System Overview

MEI633

Electronic Interlocking System

Medha Servo Drives Pvt Ltd.
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Hyderabad. -76

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Brief History

MEDHA Servo Drives Pvt. Ltd., established in 1984, is an R&D intensive firm dedicated to Railway Products. MEDHA is a Technology driven Organization, with diverse Product portfolio focused on Railways. MEDHA has designed and manufactured various World class high-tech industrial electronics products for application in Locomotives, Coaches and Railway Stations. For Locomotives, MEDHA supplies Microprocessor based Locomotive Control systems; Microcontroller based Governors, 180KVA 3ph Static Converters, Wheel Slip Control systems, Wheel Flange Lubricators and various models of Speed Recorders. For Air Conditioned Coaches, MEDHA supplies 25KVA 3ph Inverter and 2.5KVA Inverters. For Railway Stations, MEDHA supplies Integrated Power Supply systems. Various other products are at different stages of Design and Development cycle. MEDHA has a state-of-the-art Design Centre with facilities for development, testing, validation and verification of both hardware and software. MEDHA has a well -equipped manufacturing facility in India, including an automated assembly line for assembling Surface Mount Devices on PCBs. MEDHA is ISO 9001-2008 certified by M/s American Quality Assessors (accredited by ANSI-RAB). MEDHA is also certified as CMMI Level 3 Organization for its Design and Development Projects.

- Total employee strength ~1400
- R&D expenditure is ~18% of Revenues
- Design Center employs more than 300 people
- About 180 of these are Engineers with expertise in Real-time Embedded Controls, Power Electronics or Signaling.
- Medha provides In-house training, Refresher training to the nominated Indian Railway staff. Medha also provides on-site training as required by the Railways.

Development of MEI633

- MEI633 development started in 2004
- Concept proving model completed in December 2005
- Registered with RDSO as a vendor for EI development on 13-Mar-2006
- MEI633 Lab model for RDSO yard has been tested in June 2008
- Prototype for Bibinagar yard tested by RDSO in November 2008
- Field Trials at Bibinagar station started in December 2008
- 40 Development Engineers guided and supported by Signaling Domain Consultants from Railways and IRISET, Secunderabad.
- 3000 Man Months of developmental effort.
- Under the active participation and guidance of RDSO and with the support from SCR, MEI633 has incorporated more safety and reliability features during its development and proved during the Field trials.
- Based on the successful completion of the Field Trial for the stipulated period and the assessment of the System by IV&V agencies, RDSO has given the provisional approval for MEI633 Electronic Interlocking System vide their letter no. STS/L/SSI/Medha dt. 17-09-2010.
- Medha Electronic Interlocking System MEI633 has been approved by RDSO under Part-II as per RDSO/SPN/192/2005 vide their letter no. STS/L/SSI/Medha dt. 14.03.2012

Acronyms

Acronym / Abbreviation	Explanation
ATP	Automatic Train Protection/Acceptance Test Procedure
CB	Counter Box
CCIP	Control Cum Indication Panel
CENELEC	European Committee for electro technical standards
CIF	Communication Interface
CIU	Central Interlocking Unit
COM	Communication Module
COMP	Communication Processor
CRC	Cyclic Redundancy Check
CTC	Centralised Traffic Control
DL	Data Logger
EIS	Electronic Interlocking System
FPD	Front Panel Display
GUI	Graphical User Interface
HW	Hardware
IO	Input & Output
IOCOM	Input & Output Communication Module
IRS	Indian Railway Standards
IV&V	Independent Verification and Validation
MEI	Medha Electronic Interlocking System
MT	Maintenance Terminal
MTBF	Mean Time Between Failures
MTBWSF	Mean Time Between Wrong Side Failures
OC	Object Controller
OFC	Optical Fiber Communication
PCB	Printed Circuit Board
PI	Panel Interlocking
PP	Panel Processor
RDSO	Research Designs and Standards Organization
SIL	Safety Integrity Level
SMD	Surface Mount Device
SPN	Specification
SVP	Supervisory Processor
SW	Software
THR	Tolerable Hazard Rate

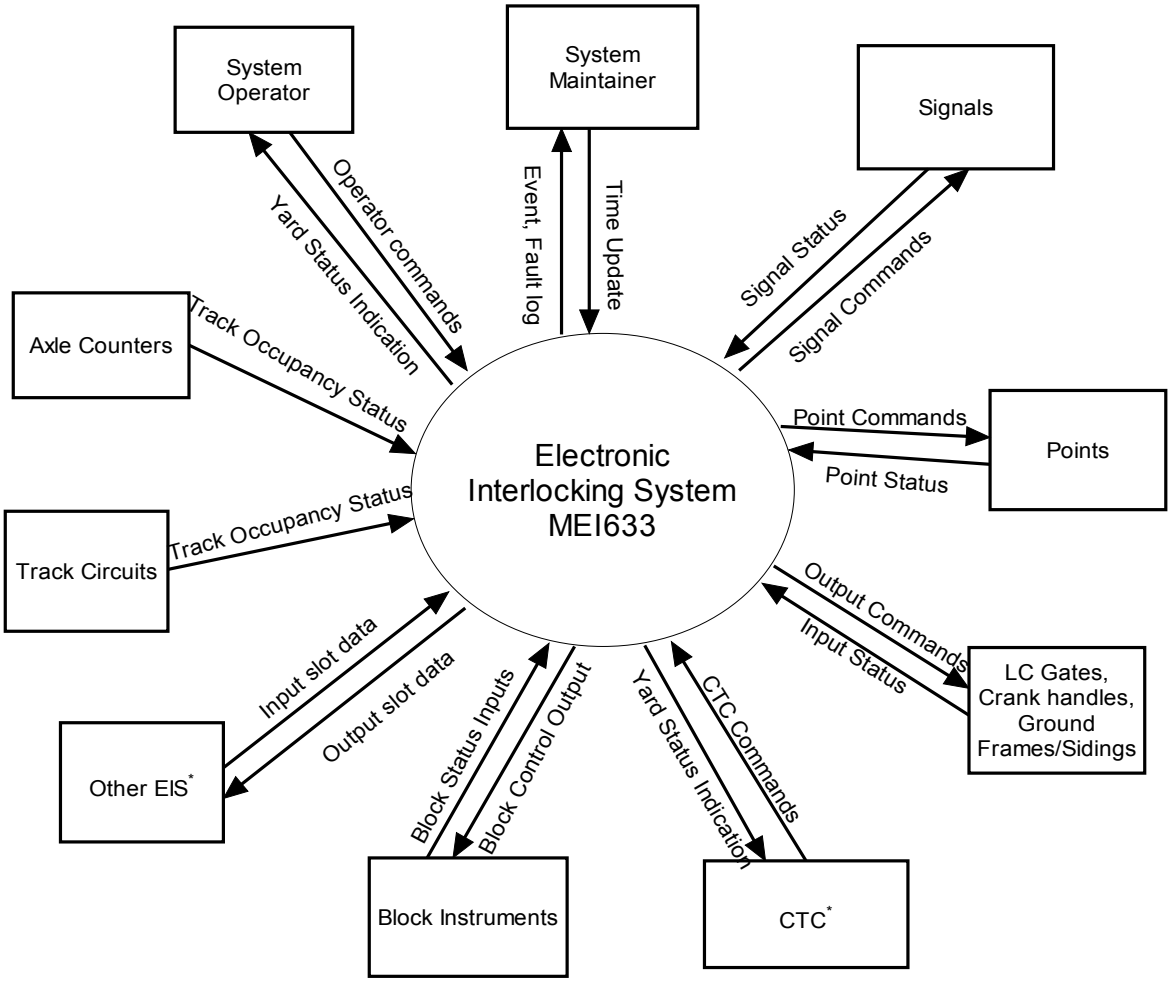
Acronym / Abbreviation	Explanation
VDU CT	Video Display Unit Control Terminal
VIC	Vital Interlocking Computer
VP	Vital Processor
WFM	Wayside Function Module
WFP	Wayside Function Processor

Overview

- MEI633 is a microprocessor based system with interface to the Points, Signals, Track Circuits, Axle Counters, Level Crossing Gates, Ground Frames, Block Instruments for Block working with adjacent stations, and crank handles for manual operation of Points. It has the provision to interface with an External Data Logger through Serial Link to log events.

- MEI633 is a self-contained independent system, which can be used standalone to control the train movement in the Yard.

Context Diagram



* Reserved for future implementation

Figure 1 MEI633 Context Diagram

- MEI633 System is implemented as multi-processor distributed system, with the System functionality being apportioned to various sub-systems. Centralized

Interlocking computation with distributed I/Os is the over-the-top feature of MEI633. Thus it can be installed as a centralized system or a distributed system

- MEI633 is cost-effective when used in distributed configuration, saving the signaling cable cost

- When the Centralized installation is used, the Relays in the Relay room have to be repeated in the field for operating the respective functions. This requires extensive use of expensive Signaling cables.

- When used in the distributed configuration, the field modules can be located in the Wayside Huts, in proximity to the functions being operated by them. For a group of Inputs and Outputs, a redundant pair of Optical fiber communication cable is used for carrying the commands from the Central Interlocking Unit to the field modules. Since the Signaling cables can be replaced with Optical fiber communication cable, substantial cost savings can be achieved.

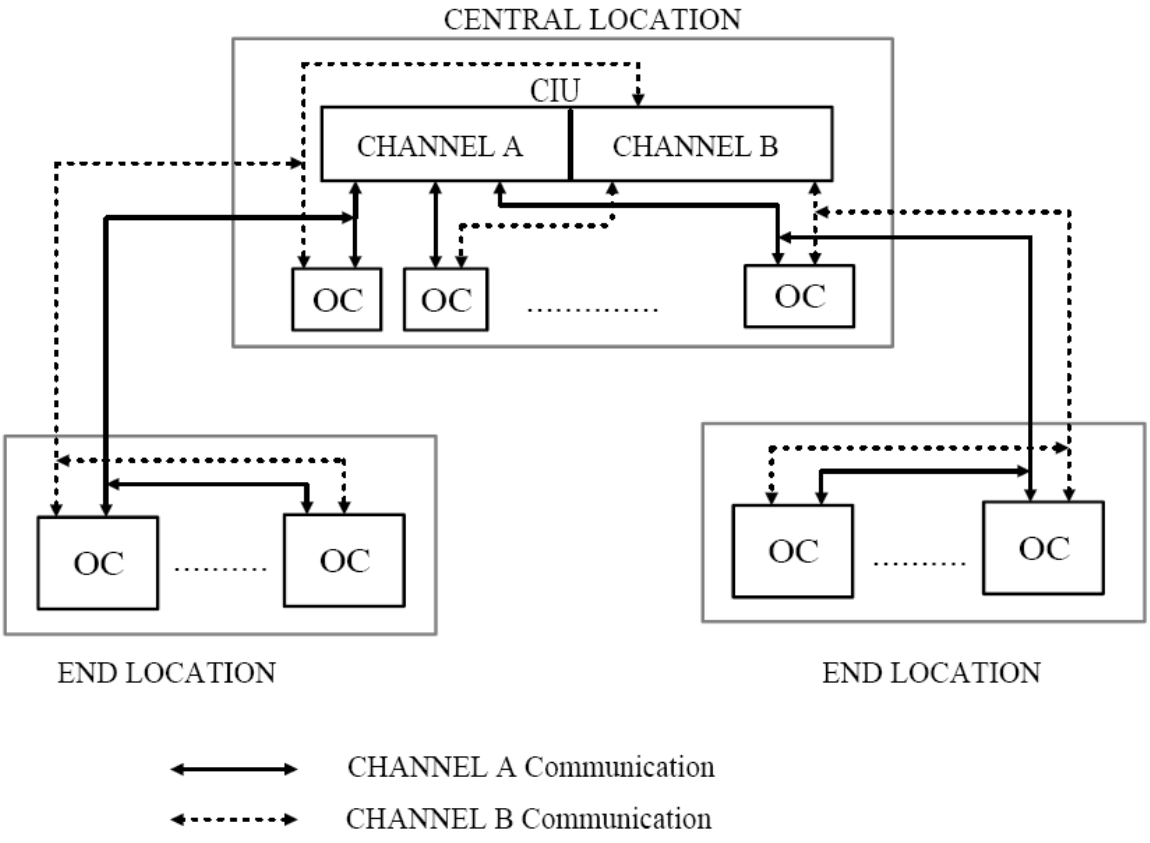


Figure 2 Generic Installation of MEI633 in Distributed configuration

- MEI633 system implements Two-out-of-Two Hardware architecture with identical Hardware and identical Software for Vital modules.

- MEI633 provides Hot Stand-by with automatic changeover for all modules, except the field modules.

- The division of the total System functionality into different subsystems provides modularity, expandability and cost-effectiveness.

- The number of Object Controllers, the number of Input and Output WFMs in each OC, and the Input and Output modules required for the Panel Processor can be selected as per the Yard I/O requirement.

- MEI633 system operates on a cycle time basis, where the Interlocking equations are executed every cycle. Accidental usage of stale data is avoided.

- MEI633 system is capable of handling the Yards up to 450 routes.

- The MEI633 comprises of the following sub-systems:

a) Central Interlocking Unit (CIU)

b) Object Controllers (OC)

c) Panel Processor Unit (PP)

d) Power Supply Module

e) Control Cum Indication Panel (CCIP)

f) Counter Box Module

g) Data Logger (DL)

h) Video Display Unit Control Terminal(VDU CT)

i) Maintenance Terminal (MT)

j) Front Panel Display Unit (FPD)

The major building blocks of MEI633 are Central Interlocking Unit (CIU), Object Controller Modules (OCM) and Panel Processor (PP). CIU collects the Yard information from OCMs and operator commands from PP/VDU CT. CIU validates and executes interlocking equations based on the available information. The outcome of the equation execution is the OCM output data and PP/VDU CT indication data. OCM output data is used to drive the output relays. Driving an output relay generally clears a signal or operates a point.

CIU

Central Interlocking Unit (CIU) consists of VIC, COMP, CIF and VHM cards, which are enclosed in a single box. Input data from PP/VDU CT Modules, OCMs is received by CIU. The received input data is processed for interlocking by CIU and output data is generated based on the input data. The respective output data is sent to PP/VDU CT Modules, Counter Box, MT and OCMs.

OCM

Object Controller Module consists of two IOCOMs namely IOCOM-A, IOCOM-B and a maximum of 8 WFMs. There can be at most 32 OCMs in a system. WFMs are connected to IOCOM-A and IOCOM-B through RS485 interface. IOCOM-A and IOCOM-B are connected to COMP-A and COMP-B respectively, through OFC interface.

Input WFM gets the status of the wayside functions in the yard.

Output WFM receives the wayside function output data from CIU through IOCOMs and drives the wayside functions connected to it.

Each Input WFM can read at most eight wayside function inputs and each Output WFM can drive at most 8 wayside function outputs.

CCIP

CCIP consists of Push Buttons/Knobs, Keys, LEDs and Buzzers. Push Buttons/Knobs are used to issue commands to System. Keys on CCIP can be in, Key In/Key Out position to enable/disable processing of the commands issued by operator to System. LEDs on CCIP indicate the yard status e.g. color light signal on/off status, point position and track occupation status. Buzzers are used to indicate the Button stuck condition or signal blank condition. CCIP is connected to PP Modules through Input and Output Cards. PP module's link status with CIU and its Health status are indicated on CCIP.

PP

Panel Processor module consists of two Panel Processors and each is connected to a common set of Input and Output cards through parallel interface. On the other hand, each Panel Processor is connected to COMP through Optical Fiber Interface. Each Panel Processor scans the state of the inputs on CCIP through Input cards, and sends the same to VICs via the respective COMP. Each of them receives Indication Information from Active VIC and drives the same to CCIP through output cards, providing visual indication to operator. Indication Information represents the current Yard status.

Counter Box

Counter Box consists of CPU card and Output card. Output card is used to drive the counters and buzzers. CPU card is connected to Output card and on the other end it is connected to COMP-A and COMP-B, through Optical Fiber Interface. CPU card receives messages from both COMPs. Ultimately it takes data to drive counters and buzzers from the Active COMP channel. Counter Box module also indicates VIC-A and VIC-B status (Active, Standby and Not Available), wrong side failure information from OC and CIU by the corresponding LEDs.

VDU CT

Video Display Unit Control Terminal (VDU CT) is a PC based application Software. VDU CT is connected to CIU through OFC interface. Operator can issue commands using the simulated buttons on the VDU CT screen. It sends the command and receives the yard status from COMP and displays the same on the VDU CT screen. With a redundant VDU CT arrangement, CCIP and PP can be eliminated and thus achieving substantial cost-effectiveness.

Front Panel Display

LED Display is connected to CIU through RS232 interface. The system consists of two units, namely Display-A and Display-B. They are used to display the system faults/recovery messages.

MT

MT (Maintenance Terminal) is a PC based application Software. MT is connected to CIU through RS232-OFC Interface. MT screen shows the status of the system, logs the events/faults received from CIU and generates alarm signal if any critical fault is received from the CIU. Proprietary serial communication protocol is used for communication between CIU and MT.

Data Logger

Data Logger (DL) is a device connected to CIU through RS232-OFC interface. DL is used to log the yard and system status in every cycle. Proprietary serial communication protocol is used for communication between CIU and Data Logger.

The MEI633 Block diagram is as follows:

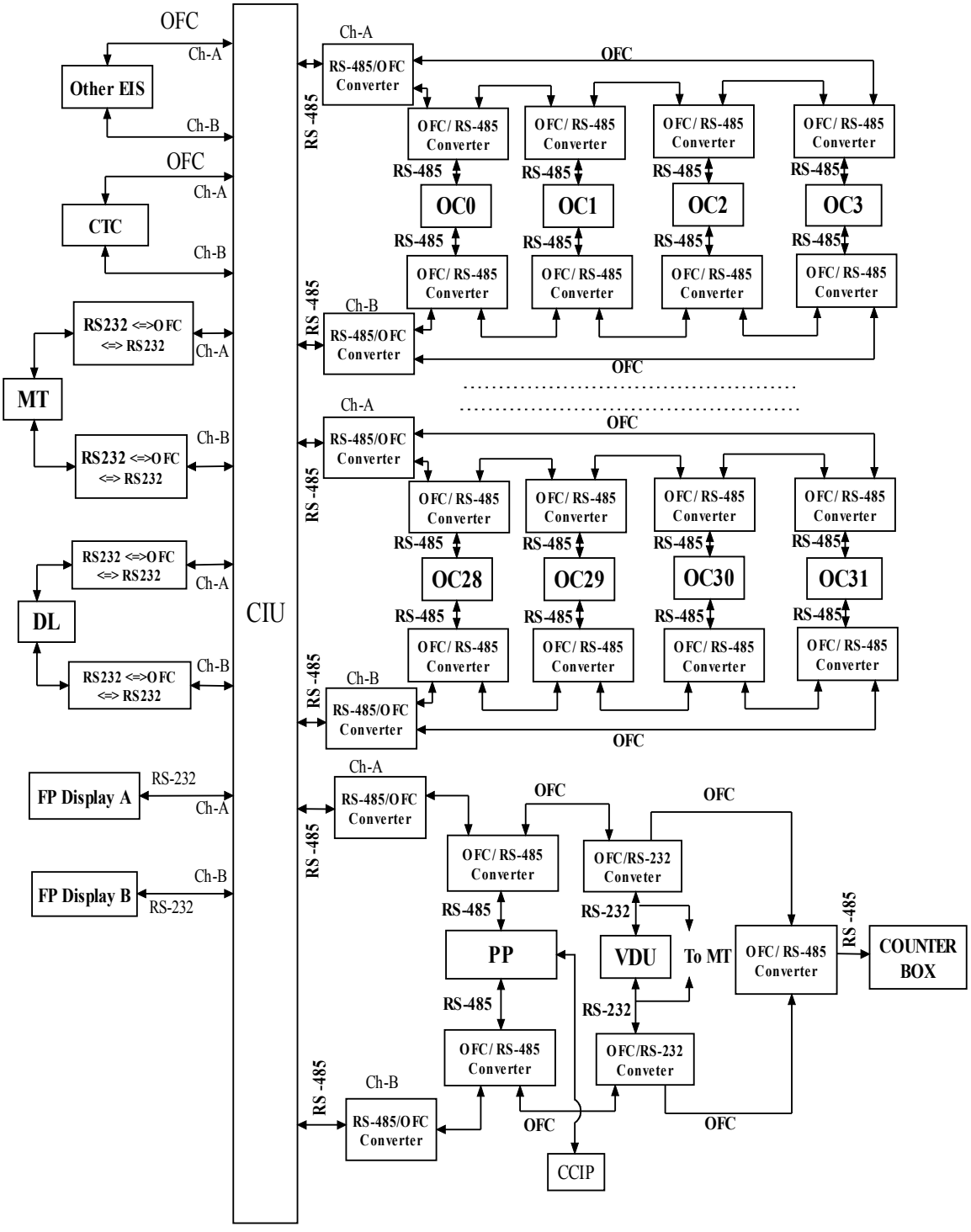


Figure 3 MEI633 Block Diagram

System Operation

- Cycle time of MEI633 is 333 ms.
- The actual state of the yard is displayed on CCIP/VDU CT.
- CIU receives commands from CCIP/VDU CT
- CIU performs interlocking equation execution based on the received commands from CCIP/VDU CT and field inputs.
- CIU generated field outputs, which are transmitted to field modules, and indication output which is transmitted to PP/VDU CT.

Performance

- Normal response time is the time taken for the corresponding Signal aspect to be 'Cleared' in the field from the time the Buttons are released on CCIP. Normal response time for MEI633 is less than 2 seconds.
- The safe state restoration time due to signal cancellation or dropping of replacement track circuit is less than 3 seconds.
- In case of wrong side failure or unavailability of communication, vital outputs are forced to safe state with in 2 cycles.
- Interlocking logic execution time reflects the route handling capacity of MEI633 system. In every cycle, a time slot of 180 msec is dedicated for complete Interlocking logic execution.

Maintenance

- CIU logs the generated events and fault codes in external flash memory in every cycle. It transmits event log to Data logger, fault information to FPD, and both event, fault information to MT.

- GIU based MT is developed as a user-friendly application providing hassle-free interface, thus making the life easy for the Maintainer to pinpoint the problems during troubleshooting.

- MT is a password-protected application, where unauthorized access is not allowed.

- The Event log/Fault analysis can be performed over a required time frame, chosen by the maintenance staff. Print facility is also available.

- The Playback feature of MT provides the Operator/Maintainer to visualize the Yard status over a required time frame and thus making the analysis easier.

- Fault messages are in simple English and greatly help to pinpoint the error location within the shortest time frame.

Example:

A) If the communication messages from IOCOM0 to COMP are corrupted – Fault code displayed on MT is "**Channel Noisy – IOCOM0**"

B) If the communication messages from IOCOM0 to COMP are not available – Fault code displayed on MT is "**Link Fail – IOCOM0**"

C) If the position of the Point18 in the field is undetermined - Fault code displayed on MT is "**Point Detection Failed – PT18**"

D) If HR Relay of Signal1 is picked up unintentionally, a wrong side failure is indicated along with safety action – Fault code displayed on MT is "**HR Wrong Side Fail – SIG1**"

Technology

- SMD components and multi-layer PCBs are used to achieve compact size.
- Automotive / Extended temperature / Industrial grade components are used to achieve higher reliability
- OFC communication is employed at longer communication distances, reducing signaling cable cost and providing noise immune communication.
- Redundant OFC cables are used between CIU and OCs in a ring fashion to achieve higher availability.
- Maintenance and diagnostics information is available at single point (Maintenance Terminal).
- GUI at Maintenance Terminal helps in creating user-friendly environment, to carry out maintenance and diagnostic activities.
- VDU CT that can substitute CCIP is easy to maintain or enhance during modifications.
- Completely isolated Power supply scheme is followed. All the electronic card power supply has a floating ground with out any physical connection to protective earth. This scheme provides good noise immunity and better protection against surge.

1. Hardware

- The Electronic Hardware design of MEI633 follows a modular approach with a provision for expandability for future requirements.

- The hardware for MEI633 can be divided broadly into the following three modules
  - Central Interlocking Unit
  - Object Controller Module
  - Panel Processor Module.

- Each Module further consists of two sub-systems that are physically arranged in two separate mechanical enclosures that can be stacked one over the other. Each sub-system is housed in standard 19" racks (with the exception to PP which is housed in 27" rack). Each enclosure houses individual PCBs pertaining to a logical sub-system of MEI633.

- The following tables list the PCBs housed in individual racks and their basic functionalities.

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
CIU Bottom Backplane	M633CBBP-01	1	Mother board for the CPU, CIF and VHM cards
Vital Interlocking Computer card (VIC card)	M633CVC-01	2	Performs the vital interlocking and indication logic computation
Communication Processor card (COMP CPU card)	M633CCC-01	2	Bridges the field modules and PP with the Vital Interlocking computer through serial interface
Communication Interface card (CIF card)	M633CIF-01	2	CIF Card provides Isolated, Full Duplex RS485 Interface to the Communication Processor Card in the CIU module
CIU Voltage and Health Monitoring card (CVH card)	M633CVH-01	2	Monitors the voltage and health of COMP and VIC cards

Table 1 Central Interlocking Unit Rack – MCI (Bottom Bin)

CIU BOTTOM BACK PLANE

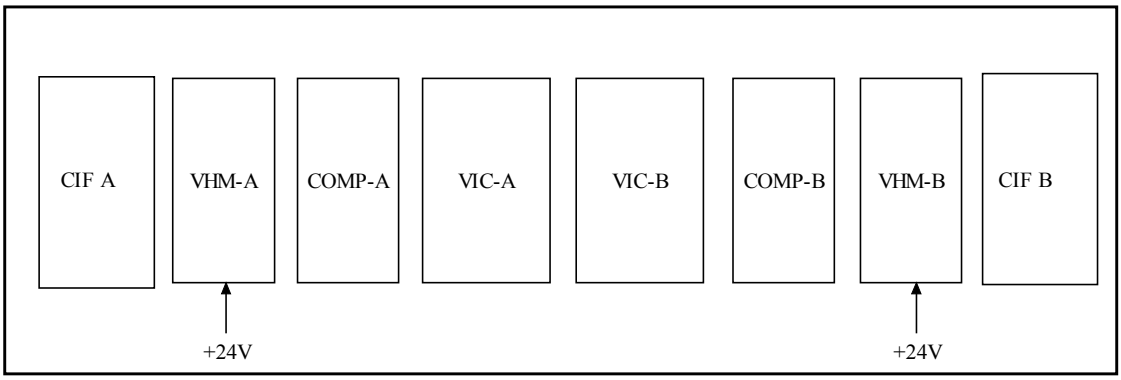


Figure 4 CIU Bottom Back Plane

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
CIU Top Backplane	M633CTBP-01	1	Mother board for the Power supply cards
Power Supply Type B	M633PSB-01	4	To provide power to COMP CPU cards (2 no.s) and VIC cards (2 no.s)

Table 2 Central Interlocking Unit Rack – MCI (Top Bin)

CIU TOP BACK PLANE

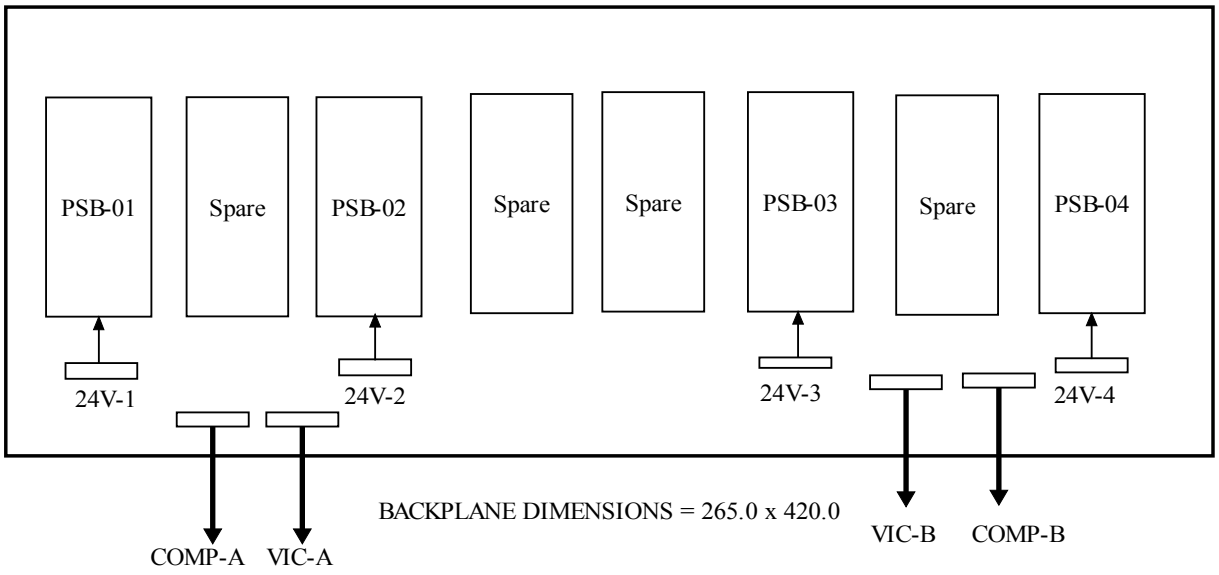


Figure 5 CIU Top Backplane

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
Front Panel Display Card	M633DISP-01	1	To display Fault codes and System status messages received from SVP

Table 3 Central Interlocking Unit Rack – MCI (Front Panel Display) – 2 no.s

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
OC Bottom Backplane	M633OBBP-01	1	Mother board for the WFM cards
Input Wayside Function Module CPU Card (Input WFM CPU Card)	M6333OCI-01	5 (max)	Reads the status of input relays
Output Wayside Function Module Output Card (Output WFM CPU Card)	M6333OCO-01	3 (max)	Drives the field output relays through the Relay Driver card
WFM Relay Driver Card (ORD Card)	M633ORD-01	3 (max)	Drives the field output relays in a fail-safe manner
Vital Cut-off Card (OVC Card)	M633OVC-01	1	Monitors the health of Output WFM CPU cards

Table 4 Object Controller Rack – MOC (Bottom Bin)

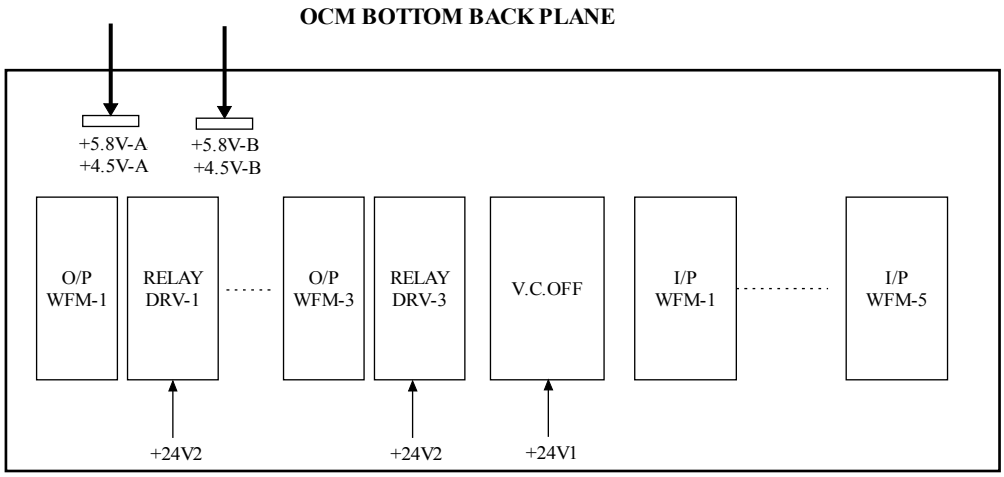


Figure 6 OCM Bottom Backplane

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
OC Top Backplane	M633OTBP-01	1	Mother board for the CPU, CIF and VHM cards
IO Communication Processor card (IOCOM CPU card)	M6333OIC-01	2	Transfers information between COMP and WFMs
Power Supply Type B	M633PSB-01	2	To provide power to IOCOM CPU cards
Power Supply Type C	M633PSC-01	2	To provide power to WFM CPU cards
OC Voltage and Health Monitoring card (OVH card)	M633OVH-01	2	Monitors the Voltage and Health of IOCOM CPU card

Table 5 Object Controller Rack – MOC (Top Bin)

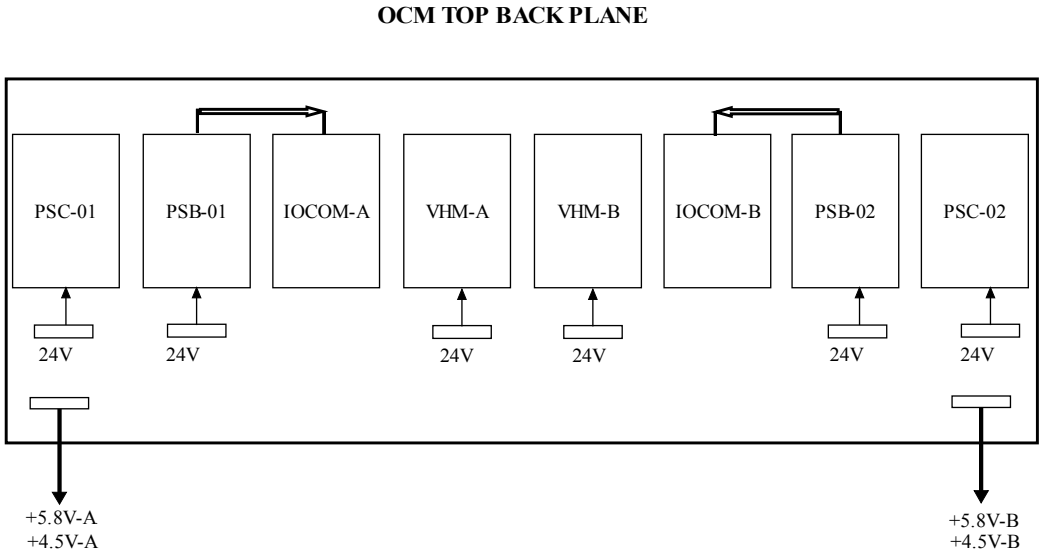


Figure 7 OCM Top Backplane

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
PP CPU Backplane	M633PCBP-01	1	Mother board for the CPU, PVH, PSB and PExD cards
PP CPU card	M6333PCC-01	2	Scans the CCIP buttons and drives the indication
Power Supply Type B	M633PSB-01	2	To provide power to the PP CPU cards
PP Extender Driver Card	M633PExD-01	2 (max)	Interface between the CPU backplane and IO backplane
PP Voltage and Health Monitoring card (PVH card)	M633PVH-01	2	Monitors the Voltage and Health of PP CPU card

Table 6 Panel Processor Rack – MPP (Bottom Bin)

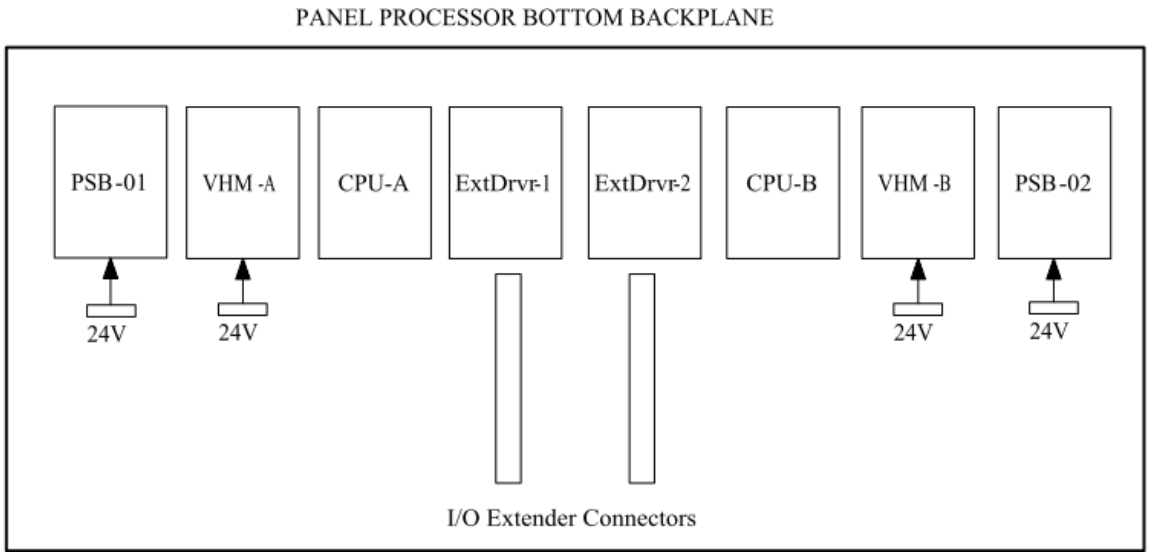


Figure 8 Panel Processor Bottom Backplane

PCB Name	MEI633 Part No.	Qty	Basic Function(s)
PP IO Backplane	M633PBP-01	4	Mother board for PExR, PP Input and Output cards
PP Receiver Card	M6333PExR-01	4	Interface between the CPU backplane and IO backplane
PP Input Card	M633PIP-01	11(max)	Interface card for scanning the CCIP buttons
PP Output Card	M633POP-01	38 (max)	Interface card for driving the CCIP indication outputs
Power Supply Card -A	M633PSA-01	8 (max)	To provide power to PExR, PP Input and Output cards

Table 7 Panel Processor Rack – MPP (Top Bin)

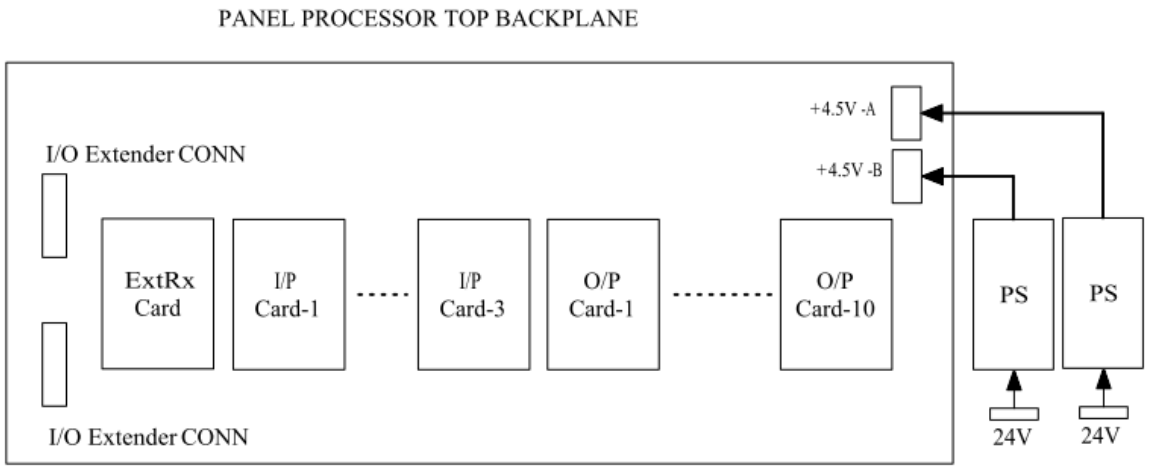


Figure 9 Panel Processor Top Backplane

Software

- The system is configurable for any change of Yard Functions or Yard Function arrangement. To achieve this, the Software has two layers:

- *Executive or System Software*: which defines what the system can do and how the various parts operate together. This Software remains constant for the system for any Yard.

- *Application Data:* It contains the logic that defines how the inputs and outputs of a particular station are related, and the Input and Output connectivity details of the System. This data is Yard specific and will change whenever the Yard configuration changes.

- The System Software and Application Data are stored in different Read Only Memories.

- The System has the facility for modification of Application Data as and when it is required.

- The System Software is designed with a provision for modular expansion. Subset of C language is used to develop the software, with pre-defined coding standards and guidelines.

- CENELEC EN 50128 guidelines for SIL4 systems are followed for System Software development.

2. Communication Technology

- The medium of communication between CIU and OC/PP is Optical Fiber interface.
- The transmission protocol ensures integrity of safety related information irrespective of the transmission medium.
- If the transmission link becomes inactive for more than a specified period, the safety information drain (user) assumes a restrictive and fail-safe state.
- Error Detection codes are used for detection of data corrupted during transmission.
- A two level CRC codes are used for vital messages to protect against data corruption.
- Encoding at transmission end and decoding at receiving end is provided to protection against intrusions.
- Failure/Corruption of data from Active communication channel for a single cycle is tolerated.
- Failure/Corruption of data from Active communication channel for two or more cycles is not tolerated and system switches over to Standby communication channel data.
- Failure/Corruption of data from both Active and Standby communication channels for a single cycle is tolerated.
- Failure/Corruption of data from both Active and Standby communication channels for two or more cycles is not tolerated. Safe state is forced on the Vital outputs in the second cycle.

➢ **Possible Communication Failures and Identification methods**

S No	Failure Rectification	Module Identity	Sequence number/ DHS	Time out	Data Integrity
1	Omission		*	*	
2	Insertion	*	*	*	
3	Stale data			*	
4	Repetition		*		
5	Imitation	*		*	*
6	Data corruption				*
7	Resequencing		*		
8	Memory failure		*		

Table 8 Possible Communication Failures and Identification Methods

Interfaces in general

CIU External Interfaces:

Subsystems	Interface	Description
CIU-PP/VDU	Serial Communication	Multidrop Optical Fiber Interface, CIU as Master and PPs/VDUs connected as Slave nodes. Max distance 1 km, Baud rate 115.2 kbps or more.
CIU-OC	Serial Communication	Ring fashion Optical Fiber Interface, CIU as Master and OCs connected as Slave nodes. Max distance 15 km, Baud rate 115.2 kbps or more.
CIU-MT	Serial Communication	RS232/OFC, Baud rate 115.2 kbps.
CIU – DL	Serial Communication	RS232/OFC, Baud rate 115.2 kbps.
CIU-FP Display	Serial Communication	RS232, Max distance 5m, Baud rate 115.2 kbps.

Table 9 CIU External Interfaces

OC External Interfaces:

Subsystems	Interface	Description
CIU-OC	Serial Communication	Ring fashion Optical Fiber Interface, CIU as Master and OCs connected as Slave nodes. Max distance 15 km, baud rate 115.2 kbps or more.
Input/Output Relays	-	24V Supply to read the potential free input relay contacts or to drive the Output relay Coil

Table 10 OC External Interfaces

Safety Concept

- The Electronic Interlocking System is designed to meet Safety Integrity Level 4 requirements as specified in the CENELEC Standard EN 50129.

- The Mean Time Between Wrong Side Failure (MTBWSF) of the system is > 10^{11} hours indicating that the wrong side failure is incredible to occur.

Software Safety Concepts

- Software is developed using C programming language, using a safe-subset.

- Software includes double stored variables for vital information. One is the actual information and the other contains the complement of the actual information.

- Software includes self-check procedures to detect faults in the hardware.

  - Non destructive RAM tests
  - Software timers test against vital reference clocks
  - Program/Application Data memory integrity tests using checksum verification
  - Address and Data bus tests
  - Relay contacts read back hardware test
  - Intermediate and final output read back test etc.

- Software performs Error Analysis and takes action based on the criticality of the failure. Fault messages are displayed on MT and FPD.

- MEI633 system incorporates primary negation and secondary negation measures to defend against hazardous failures.

- **Primary Negation: -** If an Output Relay is detected as picked up when it is not intended to be so (wrong side failure), results in withdrawing drive to VCOR by Output WFM. Thus all the output relays of that OC are forced to safe state avoiding catastrophic failures. Primary negation in case of wrong side failure detection is within 350 ms.

- **Secondary Negation: -** If a wrong side failure persists besides primary negation, and if it results in an undesired field operation (clearing a signal etc), CIU performs the correspondence check and enters shutdown mode indicating a serious hazard. The maximum time span for a wrong side failure to force CIU to shutdown is 1.3 sec from the point of its detection.

- Independent Verification and Validation of Software by approved agency.
- Software development is carried out according to CENELEC Standard EN 50128.

Hardware Safety Concepts

- ICs and other components used in the equipment are of Automotive/Extended temperature/Industrial grade.
- All components are procures from authorized vendors, thus avoiding spurious components.
- All fail-safe circuits works on continuous energisation principle such that open circuits in wiring, relay contacts, etc. or loss of power supply will not cause unsafe conditions.
- All the sub-systems of MEI633 have been subjected to the Environmental / climatic tests specified in RDSO/SPN/144 and the results are satisfactory.
- Independent Verification and Validation of Hardware by approved agency.
- Hardware FMEA in the form of Fail-safety testing for all the vital modules is carried out.
- The Power supplies for the different sub-systems have been designed to have adequate safety factor for supplying power.

Fail-Safety Concepts

- The System is designed on fail-safe principles.
- In case of any failure whether in the hardware, software or any part of the equipment, the system and the equipment controlled by it fails on the safe side.
- In case of any failure in the Vital Output Drive circuit, or when the output drive data is not available, the output relay contact is be dropped, i.e. the relay coil is de-energized for the relays being driven by the system.
- Vital output drive comprises of Reactive fail safety and Inherent fail safety.

- Hazard analysis has been performed at preliminary stages (PHA) and System level (SHA). FTA and FMEDA techniques are carried out to identify potential hazards. Hazard mitigation techniques are identified and implemented.

- System is designed for detection of following faults and restoration to safer state in case of following:

  - Variation in power supply beyond its tolerance limits, including momentary failure of the power fail system.
  - Spikes in the power supply system, stray fields caused by traction vehicles or standby diesel generator sets.
  - Insertion of PCBs in wrong slots (Mechanical polarization is provided).
  - Earthing of any component or wire or a combination of such faults.
  - Broken wires, damaged or dirty contacts, failure of a component to energize, loss of power supply or blown fuses etc.

3. Reliability, Availability, Maintainability And Safety (RAMS) Concept

All faults in MEI633 system are detected in a single cycle (333 msec) through periodic testing (Automatic diagnostic) and negated to a safe state

RAM Results:

- The THR for the sub-systems of MEI633 is according to the following table

Module	Safety Integrity Level	THR (Target)	THR (Acheived)	Failure rate(FPMH)	MTBF(Hrs)
CIU	4	$10^{-9} \leq THR < 10^{-8}$	2.48×10^{-10}	2.69	371634
OC	4	$10^{-9} \leq THR < 10^{-8}$	5.18×10^{-10}	5.6	178450
System level	4	$10^{-9} \leq THR < 10^{-8}$	1.14×10^{-9}	12.36	80860

Table 11 Tolerable Hazard Rate (THR) of MEI633

The rate of occurrence of a wrong side failure (**MTBWSF**) is 4.1691 x 10-12 / hr. This implies that the probability of Wrong Side Failure of the system is “incredible”.

The above results conclude that MEI633 system meets the required Reliability, Availability and Maintainability aspects as per CENELEC standard EN 50126 for a SIL4 system.

Advantages of MEI633

1) MEI633 compliance to RDSO specification for Electronic Interlocking Systems RDSO/SPN/192/2005 is 100%. System Hardware and Software is validated as per CENELEC SIL4 requirements and guidelines.
2) Central Interlocking with distributed I/Os – Any modification to the application logic needs implementation only in the central location without affecting the distributed modules.
3) Rugged and completely enclosed construction – System is capable of withstanding the Environmental stresses like Temperature, Humidity, Dust, Vibration etc.
4) Transparent front door is provided for monitoring the System activity (through Status LEDs & 7-Segment displays) without touching the internals. Another door is provided to avoid intrusion and reduce the environmental effects upon the Electronic Hardware. Un-authorised handling of equipment is prevented.
5) Customized design suiting to Indian Railways safety and operational requirements – Zonal specific requirements like cascading of signals and Timer value changes.
6) All communication cables are OFC and no copper cables are used outside the equipment, resulting in superior noise immunity and better EMI/EMC/Surge compliance.
7) Suitable for Centralized or Distributed installation as per the Customer's requirement.
8) Single unit that can cater upto 2048 Vital I/Os or 450 routes. Cascadable for bigger yards handling more than 1000 routes.
9) OEM offers exhaustive training to the customer by the design engineers of EI system. Modification of the Application Data by the customer is possible by easy to use GUI tools and adequate training imparted by the OEM. Vast Customer Support base of the OEM enables resolving the customer calls in a short duration.
10) Expandability of the System - Easy up-gradation of the Station is possible with

minimum downtime. System is expanded simply by addition of OC Modules. The required additional I/O setup can be made ready separately and can be connected to the system with minimal effort and time. Maximum downtime of the System will be less than a day.

11) Operational Flexibility – MEI633 can be supplied with different combinations of operator interface – 2 VDUs / 1 CCIP + 1 VDU / 2 VDUs + 1 CCIP as per the Customer's requirements.
12) MEI633 can be installed in both PI and RRI stations. The operator can continue to use the existing CCIP with Knobs (PI) or Push buttons (RRI). Over a period of time, the operator can seamlessly transfer to VDU operation.
13) Hot-Standby – For any fault arising in the active channel, System will make the Standby channel as active without any manual intervention.
14) MEI633 provides exhaustive on-line diagnostics display. The diagnostics built into the System pin-points the exact location of the fault thus enabling its easy identification and immediate rectification.
15) Complete Earthing, Lightning and Surge Protection with Ring Earth scheme is done by the OEM as per the guidelines laid out in RDSO/SPN/197/2008. All the 24V input power supplies are protected by custom designed & validated Class D fine surge & EMI filter.
16) Reliable IPS (RDSO/SPN/165/200x Amd-5) is manufactured and supplied by the OEM – No third-party dependencies exist.
17) Completely indigenous system design translates to all the customer queries/issues addressed by the Designers themselves which improves the Customer Confidence.

Validation Concept

- MEI633 system complies to Specification for Electronic Interlocking system, Spec No: RDSO/SPN/192/2005

- Card level and System level functional tests are performed by Firm and RDSO.

- Hardware Fail Safety testing for SIL 4 systems is performed by Firm and IV&V agency. Fail Safety testing is performed by RDSO also.

- Software verification and validation for CENELEC 50128 SIL4 compliance is completed by RDSO approved Independent Safety Auditor (ISA).

- System (both Hardware and Software) is certified by Independent Verification and Validation agencies.

- TOC based Route testing and Square sheet testing is performed by Firm and Railways, providing the commands from CCIP as well as VDU CT.

- MEI633 system has undergone harsh Environmental Testing at ETDC and ECIL labs (RDSO approved Central Government labs), in the functional mode (for the specified tests). A sample yard with few routes is designed to test the system's working condition during the Environmental tests.

4. On-site Testing

- Acceptance tests were carried out by RDSO for the lab setup in two phases. The first phase was the Functional Testing of MEI633 and the second phase was the Type Testing. Testing was carried out as per MEI633 ATP. MEI633 is approved by RDSO for field trials.
- Pilot station allocated for testing is Bibinagar (under SCR zone). Total number of routes for Bibinagar is 31 and I/Os are 180.
- An arrangement for Distributed architecture is made at pilot station.
- On-site trials have been completed.

Summary of MEI633 Field Trials

MEI633 Electronic Interlocking (EI) System is installed at Bibinagar Station to assess its performance for Functionality, Safety and Reliability in the actual field conditions vis-à-vis the existing Panel Interlocking (PI) system.

The Field assessment is done as per the following table

S. No	Field Trial Phase	Start Date	End Date
1	Phase-I Parallel Field Trial	24-Dec-2008	02-May-2009
2	Phase-II Stage -I Series Field Trial	06-Aug-2009	18-Dec-2009
3	Phase-II Stage-I Extended Series Field Trial	13-Jan-2010	30-Jan-2010
4	Phase II Stage II Stand-Alone Mode Field Trial	16-Jun-2010	5-Aug-2010

Table 12 Summary of MEI633 Field Trials

During the entire Field trial duration (> 250 days),

- No unsafe condition has been observed
- No train detention due to EI functioning
- No failure of any hardware / communication link
- No change-over has been observed in the trials

Pre-Installation Activities and Commissioning

MEI633 Electronic Interlocking System shall be installed at the site as per the System Installation and Commissioning Manual. Commissioning of the System shall be done in accordance with the Indian Railway Specification and the specific requirements and practices of the concerned Zonal Railway.

➢ Yard Interlocking Plan, Yard Layout and Table of Control are the inputs for Yard Data Compiler from the Railways

➢ Yard designing with relevant Yard Information
-- Yard will be designed with the relevant inputs by using the Yard Design tool.

➢ Boolean Expressions generation and Conversion to Relay Circuits
-- Boolean Expressions are generated by using the Boolean Expression generation tool.
-- Boolean Expressions are converted to Relay Circuits by using the Relay Circuits generation tool.

➢ Application Data generation
-- Application Data is generated with relevant Yard layout details by using the Application Data generation tool.

➢ Reverse Compilation
-- Reverse Compilation will generate the Relay Circuits from the System downloaded Application Data. Generated Relay Circuits will be verified by in-house Signalling experts and will be forwarded to Railways for approval.

➢ Testing the Application Data
-- Generated Application Data will be tested by using the Interlocking Simulator, Video Display Unit and Field Simulation Panel tools.

➢ Route testing and Square Sheet testing can be performed on Simulated Yard to verify the Safety of Interlocking by Firm and Railways.

➢ After the above procedure System can be installed and commissioned in the field after the necessary approvals from Railways.

Maintenance and Services

- The MEI633 Electronic Interlocking System will be provided with a Maintenance and Troubleshooting Manual using which the users will be able to keep the system in good health.

- Adequate quantities of spare cards will be kept in the station to handle any situation that calls for replacement of the cards. The spare cards will be periodically checked and verified for correct functionality.

- Earthing for the installation will be checked once in every six months and regular maintenance activities will be carried out.

- Maintenance team will comprise of two qualified Service Engineers available at the proximity of the installation location and they can be easily contacted through cell phone. Service Engineers will work in co-ordination with the concerned railway staff to make them more conversant with the system operation, maintenance and troubleshooting during the period.

- Medha will provide a warranty period of 1 year or more as agreed up on after the acceptance of MEI633 system by the Railways.

- During the warranty period, Medha will replace the defective parts with in the shortest possible time.

- Medha extends its support even after the expiry of warranty period with the similar spirit.

Training

- MEI633 Training Manual provides basic information on Railway Signaling Domain, MEI633 Modules & Sub-systems and System Operation.

- In-house training for a period of two weeks will be provided to the Indian Railway S&T staff as nominated by the zonal railways, for the system operation, maintenance and troubleshooting.

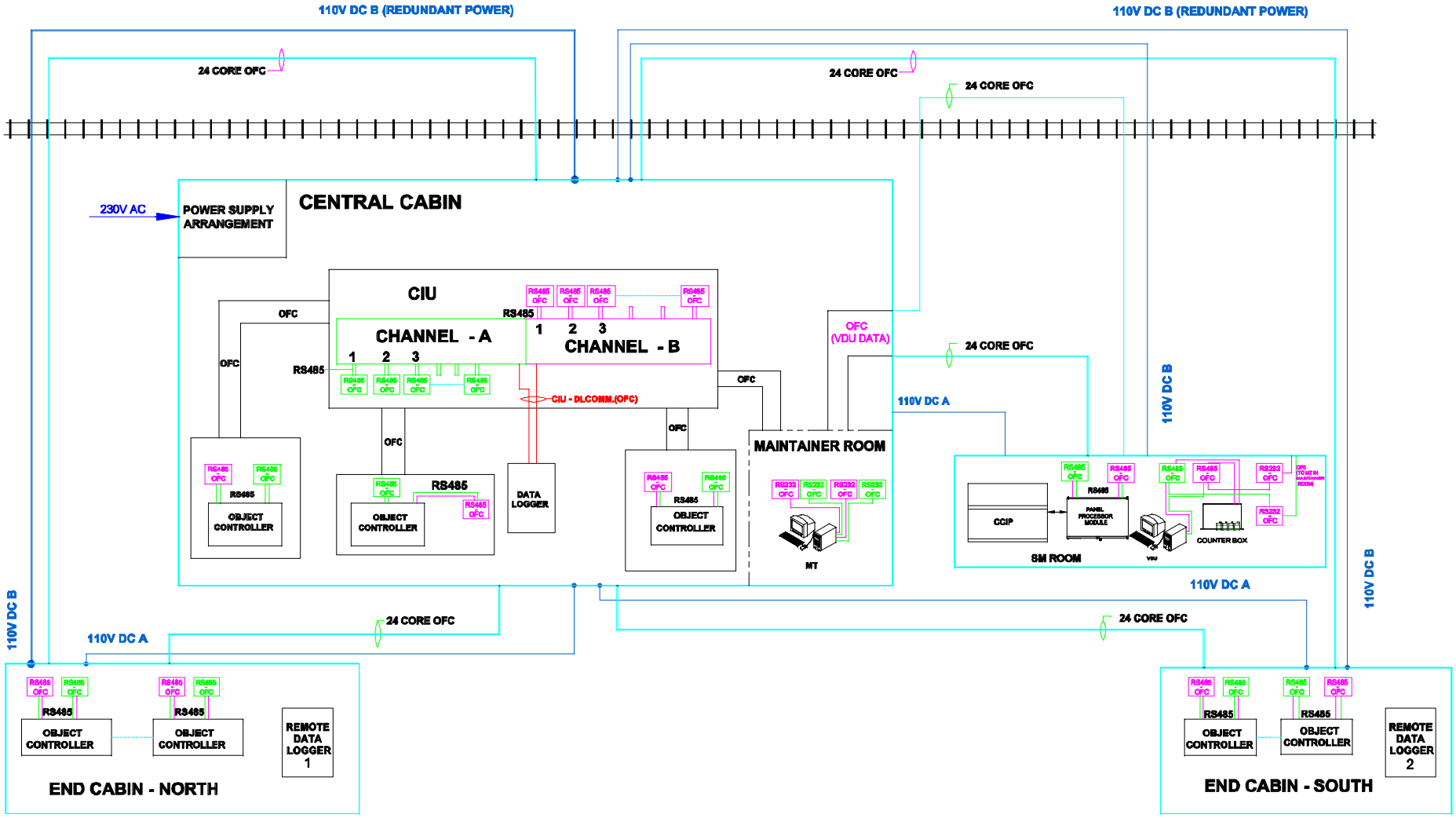
- Refresher training will be provided as required by the Railways.

ANNEXURE A : MEI633 TYPICAL CONFIGURATION DIAGRAMS

1. For 110VDC Supply
2. For 230VAC Supply

MEI633 TYPICAL CONFIGURATION DIAGRAM - 1

(110VDC Supply)



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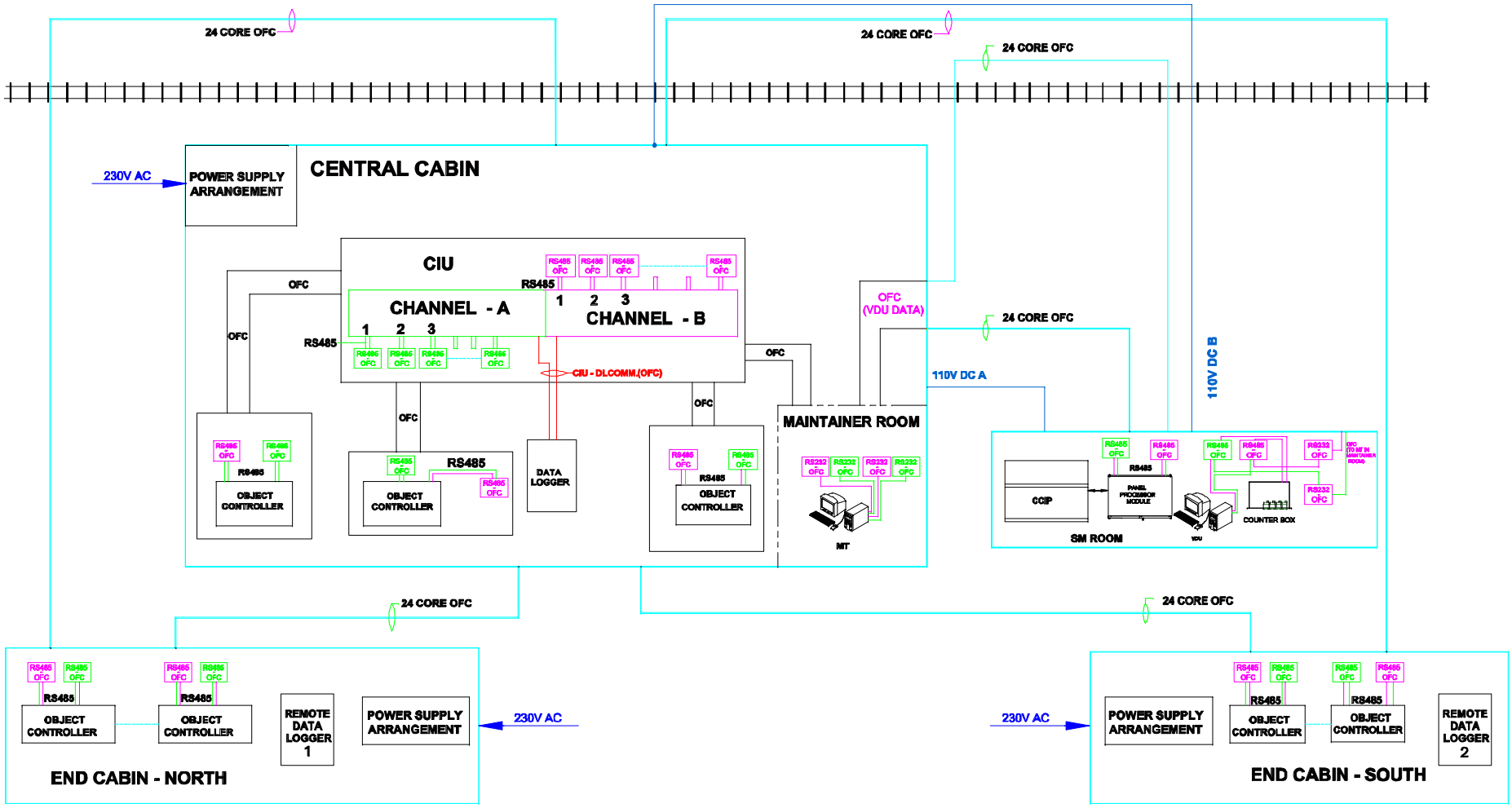
MEI633 TYPICAL CONFIGURATION DIAGRAM - 2

(230V AC Supply)



MEDHA

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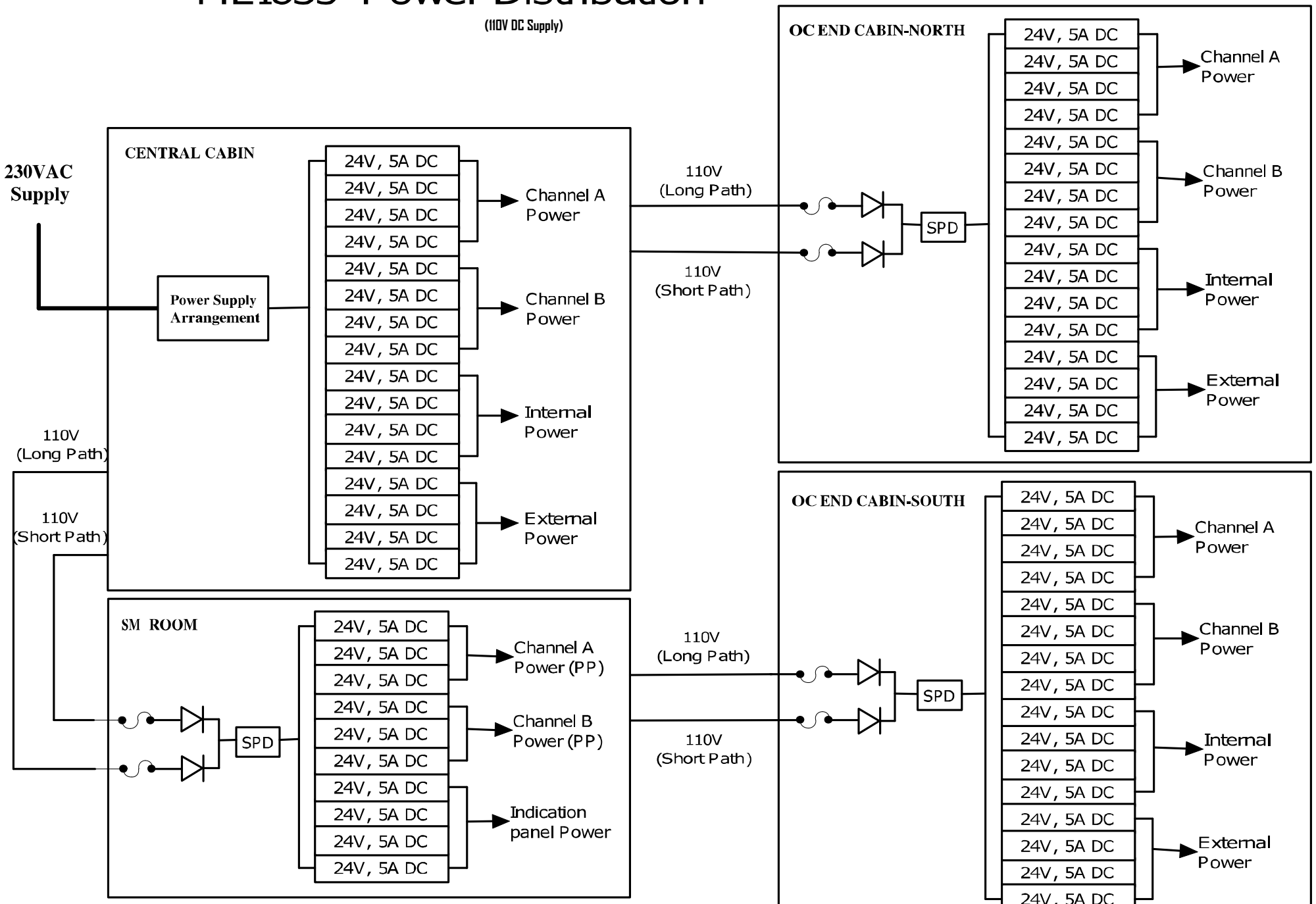
ANNEXURE B : MEI633 POWER DISTRIBUTION

1. For 110VDC Supply
2. For 230VAC Supply

MEI633 Power Distribution

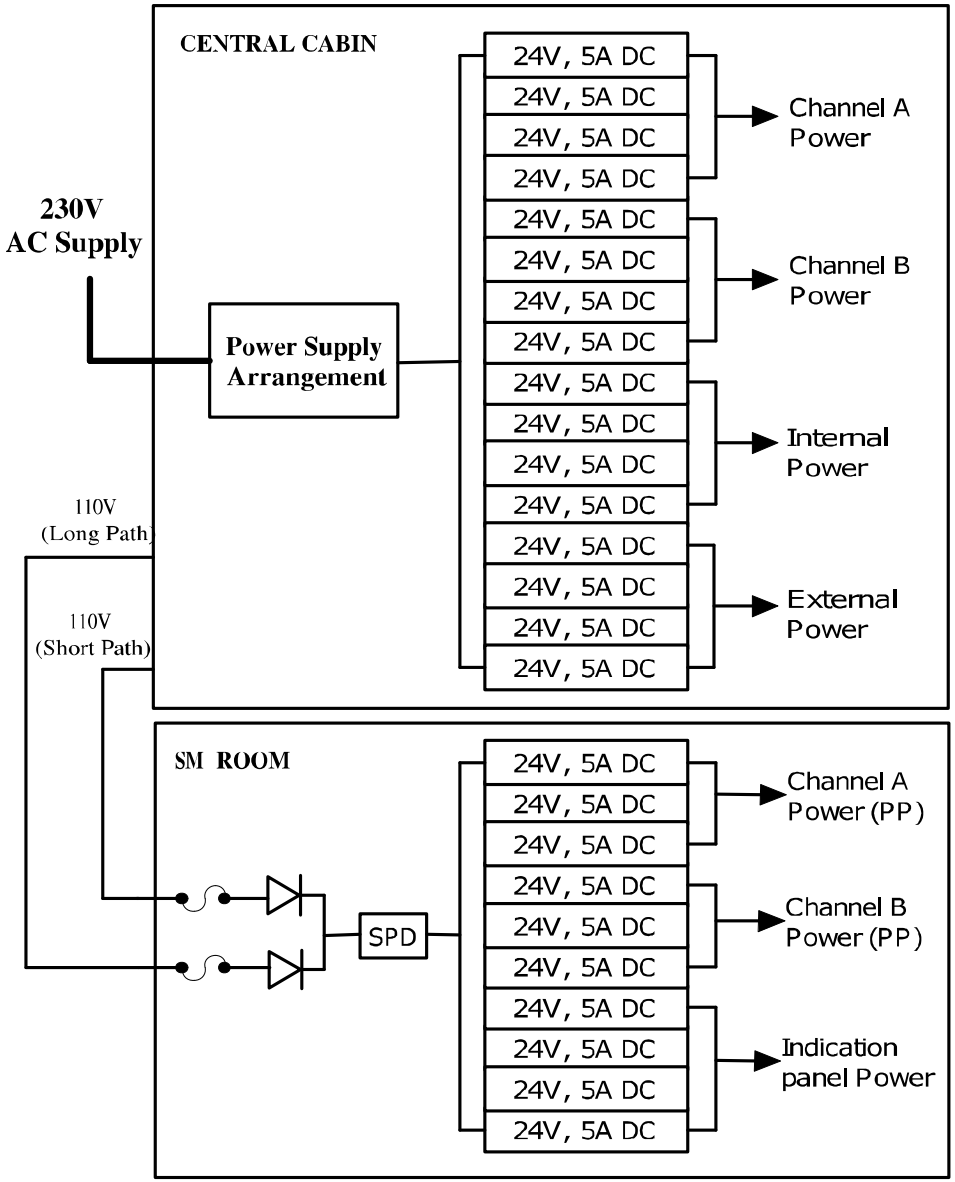
(110V DC Supply)

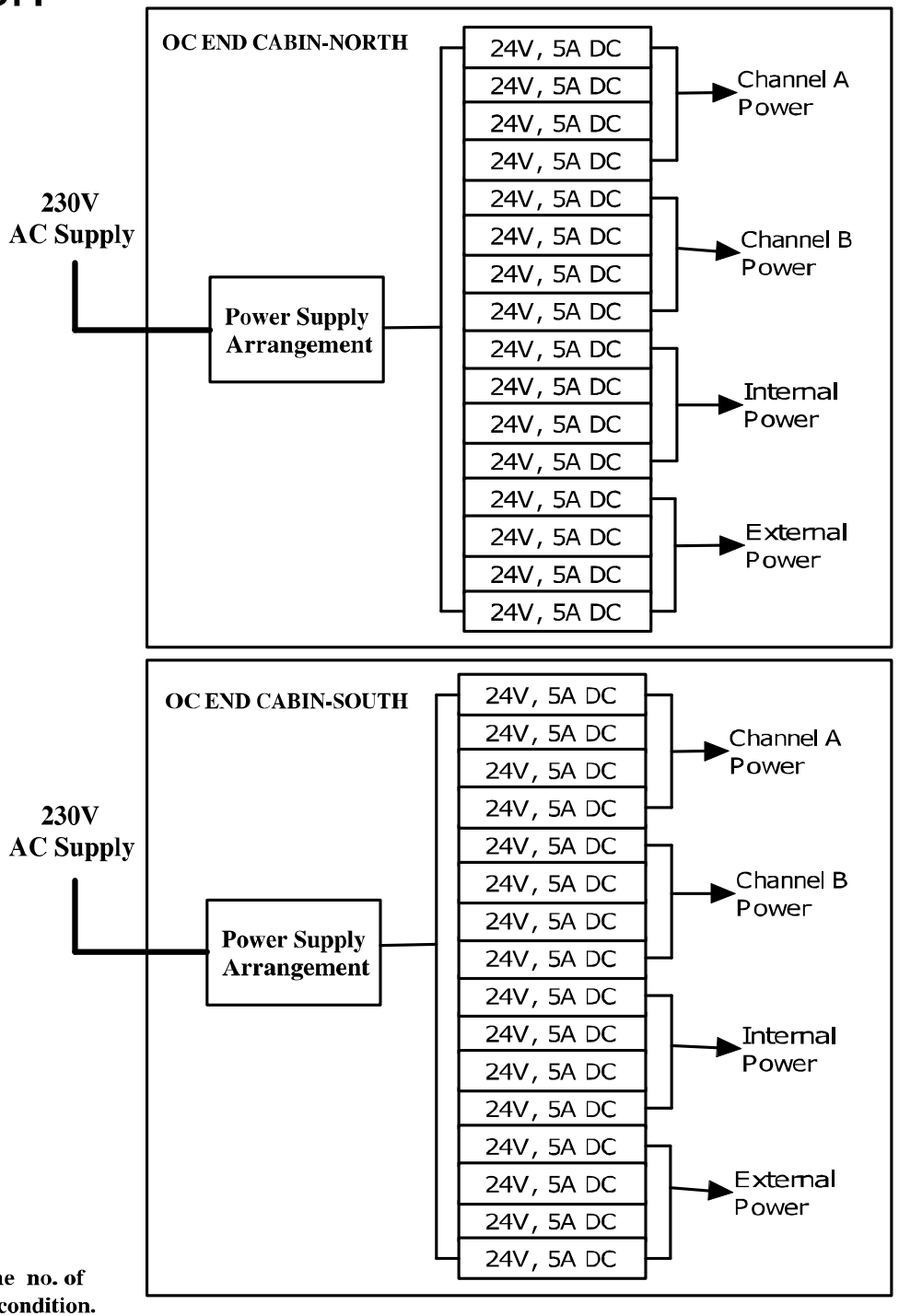


Note: The above diagram depicts the requirement for maximum configuration of MEI633. The no. of 110V -24V converters in n+1 configuration will be decided according to the actual load condition.

MEI633 Power Distribution

(230V AC Supply)





Note: The above diagram depicts the requirement for maximum configuration of MEI633. The no. of 110V -24V converters in n+1 configuration will be decided according to the actual load condition.

ANNEXURE C : MEI633 COMMUNICATION ARRANGEMENT

MEI633 Communication Arrangement