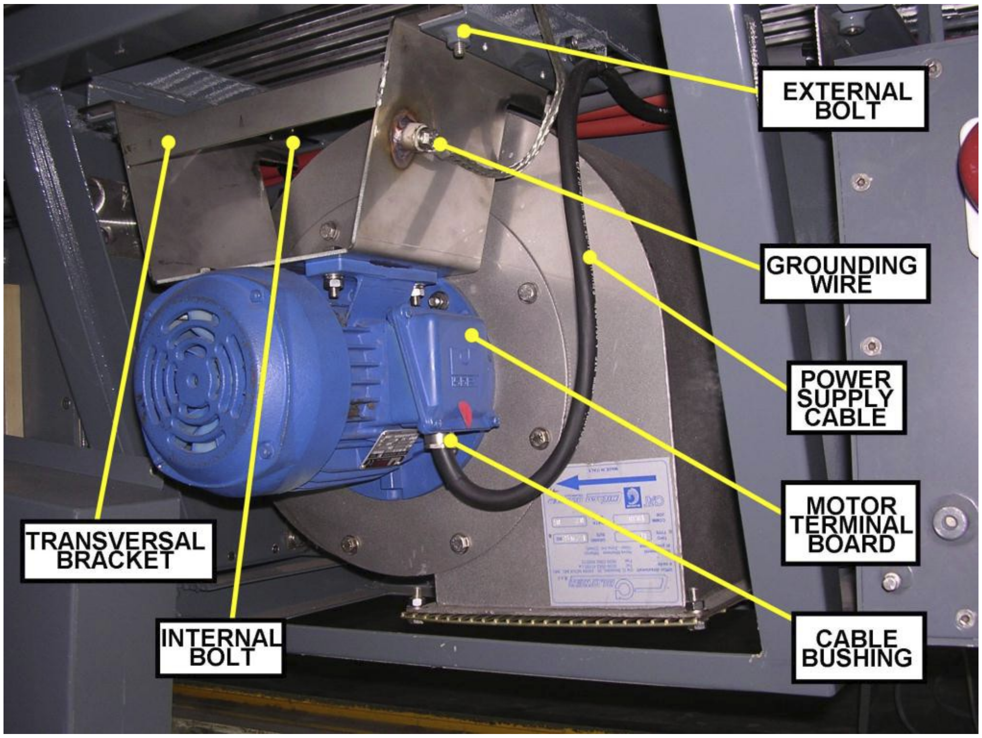


Figure 2 - TRACTION INVERTER - MOTOR FAN COMPARTMENT

3. Remove the Motor Power Supply Terminal Board Cover by loosening relevant hardware. Retain hardware and Cover for later use.

4. Loosen the Cable Bushing and remove the Motor Power Supply Cable, by disconnecting the relevant Terminals.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-07-00/R-00**

System:	Sheet:
PROPULSION	**7/10**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**INVERTER COOLING MOTOR FAN**

Component:	Man Hours:
	1.5

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

5. Secure the Motor Power Supply Cable by relevant Clamp and protect Cable Terminals using suitable Protection Caps.

6. Position one end of suitable lifting Rope onto the Inverter Cooling Motor Fan Transversal Bracket and connect the other end to the Shop Crane Hook.

7. Carefully raise, for safety reasons, the Shop Crane Hook in order to have the lifting Rope not completely stretched.

WARNING: HEAVY OBJECT - COOLING FAN MODULE WEIGHS 70.55 LB. SUPPORT COOLING FAN MODULE WITH SUITABLE LIFTING DEVICE. COMPLY CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH.

8. Remove the 2 Inverter Cooling Motor Fan External Bolts.
9. Remove the 2 Inverter Cooling Motor Fan Internal Bolts.

NOTE: Now the Inverter Cooling Motor Fan is free. It remains in position because it is supported by the Upper Brackets.
To remove it a first movement (shift) in the lateral direction is needed to allow the disengagement of the Cooling Fan from Cooling Duct.

10. Raise the Shop Crane Hook in order to have the Inverter Cooling Motor Fan supported by the lifting Rope.

11. Lower the Inverter Cooling Motor Fan on a suitable shop device provided with wood edges shaped so that they should safely support the motor.

12. Make available the removed Inverter Cooling Motor Fan for Repair.

NOTE: Do not forget to collect the Motor Terminal Board, relevant hardware and Cable Bushing in suitable box.

13. Remove the Fan Weldment Packing and discard.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-07-00/R-00**		
System: **PROPULSION**		Sheet: **8/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**	
Component:		Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

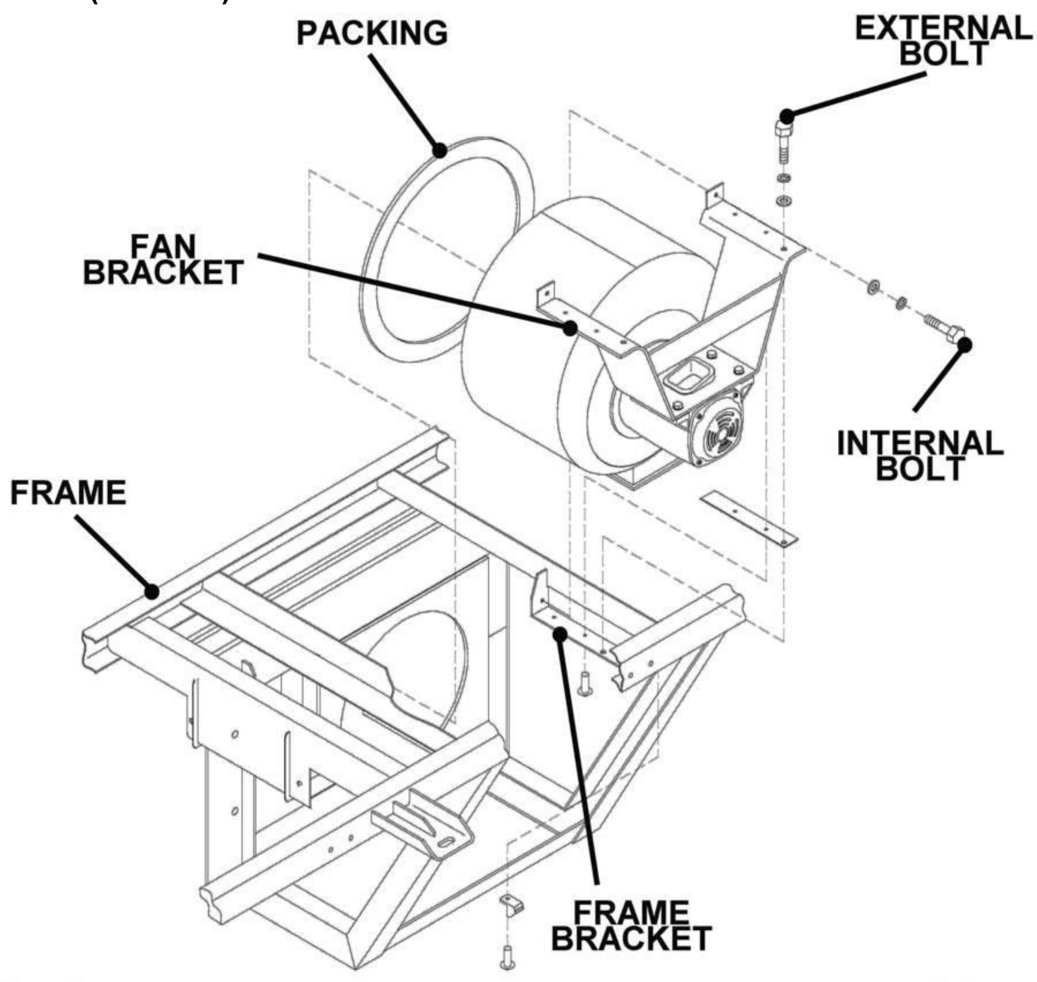


Figure 3- INVERTER COOLING MOTOR FAN REMOVAL / INSTALLATION

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-07-00/R-00**	
System: **PROPULSION**	Sheet: **9/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION
To perform the task proceed as follows:

NOTE: It is assumed that:
1. The Vehicle is in Safety Conditions in accordance with LACMTA Overhaul Regulations.
2. The Inverter Cooling Motor Fan is ready for On Vehicle installation.

1. Install new Fan Weldment Packing paying attention to completely remove adhesive residue, using recommended agent, before positioning the new Gasket.

2. On Traction Inverter:
   a) Clean the Inverter Cooling Motor Fan Compartment using recommended agent and cleaning rags.
   b) Make free the Inverter Cooling Motor Fan Terminals and Cable from Protection Caps. and Clamp.

3. Position one end of suitable lifting Rope onto the Inverter Cooling Motor Fan Transversal Bracket and connect the other end to the Shop Crane Hook.

4. Carefully raise the Inverter Cooling Motor Fan using the shop Crane.
5. Stop the raising when the Inverter Cooling Motor Fan Brackets are about 1/3 inch higher than the Frame Brackets in order to allow the Inverter Cooling Motor Fan secure sliding in to its position
6. Carefully slide the Inverter Cooling Motor Fan for about 1/3 of its Brackets dimension and, at the same time, lower it in order to match the Inverter Cooling Motor Fan with the Cooling Channel.

CAUTION: DURING INVERTER COOLING MOTOR FAN SLIDING PAY ATTENTION TO NOT DAMAGE THE PACKING.

7. Lower the Inverter Cooling Motor Fan to allow the Frame Upper Brackets to completely support it.

NOTE: Now the Inverter Cooling Motor Fan is still free but it remains in position because it is supported by the Frame Upper Brackets.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-07-00/R-00**	
System: **PROPULSION**	Sheet: **10/10**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **INVERTER COOLING MOTOR FAN**
Component:	Man Hours: **1.5**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

8. Carefully lower the Shop Crane Hook in order to have the lifting Rope not completely stretched.

WARNING: KEEP IN PLACE THE LIFTING ROPE UNTILL THE INVERTER COOLING MOTOR FAN IS SECURED TO THE FRAME

9. Install Inverter Cooling Motor Fan Internal Bolts and torque to **15.5 ft-lb**.

10. Install Inverter Cooling Motor Fan External Bolts and torque to **15.5 ft-lb**.

11. Connect the Motor Power Supply Cable Terminals and tighten the Cable Bushing.

12. Lower the Shop Crane Hook in order to easily remove the Lifting Rope End from Inverter Cooling Motor Fan Transversal Bracket first and then the other end from the Shop Crane Hook.

13. Remove the Protection Cap from the Grounding Wire Terminal and Install it by tightening the relevant hardware.

14. Once completed the Inverter Cooling Motor Fan installation, switch on the relevant Propulsion Motor Fan Circuit Breaker 2F06.

15. Restore the Electrical Power.

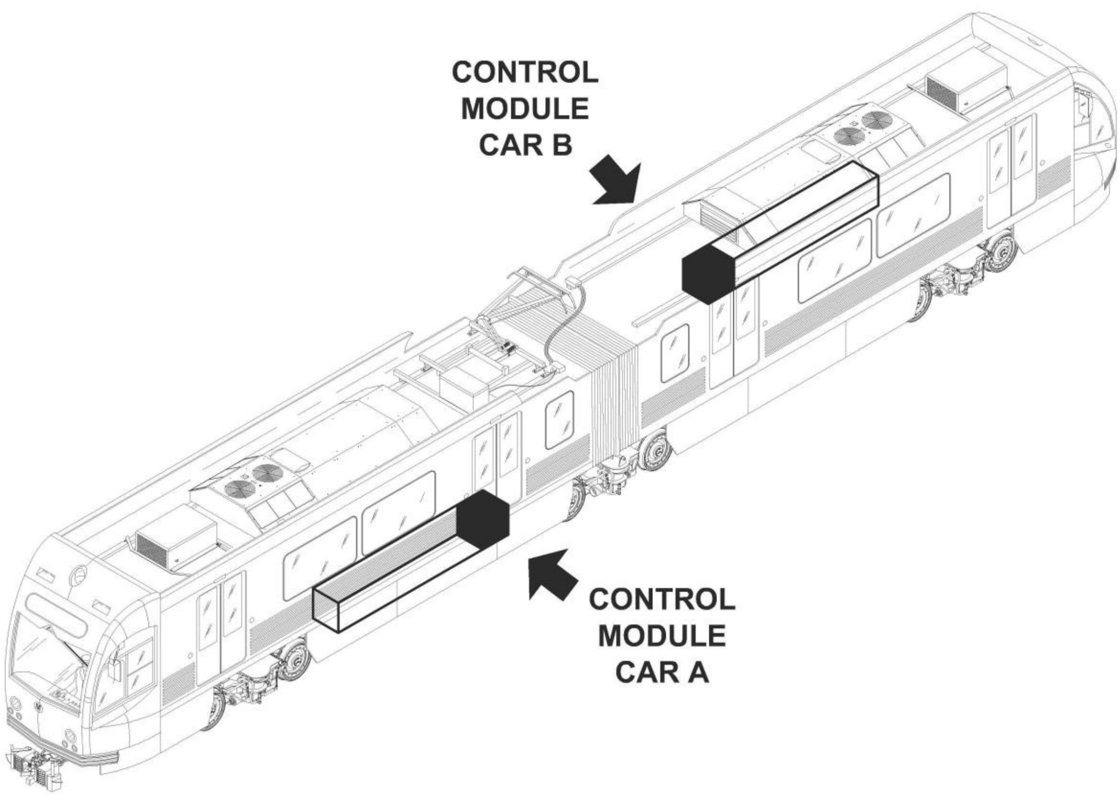
16. Record Task results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET	
	Card Code: **R-C-07-03-08-00/R-00**
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-03-08-00/R-00

System:	Sheet:
PROPULSION	**2/8**

Subsystem/Assy:	Unit:
TRACTION INVERTER HV COMPONENTS	**MOTOR FAN CONTACTOR**

Component:	Man Hours:
	1.0

Maintenance Task:
REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP, SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

TOOLS:

LACMTA Standard Tools Kit

CONSUMABLES:

CRC 2000 Contact Cleaner
CRC Industrial - Precision Cleaner M3 PN 147535

SPARE PARTS:

CMF CONTACTOR Type 3 POLES CONTACTOR P/N 211VK01330B011020

P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-03-08-00/R-00**
System: **PROPULSION**		Sheet: **3/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it. Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.
2. Disconnect the Grounding Cable, release Safety Latches and remove the Cover of the Control Module to gain access to CMF Contactor.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1

3. Disconnect Electrical Connections from CMF Contactor.
4. Remove the CMF Contactor by removing fixing Screws, Washers and Nuts.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-08-00/R-00**	
System: **PROPULSION**	Sheet: **4/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

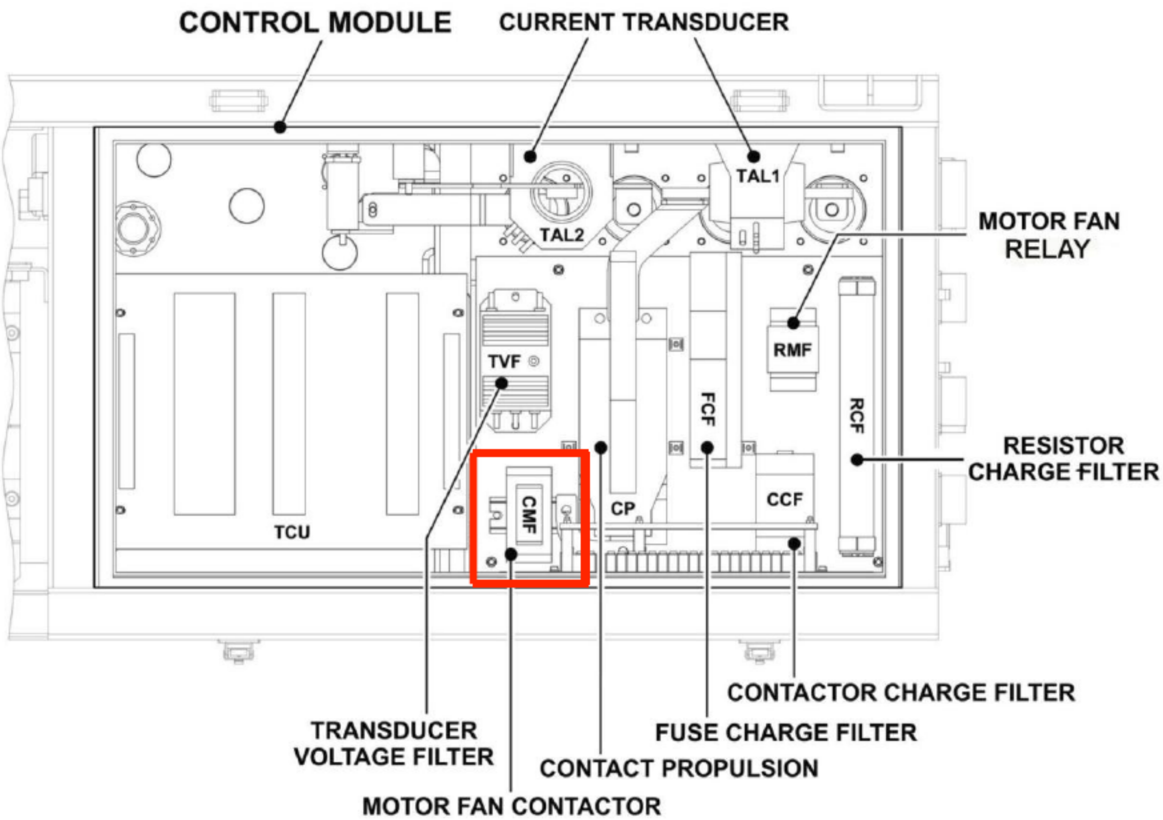


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-03-08-00/R-00**		
System: **PROPULSION**		Sheet: **5/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

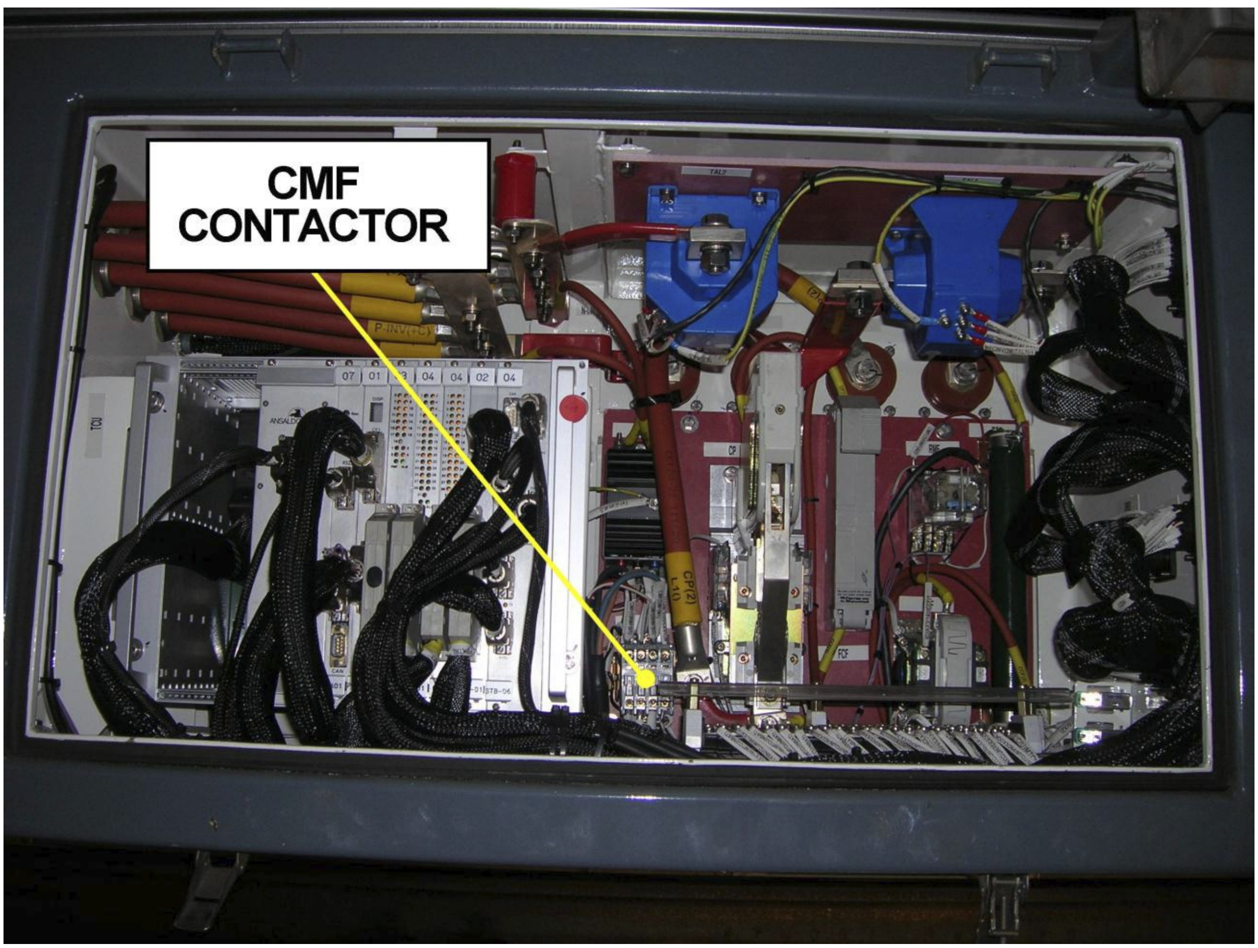


Figure 2 - CONTROL MODULE - INTERIOR

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-03-08-00/R-00**	
System: **PROPULSION**	Sheet: **6/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 through 3):

1. Install the CMF Contactor in its position.
2. Install the fixing Screws, Washers and Nuts. Tighten as required.
3. Clean the Auxiliary and Main contacts with the recommended agent and a lint-free rag.
4. Connect the Electrical Connections to CMF Contactor.
5. Reinstall the Control Module Cover and secure it by locking the Safety Latches.
6. Reconnect the Grounding Cable.
7. Record task results on the Defect Report Card for administrative and maintenance planning.
8. Once completed, proceed as follows:
   a. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.
   b. Restore Electrical Power.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS(**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

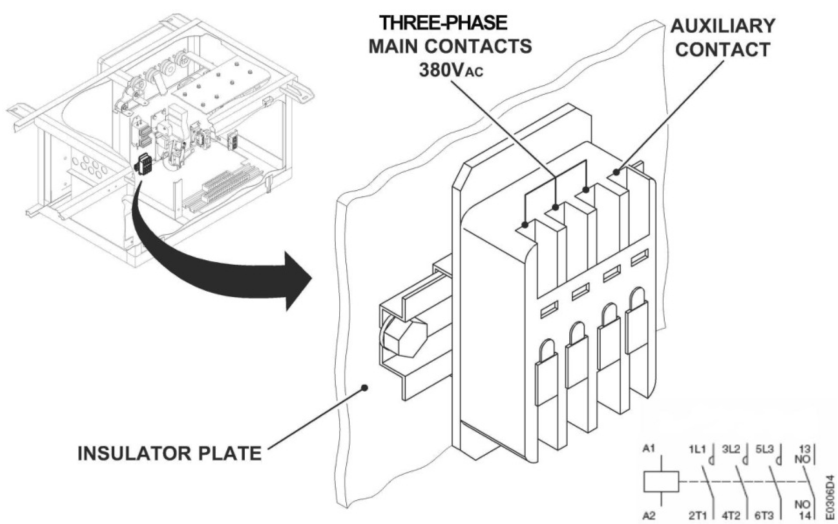


Figure 3 - MOTOR FAN CONTACTOR

P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-03-08-00/R-00**
System: **PROPULSION**		Sheet: **7/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

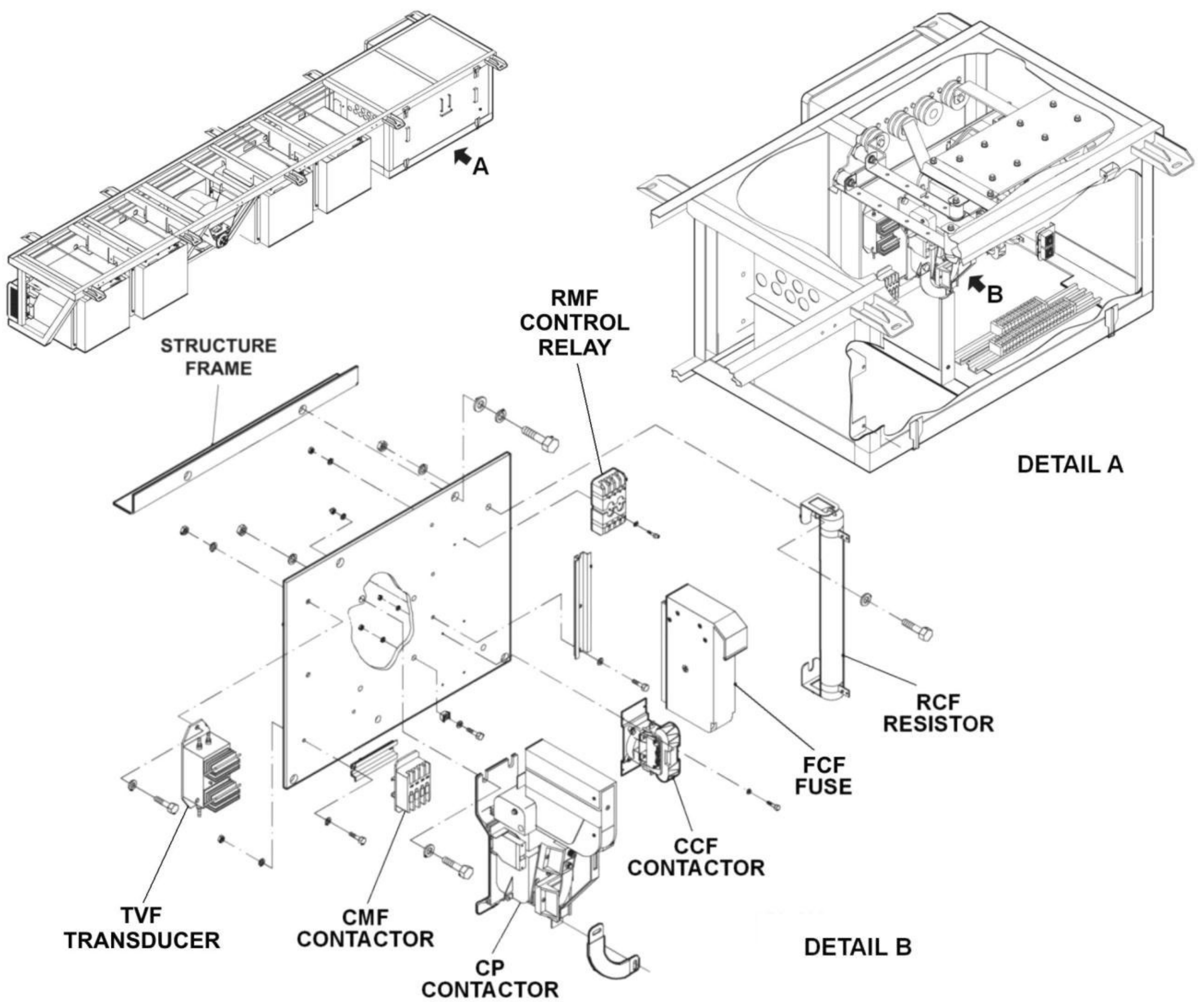


Figure 4 - CONTROL MODULE - MOTOR FAN CONTACTOR (CMF) REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET	
Card Code: **R-C-07-03-08-00/R-00**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **TRACTION INVERTER HV COMPONENTS**	Unit: **MOTOR FAN CONTACTOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

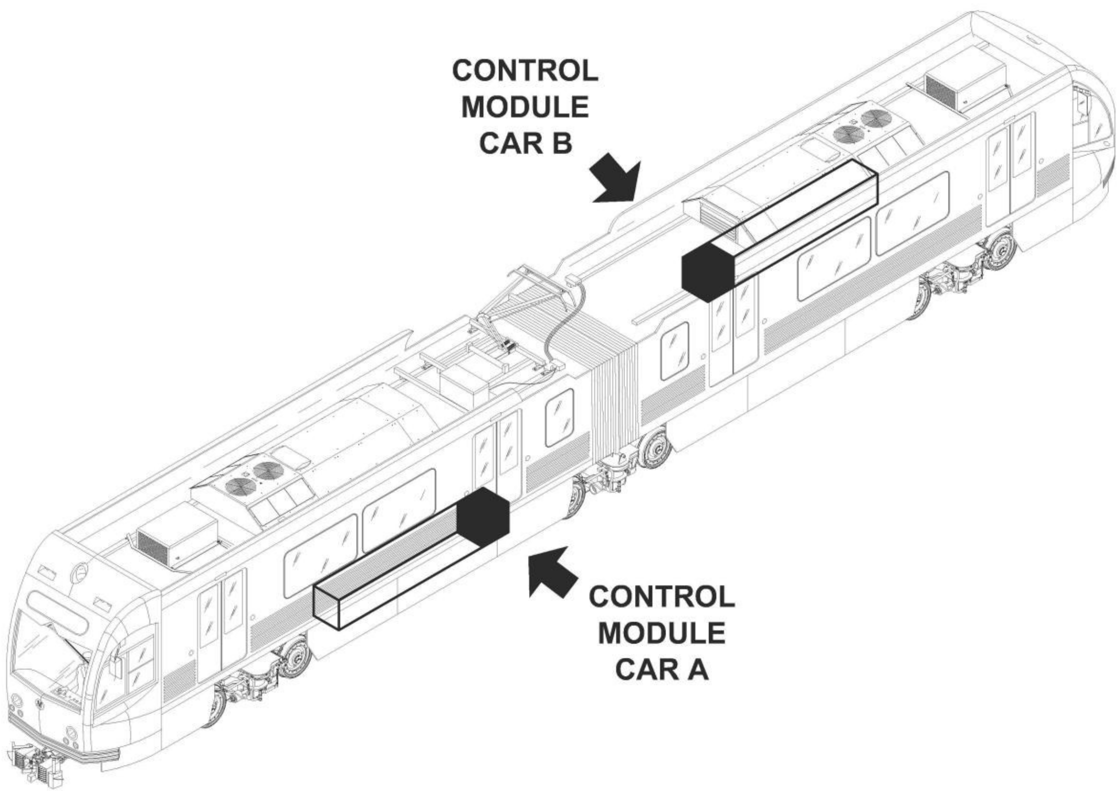
PROCEDURE (CONT'D):

INTENTIONALLY LEFT BLANK

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-04-01-00/R-00**	
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit: **BOARDS**
Component:	Man Hours: **1**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-04-01-00/R-00

System:	Sheet:
PROPULSION	**2/8**

Subsystem/Assy:	Unit:
TRACTION CONTROL UNIT (TCU)	**BOARDS**

Component:	Man Hours:
	1

Maintenance Task:
REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.

CAUTION: A TECHNICIAN HANDLING ELECTRONIC ASSEMBLIES AND COMPONENTS SHOULD WEAR A CONDUCTIVE WRIST STRAP WITH A GROUND WIRE CONNECTED EITHER TO GROUND OR CHASSIS (VEHICLE) GROUND.

CAUTION: NEVER TOUCH OR HANDLE THE PC BOARD BY ITS TRACES, CONNECTOR TEETH, OR COMPONENTS.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Vacuum Cleaner

CONSUMABLES:

Industrial - Precision Cleaner M3 PN 147535.
Dry Compressed Air for Electronic Equipment (commercial).

SPARE PARTS:

PIA-02 Board P/N:	231EE60446B
PCA-01 Board P/N:	231EE60412B
NDI-01 Board P/N:	231EE60440B
NDO-06 Board P/N:	231EE60441B
FBK-01 Board P/N	231EE60423B
STB-06 Board P/N	231EE60422B
Power Supply P/N	211EG23527B

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-04-01-00/R-00**		
System: **PROPULSION**		Sheet: **3/8**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit: **BOARDS**	
Component:		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the Task proceed as follows (Refer to Figures 1 through 4):

1. Remove Skirts according to Sheet R-C -02-05-00-00 / R-00 to gain access to Control Module.

WARNING BEFORE PERFORMING INSPECTION OR MAINTENANCE PROCEDURES TO THE TRACTION INVERTER, VERIFY CAPACITORS ARE FULLY DISCHARGED UTILIZING A VOLTMETER AND MEASURE CAPACITOR VOLTAGE AT TVF VOLTAGE TRANSDUCER CONNECTION LUGS. THESE CONNECTION POINTS ARE LOCATED IN THE CONTROL MODULE OF TRACTION INVERTER.SEE FIGURE 1.

2. Gain access to TCU by removing the Grounding Cable, Safety Latches and cover from the Control Module.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-04-01-00/R-00**		
System: **PROPULSION**		Sheet: **4/8**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit: **BOARDS**	
Component:		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):
REMOVAL

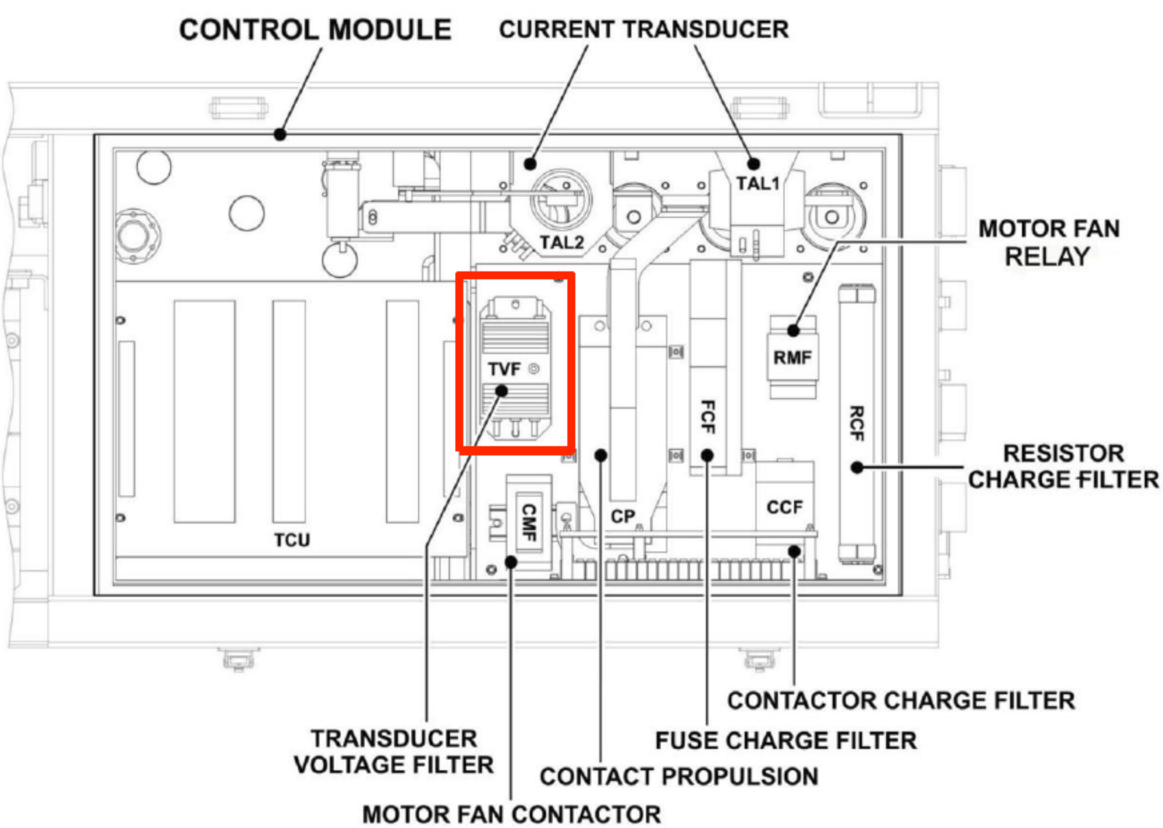


Figure 1 - CONTROL MODULE

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-04-01-00/R-00

System:	Sheet:
PROPULSION	**5/8**

Subsystem/Assy:	Unit:
TRACTION CONTROL UNIT (TCU)	**BOARDS**

Component:	Man Hours:
	1

Maintenance Task:
REPLACEMENT

PROCEDURE (CONT'D):

REMOVAL

3. Locate the TCU

DETAIL" A" Two ties each couple of " P" and " N" cables

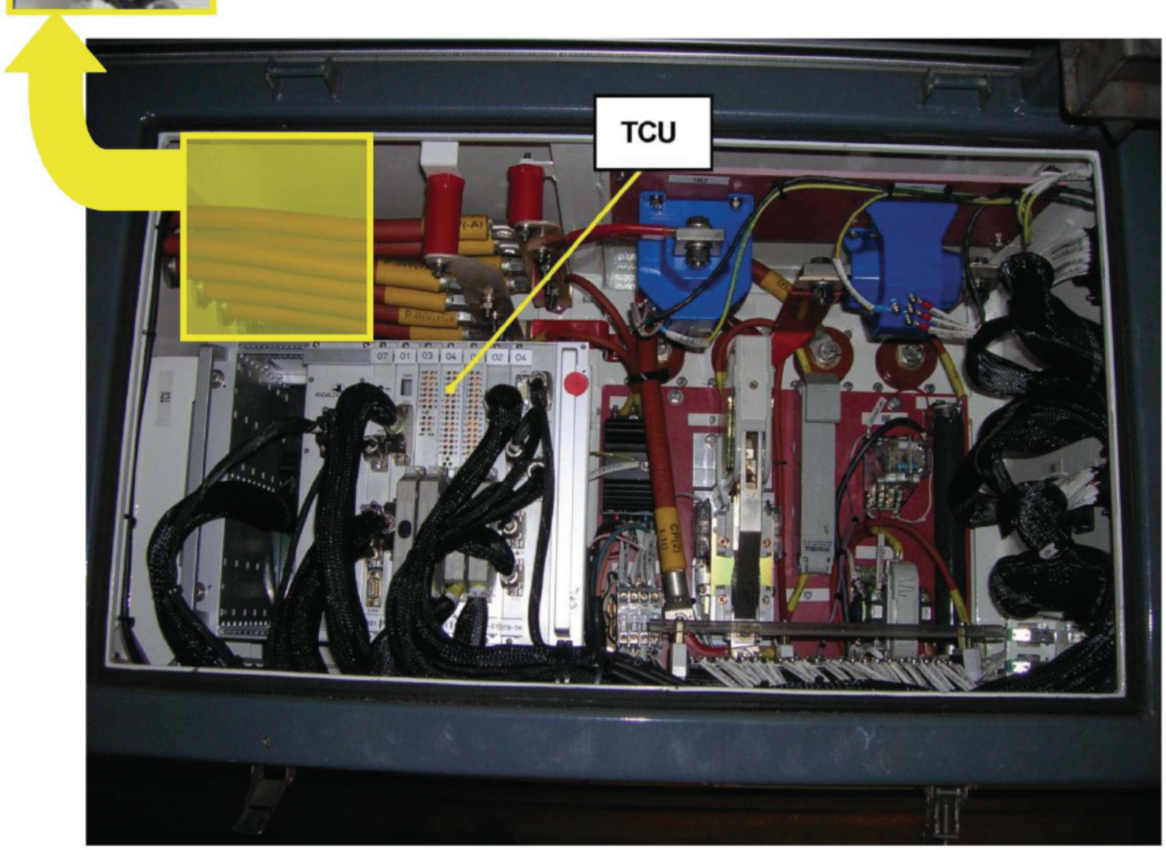


Figure 2 - CONTROL MODULE INTERIOR-TCU LOCATION

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-04-01-00/R-00**		
System: **PROPULSION**		Sheet: **6/8**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit: **BOARDS**	
Component:		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

1 Locate the Board to be replaced

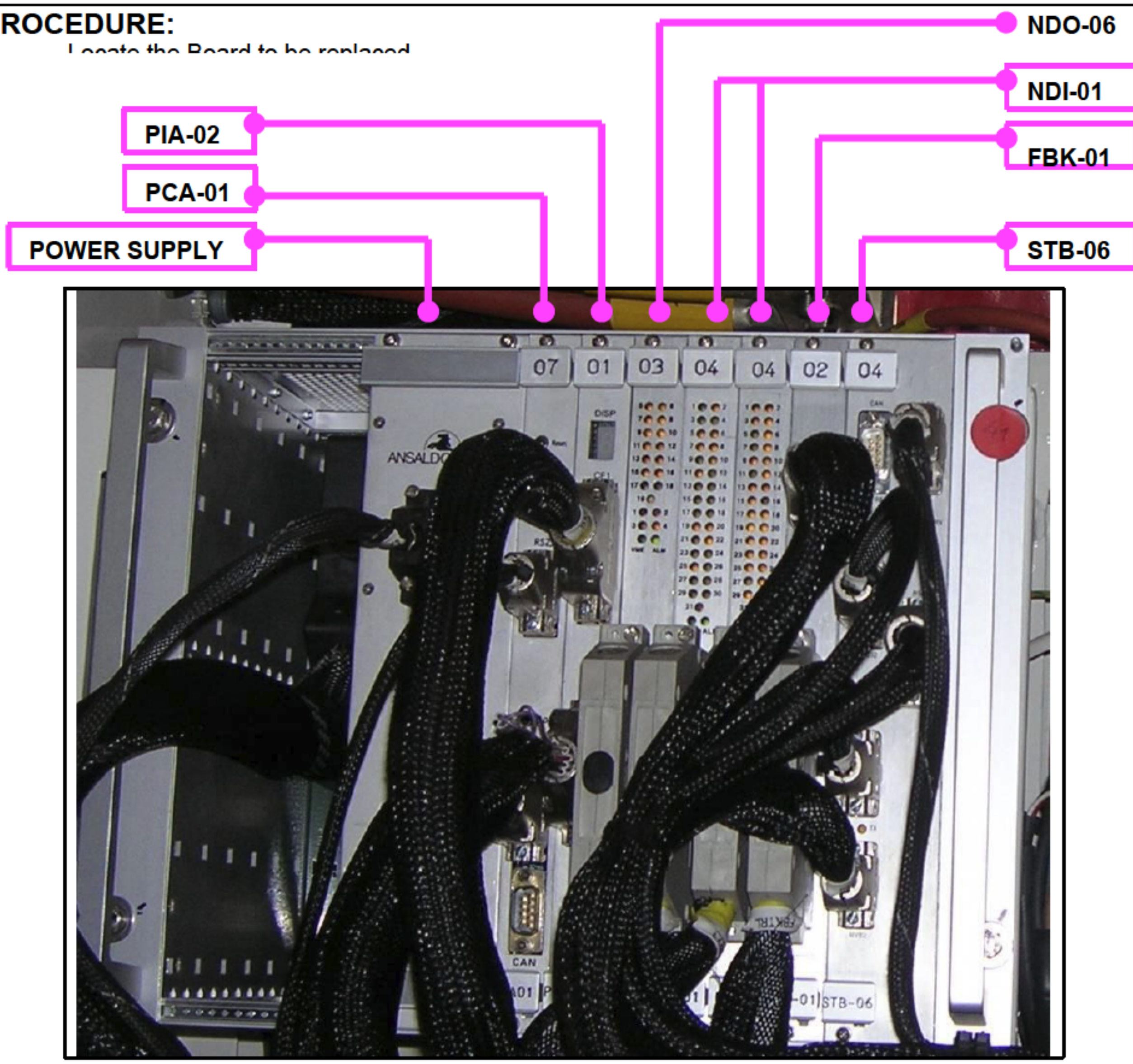


Figure 3 - TCU - BOARDS LOCATION & IDENTIFICATION

P2550 CORRECTIVE MAINTENANCE SHEET

		Card Code: **R-C-07-04-01-00/R-00**
System: **PROPULSION**		Sheet: **7/8**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit: **BOARDS**	
Component:		Man Hours: **1**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

5. Disconnect the Board Connectors using suitable screwdriver

6. Loose the Board Fixing Screws. Retain them for later use.

7. Carefully pull the Board out from the TCU Rack and slide it out from the relevant guide.

CAUTION: A TECHNICIAN HANDLING ELECTRONIC ASSEMBLIES AND COMPONENTS SHOULD WEAR A CONDUCTIVE WRIST STRAP WITH A GROUND WIRE CONNECTED EITHER TO EARTH OR CHASSIS (VEHICLE) GROUND.

CAUTION: NEVER TOUCH OR HANDLE THE PC BOARD BY ITS TRACES, CONNECTOR TEETH, OR COMPONENTS.

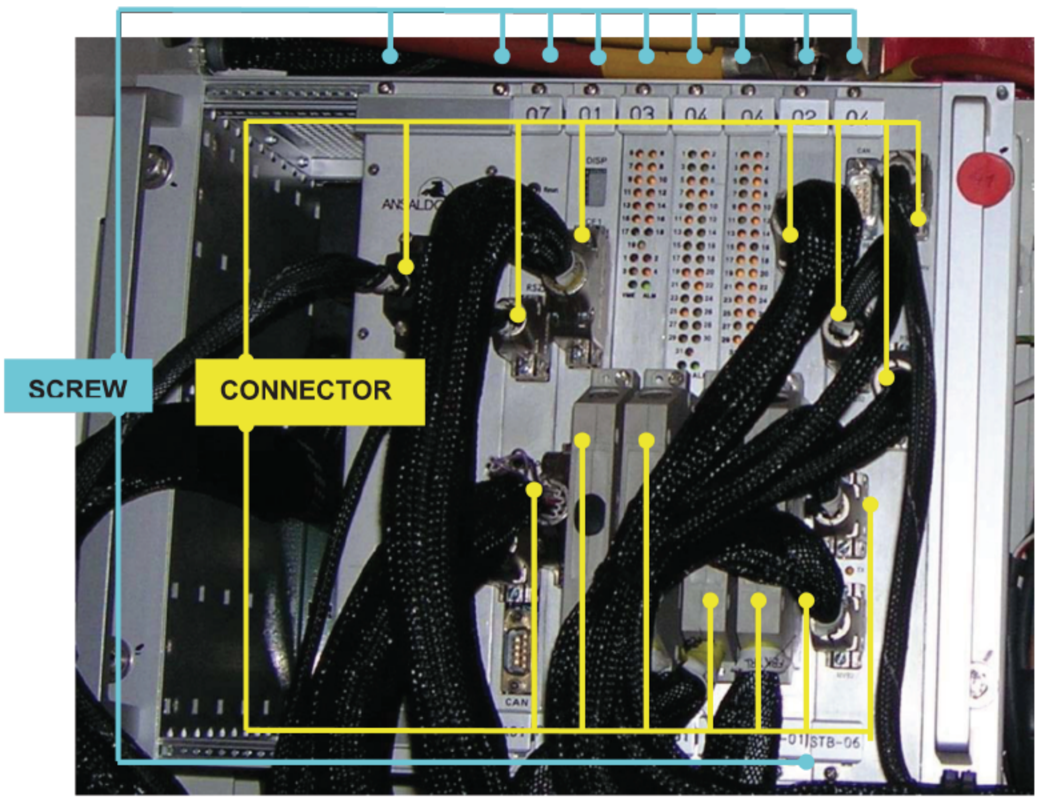


Figure 4 - TCU - BOARDS REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-04-01-00/R-00**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **TRACTION CONTROL UNIT (TCU)**	Unit: **BOARDS**
Component:	Man Hours: **1**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the Task proceed as follows (Refer to Figures 1 through 4):

To perform the Task proceed as follows:

NOTE: It is assumed that the Vehicle is in Safety Conditions in accordance with LACMTA Maintenance Shop Regulations.

1. Check the Board receptacle for signs of overheating.

2. Slide the Board into its guide, assure proper alignment to the receptacle and push firmly to seat the Board into the receptacle.

3. Secure the Board by tightening the relevant fixing Screws.

5. Reconnect the Board Connectors.

6. Reinstall the Control Module Cover and secure it by locking the Safety Latches.

7. Reconnect the Grounding Cable.

8. Record task results on the Defect Report Card for administrative and maintenance planning.

9. Reinstall the Skirts according to Sheet R-C -02-05-00-00 / R-00.

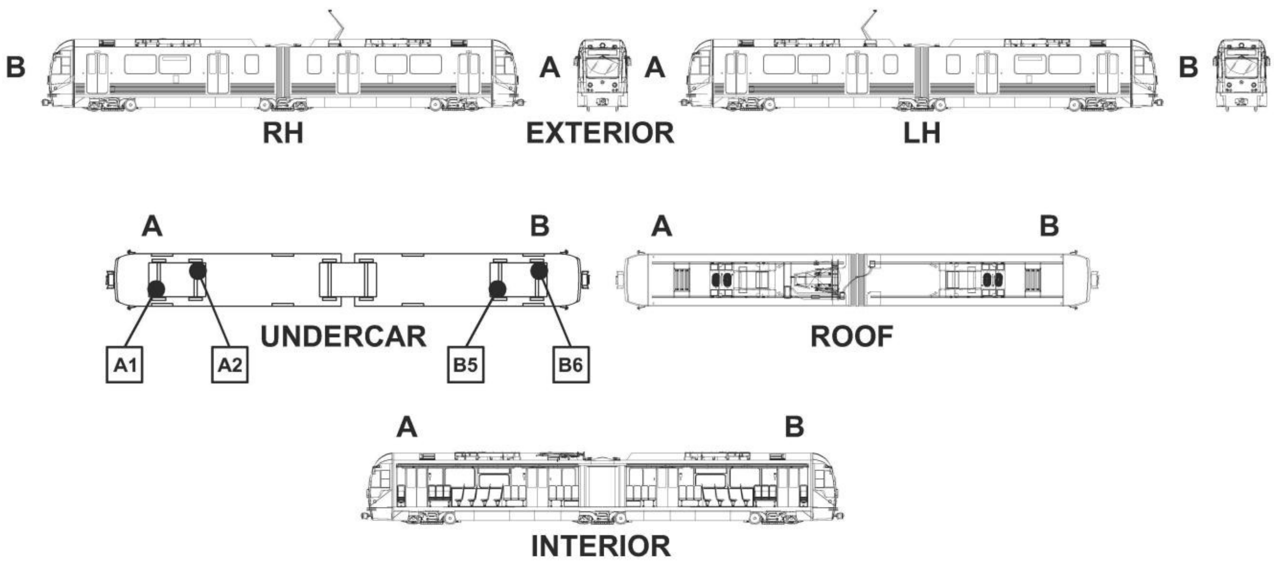
NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-01-00/R-00**
System: **PROPULSION**	Sheet: **1/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET			
Card Code: **R-C-07-05-01-00/R-00**			
System: **PROPULSION**			Sheet: **2/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**		
Component:			Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**			

SAFETY PRECAUTIONS:

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

CAUTION: BEFORE PROCEEDING TO THE NEXT STEPS BE SURE THAT THE GEARBOX AND THE MOTOR ARE SAFELY SUPPORTED ON THE BOTTOM SIDE.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE HALF COUPLING.
ONLY USE THE RECOMMENDED TYPE OF GREASE.

CAUTION: DO NOT FULL TIGHTEN THE MOTOR MOUNTING BOLTS.
LEAVE THE BOLTS WITH A CLEARANCE OF ABOUT 0.1 “ (2.5 mm) ALLOWING THE MOTOR TO MOVE AXIALLY (FROM THE GEARBOX) IN ORDER TO NOT STRESS THE ELASTIC ELEMENTS.

CAUTION: IF THE DEFORMATION OF ELASTIC ELEMENTS BETWEEN THE MOTOR AND THE GEARBOX ARE LARGER THAN:

- 1.2" (5 MM) AXIAL
- 0.08" (2 MM) RADIAL

THEN THE TRUCK CANNOT BE STORED IN THIS WAY FOR LONGER TIME (MORE THAN 1 DAY).

CAUTION: ANY DAMAGE ON THE EXISTING PAINT LAYER OF THE GEARBOX, GEAR COUPLING AND REACTION ROD MUST BE REPAIRED.

CAUTION: ALL BOLTS HAVE TO BE TREATED WITH A RECOMMENDED MOUNTING GREASE.

CAUTION: THE SEALING RINGS (7) MUST ALWAYS BE REPLACED WITH A NEW ONE WHEN THE LUBRICANT IS CHANGED.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit
Overhead Crane (min. capacity 200 Lb)

Grease Gun

CONSUMABLES:

Grease Type:Texaco Coupling Grease, as needed
Bolts Mounting Grease Type: Molykote BR2 Plus

SPARE PARTS:

Traction Motor P/N: AA041MU MFR PN: 232MESE122E
Safety Plate P/N: AA04040

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-01-00/R-00**
System: **PROPULSION**	Sheet: **3/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:
PRELIMINARY OPERATIONS

1. It is assumed that:
   a. The Vehicle is set in accordance with LACMTA Maintenance Shop safety Regulations.
   b. The Truck has been removed from Vehicle according to Sheet R-C-12-01-00-00 / R-00.
   c. The Truck is positioned in order to have it available to safely accomplish the Task.
   d. The Hoses, Electrical Connectors and Equipment installed on the Truck are secured and protected to avoid damage during Task performing.
   e. Wheel Chocks are installed in both running directions.
2. Disconnect the following Electrical Connections:
   a. Traction Motor Power Supply Cables (from Cable Connections End to Quick Disconnect Box).
   b. Traction Motor Grounding Cable and relevant Terminals connections.

REMOVAL

1. **UNCOUPLING** (Refer to Figure 1)
   a. Remove the Flange Connections (Bolts 8 and Hex Nuts 9).
   b. Remove the Screw Plugs (6) and Sealing Ring (7).
   c. Move the Sleeve (1) of the Coupling Halves (Motor Side and Gearbox Side) backwards respectively to the Motor and the Gearbox.

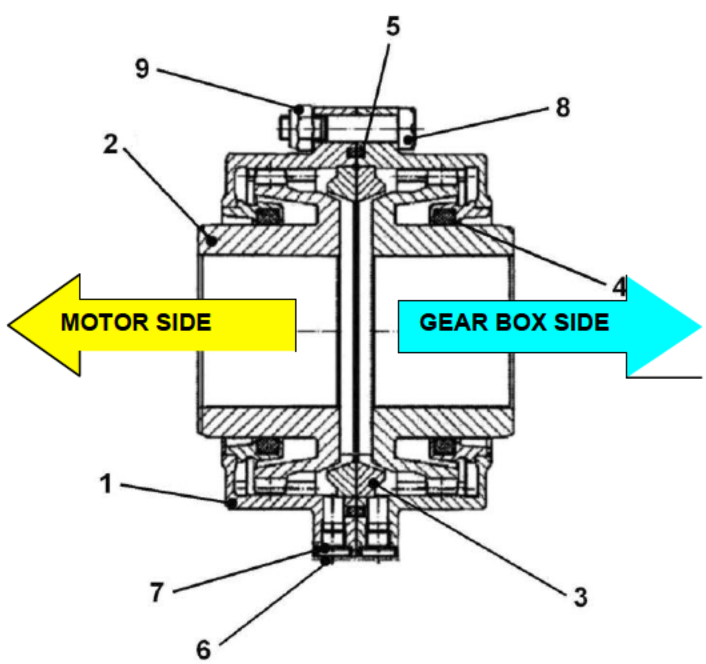


Figure 1 - UNCOUPLING -

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-01-00/R-00**	
System: **PROPULSION**	Sheet: **4/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

2. TRACTION MOTOR - GEAR BOX DISCONNECTION
(Refer to Figure 2)

a. Support the Motor and the Gearbox.

CAUTION:
BEFORE PROCEEDING TO THE NEXT STEPS BE SURE THAT THE GEARBOX AND THE MOTOR ARE SAFELY SUPPORTED ON THE BOTTOM SIDE.

b. Remove the 4 Screws M20x110 connecting the Motor to the Gearbox.

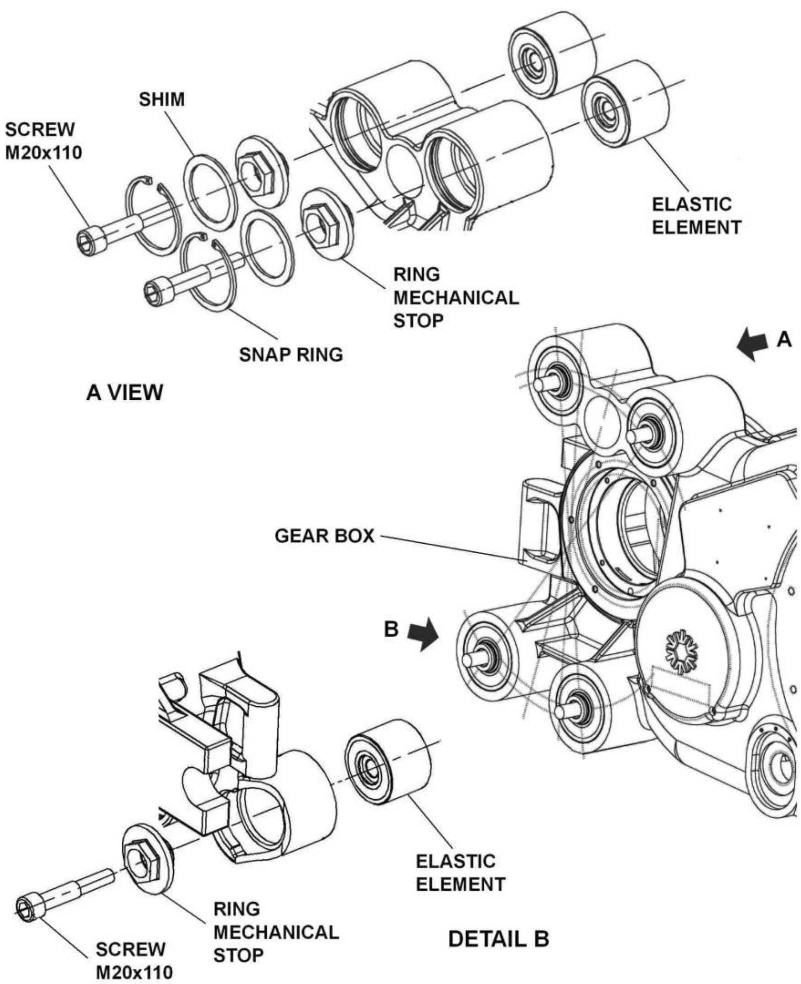


Figure 2 Traction Motor - Gear Box Disconnection

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-05-01-00/R-00

System:	Sheet:
PROPULSION	**5/14**

Subsystem/Assy:	Unit:
TRACTION MOTOR	**TRACTION MOTORS (01M 01-02)**

Component:	Man Hours:
	8.0

Maintenance Task:	
REPLACEMENT	

PROCEDURE (CONT'D):

3. TRACTION MOTOR REMOVAL (Refer to Figure 3)

a. Apply a suitable Sling to Traction Motor to safely lift it.
b. Remove Screw (6) with Washer (5) and Safety Nose (4).
c. Remove Screws (1) with Safety Plates (2), then remove the Motor Support Collar (3).
d. Using a suitable Lifting Device, slowly lift Traction Motor from Gear Unit.

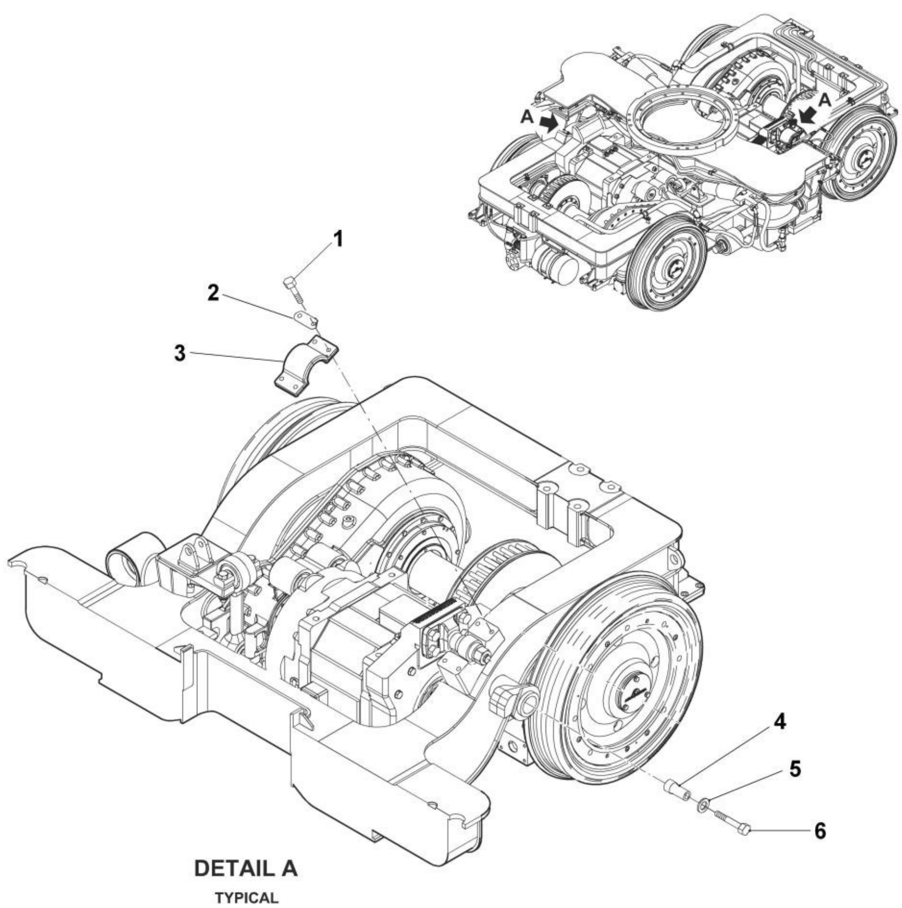


Figure 3 Traction Motor Removal

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-05-01-00/R-00**		
System: **PROPULSION**		Sheet: **6/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**	
Component:		Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

4. COUPLING REMOVAL
Refer to Sheet H-C-07-06-02-00/R-00

INSTALLATION

1. COUPLING INSTALLATION
Refer to Sheet H-C-07-06-02-00/R-00

2. TRACTION MOTOR ASSEMBLY
(Refer to Figure 4)

CAUTION:

BEFORE PROCEEDING TO THE NEXT STEPS BE SURE THAT THE GEARBOX AND THE MOTOR ARE SAFELY SUPPORTED ON THE BOTTOM SIDE.

a. Support the Motor and the Gearbox.
b. Move both the Sleeve (1) of the Coupling (Motor Side and Gearbox Side) backwards so that both Coupling Halves can pass when lifting the Gearbox.
c. Apply a Sling to the Traction Motor to safely lift it.
d. Using a suitable Lifting Device, slowly install the Traction Motor on the Truck.

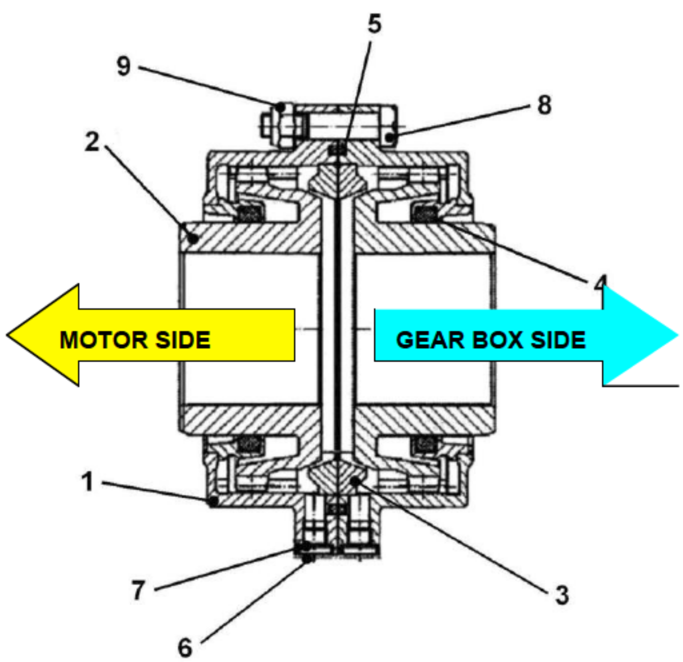


Figure 4 - COUPLING -

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-01-00/R-00**

System:	Sheet:
PROPULSION	**7/14**

Subsystem/Assy:	Unit:
TRACTION MOTOR	**TRACTION MOTORS (01M 01-02)**

Component:	Man Hours:
	8.0

Maintenance Task:	
REPLACEMENT	

PROCEDURE (CONT'D):

3. CONNECTION TRACTION MOTOR - GEAR BOX (Refer to Figure 5)

a. Connect the Gearbox to the Motor by means of the 4 x M20x110 Bolts.

CAUTION:
DO NOT FULL TIGHTEN THE MOTOR MOUNTING BOLTS. LEAVE THE BOLTS WITH A CLEARANCE OF ABOUT 0.**1 " (2.5 mm**) ALLOWING THE MOTOR TO MOVE AXIALLY (FROM THE GEARBOX) IN ORDER TO NOT STRESS THE ELASTIC ELEMENTS.

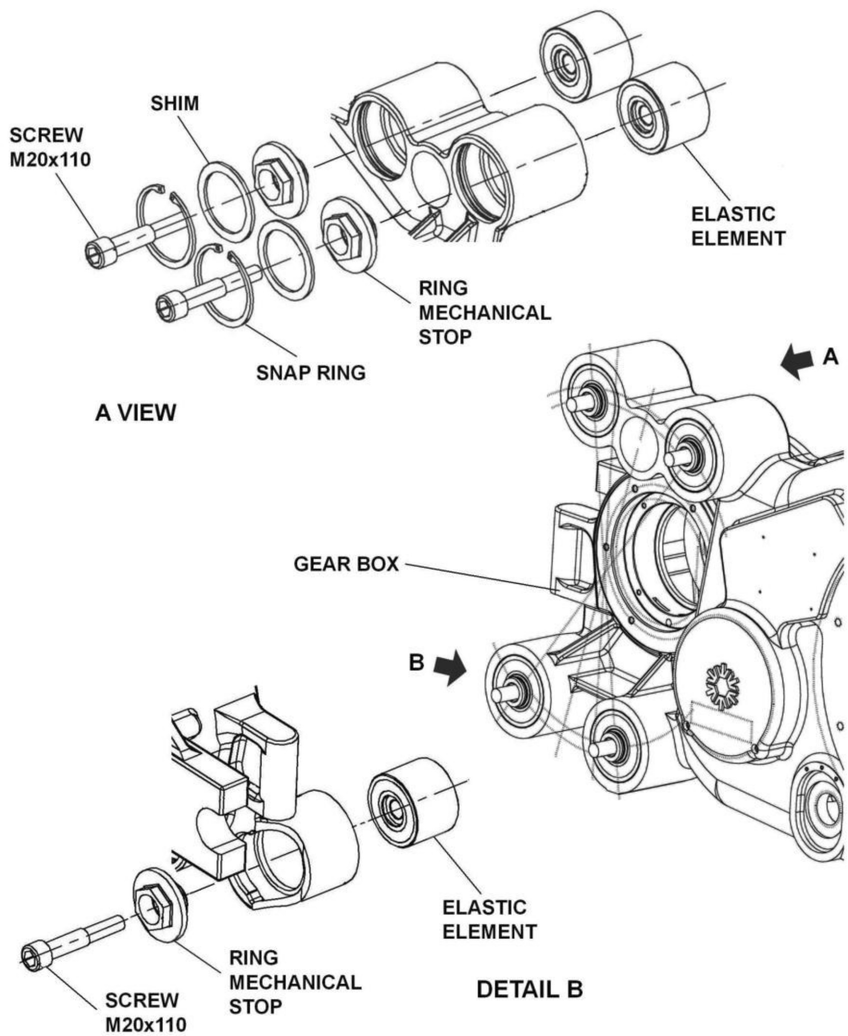


Figure 5 Traction Motor - Gear Box Connection

P2550 CORRECTIVE MAINTENANCE SHEET			
Card Code: **R-C-07-05-01-00/R-00**			
System: **PROPULSION**			Sheet: **8/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**		
Component:			Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**			

PROCEDURE (CONT'D):

3 CONNECTION TRACTION MOTOR - GEAR BOX (cont'd)

b. Position the Truck on the Truck Tramming Stand (Refer to Fig 6).

c. Press the Truck in order to meet the AW0 value and record the corresponding (deflection) value.

d. Continue to press the Truck in order to meet a deflection value of 0.2" more that the previously noted value (AW0).

NOTE: The Value of 0.2" is the average Value between the AW0 and AW4 values.

e. Disassemble the Snap Rings (DIN 472) and remove the Shims (DIN 988) (Refer to Fig 5).

f. Fix and torque the 4x M20 Bolts between Motor and Gearbox. to **288 ft-lb.**

CAUTION:
BEFORE FIXING THE 4X M20 BOLTS, BLOCK THE MECHANICAL STOP PART WITH A WRENCH (SIZE 46 MM).DOING SO YOU ARE SURE THAT THE INSIDE BUSH OF THE ELASTIC ELEMENT IS NOT PRE-STRESSED WHEN FIXING THE M20 BOLTS.

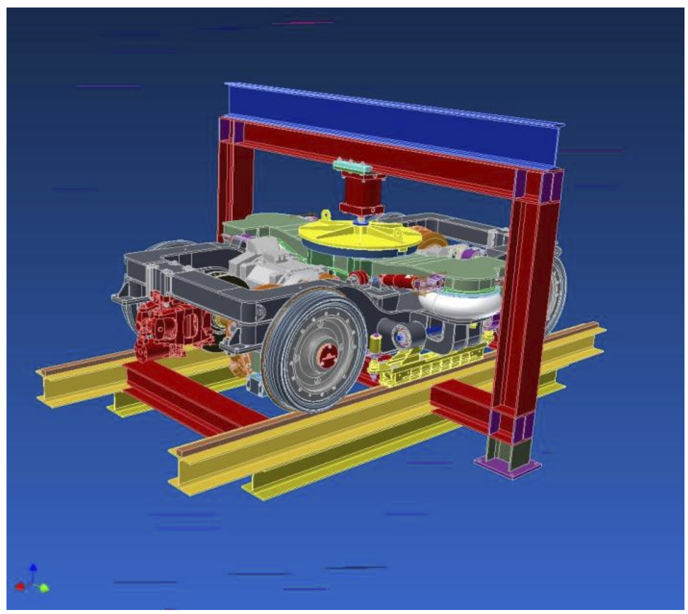


Figure 6 Truck Tramming Stand

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-01-00/R-00**	
System: **PROPULSION**	Sheet: **9/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

3 CONNECTION TRACTION MOTOR - GEAR BOX (cont'd)

g. Adjust the Motor on the Motor Adjustment Point (backside of the motor) to reach

1.38" (35±1 mm)

between Motor and Gearbox on the 4 places of the elastic elements.

(Refer to figures 7 & 8)

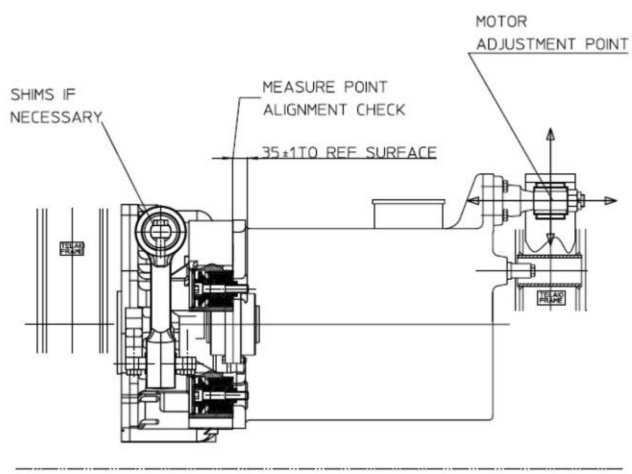


Figure 7 Motor Adjustment

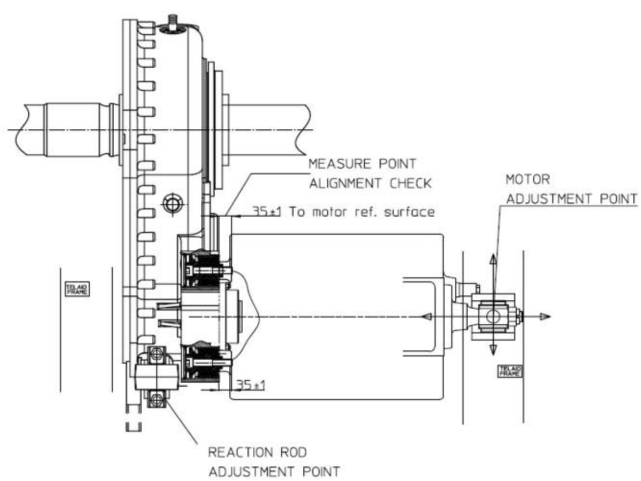


Figure 8 Motor Adjustment

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: R-C-07-05-01-00/R-00		
System: **PROPULSION**		Sheet: **10/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**	
Component:		Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

3 CONNECTION TRACTION MOTOR - GEAR BOX (cont'd)

h. Check that the clearance between Mechanical Stop and Housing is:

0.12" (3 ± 0.3 mm)

(Refer to figure 9).

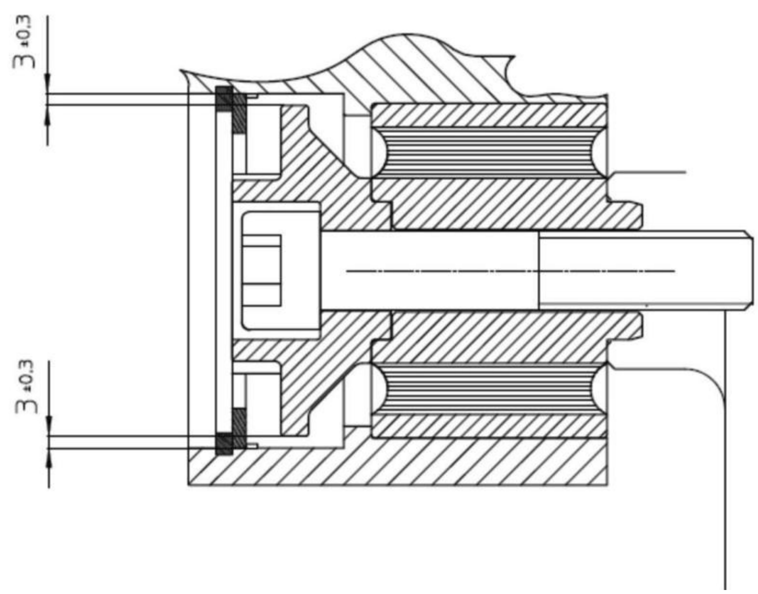


Figure 9 Motor Adjustment

i. Paint the 3 grooves for the Snap Rings from the Gearbox Housing.
j. Assemble the 3 Shims and the 3 Snap Rings before the paint is dry.
k. Release the pressure from the Truck Tramming Stand in order to allow the the Truck to go to the Top Mechanical Stops.
l. Measure the deformation of the Elastic Elements, both Axial and Radial.

CAUTION: IF THE DEFORMATION OF ELASTIC ELEMENTS BETWEEN THE MOTOR AND THE GEARBOX ARE LARGER THAN:

- 1.2" (5 mm) AXIAL
- 0.08" (2 mm) RADIAL

THEN THE TRUCK CANNOT BE STORED IN THIS WAY FOR LONGER TIME (MORE THAN 1 DAY).

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-01-00/R-00**	
System: **PROPULSION**	Sheet: **11/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

3 CONNECTION TRACTION MOTOR - GEAR BOX (cont'd)

m. Check the M20 Bolts of the Reaction Rod for torque design value of **288 ft-lb** (390 Nm).
n. Check the M20 Bolts connecting Motor and Gearbox for torque design value of **288 ft-lb** (390 Nm).
o. Complete the painting on the resting blank areas of the Ring Gear Flanges around the parts used to connect both Coupling Halves (Fit Bolts, Nuts).

CAUTION: ANY DAMAGE ON THE EXISTING PAINT LAYER OF THE GEARBOX, GEAR COUPLING AND REACTION ROD MUST BE REPAIRED.

p. After the paint is dry for the Gearbox - Motor Connection:

- Paint a White continuous Mark Line on the Heads of the 2 Bolts M20x100 and on the bottom Spherolastic Bearing of the Reaction Rod.
- Paint a White continuous Mark Line on the Heads of the 2 Bolts M20x100 and on the top Spherolastic Bearing of the Reaction Rod.
- Paint a White continuous Mark Line on the Heads of the 4 bolts M20x110 (5) and on the Gearbox Housing.

NOTE: This Paint Mark will enable easy visual check to see if the Bolts are still properly tighten when the Truck will be installed on Vehicle in Service.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-01-00/R-00**	
System: **PROPULSION**	Sheet: **12/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

4. TRACTION MOTOR INSTALLATION (Refer to Figure 10)

a. Install Motor Support Collar (3) and lock then with Screws (1) and Safety Plates (2).
b. Tighten the Screws (1) to torque value of **144 ft-lb** (195 Nm).
b. Install Safety Nose (4), Screw (6) and Washer (5).
c. Tighten the Screw (6) to torque value of **288 ft-lb** (390 Nm).

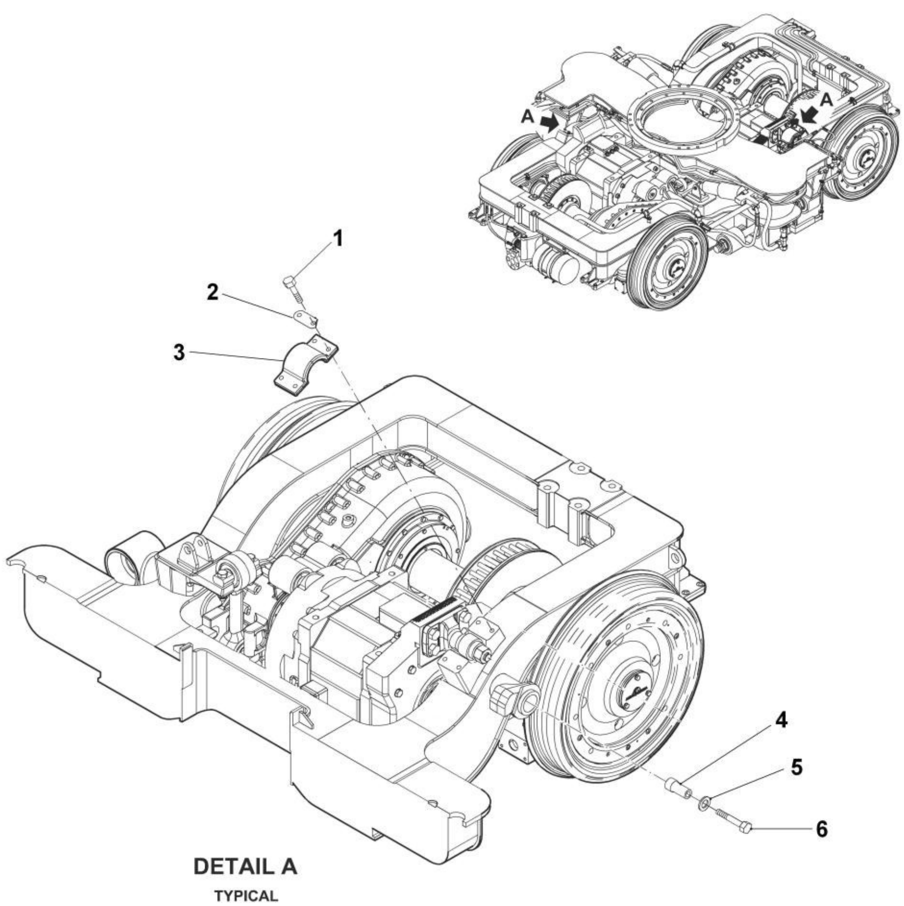


Figure 10 Traction Motor Installation

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-01-00/R-00**
System: **PROPULSION**	Sheet: **13/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

5. COUPLING (Refer to Figure 11)

a. Both Sleeves should be arranged in such a way that the Screw Plugs (6) of both Coupling Halves are in alignment.

b. Install the Flange Connections (Bolts 8 and Nuts 9).

CAUTION:
ALL BOLTS HAVE TO BE TREATED WITH A RECOMMENDED MOUNTING GREASE.

c. Torque the Self-Locking Nuts (9). to **34 ft-lb** (46 Nm).

WARNING:
TAKE CARE THAT THE FIT BOLT COULD BE EASILY MOUNTED!
IT IS NOT ALLOWED TO MOUNT THE FIT BOLTS BY BEATING!

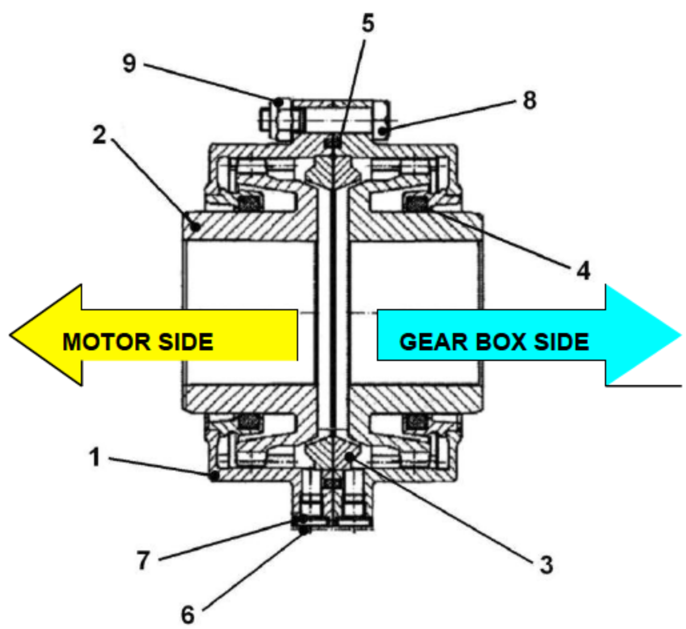


Figure 11 - COUPLING -

d. Fill the Coupling with the recommended lubricant
To fill the Coupling proceed as follows:

- Open the Screw Plugs (6).
- Fill the lubricant in the Coupling using a suitable Grease Gun.
  NOTE The Lubricant quantity needed is:
  0.1 kg per Coupling Half 50 g per Filler Hole = 2 x 50 g
  0.2 kg per Coupling 50 g per Filler Hole = 4 x 50 g
  NOTE: An optimum distribution of lubricant can be achieved by pushing the Sleeve in direction up to Shaft End until to stop and hold it (fix it).
- Reassemble the Screw Plug (6) and the Sealing Ring (7).

CAUTION: THE SEALING RINGS (7) MUST ALWAYS BE REPLACED WITH A NEW ONE WHEN THE LUBRICANT IS CHANGED.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-01-00/R-00**	
System: **PROPULSION**	Sheet: **14/14**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **TRACTION MOTORS (01M 01-02)**
Component:	Man Hours: **8.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

FINAL OPERATIONS

1. Reconnect the following Electrical Connections:
   a. Traction Motor Power Supply Cables (from Cable Connections End to Quick Disconnect Box).
   b. Traction Motor Grounding Cable and relevant Terminals connections.

2. Record Task results on the Defect Report Card for administrative and maintenance planning.

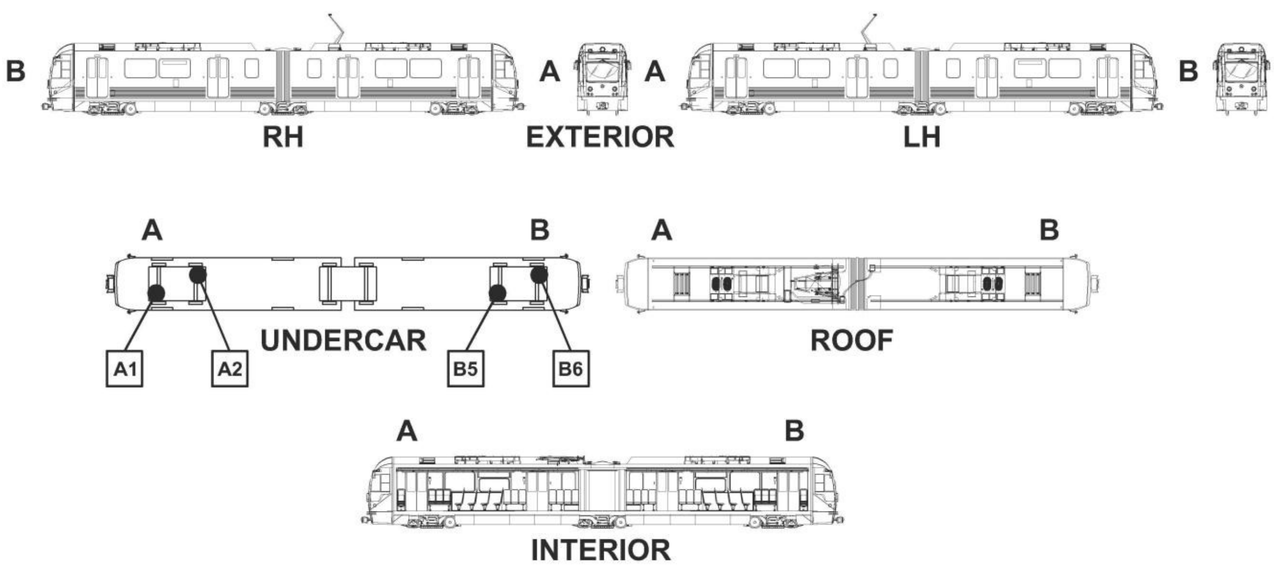
NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-02-00/R-00**
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-02-00/R-00**		
System: **PROPULSION**		Sheet: **2/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

CRC 2000 Contact Cleaner

SPARE PARTS:

Traction Motors Speed Sensor	(P/N 211VT01355B)
O-Ring	(P/N TBD)

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-02-00/R-00**
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-02-00/R-00**	
System: **PROPULSION**	Sheet: **4/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

REPLACEMENT

REMOVAL(Refer to Figures 1 through 3)

To perform the task proceed as follows:

1. Locate the Speed Sensor.

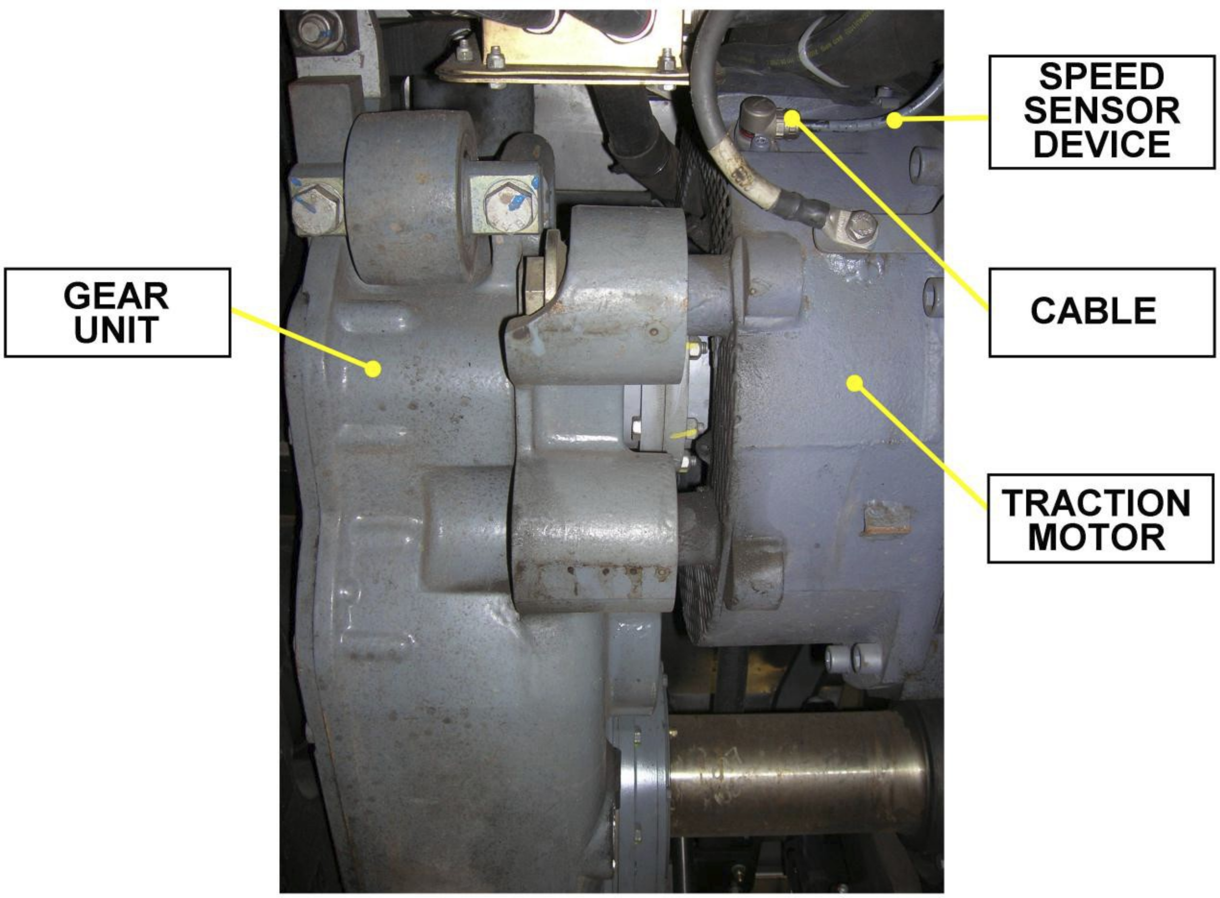


Figure 1 - TRACTION MOTOR SPEED SENSOR LOCATION

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:
R-C-07-05-02-00/R-00

System: **PROPULSION**		Sheet: **5/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

2. Open Sensor Housing and disconnect the Terminals of the Sensor Cable from the Sensor Connector.

3. Slide out the Sensor Cable from the Cable Bushing in the Sensor Housing.

4. Remove the Sensor from Traction Motor by loosening the relevant Fixing Screws.

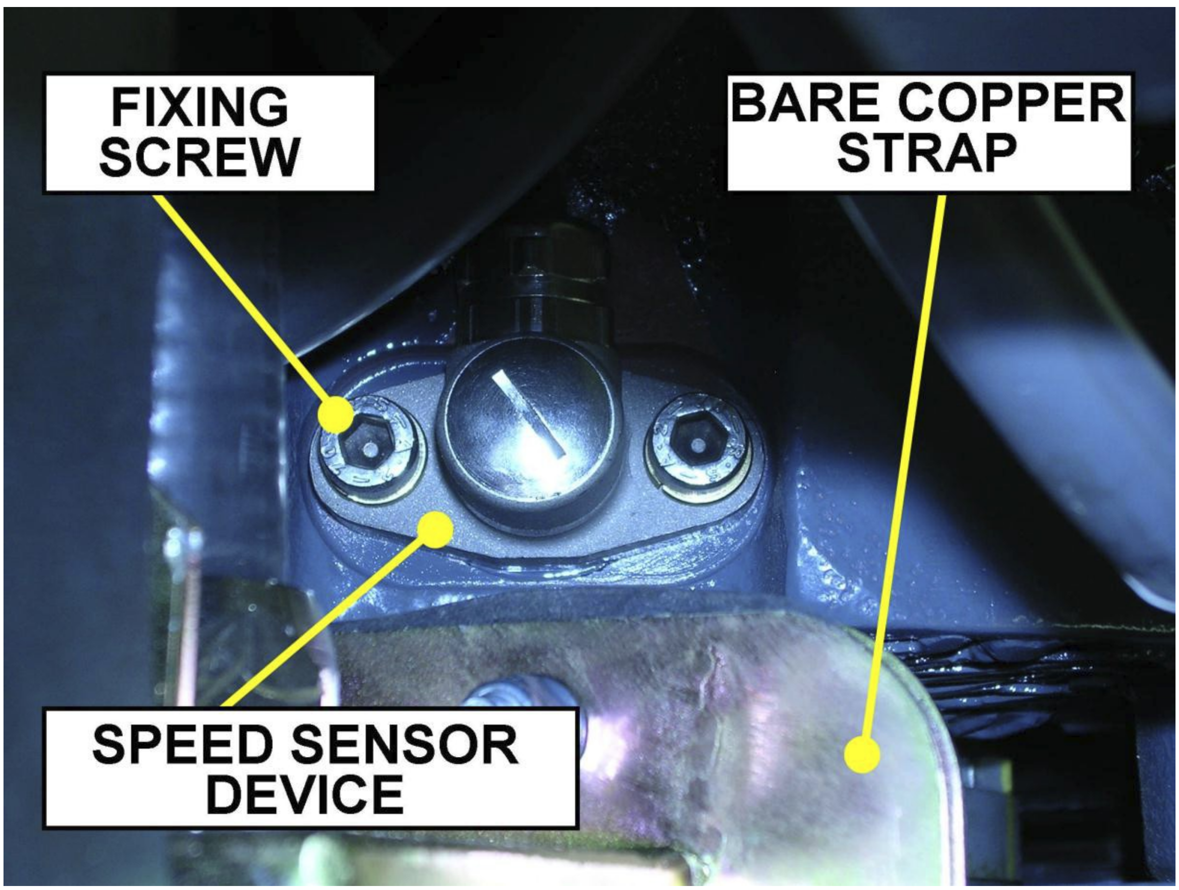


Figure 2 - TRACTION MOTOR SPEED SENSOR

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-05-02-00/R-00**		
System: **PROPULSION**		Sheet: **6/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

INSTALLATION

1. Measure, the dimension between the Sensing End and the Sensor Assembly Plate, to assure proper gap of **0.0276 inches ± 0.0079** between the Sensing End and the Polar Wheel.

NOTE: The dimension should never be **less than 1.1378 inches or over 1.1417 inches.**

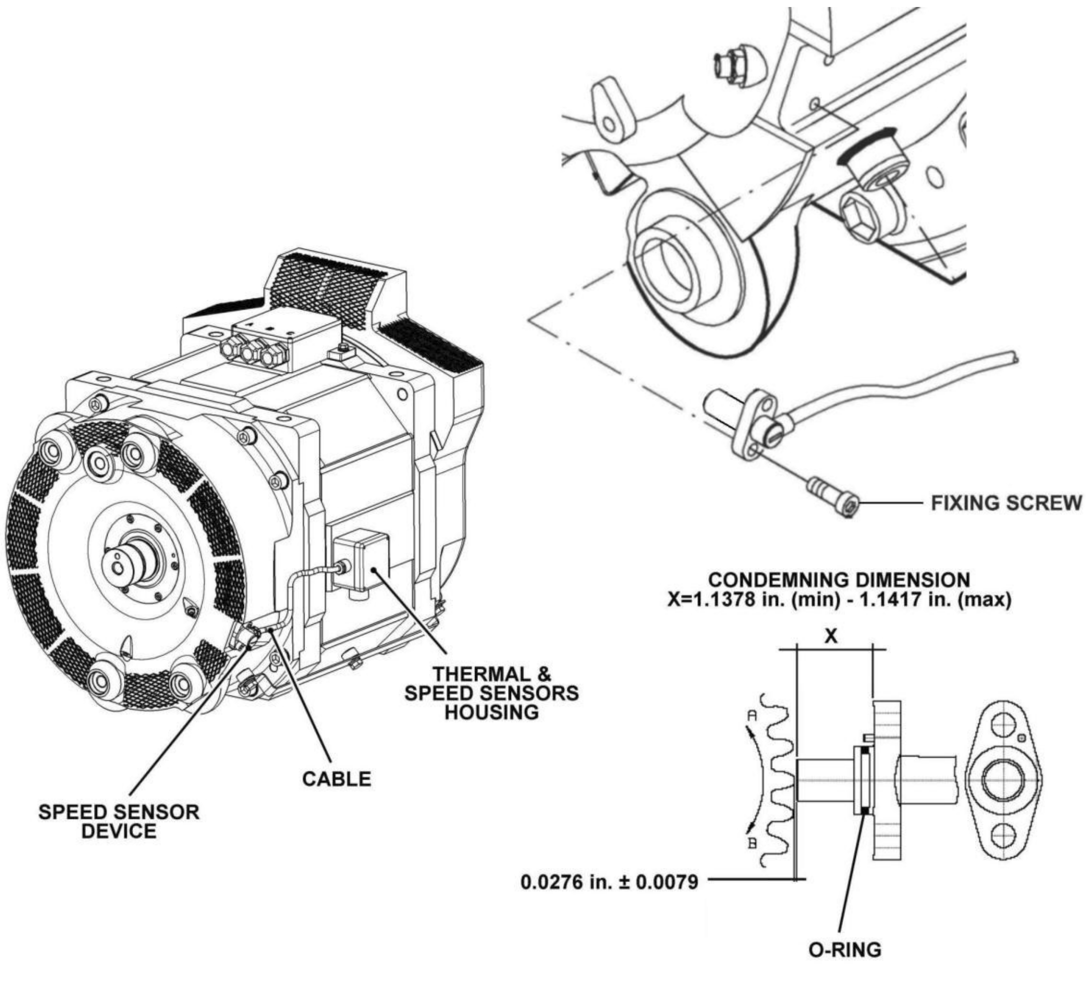


Figure 3 - TRACTION MOTOR SPEED SENSOR GAP CHECKING

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-02-00/R-00**
System: **PROPULSION**	Sheet: **7/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

2. Clean the Sensor Assy, Sensing End and Cable using recommended cleaner and lint free-rag.

3. Thoroughly clean the Sensor mating surface on the Traction Motor using recommended cleaner and lint free-rag.

4. Insert the Sensor Cable on the Cable Bushing in the Sensor Housing.

5. Reconnect the new Sensor Terminals, paying attention to respect the Wiring Diagram Color Codes as in the old one.

6. Reinstall the Sensor by tightening the Fixing Screws to **20 ft-lb**.

7. Restore the Electrical Power.

8 Record Task results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-05-02-00/R-00**		
System: **PROPULSION**		Sheet: **8/8**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **ACTIVE SPEED SENSOR**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

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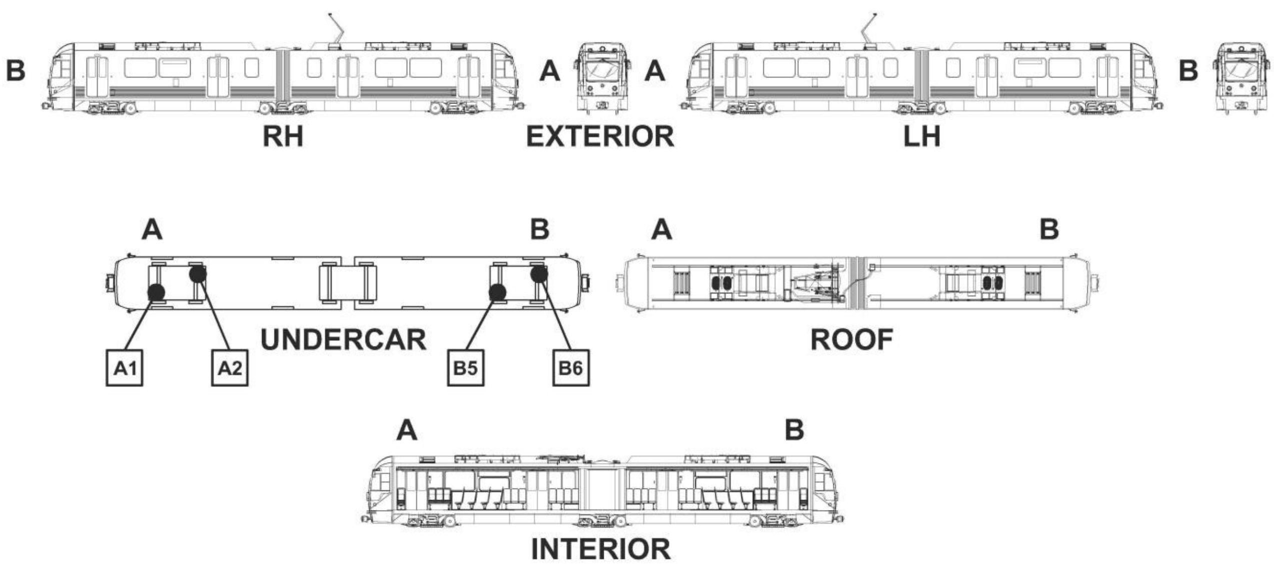
P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-05-03-00/R-00**
System: **PROPULSION**		Sheet: **1/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **THERMAL SENSOR ASSEMBLY**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-05-03-00/R-00**		
System: **PROPULSION**		Sheet: **2/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **THERMAL SENSOR ASSEMBLY**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: ALWAYS WEAR EYE PROTECTION AND GLOVES WHILE PERFORMING THIS MAINTENANCE TASK.

WARNING: ELECTRICAL HAZARD IS PRESENT THROUGHOUT THE PROPULSION SYSTEM AND CAUTION MUST BE TAKEN WHILE WORKING ON OR NEAR THE EQUIPMENT.
REMOVE ALL ELECTRICAL POWER BEFORE PERFORMING MAINTENANCE TO THE SYSTEM.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

WARNING: HIGH VOLTAGE IS PRESENT ON THE INVERTER GROUP. AFTER REMOVING ALL POWER FROM THE VEHICLE, WAIT A MINIMUM OF 1 MINUTE PRIOR TO REMOVING OR OPENING MAIN INVERTER GROUP,SINCE THE CAPACITORS DISCHARGE TIME IS 10 SECONDS.
FAILURE TO COMPLY WITH SAFETY REGULATIONS COULD RESULT IN SERIOUS INJURY OR EVEN DEATH IF NOT FOLLOWED.

WARNING: WORKING AREAS MUST BE WELL VENTILATED, LIGHTED, AND CLEAR OF DEBRIS FOR OBVIOUS SAFETY REASONS.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

CRC 2000 Contact Cleaner
Sealant RHODORSIL CAF 730
Grease COMPOUND DOW CORNING 340

SPARE PARTS:

Traction Motors Thermal Sensor (P/N 232METS122C)

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-05-03-00/R-00**
System: **PROPULSION**	Sheet: **3/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **THERMAL SENSOR ASSEMBLY**
Component:	Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.
2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures

NOTE The tag must indicate the name of the person who removed Power. That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REPLACEMENT
(Refer to Figure 1)

REMOVAL

To perform the task proceed as follows:

1. Open Sensor Housing (5) and disconnect the Terminals of the Sensor Cable from the Connector (3).
2. Slide out the Sensor Cable from the Cable Bushing (8).
3. Remove Screws (1) and Lock Washers (2), then remove the Sensor Assembly from Traction Motor.

DISASSEMBLY

1. Remove the Cable Bushing (8) from Sensor Housing (5).
2. Disconnect the Terminals of the Sensor Cable from the Connector (3).
3. Loosen the Cable Bushing (6) and slide out the Sensor (7), then remove the Cable Bushing (6).
4. Remove the Connector (3) by loosening the Fixing Screws (4).

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-05-03-00/R-00**		
System: **PROPULSION**		Sheet: **4/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **THERMAL SENSOR ASSEMBLY**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

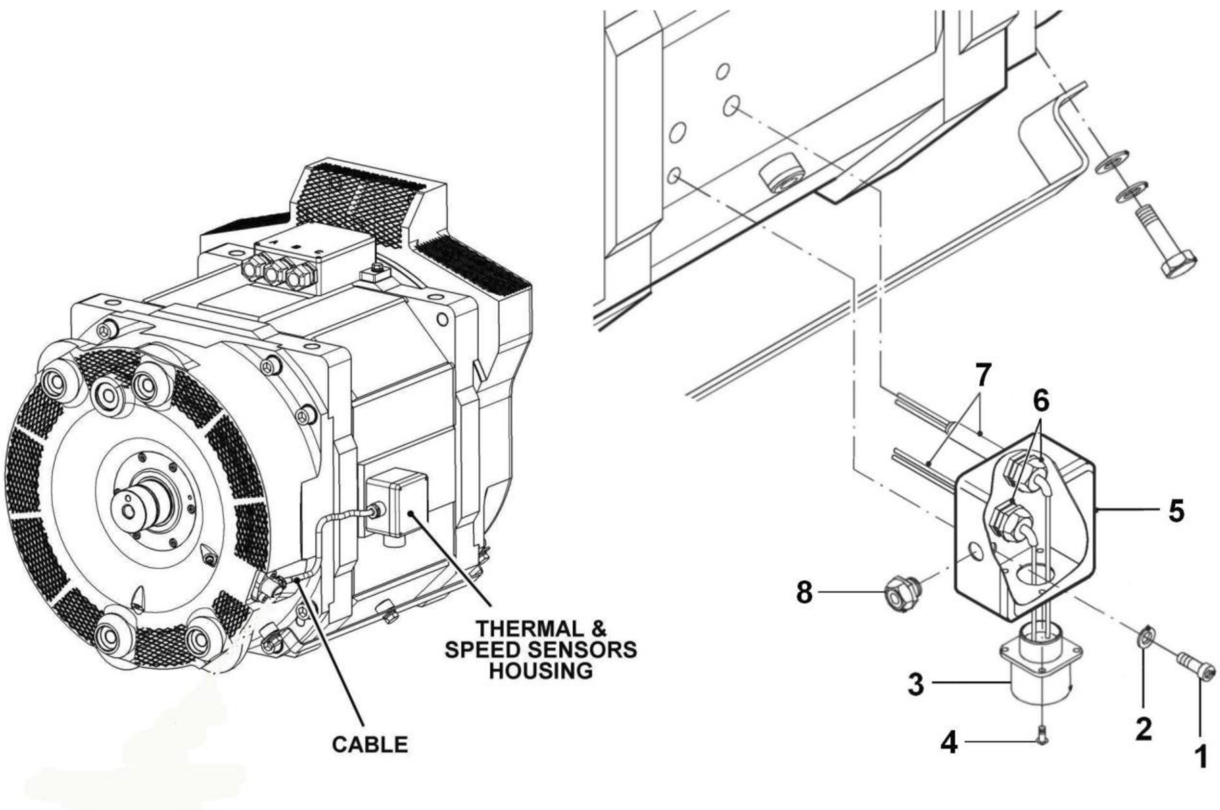


Figure 1 - TRACTION MOTOR THERMAL SENSOR REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-05-03-00/R-00**
System: **PROPULSION**		Sheet: **5/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **THERMAL SENSOR ASSEMBLY**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

REASSEMBLY

1. Install the Cable Bushing (8) on the Sensor Housing (5).
2. Install the Connector (3) by tightening the Fixing Screws (4).
3. Install the Cable Bushing (6) and insert the Sensor (7).
4. Connect the Terminals of the Sensor Cable to the Connector (3), paying attention to respect the Wiring Diagram Color Codes shown in the Label inside the Cover.

INSTALLATION

1. Thoroughly clean the Sensor Assembly mating surface on the Traction Motor using recommended cleaner and lint free-rag.

   NOTE: Coat the Sensor Assembly mating surface on the Traction Motor with Sealant RHODORSIL CAF 730.

   Coat holes of Sensor (7) with thermal-conductive Grease COMPOUND DOW CORNING 340.

2. Install the Sensor Assembly on Traction Motor and fasten it with the Screws (1) and Lock Washers (2). Torque the Screws (1) to **6.2 ft-lb.**
3. Insert the Sensor Cable onto the Cable Bushing (8).
4. Connect the Terminals of the Sensor Cable to the Connector (3), paying attention to respect the Wiring Diagram Color Codes shown in the Label inside the Cover.
5. Restore the Electrical Power.
6. Record Task results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-05-03-00/R-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **TRACTION MOTOR**	Unit: **THERMAL SENSOR ASSEMBLY**	
Component:		Man Hours: **1.0**
Maintenance Task: **REPLACEMENT**		

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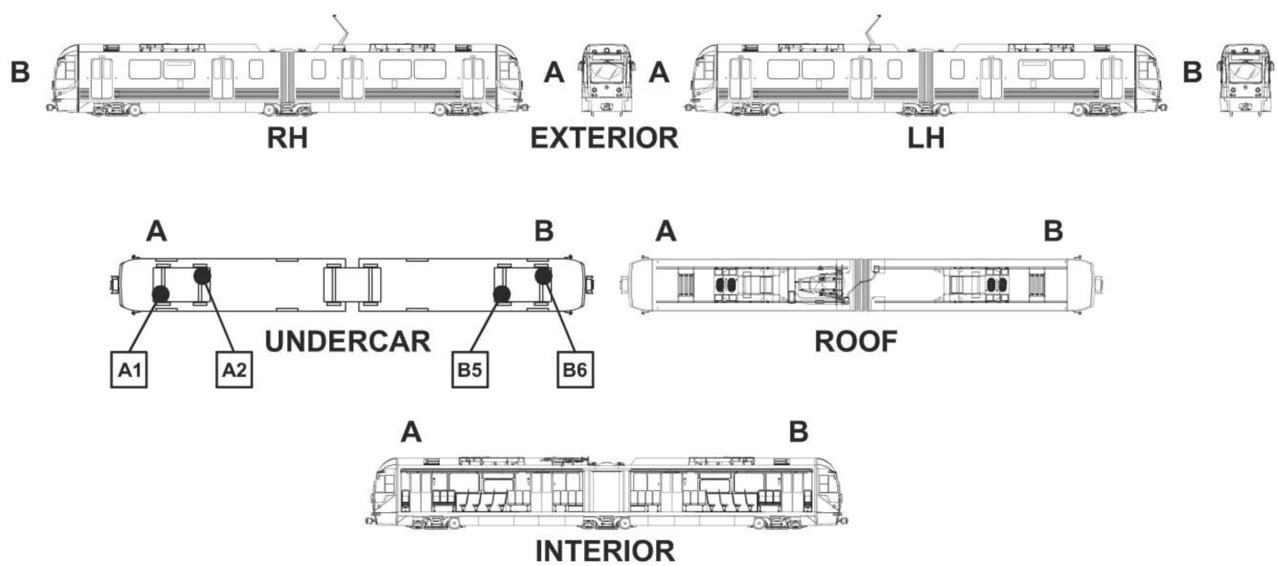
P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-06-01-00/S-00**	
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1.5**
Maintenance Task: **SERVICE**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-06-01-00/S-00**		
System: **PROPULSION**		Sheet: **2/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1.5**
Maintenance Task: **SERVICE**		

SAFETY PRECAUTIONS:

WARNING: BLUE FLAG THE VEHICLE IN ACCORDANCE WITH ALL LACMTA BLUE FLAG POLICIES, RULES, & PROCEDURES IN ORDER TO WARN THAT MAINTENANCE PERSONNEL ARE WORKING ON, UNDER, OR NEAR ROLLING EQUIPMENT.

WARNING: BEFORE BEGINNING ANY WORK UNDER THE TRUCK, MAKE SURE THE TRACTION MOTOR NEAR THE GEARBOX IS DE-ENERGIZED. BEFORE BEGINNING ANY WORK ON THE DRIVE UNITS, MAKE SURE THAT NEITHER THE VEHICLE NOR THE TRUCK OR THE WHEEL SET CAN MOVE.

CAUTION: INSPECTION OF THE GEARBOX OIL LEVEL MUST BE PERFORMED:
A) WITH VEHICLE ON LEVEL TRACK.
B) AFTER THE VEHICLE HAS BEEN IN STATIONARY MODE FOR AT LEAST 20 MINUTES.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit

CONSUMABLES:

OIL: Mobilube SHC 75W90-LS
GREASE: Mobilux EP2
Solvent naphtha, Pentex 2000 / Fa. Pentol AG, Aral 4005,MPA / Fa. Herberts, D-42202 Wuppertal, Rivolta MTX, Loctite 7061 or 7063 FOR THREADS, Loctite 243, Loctite 518
ITEMS:
Retaining Wire

SPARE PARTS:

Plastic plug Kapsto GPN300 F2

Copper Ring (DIN7603-Cu-A27x32)

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-06-01-00/S-00**
System: **PROPULSION**	Sheet: **3/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**
Component:	Man Hours: **1.5**
Maintenance Task: **SERVICE**	

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Remove Electrical Power from Vehicle by lowering the Pantograph and deenergizing the catenary.

2. Lock out and tag out the catenary in accordance with all LACMTA Safety Rules, Regulations, Policies, and Procedures.

NOTE The tag must indicate the name of the person who removed Power.
That person knows why the Power was removed and when it safe to restore it.
Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

SERVICE

1. **Check for Gearbox Oil Leakage** (refer to figure 1)

a. Inspect Gear Unit for oil leakage on the following items:

- Inspection Cover (2)
- Oil Fill Plug (4)
- Oil Drain Plug (6)
- Oil Gauge Glass (7)
- Coupling Halves Connection (9)

2. Tighten the Oil Fill Cap (4).

3. Tighten the Magnetic Oil Drain Plug (6) with a torque of **58.8 ft-lb** (80 Nm.). Secure the Magnetic Oil Drain Plug (6) with a retaining wire.

4. Apply Loctite 243 to the Bolts of the Inspection Cover (2) and torque them to **18.5 ft-lb** (25 Nm).

5. Apply Loctite 243 at the thread of the Oil Gauge Glass (7) and tighten it into the housing with a torque of **60.5 ft-lb** (82 Nm).

6. Apply Loctite 243 at the Coupling Halves Connection (9) and tighten them cross-wise with a torque of to **58 ft-lb** (79 Nm).

P2550 CORRECTIVE MAINTENANCE SHEET			
Card Code: **R-C-07-06-01-00/S-00**			
System: **PROPULSION**			Sheet: **4/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**		
Component:			Man Hours: **1.5**
Maintenance Task: **SERVICE**			

PROCEDURE (CONT'D):

OIL CHANGE

Change Gearbox Oil and check the Magnetic Oil Drain and the Fill Cap for metal dust. To perform the task proceed as follows(refer to Figure 1):

NOTE: Oil change should be carried out when the gear is warm (i.e. immediately after operating), because warm oil drains more easily and dirt particles are rinsed out with the oil.

1. Cut through the Retaining Wire (67) of the magnetic Oil Drain Cap (40) and remove the Wire.
2. Clean the area around the magnetic Oil Drain Cap (40) using recommended agent.
3. Unscrew the magnetic Oil Drain Cap (40) and remove the Copper Ring (46).
4. Collect the Oil in a container.

CAUTION: THE DRAINED OIL MAY BE VERY HOT.

5. Examine the magnetic Oil Drain Cap (40) for dirt. Fine dust is normal. If metal chips are found then, the Gearbox should be inspected more closely.

6. Clean the magnetic Oil Drain Cap (40) using recommended agent.
7. Fit the magnetic Oil Drain Cap (40) with a new Copper Ring (46) and screw it into the Housing with a tightening torque of **58.8 ft-lb** (80 Nm).
8. Secure the magnetic Oil Drain Cap (40) with Retaining Wire (67).
9. Cut through the Retaining Wire (67) of the Oil Fill Cap (40) and remove the Wire.
10. Clean the area around the magnetic Oil Fill Cap (40) using recommended agent.
11. Unscrew the Oil Fill Cap (40) and remove the Copper Ring (46).
12. Examine the magnetic Oil Fill Cap (40) for dirt. Fine dust is normal. If metal chips are remarked, the Gearbox should be inspected more closely.
13. Clean the Oil Fill Cap (40) using recommended agent.

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-06-01-00/S-00**		
System: **PROPULSION**		Sheet: **5/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1.5**
Maintenance Task: **SERVICE**		

PROCEDURE (CONT'D):

14. Pour in 5.0 liter of oil (0,5 liter oil rests in the gearbox after draining), there is now totally 5.5 liter oil in the Gearbox.

CAUTION: MAKE SURE THAT NO DIRT ENTERS THE GEARBOX.ONLY USE THE SPECIFIED TYPE OF OIL.

CAUTION: THE GEARBOX MUST NOT OPERATE WITHOUT OIL.

15. Check the Oil Level. Therefore, take a closer look at the Oil Gauge Glass. The Oil Level has to be at the maximum, this means at the top of the Red Circle on the Oil Gauge Glass.

NOTE: After driving, the fixed Oil Capture Device is filled up again and the Oil Level has to stay between the Minimum and the Maximum, marked by a Red Circle on the Oil Gauge Glass.

16. If necessary adapt the oil level by draining and topping up with oil.

NOTE: Too much Oil in the Gearbox is just as harmful as too little oil.

17. If the oil level is okay insert the Oil Fill Cap (40) in the housing (1.01) with a new copper ring (46) and tighten with a torque of **58.8 ft-lb** (80 Nm).

18. Secure the Oil Fill Cap (40) with retaining Wire (67).

19. Restore Power.

20. Record Task results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-06-01-00/S-00**		
System: **PROPULSION**		Sheet: **6/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1.5**
Maintenance Task: **SERVICE**		

PROCEDURE (CONT'D):

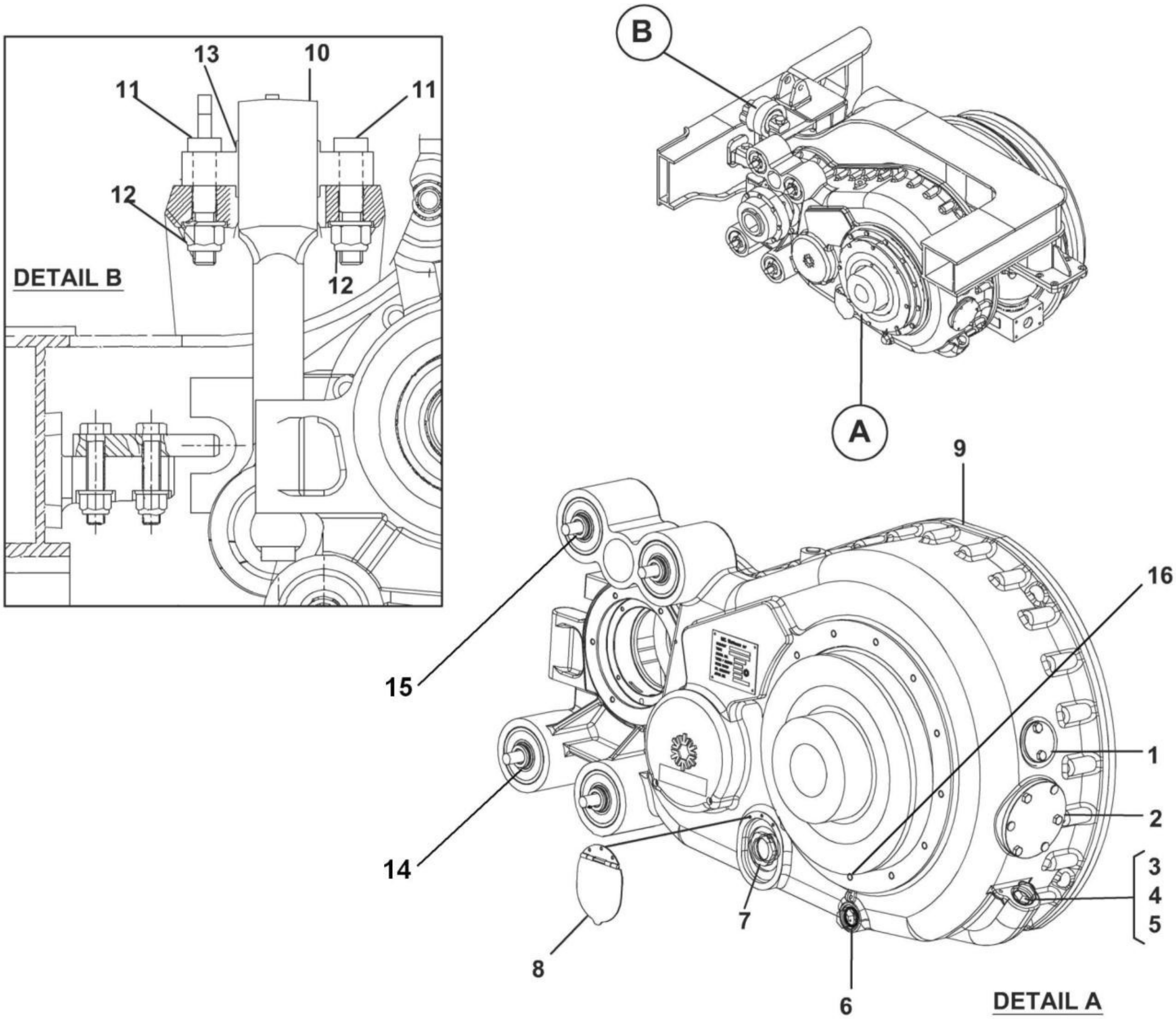


Figure 1 - GEARBOX

P2550 CORRECTIVE MAINTENANCE SHEET		
		Card Code: **R-C-07-06-01-00/S-00**
System: **PROPULSION**		Sheet: **7/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1.5**
Maintenance Task: **SERVICE**		

PROCEDURE (CONT'D):

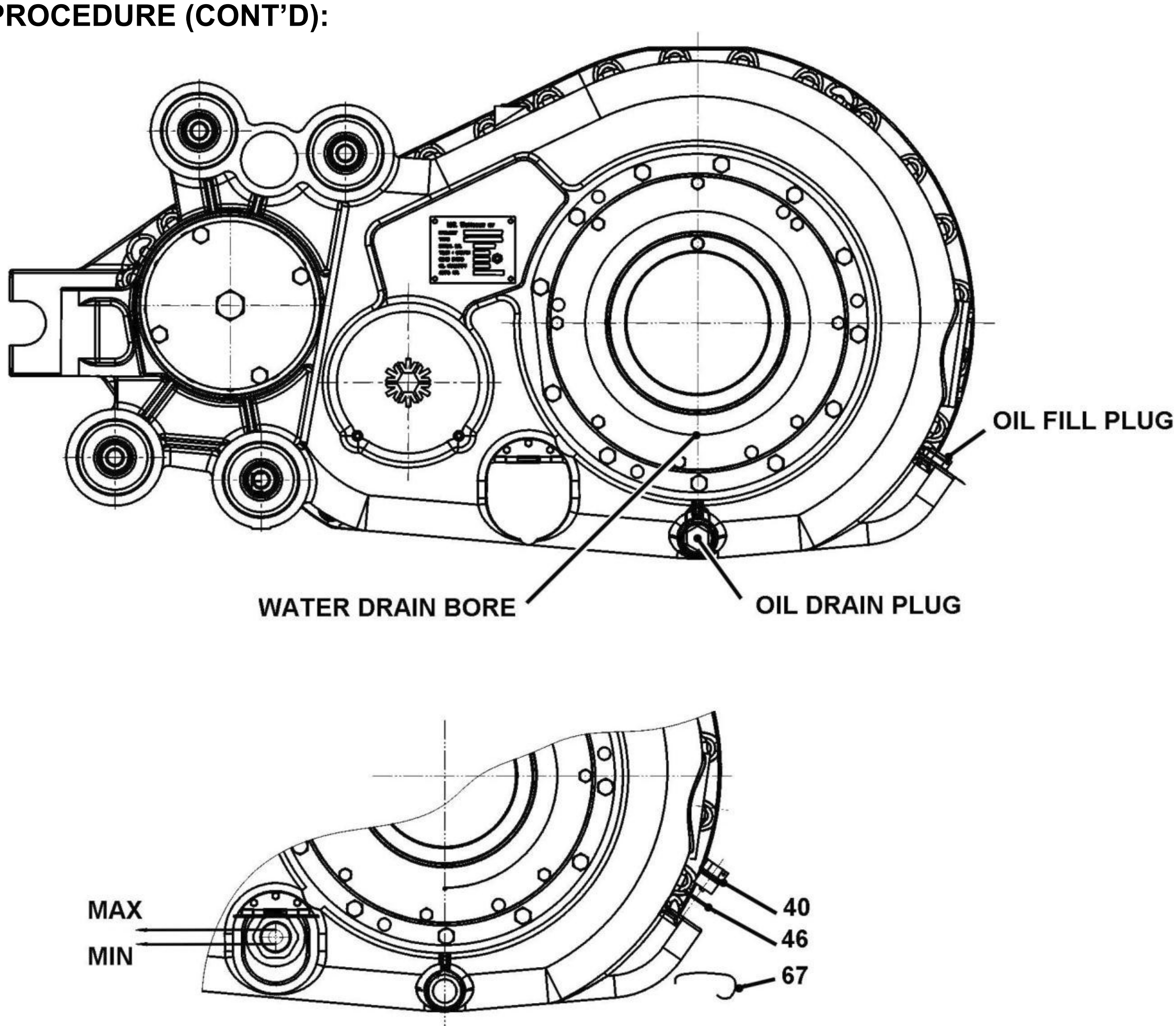


Figure 2 - GEAR UNIT - OIL REFILL

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-06-01-00/S-00**		
System: **PROPULSION**		Sheet: **8/8**
Subsystem/Assy: **GEARBOX ASSY**	Unit: **GEARBOX**	
Component:		Man Hours: **1.5**
Maintenance Task: **SERVICE**		

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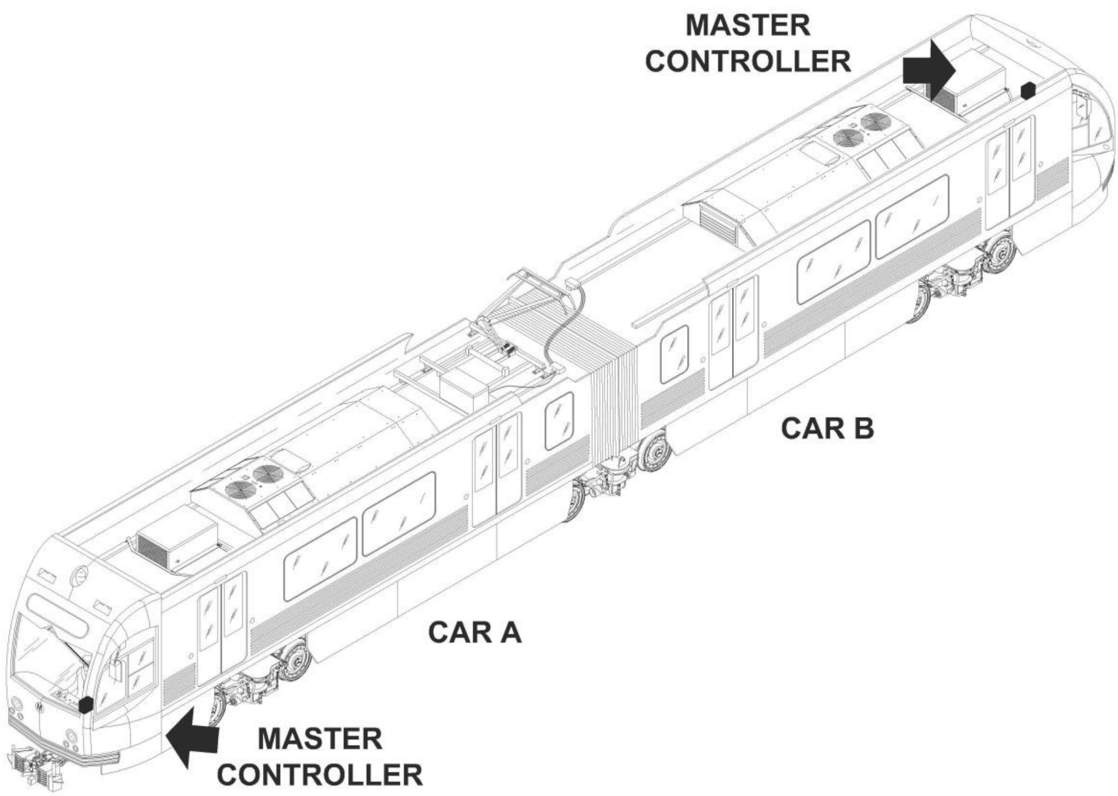
P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-08-01-00/R-00**
System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MASTER CONTROLLER (3A01)**
Component:	Man Hours: **1.00**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-01-00/R-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MASTER CONTROLLER (3A01)**
Component:	Man Hours: **1.00**
Maintenance Task: **REPLACEMENT**	

SAFETY PRECAUTIONS:

WARNING: CONTACT WITH ENERGIZED ELECTRICAL PARTS CAN CAUSE PERSONAL INJURY. TO AVOID ACCIDENTS, KEEP HANDS, TOOLS (ETC.) AWAY FROM ANY ELECTRICAL PARTS, IF THE CIRCUIT NEEDS TO BE ENERGIZED FOR TESTING PURPOSES. IN ANY OTHER CASE, DE-ENERGIZE THE CIRCUIT.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Small set of screw wrench.
Socket wrench.
Elbowed wrench.
Digital Multimeter.
Vacuum Cleaner.

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

MASTER CONTROLLER PN AA0437E MFR 3-C.4504

P2550 CORRECTIVE MAINTENANCE SHEET

		Card Code: **R-C-07-08-01-00/R-00**
System: **PROPULSION**		Sheet: **3/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MASTER CONTROLLER (3A01)**	
Component:		Man Hours: **1.00**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Open the 3F18, 3F05 and 3F20 Circuit Breakers and place a tag on them.

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the Task proceed as follows (Refer to Figure 1):

1. Remove the Fixing Screws from the Master Controller Plate.
2. Remove the Master Controller Inspection Panel, located in the Console Structure, to gain lateral access to the Master Controller connectors.
3. Disconnect the V3U01 and the VM1 connectors located on the Master Controller Power Supply.
4. Lift the Master Controller from its position, paying attention to not damage the components.
5. Place the Master Controller in suitable and secure position to have it available for maintenance.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-01-00/R-00**	
System: **PROPULSION**	Sheet: **4/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MASTER CONTROLLER (3A01)**
Component:	Man Hours: **1.00**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

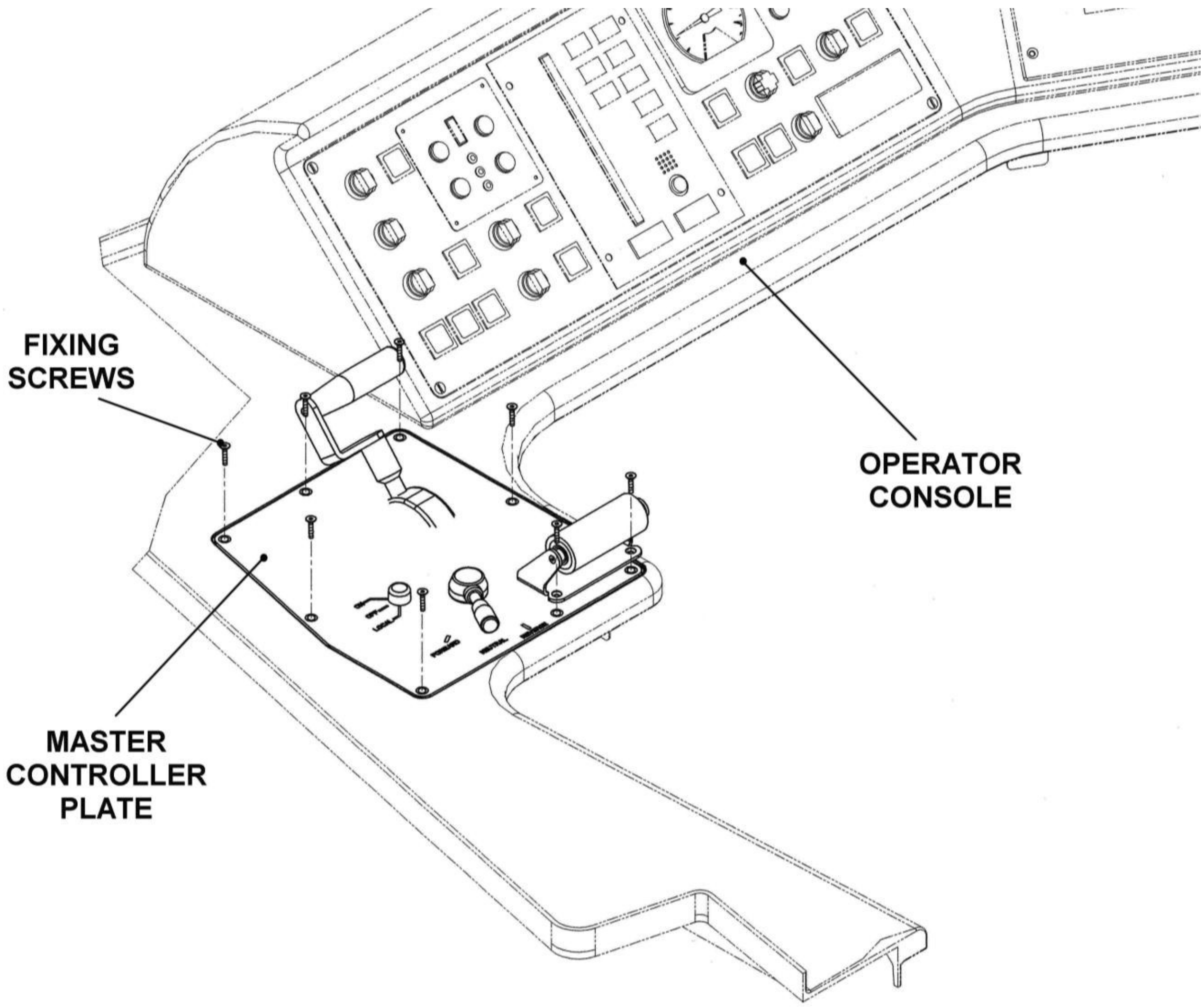


Figure 1 - MASTER CONTROLLER - REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-01-00/R-00**

System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MASTER CONTROLLER (3A01)**
Component:	Man Hours: **1.00**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figure 1):

1. Install the Master Controller on its position, paying attention to not damage components.

2. Reinstall and tighten the Fixing Screws on the Master Controller Plate.

3. Connect the V3U01 and the VM1 connectors.

4. Reinstall the Master Controller Inspection Panel, located in the Console Structure.

5. Set the Master Controller Handle to FSB position and Transfer Switch to OFF position.

6. Place the CB 3F18 (LV Locker each CAR) to "ON" position.

7. Make sure you check train lines on the new master controller. Also check for the proper Rate Reference when in brake, coast and power modes respectively.

8. Restore Electrical Power.

9. Record tasks results on the Defect Report Card for administrative and maintenance planning.

<u>**NOTE:**</u> At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-08-01-00/R-00**		
System: **PROPULSION**		Sheet: **6/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MASTER CONTROLLER (3A01)**	
Component:		Man Hours: **1.00**
Maintenance Task: **REPLACEMENT**		

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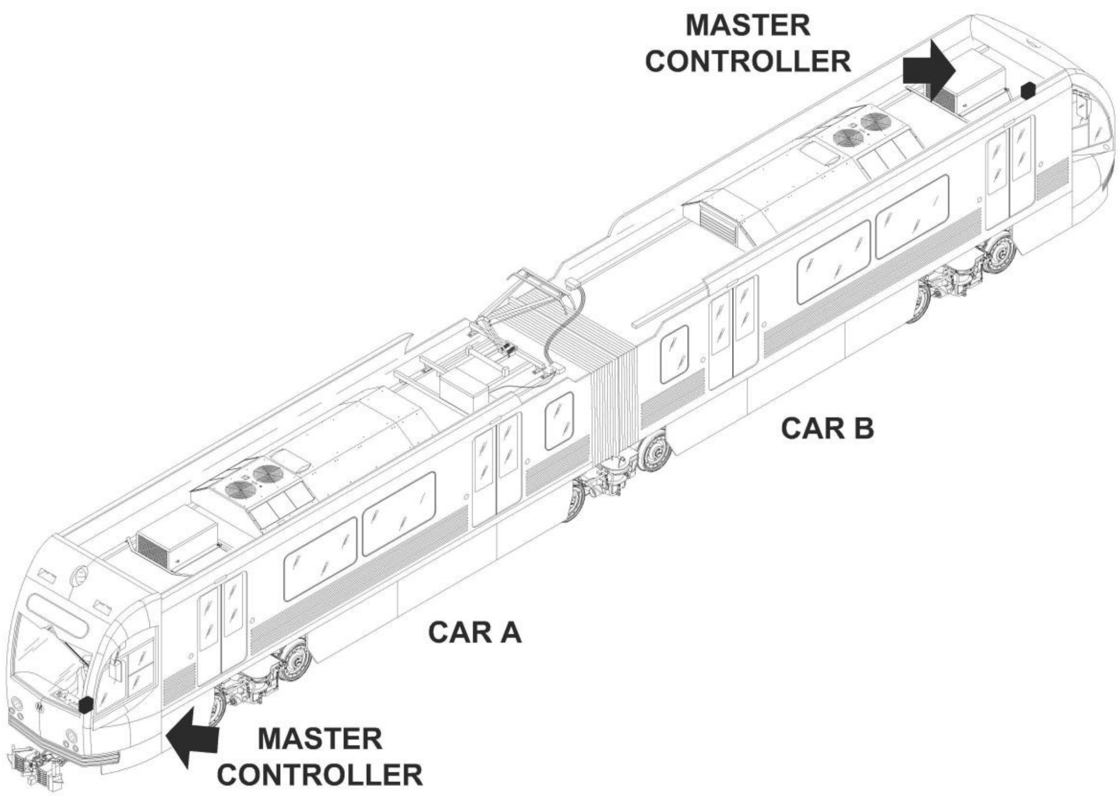
P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-02-00/R-00**	
System: **PROPULSION**	Sheet: **1/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MICROSWITCHES**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-02-00/R-00**	
System: **PROPULSION**	Sheet: **2/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MICROSWITCHES**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

SAFETY PRECAUTIONS:

WARNING: CONTACT WITH ENERGIZED ELECTRICAL PARTS CAN CAUSE PERSONAL INJURY. TO AVOID ACCIDENTS, KEEP HANDS, TOOLS (ETC.) AWAY FROM ANY ELECTRICAL PARTS, IF THE CIRCUIT NEEDS TO BE ENERGIZED FOR TESTING PURPOSES. IN ANY OTHER CASE, DE-ENERGIZE THE CIRCUIT.

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Small set of screw wrench.
Socket wrench.
Elbowed wrench.
Digital Multimeter.
Vacuum Cleaner.

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

MICROSWITCH MFR PN S826A
MICROSWITCH MFR PN S847W
MICROSWITCH MFR PN S800C

P2550 CORRECTIVE MAINTENANCE SHEET

		Card Code: **R-C-07-08-02-00/R-00**
System: **PROPULSION**		Sheet: **3/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MICROSWITCHES**	
Component:		Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Open the 3F18, 3F05 and 3F20 Circuit Breakers and place a tag on them.

> **NOTE** The tag must indicate the name of the person who removed Power.
>
> That person knows why the Power was removed and when it safe to restore it.
>
> Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 and 2):

1. Remove the Master Controller Inspection Panel, located in the Console Structure, to gain lateral access to the Master Controller Micro switches.

2. Take note of Wire Markers / Labels first and then remove the Micro switch connections.

3. Take note of the Micro switch Action Roll position.

4. Remove the Micro switch Fixing Screws. Retain them for later use.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-02-00/R-00**	
System: **PROPULSION**	Sheet: **4/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MICROSWITCHES**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

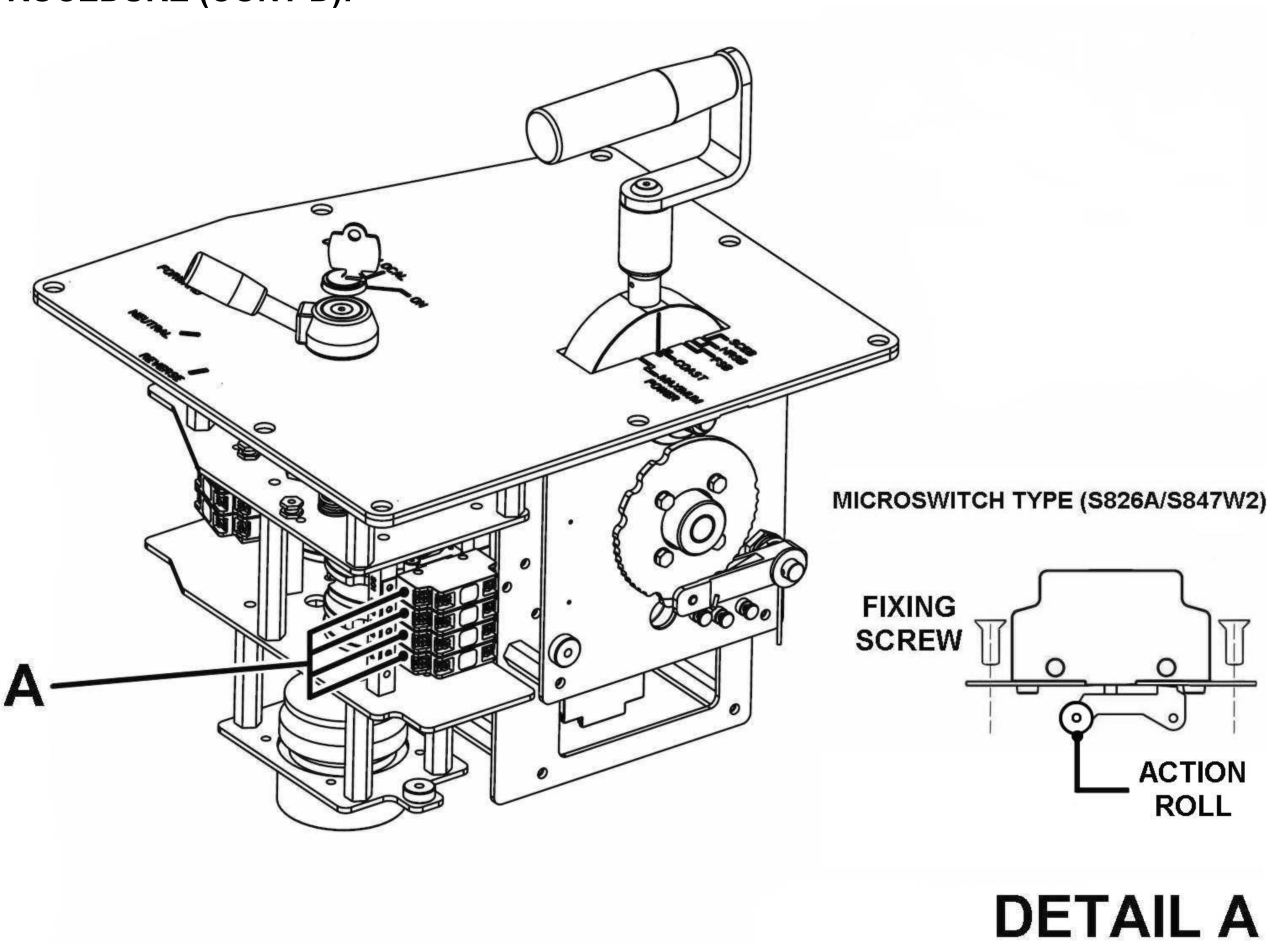


Figure 1 - MASTER CONTROLLER - MICROSWITCHES WITH ACTION ROLL

P2550 CORRECTIVE MAINTENANCE SHEET

	Card Code: **R-C-07-08-02-00/R-00**
System: **PROPULSION**	Sheet: **5/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MICROSWITCHES**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

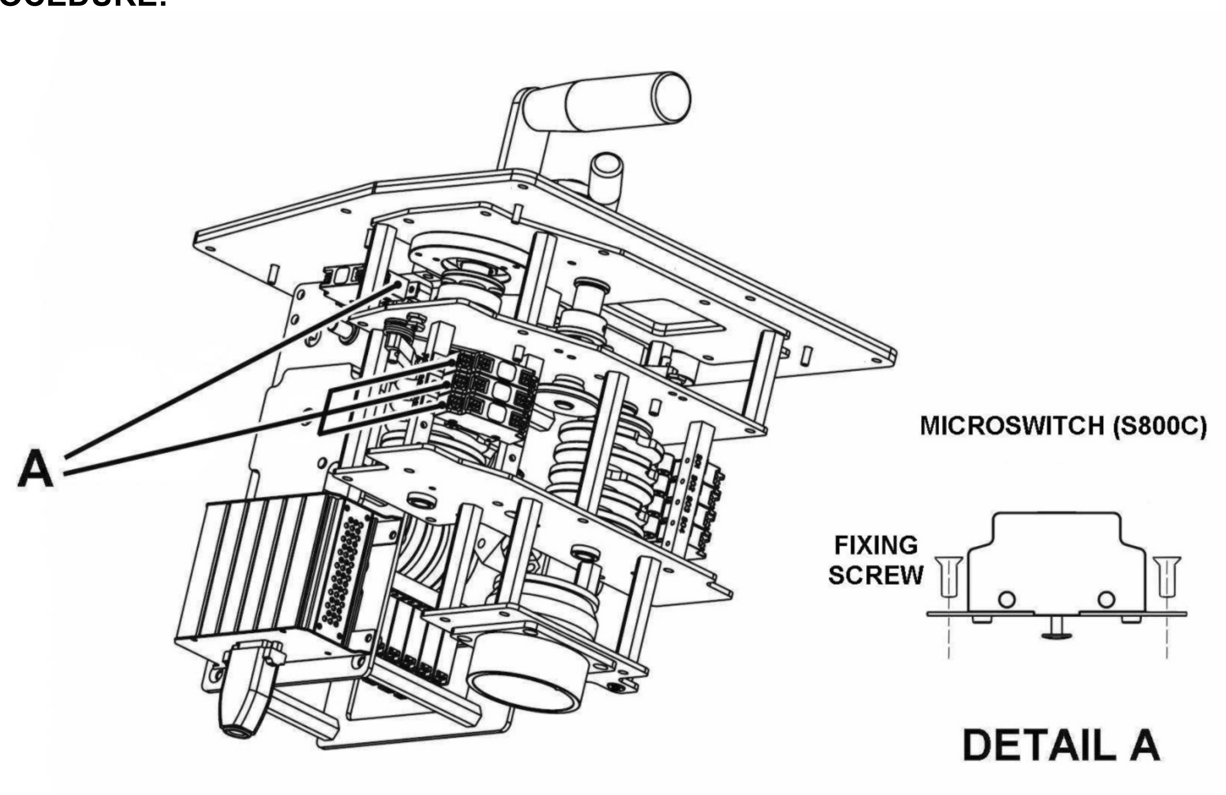


Figure 2 - MASTER CONTROLLER - MICROSWITCHES WITHOUT ACTION ROLL

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-02-00/R-00**	
System: **PROPULSION**	Sheet: **6/6**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **MICROSWITCHES**
Component:	Man Hours: **1.25**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 and 2):

1. Install the new Microswitch by tightening relevant fixing screws.

CAUTION: FOR THE INSTALLATION OF THE MICROSWITCHES EQUIPPED WITH ACTION ROLL PAY ATTENTION TO PLACE THE ACTION ROLL IN THE SAME POSITION PREVIOUSLY NOTED.

2. Connect Wirings according to the Wire Markers / Labels previously noted.

3. Tighten the Microswitch Fixing Screws.

4. Reinstall the Master Controller Inspection Panel, located in the Console Structure.

5. Set the Master Controller Handle to FSB position and Transfer Switch to OFF position.

6. Place the CB 3F18 (LV Locker each CAR) to "ON" position.

7. Check for proper train lines.

8. Restore Electrical Power.

9 Record tasks results on the Defect Report Card for administrative and maintenance planning.

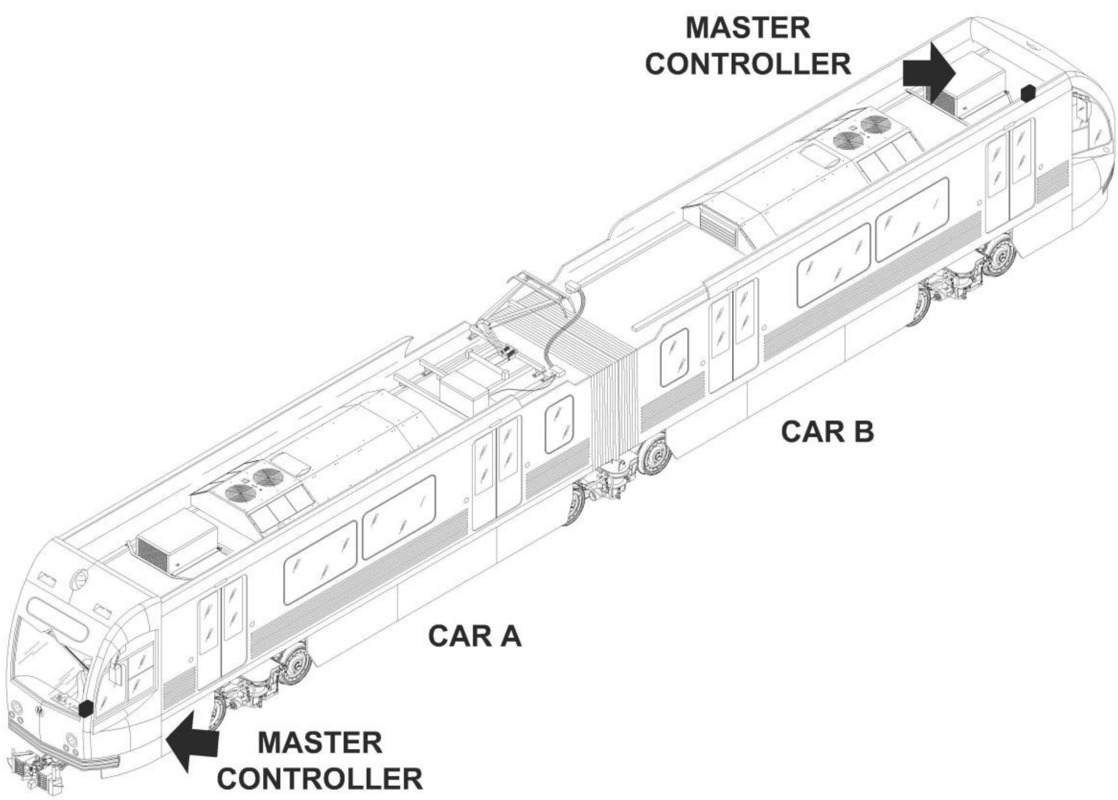
NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-03-00/R-00**	
System: **PROPULSION**	Sheet: **1/8**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **RATE REFERENCE ENCODER (3U01)**
Component:	Man Hours: **1.75**
Maintenance Task: **REPLACEMENT**	

LOCATION:



P2550 CORRECTIVE MAINTENANCE SHEET

Card Code:

R-C-07-08-03-00/R-00

System:	Sheet:
PROPULSION	**2/8**

Subsystem/Assy:	Unit:
MASTER CONTROLLER	**RATE REFERENCE ENCODER (3U01)**

Component:	Man Hours:
	1.75

Maintenance Task:

REPLACEMENT

SAFETY PRECAUTIONS:

WARNING: **CONTACT WITH ENERGIZED ELECTRICAL PARTS CAN CAUSE PERSONAL INJURY. TO AVOID ACCIDENTS, KEEP HANDS, TOOLS (ETC.) AWAY FROM ANY ELECTRICAL PARTS, IF THE CIRCUIT NEEDS TO BE ENERGIZED FOR TESTING PURPOSES. IN ANY OTHER CASE, DE-ENERGIZE THE CIRCUIT.**

WARNING: BEFORE PERFORMING MAINTENANCE PROCEDURES AND TOUCHING ANY COMPONENT, USE A RELIABLE HIGH VOLTAGE TEST PROBE TO VERIFY THAT NO VOLTAGE IS PRESENT.

TOOLS:

LACMTA Maintenance Shop Standard Tools Kit.
Small set of screw wrench.
Socket wrench.
Elbowed wrench.
Digital Multimeter.
Vacuum Cleaner.

CONSUMABLES:

Cleaner / Degreaser

SPARE PARTS:

RATE REFERENCE ENCODER	Type BRF-6	MFR PN:	64121240

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-03-00/R-00**		
System: **PROPULSION**		Sheet: **3/8**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **RATE REFERENCE ENCODER (3U01)**	
Component:		Man Hours: **1.75**
Maintenance Task: **REPLACEMENT**		

PROCEDURE:

PRELIMINARY OPERATIONS

Set the Vehicle in safety conditions in accordance with LACMTA Maintenance Shop Regulations:

1. Open the 3F18, 3F05 and 3F20 Circuit Breakers and place a tag on them.

NOTE The tag must indicate the name of the person who removed Power.

That person knows why the Power was removed and when it safe to restore it.

Only the individual whose name appears on the tag or a person with his approval should remove the tag and restore Power.

REMOVAL

To perform the task proceed as follows (Refer to Figures 1 and 2):

1. Remove the Key (Transfer switch in OFF position).

2. Remove the Master Controller Inspection Panel, located in the Console Structure, to gain lateral access to the Master Controller connectors.

3. Disconnect the V3U01 and the VM1 connectors located on the Master Controller Power Supply.

4. Remove the Master Controller Power Supply fixing Screws.

5. Shift away the Master Controller Power Supply from the Encoder to disconnect the movable connector (SUB-D-15P).

6. Remove the Encoder by loosening the relevant fixing Screws.

7. Remove the Encoder Gear by loosening the Grub Screws. Retain the Gear for later use.

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-03-00/R-00**	
System: **PROPULSION**	Sheet: **4/8**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **RATE REFERENCE ENCODER (3U01)**
Component:	Man Hours: **1.75**
Maintenance Task: **REPLACEMENT**	

PROCEDURE:

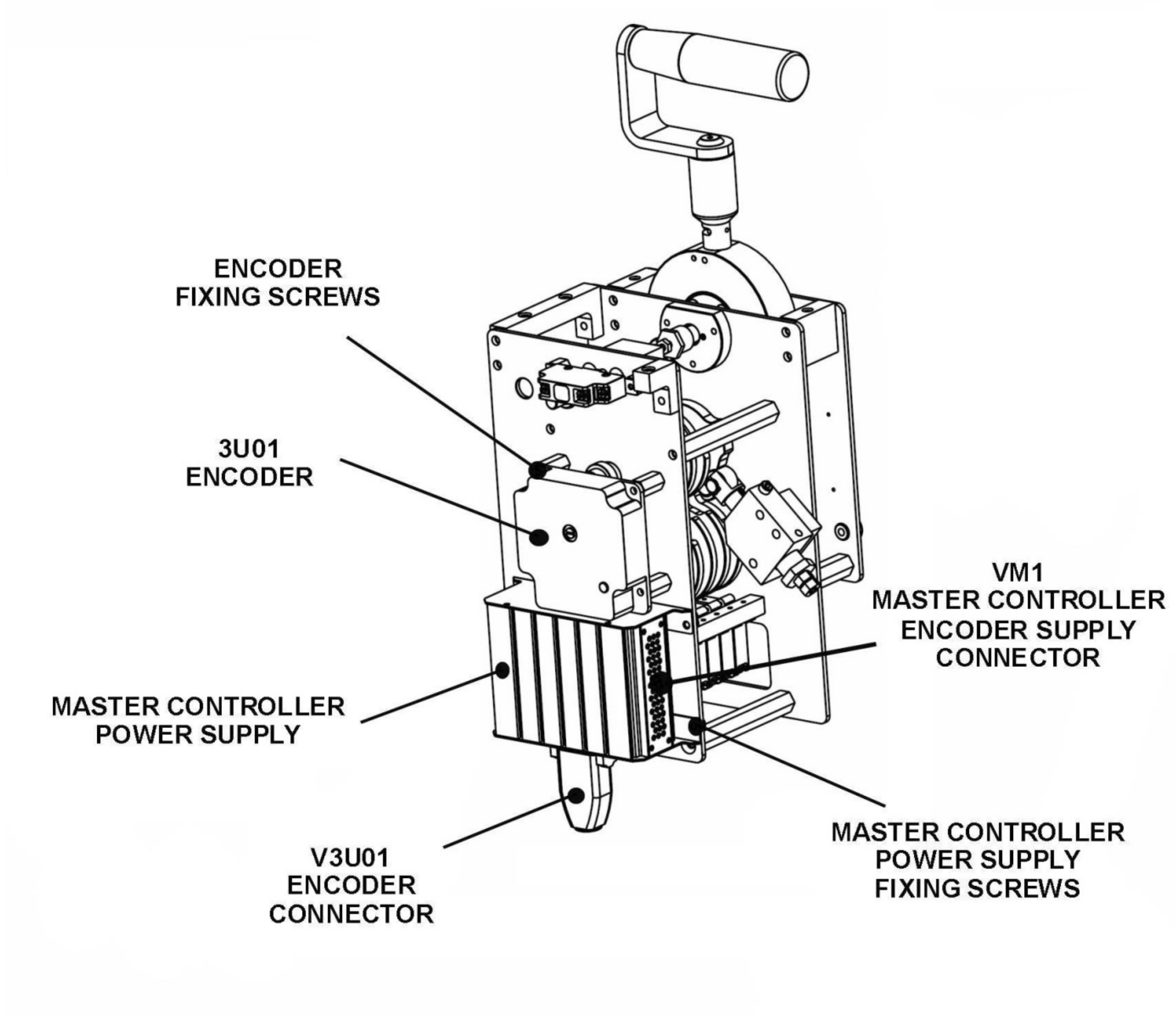


Figure 1 - MASTER CONTROLLER - COMPONENTS

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-03-00/R-00**

System:	Sheet:
PROPULSION	**5/8**

Subsystem/Assy:	Unit:
MASTER CONTROLLER	**RATE REFERENCE ENCODER (3U01)**

Component:	Man Hours:
	1.75

Maintenance Task: **REPLACEMENT**

PROCEDURE (CONT'D):

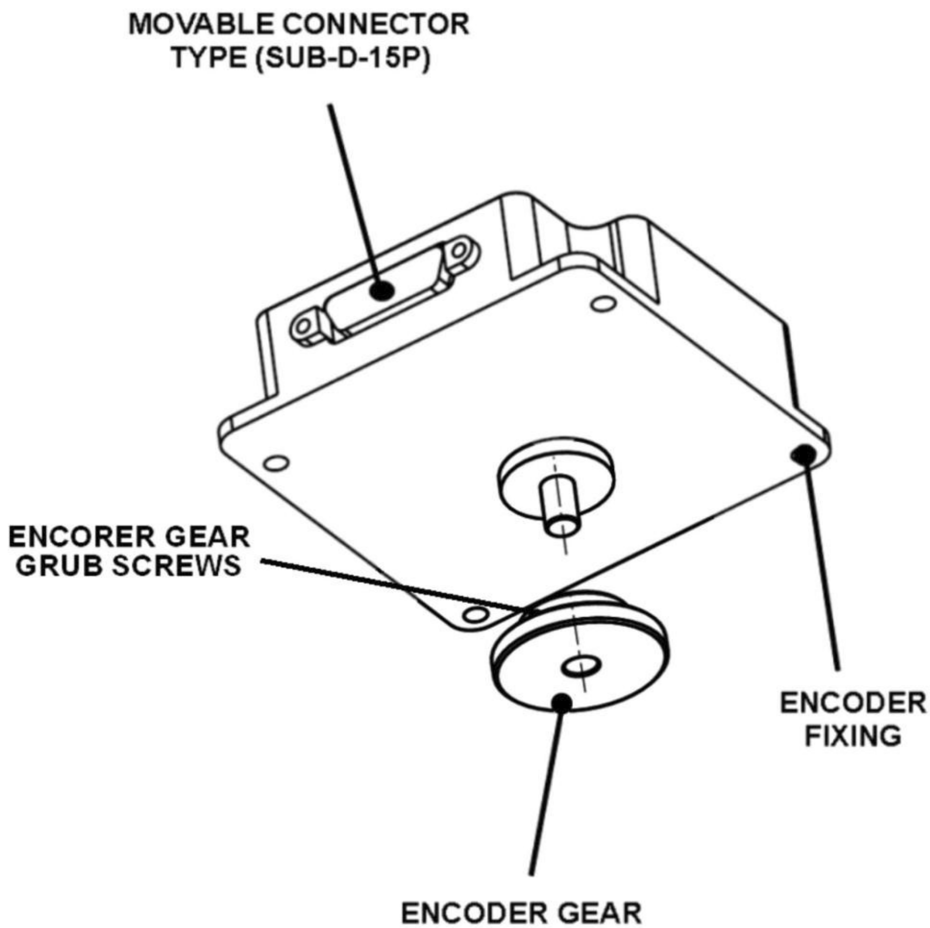


Figure 2 - ENCODER - REPLACEMENT

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-03-00/R-00**		
System: **PROPULSION**		Sheet: **6/8**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **RATE REFERENCE ENCODER (3U01)**	
Component:		Man Hours: **1.75**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

INSTALLATION

To perform the task proceed as follows (Refer to Figures 1 and 2):

1. Restore the Encoder Gear by lightly tightening the Set Screws, but loose to make adjustment.

NOTE: The Grub Screws will be tightened after the Adjustment procedure.

2. Install the Encoder by tightening the relevant fixing screws.
3. Restore the Master Controller Power Supply by connecting the Movable Connector and tightening the relevant fixing Screws.
4. Connect the moveable connector (SUB-D-15P).

ADJUSTMENT

To adjust the Encoder Signal output proceed as follows (Refer to Figures 3 and 4):

1. Place the Transfer switch in "LOCAL" position and the Control Handle in "COAST" position.
2. Remove the Master Controller Inspection Panel, located in the Console Structure, to gain lateral access to the Master Controller Connectors.
3. Apply an external Power Supply 37.5 VDC to the Encoder through Encoder Connector Pins 15 (+) and 1 (-).
4. Connect a Digital Multi Meter to the Output Signal (Pin 8 and Pin 13) of Encoder Connector.
5. Rotate the Adjustment Screw, using flat head screwdriver, to obtain **12 mA (+/- 0.3 mA)** on Multi Meter Display.
6. Lightly tighten one the Grub Screws and verify that the Output Signal (pin 8 and 13) is according to the Rate Reference Signal.
7. Tighten completely both the Grub Screws.
8. Mark, using red marker pen, both the Grub Screws.
9. Remove the external Power Supply 37.5 VDC.
10. Install the Master Controller Inspection Panel, located in the Console Structure.
11. Set the Master Controller Handle to FSB position and Transfer Switch to OFF position.
12. Place the CB 3F18 (LV Locker each CAR) to "ON" position.
13. Restore Electrical Power.
14. Record tasks results on the Defect Report Card for administrative and maintenance planning.

NOTE: At Task Completion it is recommended to check the correct operation and/or functions of the Subsystem to which the replaced Equipment pertains.

Refer to **HOW TO USE THE R-CM SHEETS (**para 07-III-04-01-02 of this Section) and follow the prescriptions provided at Step 3 **"At every Task Completion."**

P2550 CORRECTIVE MAINTENANCE SHEET		
Card Code: **R-C-07-08-03-00/R-00**		
System: **PROPULSION**		Sheet: **7/8**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **3U01 RATE REFERENCE ENCODER**	
Component:		Man Hours: **1.75**
Maintenance Task: **REPLACEMENT**		

PROCEDURE (CONT'D):

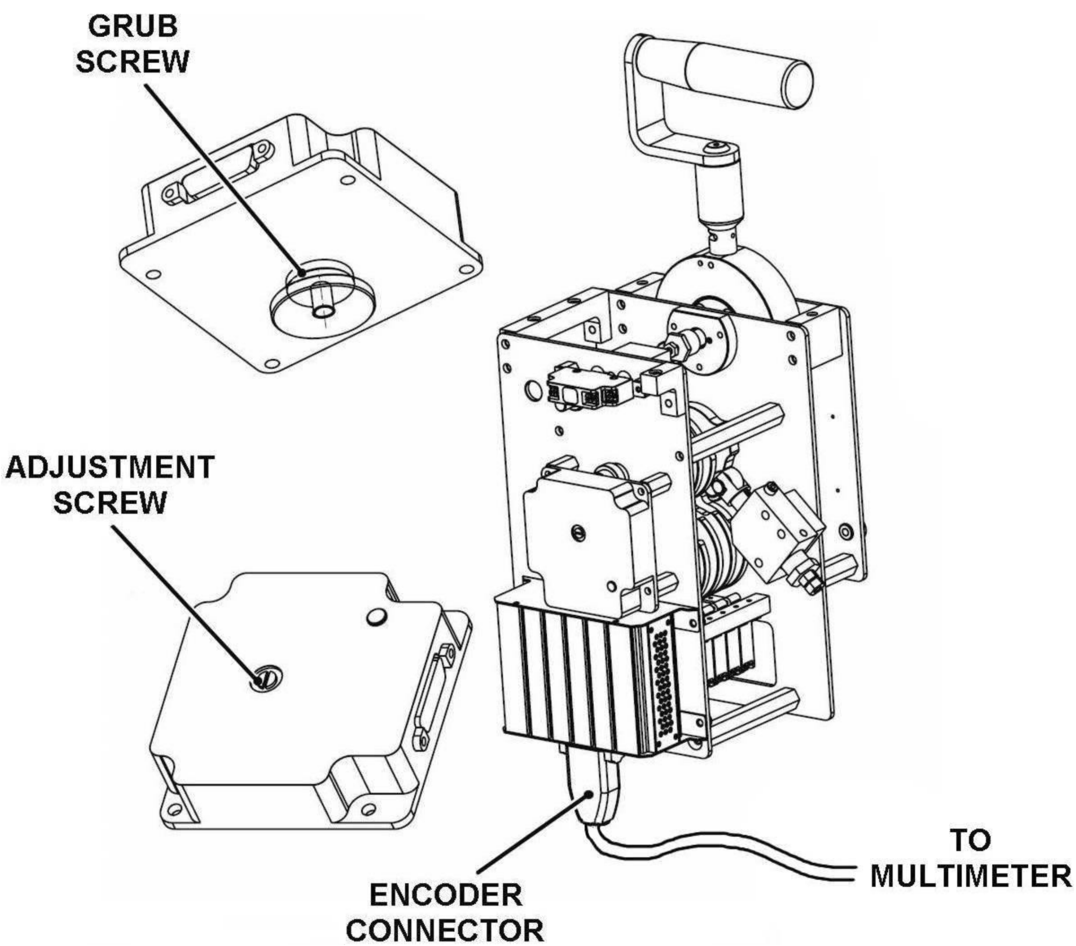


Figure 3 - ENCODER - ADJUSTMENT

P2550 CORRECTIVE MAINTENANCE SHEET

Card Code: **R-C-07-08-03-00/R-00**	
System: **PROPULSION**	Sheet: **8/8**
Subsystem/Assy: **MASTER CONTROLLER**	Unit: **3U01 RATE REFERENCE ENCODER**
Component:	Man Hours: **1.75**
Maintenance Task: **REPLACEMENT**	

PROCEDURE (CONT'D):

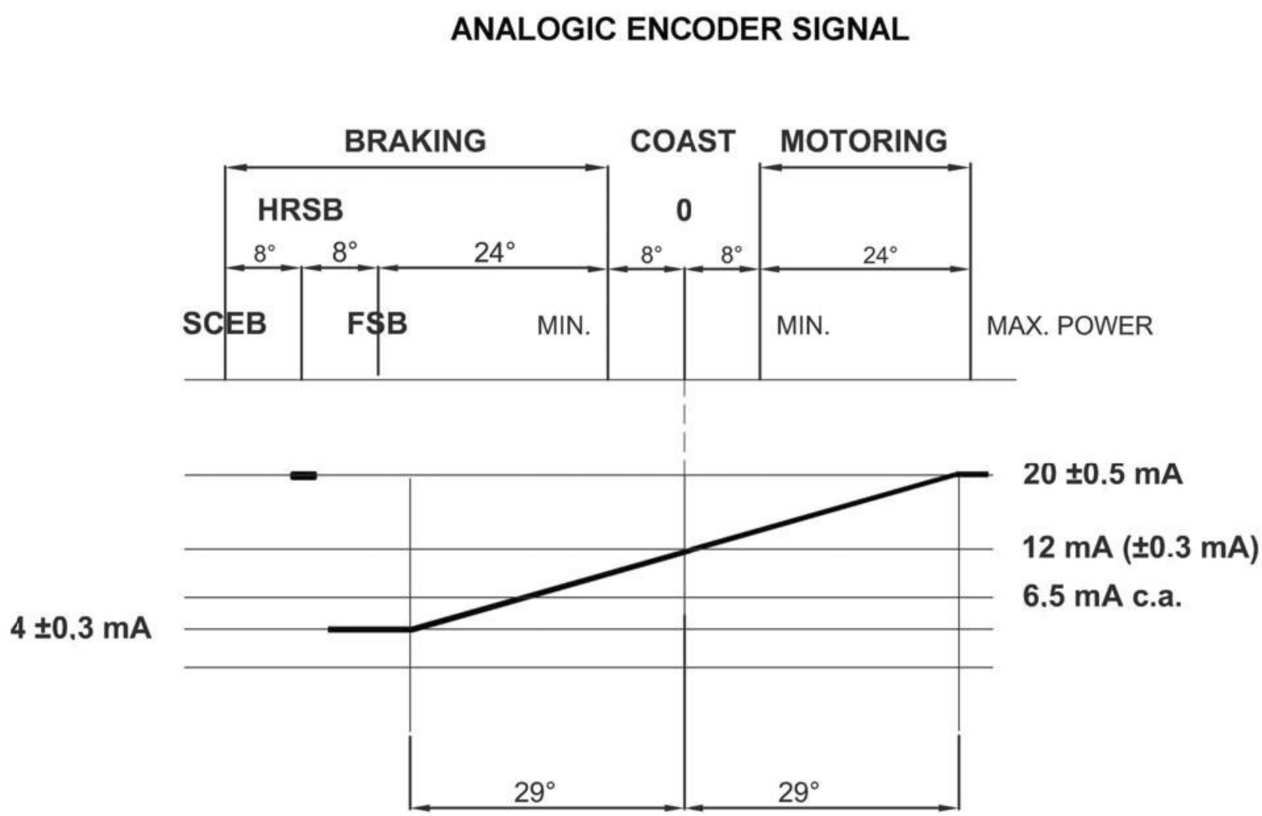


Figure 4 - MASTER CONTROLLER - RATE REFERENCE

07-III-06 CONSUMABLE MATERIALS LIST (R-CML)

The Consumable Materials needed to accomplish the "Propulsion System" Running Maintenance are listed, sequenced in alphabetical order, by SUBSYSTEM /ASSY -UNIT / COMPONENT, in the following Table 07-III-06.1.

Table 07-III-06.1 Running Maintenance Consumable Materials List (R-CML)

SYSTEM 07	PROPULSION		
SUBSYSTEM /ASSY - UNIT / COMPONENT	**AGENT**	**PN**	**MTA PN**
BRAKING RESISTOR	Cleaner / Degreaser	(commercial)	
GEARBOX	OIL: Mobilube SHC 75W90-LS		
	GREASE: Mobilux EP2		
	Solvent naphtha		
	Pentex 2000 / Fa. Pentol AG		
	Aral 4005		
	MPA / Fa. Herberts, D-42202 Wuppertal		
	Rivolta MTX		
	Loctite 7061 or 7063 (for Threads)		
	Loctite 243, Loctite 518		
GEARBOX - MOTOR COUPLING	Grease Type:Texaco Coupling Grease		
INVERTER COOLING MOTOR FAN	Cleaner / Degreaser	(commercial)	
LINE REACTOR (1L01)	Cleaner / Degreaser	(commercial)	
MASTER CONTROLLER	BEACOM EP2 Esso		
	MOLY Esso Multipurpose Grease		
	Cleaner / Degreaser	(commercial)	
PRECHARGE SYSTEM	CRC 2000 Contact Cleaner		
	CRC Industrial - Precision Cleaner	M3 PN 147535	
RETURN CURRENT SYSTEM - GROUNDING CONTACT	Cleaner / Degreaser	(commercial)	
	White Alcohol Spirits		
	Anti-Oxidant Joint Compound Korp - Shield	AA00FFX	
TRACTION CONTROL UNIT (TCU)	CRC Industrial - Precision Cleaner	M3 PN 147535	
	Dry Compressed Air for Electronic Equipment	(commercial)	

(cont'd)

(cont'd)

Table 07-III-06.1 Running Maintenance Consumable Materials List (R-CML)

SYSTEM 07	PROPULSION SYSTEM		(cont'd)
SUBSYSTEM /ASSY - UNIT / COMPONENT	**AGENT**	**PN**	**MTA PN**
TRACTION INVERTER HV COMPONENTS	Cleaner / Degreaser	(commercial)	
	CRC Industrial - Precision Cleaner	M3 PN 147535	
	Dry Compressed Air for Electronic Equipment	(commercial)	
TRACTION MOTOR	Esso Beacon EP 2 Grease	211MX40043B	
TRACTION MOTOR ACTIVE SPEED SENSOR	CRC 2000 Contact Cleaner		
TRACTION MOTOR THERMAL SENSOR	CRC 2000 Contact Cleaner		
	RHODORSIL CAF 730 Sealant		
	COMPOUND DOW CORNING 340 Grease		
	Safety Wires		
	Retaining Wire		

07-III-07 TEST EQUIPMENT & SPECIAL TOOLS LIST (R-TESTL)

The Tools and Test Equipment needed to accomplish the “Propulsion System” Running Maintenance are listed, sequenced in alphabetical order, by SUBSYSTEM /ASSY -UNIT / COMPONENT, in the following Table 07-III-07.1.

Refer to “Tools and Test Equipment Manual” for Special Tools / Test Equipment Description and Maintenance.

Table 07-III-07.1 Running -Test Equipment & Special Tools List (R-TESTL)

SYSTEM 07	PROPULSION			
SUBSYSTEM /ASSY - UNIT / COMPONENT	**LACMTA STANDARD TOOLS KIT**	**LACMTA WORKSHOP DEVICES**	**SPECIAL TOOL / TEST EQUIPMENT**	**PN**
BRAKING RESISTOR	X	High Pressure Steam Cleaner		
GEARBOX	X		**Hydraulic Equipment Set With Pressure Gauge And Supply Lines**	T.1
			Hex Head Screw ISO4017 - M8x35	T.2
			Hex Head Screw ISO4017 - M6x25	T.3
			Hex Head Screw ISO4017 - M10x55	T.4
			Special Tool For Removing The Threaded Dowel	T.5
			Hex Head Screw ISO4017 - M12x35	T.6
			Bearing Stamp MCW no. LAA681	T.7
			Hex Head Screw ISO4017 - M6x55	T.8
			Pinion Lifting Device	T.9
			Lifting Tool Intermediate Shaft MCW no. LAA677	T.10
			Eye Nut DIN582 - M16	T.11
			Lifting Tool Gearwheel MCW no. LAA682	T.12
			Aluminium Heating Ring SKF or FAG supplied	T.13
			Cover Tool MCW no. LAA683	T.14
			Special Threaded Rot M6 MCW no. LAA684	T.15
			Special Threaded Rot M10 MCW no. LAA685	T.16

Table 07-III-06.1 Running -Test Equipment & Special Tools List (R-TESTL)

SYSTEM 07	PROPULSION			(cont'd)
SUBSYSTEM /ASSY - UNIT / COMPONENT	**LACMTA STANDARD TOOLS KIT**	**LACMTA WORKSHOP DEVICES**	**SPECIAL TOOL / TEST EQUIPMENT**	**PN**
GEARBOX (cont'd)	X		Master Cover Intermediate Shaft MCW no. LAA676	T.17
			Master Thickness Ring - Gearwheel MCW no. SHA628	T.18
			Special Tool For Elastic Elements	T.20
REACTION ROD			Press Fixture For Ultrabush	T.19
PROPULSION SYSTEM COMPONENTS			Multimeter (Fluke 87 V/E)	4EB19
MVB, LONWORKS and WTB			Cable Certifier (Type LT 8600)	
INVERTER COOLING MOTOR FAN	X	Air Gun		
		Dial Indicator		
		Module Support Hydraulic Device		
INVERTER COOLING MOTOR FAN AIR GRILLE		Vacuum Cleaner		
LINE REACTOR (1L01)	X	High Pressure Water Gun		
		Module Support Hydraulic Device		
MASTER CONTROLLER	X		Multimeter (Fluke 87 V/E)	4EB19
		Vacuum Cleaner		
PRECHARGE SYSTEM	X			
RETURN CURRENT SYSTEM - GROUNDING CONTACT	X			
TRACTION CONTROL UNIT (TCU)	X	Vacuum Cleaner	PTU (Dell) Laptop with specific SW installed. Refer to Table 00-22.1 for SW List	
TRACTION INVERTER HV COMPONENTS	X	Vacuum Cleaner		
		Module Support Hydraulic Device		
			HI POT Power Supply	
			Megohmmeter	
			Multimeter (Fluke 87 V/E)	4EB19
			Phase Sequence Meter	2NV55

(cont'd)

(cont'd)

Table 07-III-07.1 Running -Test Equipment & Special Tools List (R-TESTL)

SYSTEM 07	PROPULSION (cont'd)			
SUBSYSTEM /ASSY - UNIT / COMPONENT	**LACMTA STANDARD TOOLS KIT**	**LACMTA WORKSHOP DEVICES**	**SPECIAL TOOL / TEST EQUIPMENT**	**PN**
TRACTION MOTOR	X	Overhead Crane (min. capacity 200 Lb)		
		Torque Wrench 120 through 320 ft-lb		
		Grease Gun with extension		
			Phase Sequence Meter	2NV55
TRACTION MOTOR ACTIVE SPEED SENSOR	X			
TRACTION MOTOR THERMAL SENSOR	X			

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