USER MANUAL

FOR

ONBOARD KAVACH

Document Number : 5 53 76 0020

Version: 1.0

Date Published: 25 - 04 - 2025

Prepared by

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Hyderabad

DOCUMENT DATA SHEET

Title of the Document	File Name	Pages	Figures	Tables
User Manual for Onboard KAVACH	User Manual for Onboard KAVACH	31	17	0

Abstract

This document details user manual for Onboard KAVACH of Train Collision Avoidance System

DOCUMENT CONTROL SHEET

#	Name	Function	Level	Signature
1	K.V.Rajasekhar	GM-KAVACH Projects	Approve	
2	Hemant Sagade	Safety Manager	Review	
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CHANGE HISTORY

#	Name of the Document	Date	Reason for changes	Version No.
1	User Manual for Onboard KAVACH	25-04-2025	Initial Release	1.0

REFERENCES

#	Document Name	Document Number	Version Number/Year	Source
1	Safety and Reliability Requirements of Electronic Signaling Equipment	RDSO/SPN/ 144/2006	Rev 2	RDSO
2	RDSO Specification for Train Collision Avoidance System	RDSO/SPN/ 196/2020	4.0, Amdt 4	RDSO
3.	Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)	EN50126-1&2	2007	CENELEC
4.	Railway applications - Communications, Signaling, and processing systems - Software for railway control and protection systems.	EN50128	Jun-11	CENELEC
5.	Railway applications – Communication, Signaling and Processing systems –Safety related electronic systems for Signaling.	EN50129	2010	CENELEC
6.	Railway applications – Communication, Signaling and processing systems, Safety related communication in closed transmission systems	EN50159	Sep-10	CENELEC
7.	Railway application systems Electromagnetic Compatibility	EN50121-4	2008	CENELEC
8.	Railway applications. Insulation coordination. Basic requirements. Clearances and Creepage distances for all electrical and electronic equipment	EN50124-1	Mar-01	CENELEC

GLOSSARY OF TERMS

#	Abbreviation	Meaning
1	2oo3	Two Out Of Three
2	BC	Brake cylinder
3	BIU	Brake interface unit
4	BL	Box Lever
5	BP	Brake pipe
6	CAB	Cabin
7	CAN	Controller area network
8	CCB	Computer Controlled Brake
9	CENELEC	European Committee for Electro Technical Standardization
10	DC	Direct Current
11	DMI	Driver machine interface
12	DPS	Digital Power Supply
13	EMI	Electromagnetic interference
14	GPS	Global Positioning System
15	GSM	Global System for Mobile Communications
16	HLT	Health
17	LE	Light engine
18	LED	Light-emitting diode
19	Loco	Locomotive
20	LP-OCIP	Loco pilot’s operation cum indication panel
21	MCB	Molded circuit breaker
22	MHz	Megahertz
23	MR	Main reservoir
24	OVRD	Override
25	PPC	Peripheral Processing Card
26	PS	Power Supply

#	Abbreviation	Meaning
27	PWR	Power
28	RDAC	Radio is active (LED indication on PPC module)
29	RDSO	Research Designs and Standards Organization
30	RDRT	Radio reception and transmission (LED indication on PPC module)
31	RF	Radio Frequency
32	RFID	Radio Frequency Identification Number
33	RPS	Radio power supply
34	SOS	“Save our souls” a distress message
35	SPAD	Signal passing at danger
36	SPN	Specification
37	V	Volts
38	VC	Vital Computer
39	VGW	Vital Gate Way

TABLE OF CONTENTS

LIST OF FIGURES

1 ONBOARD KAVACH OVERVIEW MANUAL :

Onboard KAVACH is installed in the locomotive and performs the KAVACH functionality.The Onboard KAVACH system is suitable for both Electric and Diesel locomotives. The Onboard KAVACH communicates with the Stationary KAVACH unit in its vicinity and follows the movement authority, speed restriction as given by the Stationary KAVACH.

The Onboard KAVACH also displays the approaching Signal aspect, Speed restriction and current speed of the loco and other information to the Loco Pilot on Loco Pilot Operation Cum Indication Panel (LP-OCIP). The Onboard KAVACH is capable of applying the brake of the locomotive to maintain speed restrictions and stop the loco before the end of authority.

The Onboard KAVACH establishes RF communication with the Stationary KAVACH unit in its vicinity. The Onboard KAVACH reads the RFID Tag data, decodes the RFID Tag data and extracts its location information and transmits it to the Stationary KAVACH unit over RF.

The Onboard KAVACH on receiving the RF packet from the Station estimates the movement authority and stops within this distance. Also, Onboard KAVACH displays the loco current speed and approaching signal aspect with its signal ID and distance from its current position on the LP-OCIP.

Onboard KAVACH unit is installed in locomotive and comprises of

a. Power supply sub-system
b. KAVACH sub-system
c. GPS - GSM Antenna
d. LP-OCIP
e. Cab Input unit
f. Brake interface unit
g. RFID Readers
h. Speedometer unit
i. Pulse Generators
j. Radio unit
k. RF antennae(Tx and Rx)

Cab Input signals like locomotive cabin selection, forward, or reverse movement selection from the locomotive relay panel are wired to the Cab Input unit. The Radio antennae are installed on the top of the locomotive and connected to the Radio unit. The Radio Modems, GPS-GSM Antenna and LP-OCIP are connected to the KAVACH sub-system. RFID Readers are fixed underneath the locomotive and connected to the KAVACH sub-system.Speedometer and Pulse Generators are connected to the KAVACH sub-system.

2 SYSTEM OPERATION :

Based on signal information from Stationary KAVACH and available track data, Onboard KAVACH decides the most restrictive target and monitors it. Based on the current speed of the train and braking characteristics,KAVACH advises safe permitted speed to the loco pilot on the LP-OCIP. If the loco pilot exceeds this limit,Onboard KAVACH will apply appropriate brakes to control train within safe speed limits.

When the target is far away, Onboard KAVACH monitors the most restrictive speed (minimum of section speed, loco max speed, loco/train maximum speed, mode related speed, loop line speed, PSR, and TSR). This speed limit is displayed on the LP-OCIP as Max Permitted Speed.

Onboard KAVACH monitors the actual train speed and responds as follows :

- If Train speed is above the permitted speed limit by 2 KMPH, the “Over-Speed” alarm will be issued.
- If Train speed is above the permitted speed limit by 5 KMPH, Normal service brake will be applied.
- If Train speed is above permitted speed limit by 8 KMPH, Full-service brake will be applied.
- If Train speed is above permitted speed limit by 10 KMPH, Emergency brake will be applied.

Whenever the target is approaching, in addition to the most restrictive speed, the safe target speed is also calculated for the target distance. The safe target speed limit will be computed by allowing 7 seconds of tolerance for the Loco pilot reaction.

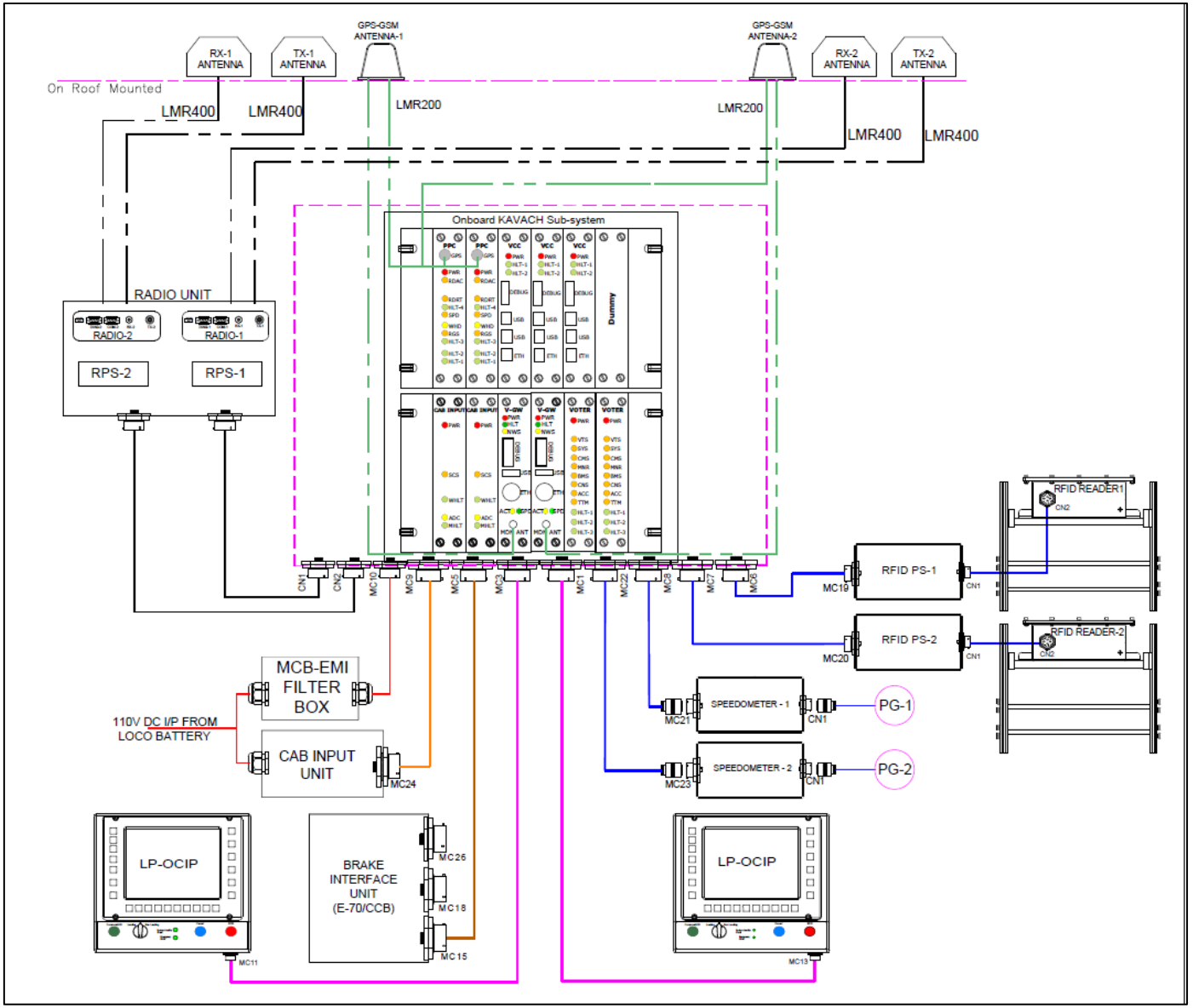

Figure 1 : Onboard KAVACH Overview

3 MODULES AND CONNECTIONS :

The Onboard KAVACH is divided into sub-systems are divided into modules.Each card is housed in a cassette as a module.The modules are placed in sub-rack and these sub-racks are placed in an enclosure to form the Onboard KAVACH unit.

All the modules in the sub-system are connected through wire-harness and the wire-harness between the sub-systems are connected in the KAVACH system for a proper interface between them.

In a subsystem, the interfaces between the modules are done using automotive-grade connectors and between the sub-systems is done using MIL connectors.

All the external peripherals for the Onboard KAVACH are connected through the MIL grade connector to achieve proper connectivity.

4 INPUT AND OUTPUT CONNECTIONS OF ONBOARD KAVACH SYSTEM :

- **The input connection for Onboard KAVACH unit are :**

a) 110VDC Power Supply from the Loco Battery

b) GPS Antenna connection with LMR 200 cable

c) GSM Antenna connection with LMR 200 cable

d) RF Antennas(Tx & Rx) connection with LMR 400 cable

e) Speedometer & Pulse generator connection

f) RFID Reader connection

g) Cab input unit connection

- **The output connection for Onboard KAVACH unit are :**

a) LP-OCIP connection

b) Brake interface unit connection

4.1 POWER SUPPLY SYSTEM :

The Onboard KAVACH works on either 110V DC or 72V DC power supply from the locomotive battery. The Electric locomotive runs with 110V DC and the Diesel locomotive runs with 72V DC.

The incoming Locomotive Power supply is protected against short-circuiting using MCBs.

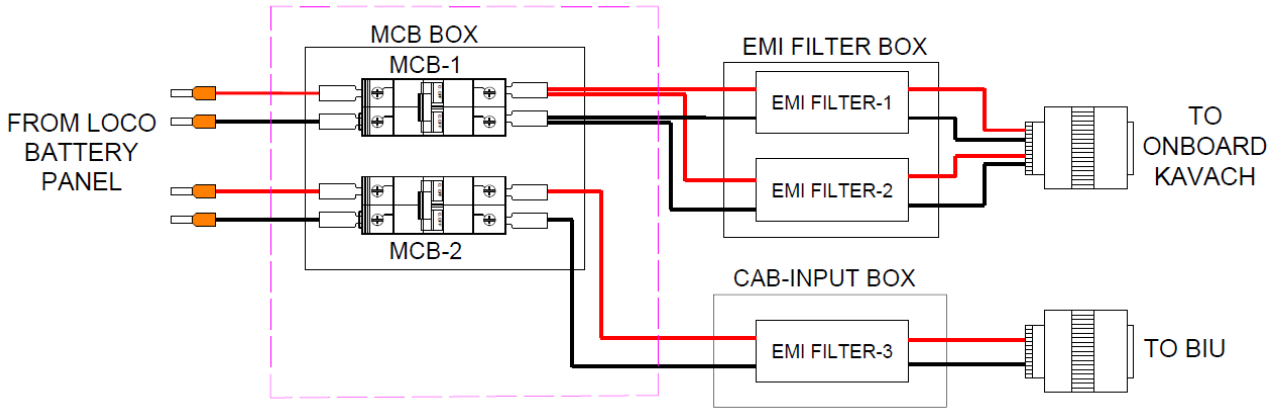

Figure 2 : Power connectivity

The incoming 110V DC power supply is fed to EMI/EMC Filter before connecting to the KAVACH subsystem.110VDC power supply is also distributed to Brake Interface Unit (BIU).

In the KAVACH system, the incoming 110V DC power supply is connected to the Power supply sub-system to derive 24VDC & 5VDC power supply required for sub-systems and modules of the KAVACH system. Each sub-system and modules is provided with fuse protection against short-circuiting.

4.2 SUB-SYSTEM :

- **The KAVACH sub-system comprises of following modules :**

  A. Peripheral Processing module

  B. Vital Computer module

  C. Voter module

  D. Vital Gateway module

  E. Cab Input

  F. Digital Power Supply

- **Other :**

  G. EMI Filter unit

  H. LP-OCIP

  I. Radio unit

  J. Cab Input unit

  K. RFID Readers

L. Speedometer unit & Pulse generator

M. Brake Interface unit

4.3 MODULES HOUSING :

The housing will accommodate the sub-systems in sub-rack.The arrangement of sub-rack is given below:

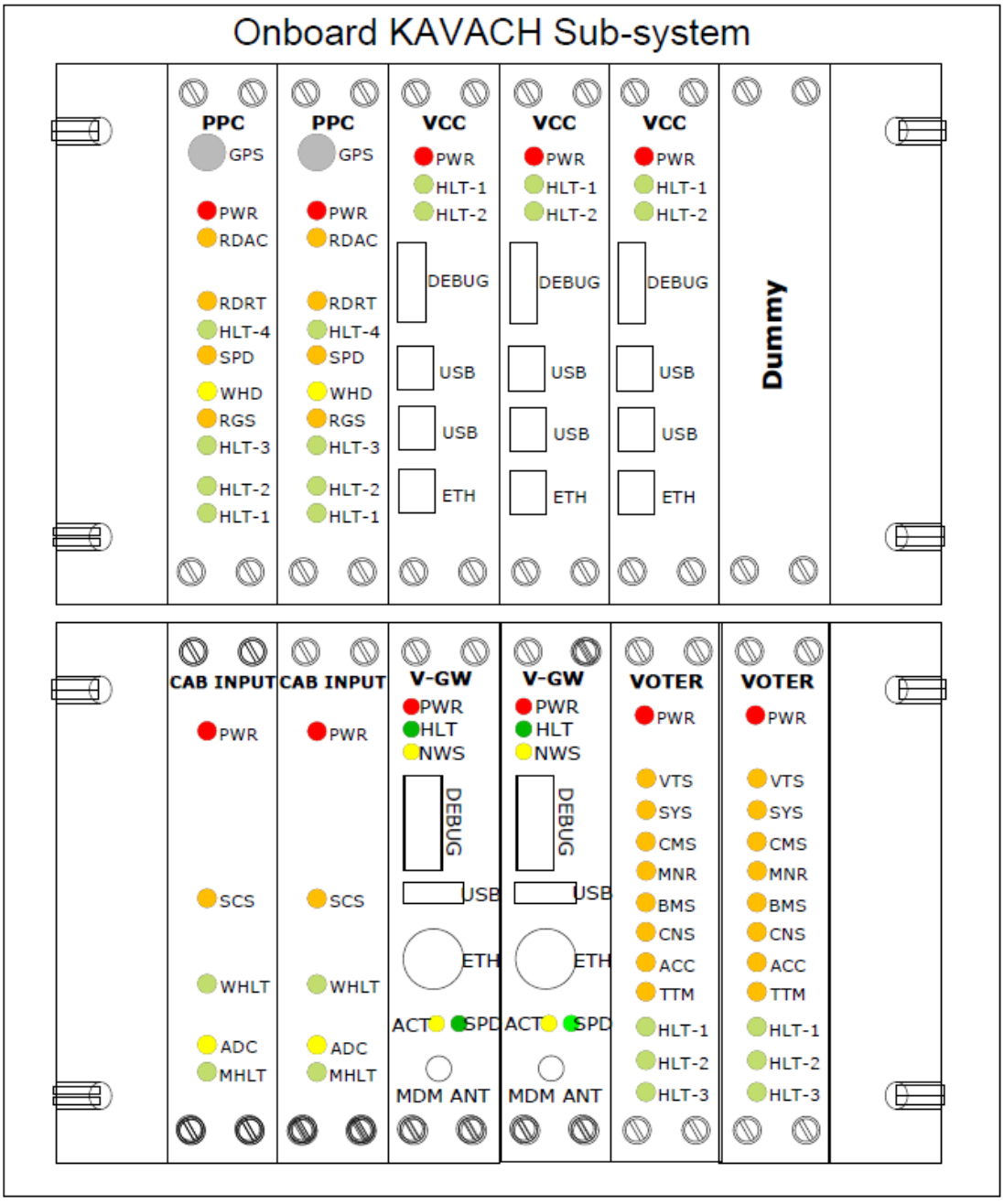

Figure 3 : Kavach sub rack unit

4.4 DIAGNOSTIC LED / INDICATION OF EACH CARD :

Each card has Diagnostic LED indications on the fascia and the details for each card are as follows:

A. Peripheral Processing Card(PPC)

In stationary KAVACH, the Peripheral Processing Card (PPC) is used for communicating with radio modems,GPS module,Pulse generator and RFID Reader. PPC exchanges data with either the Vital Computer module or Voter module through CAN Bus. For availability, two PPC modules work in hot standby configuration.

Diagnostic LED indications on Peripheral Processing card (PPC) are as follows:

#	LED	Description
1	PWR	PSU Available
2	RDAC	Radio Active Status
3	RDRT	Radio Transmission/Reception Status
4	HLT4	Micro-controller4 health status
5	SPD	Speedometer health
6	WHD	Wheel Diameter status
7	RGS	GPS Signal status
8	HLT3	Micro-controller3 health status
9	HLT2	Micro-controller2 health status
10	HLT1	Micro-controller1 health status

B. Vital Computer Card(VCC)

In Onboard KAVACH, 2 out of 3 redundancy is implemented by using three Vital Computer Modules (VCC). The three Vital Computer module (VCC) modules process the data received from the Peripheral Processing modules for deriving the required outputs. The Vital computer modules send this processed data to the Voter module for the implementation of 2oo3 voting logic. The final output is the 2oo3 voted data. The Vital Computer (VCC) module receives the data from the Peripheral Processing

modules on System Bus (CAN Bus) and the derived decision is communicated to the Voter module also on the System Bus.

Diagnostic LED indications on Vital Computer card (VCC) are as follows:

#	LED	Description
1	PWR	24V DC Available
2	HLT1	ARM Processor health status
3	HLT2	Micro controller health status

C. Voter Card(VTR)

Onboard KAVACH implements 2 out-of 3 (2oo3) decisions making, to derive the final output. The Voter module receives the decisions from Vital Computer1, Vital Computer2 and Vital Computer3 modules on System Bus. The Voter card than implements 2oo3 decision making logic and derives the final decision. The voted final decision shall be sent to the destination module on the System bus. Under any circumstances, the Voter does not modify the decisions received from Vital Computer1, Vital Computer2 and Vital Computer3 modules or the final voted decision.For availability, two VTR modules work in hot standby configuration.

Diagnostic LED indications on Voter card (VTR) are as follows:

#	LED	Description
1	PWR	24V DC Available
2	VTS	Voter status
3	SYS	System healthy status
4	CMS	Communication healthy status
5	MNR	Maintenance required
6	BMS	Bus Master Active
7	CNS	CAN bus status
8	ACC	Active CAN Network Status
9	TTM	Train Trigger mark

10	HLT1	Micro-controller1 health status
11	HLT2	Micro-controller2 health status
12	HLT3	Micro-controller3 health status

Note: TTM LED indication on Voter module is negligible

D. Vital Gateway Card (V-GW)

The Vital Gateway module logs the data/events received from the Voter module. The Vital Gateway module receives data on System Bus which is a dual isolated CAN Bus and stores the data/events. The logged events can be downloaded to a Personal Computer (PC) or Laptop through Ethernet interface.

The Vital Gateway module works on a dual 24V DC input power supply. Ethernet port on the VGW module is used for downloading the data log to a Personal Computer (PC) or Laptop.

The VGW module is also responsible for the KAVACH system to generate GSM packets to transmit on the GSM network and gets the encryption keys from the Key Management System (KMS).There is a provision for a separate SIM insertion connector for each GSM module.For availability, two VGW modules work in hot standby configuration.

Diagnostic LED indications for Vital Gateway card (VGW) are as follows:

#	LED	Description
1	PWR	PSU Available
2	HLT	System on chip(SOC) health status
3	NWS	GSM Signal health status
4	ACT	Network Activity Status
5	SPD	Speed/Link Status

E. Cab Input Card

The Cab Input card reads the cab inputs like BL Key-1,BL Key-2,Forward and Reverse and Horn.Each input is scanned and sent to the Vital Computer modules on System Bus, which is a dual isolated CAN Bus.

Diagnostic LED indications for Cab Input are as follows:

#	LED	Description
1	PWR	24V DC Available
2	SCS	Scan Inputs
3	WHLT	Micro-controller2 health status
4	ADC	Additional Scan Inputs
5	MHLT	Micro-controller1 health status

F. Digital Power Supply Card(DPS)

The input power supply to the Onboard KAVACH unit is 110V DC. The Onboard KAVACH unit requires 24V DC and 5V DC power supplies for its functioning. The Digital Power supply module generates required 24V DC and 5V DC power supplies from 110V DC. For availability, two DPS modules work in hot standby configuration.

4.5 EMI FILTER UNIT :

The EMI filter protects against EMI interference to the KAVACH system.There shall be two EMI filters in the unit.EMI filter is provided at input 110V DC power supply to the Onboard KAVACH system and another EMI filter is provided at input 110V DC power supply to BIU.

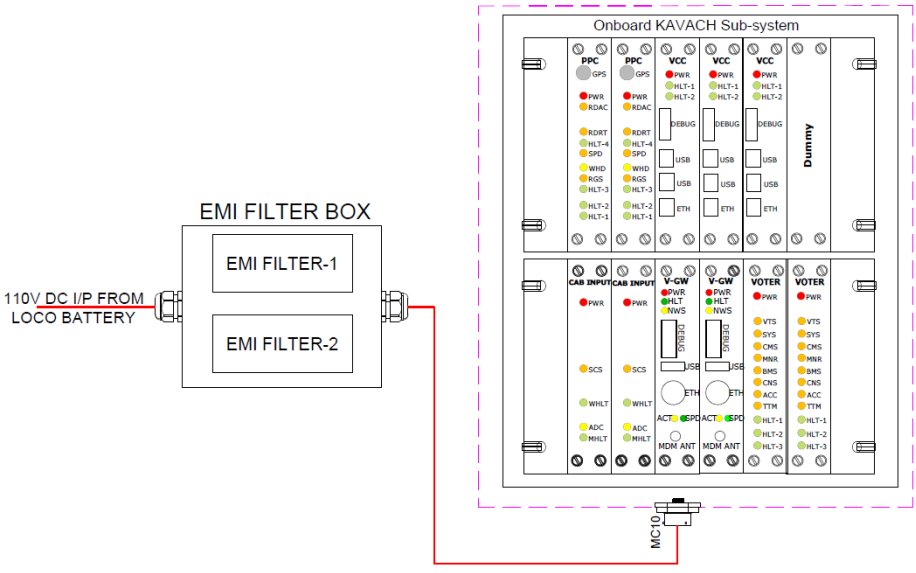

Figure 4 : EMI Filter unit connectivity

4.6 LP-OCIP UNIT :

The Loco Pilot will interact with the Onboard KAVACH through LP-OCIP.There will be two LP-OCIP units connected to Onboard KAVACH. One LP-OCIP is installed at Cabin-A and another LP-OCIP in Cabin-B of the loco. The LP-OCIP interface has cable harnesses, one for signals from KAVACH sub-system.

#	Switch Name	Colour	Description
1	COMMON /ACK	Black	ACK - Loco Pilot to acknowledge. COMMON - To press along with SOS
2	CANCEL	Blue	To cancel the command given through previous switch operation
3	SOS	Red	To generate SOS
4	Leading	Yellow	Active cab
5	Non-Leading	Yellow	Non Active cab

There are two LEDs on the LP-OCIP :

#	LED Name	Color	Description
1	SYSTEM HEALTHLY/FAULTY	GREEN RED	System OK System Faulty status
2	EMERGENCY /SOS	GREEN RED	SOS not generated SOS when generated

The arrangement between LP-OCIP and Onboard KAVACH is as follows:

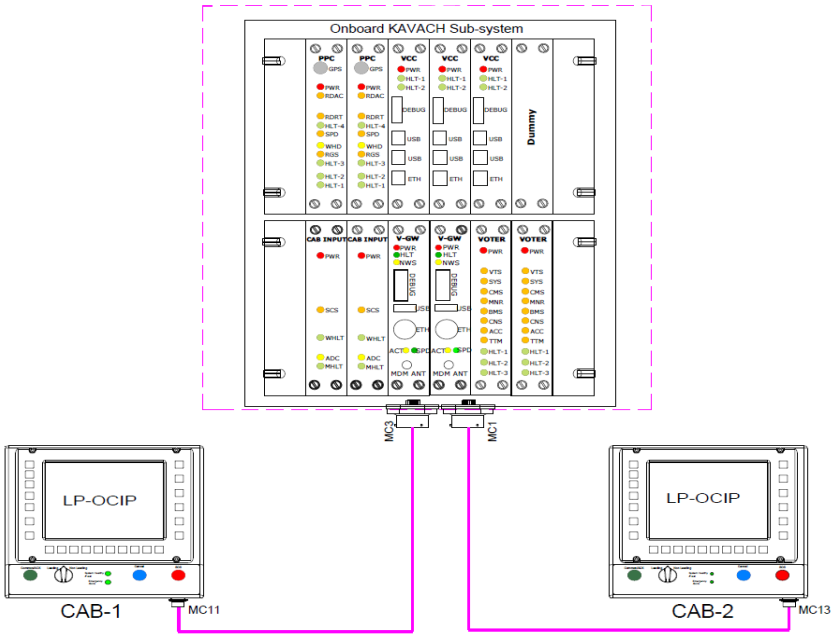

Figure 5 : LP-OCIP connectivity

4.7 RADIO UNIT :

Radio unit with Radio modems are installed in the locomotive.The Radio modems are connected to the KAVACH sub-system through Radio Power Supply card (RPS).The RF Antennas(Tx and Rx) are connected to the Radio unit via LMR 400 cables.

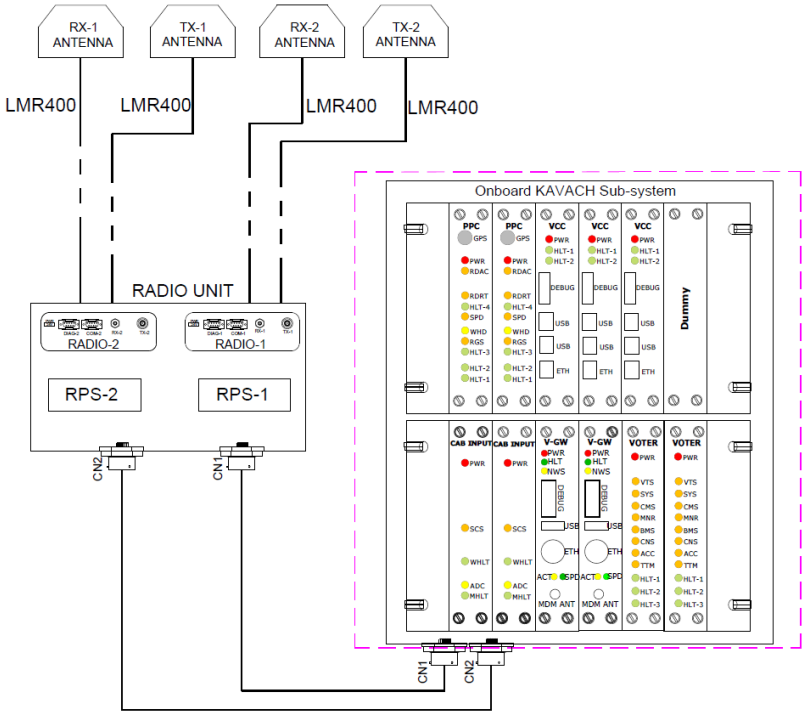

Figure 6 : Radio connectivity

4.8 RF ANTENNAES :

The RF Antennas are connected on the roof top of the locomotive.The RF Antennas are connected to the Radio unit via LMR 400 cables.

The antenna cable & antenna shall be suitable to provide a minimum range of communication.Antenna shall be tuned to minimum frequency of 425 to 430 MHz preferably with a minimum gain of 3dB.

4.9 CAB INPUT UNIT :

The Onboard KAVACH requires the loco inputs to identify which cabin is active which is known through the input of BL-Key1and BL-Key2.The loco movement direction forward and reverse is also required to be known by Onboard KAVACH. These inputs are taken from loco panel through Cab Input unit.

The connectivity between the CAB Input box and KAVACH unit is shown below

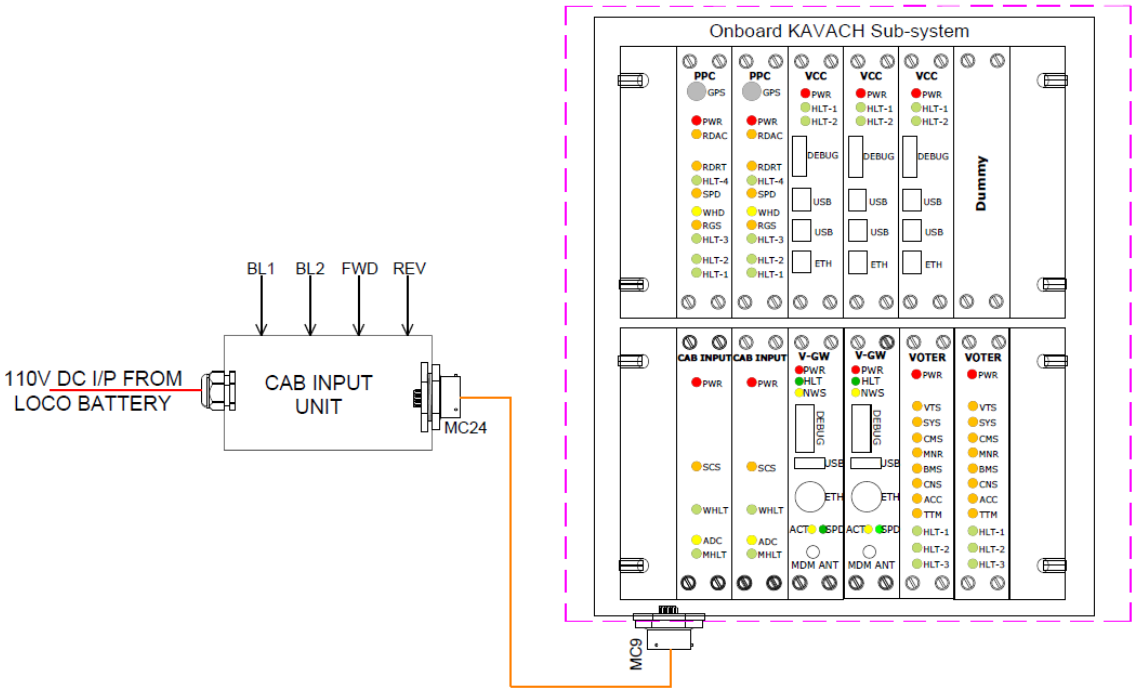

Figure 7 : Cab Input connectivity

4.10 RFID READER :

The RFID tags are installed on the tracks and the RFID Reader will read the tags. There will be two RFID Readers installed underneath the loco. One RFID reader is installed at cabin-A side and another RFID Reader is installed at cabin-B side.The RFID Reader works on a 24V DC supply which is supplied through RFID PS unit.

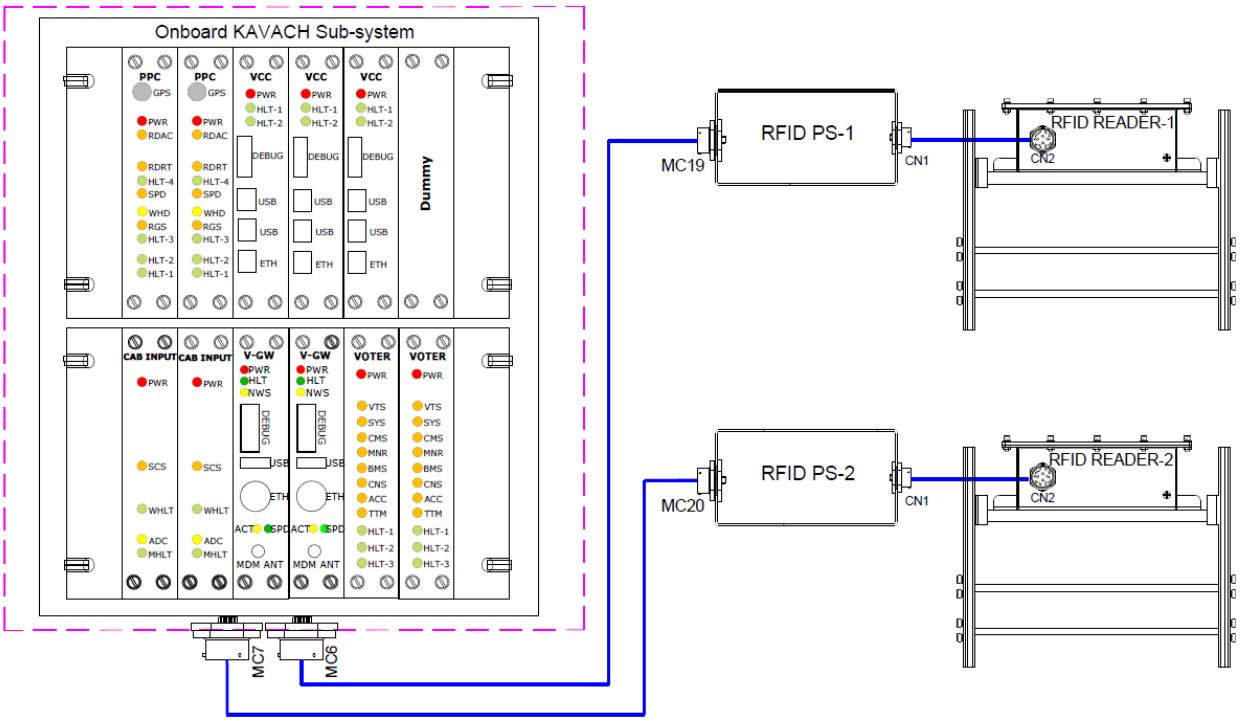

Figure 8 : RFID Reader connectivity

4.11 SPEEDOMETER & PULSE GENERATOR :

One of the vital inputs for the Onboard KAVACH is the loco speed information.Onboard KAVACH will interface with two pulse generators for speed and odometry calculation.The Onboard KAVACH will calculate the speed and the odometry by getting the pulses per revolution of the wheel from both the pulse generators.

The speedometer unit powers the pulse generators.The pulse generator generates two pulses with phase shift and is sent to PPC for determining the direction of wheel rotation (forward or reverse).The Onboard KAVACH functions only if speed derived from both the speedometer units match.

The connectivity between the Speedometer and KAVACH unit is shown below

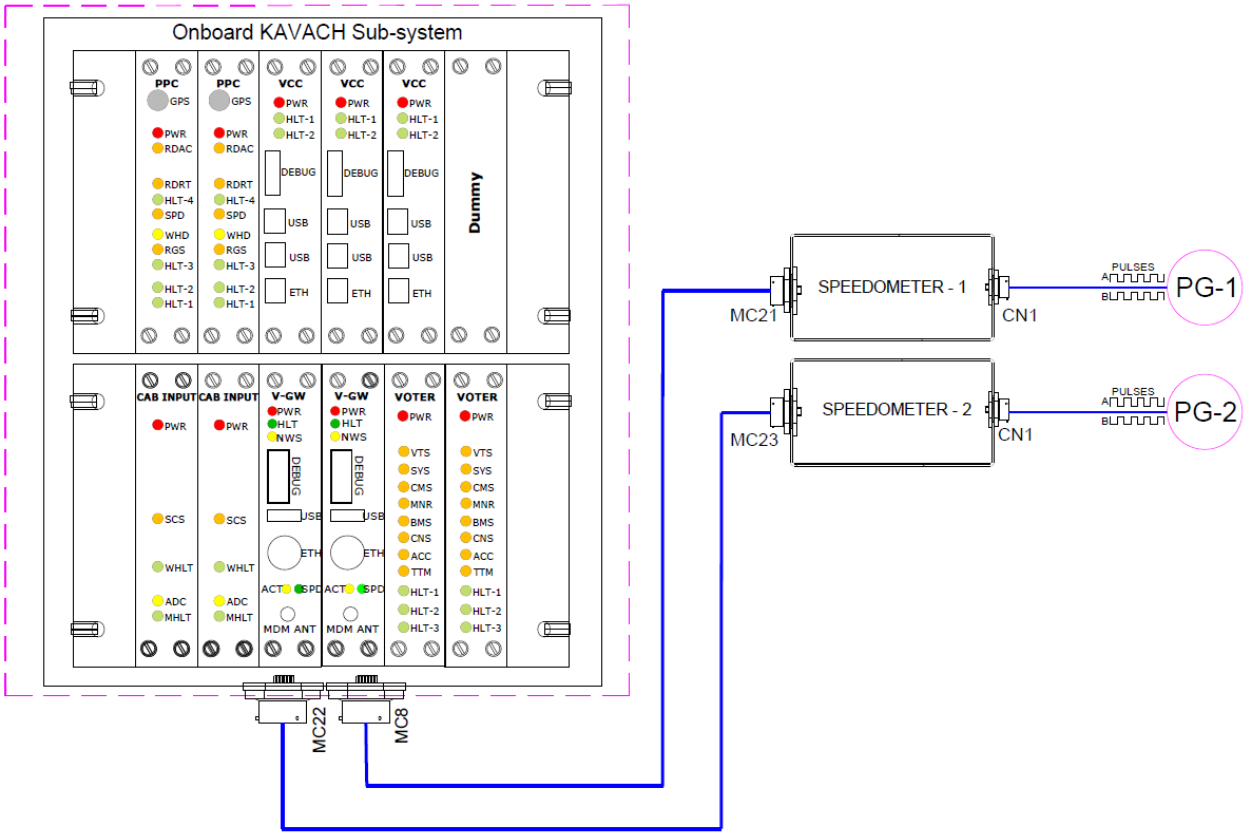

Figure 9 : Speedometer & Pulse generator connectivity

4.12 BRAKE INTERFACE UNIT (BIU) :

The Brake Interface Unit (BIU) is the output of the Onboard KAVACH. The Brake Interface Unit (BIU) will have a pneumatic interface with the existing locomotive braking system and is connected to the Onboard KAVACH system electrically.

Brake Interface Unit is connected to the Main Reservoir (MR) and Brake Pipe (BP) of the locomotive pneumatically and maintains the required air pressure in the Brake Pipe (BP) based on the brake command received from the Onboard KAVACH unit.

The Brake Interface Unit (BIU) also provides a separate pneumatic interface for Light Engine (LE) braking system. The Onboard KAVACH can send the brake commands to the Brake Interface Unit (BIU) through dual isolated RS-485 interfaces connected between them. The Brake Interface Unit (BIU) is capable of activating Normal Brake (NB), Full Service Brake (FSB) and Emergency Brake (EB) based on the brake command received from the Onboard KAVACH unit.

The connectivity between the BIU and KAVACH unit is shown below

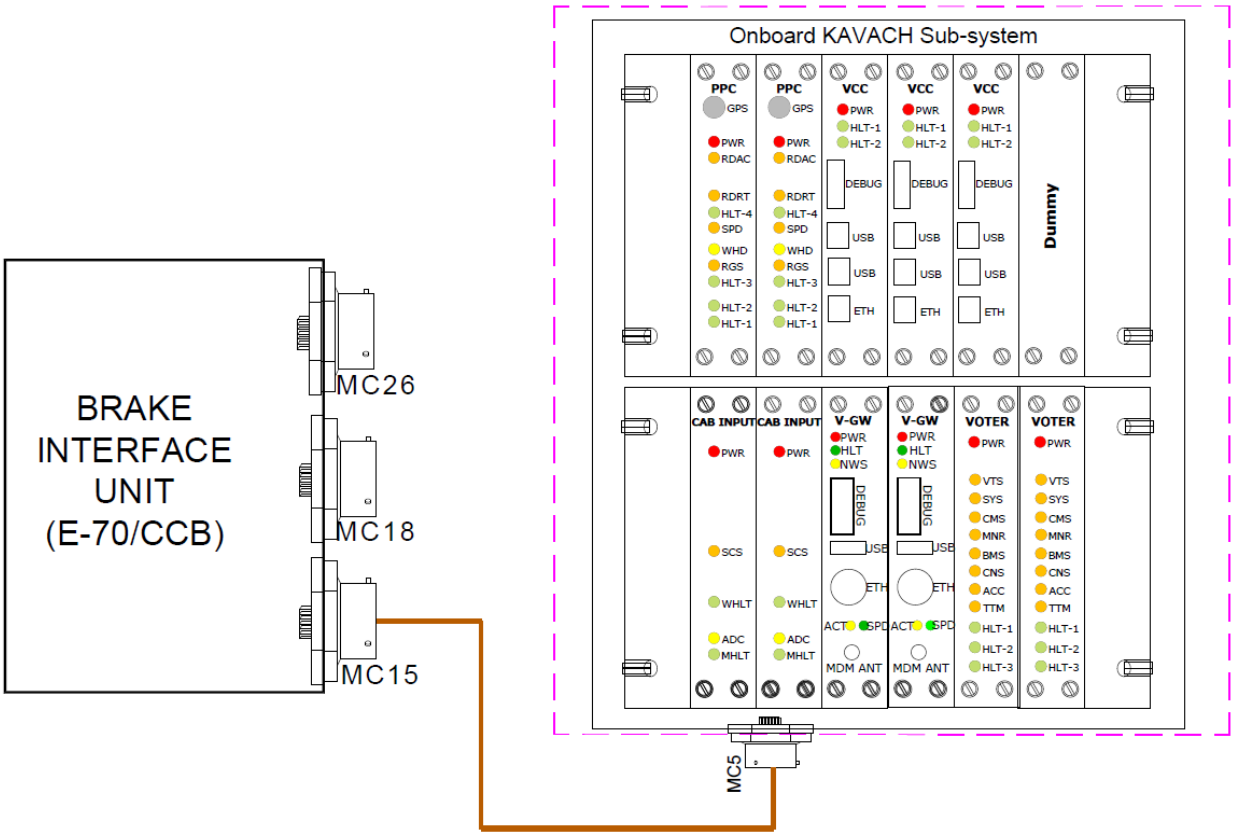

Figure 10 : BIU connectivity

4.12.1 Brake Interface Unit for IRAB

IRAB BIU is used to interface the braking commands from Vital Computer to IRAB braking system of the locomotive. It is connected to the Vital Computer through a communication cable, and to the braking system of the locomotive through pneumatic pipes. Pressure sensors are installed on the MR, BP, BC1 and BC2 pipes to communicate these pressure values to the Vital Computer. Depending upon the train speed and available distance to stop, Vital Computer determines the braking effort needed and sends a command to the BIU. Based on this command, BIU applies normal brake, full-service brake or emergency brake.

Figure 11 : BIU - IRAB

4.12.2 Brake Interface Unit for E-70/CCB

E-70/CCB Interface Unit is used to interface braking commands from Vital Computer to E-70, CCB or electro-pneumatic braking systems of the locomotive in 3phase Locomotives. It is connected to the Vital Computer through a communication cable MC15. Pressure sensors are installed on the MR, BP, and BC pipes to communicate these pressure values to the Vital Computer through a MC26. Depending upon the train speed and available distance to stop, Vital Computer determines the braking effort needed and sends a command to the Brake interface unit. Based on this command, Brake Interface communicates normal brake, full-service brake, or emergency brake request to the E-70, CCB or electro-pneumatic braking system.

Figure 12: BIU - E70/CCB

- **LED indications for BIU - E70/CCB are as follows:**

Figure 13 : LEDS on BIU - E70/CCB

The E-70/CCB Interface Unit have LED indications for each type of brake, described below,

1. **CAB-A NB** : This LED will glow, when BIU applies Normal brake for CAB -A.
2. **CAB-A FSB** : This LED will glow, when BIU applies Full Service brake for CAB-A.
3. **CAB-A EB** : This LED will glow, when BIU applies EB brake for CAB-A.
4. **CAB-B NB** : This LED will glow, when BIU applies Normal brake for CAB -B
5. **CAB-B FSB** : This LED will glow, when BIU applies Full Service brake for CAB-B
6. **CAB-B EB** : This LED will glow, when BIU applies EB brake for CAB-B.
7. **LE MODE** : This LED will glow, when BIU applies LE brake if Loco configured as LE.
8. **ISO MODE** : This LED will glow, whenever BIU Isolation switch kept in Isolation position.
9. **QRV Pickup** : This LED will glow, when BIU applies No brakes except EB.
10. **TR. CUT OFF** : This LED will glow, when BIU applies no brakes, but this LED will be OFF for all type of brake commands for traction disable.

4.13 GPS & GSM ANTENNA :

GPS Antennas are connected to the GPS sub-module available on Peripheral Processing card (PPC) card.

GSM Antennas are connected to Vital Gateway card(V-GW).

The connectivity is shown in the following figure:

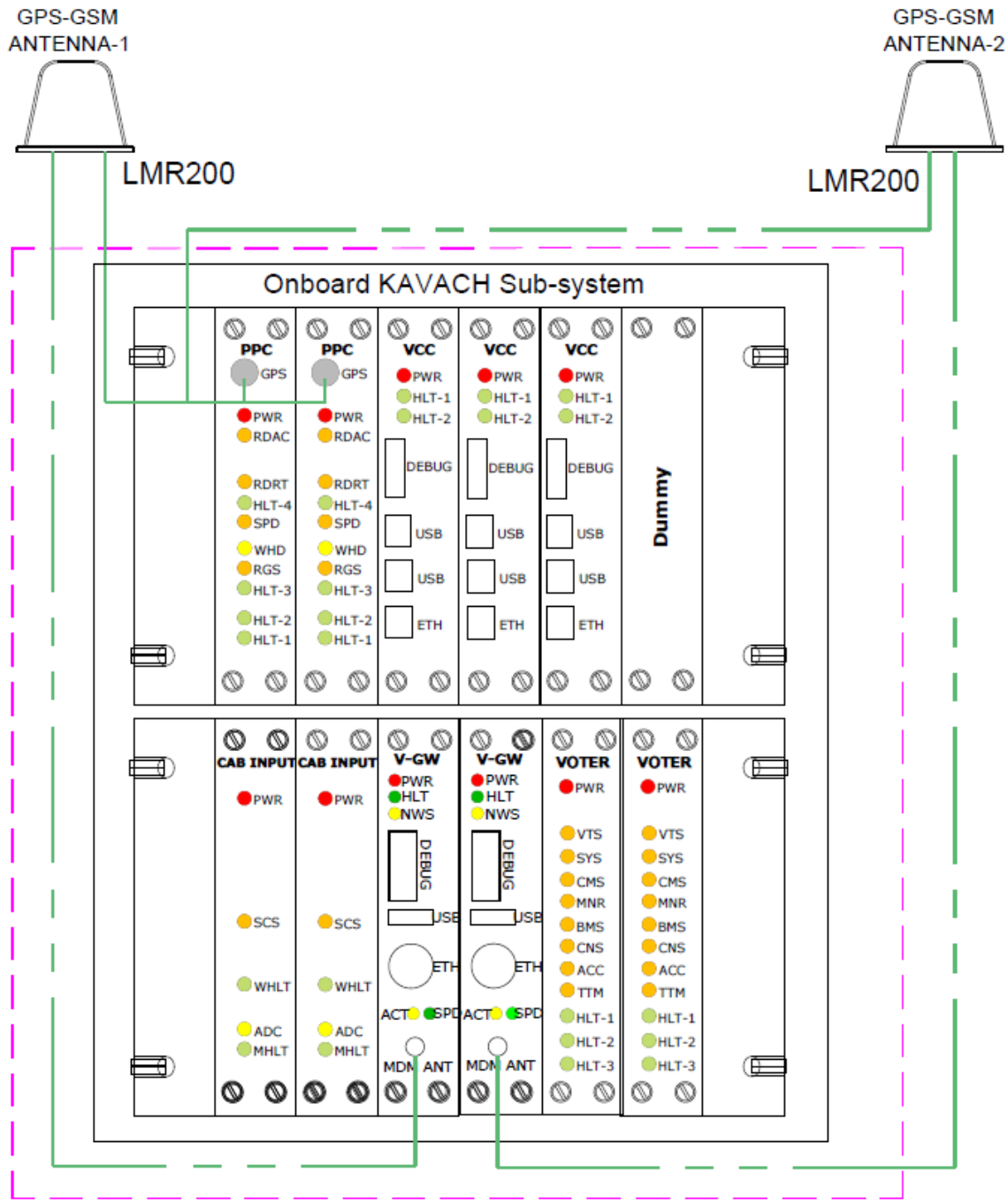

Figure 14 : GPS & GSM Antenna connectivity

4.14 ELECTROMECHANICAL COUNTER :

There are three event counters that count the number of times special events occur. Two of these counters are located on the Onboard KAVACH unit, and one is located on the BIU.

1. **TRIP/OV Counter :** Gets incremented every time when Onboard KAVACH enters Trip or Override mode.

2. **SOS Counter :** Gets incremented every time when Onboard KAVACH generates or receives an SOS message.

3. **Isolation Mode Counter :** Gets incremented every time when the switch on BIU is selected to Isolation mode.

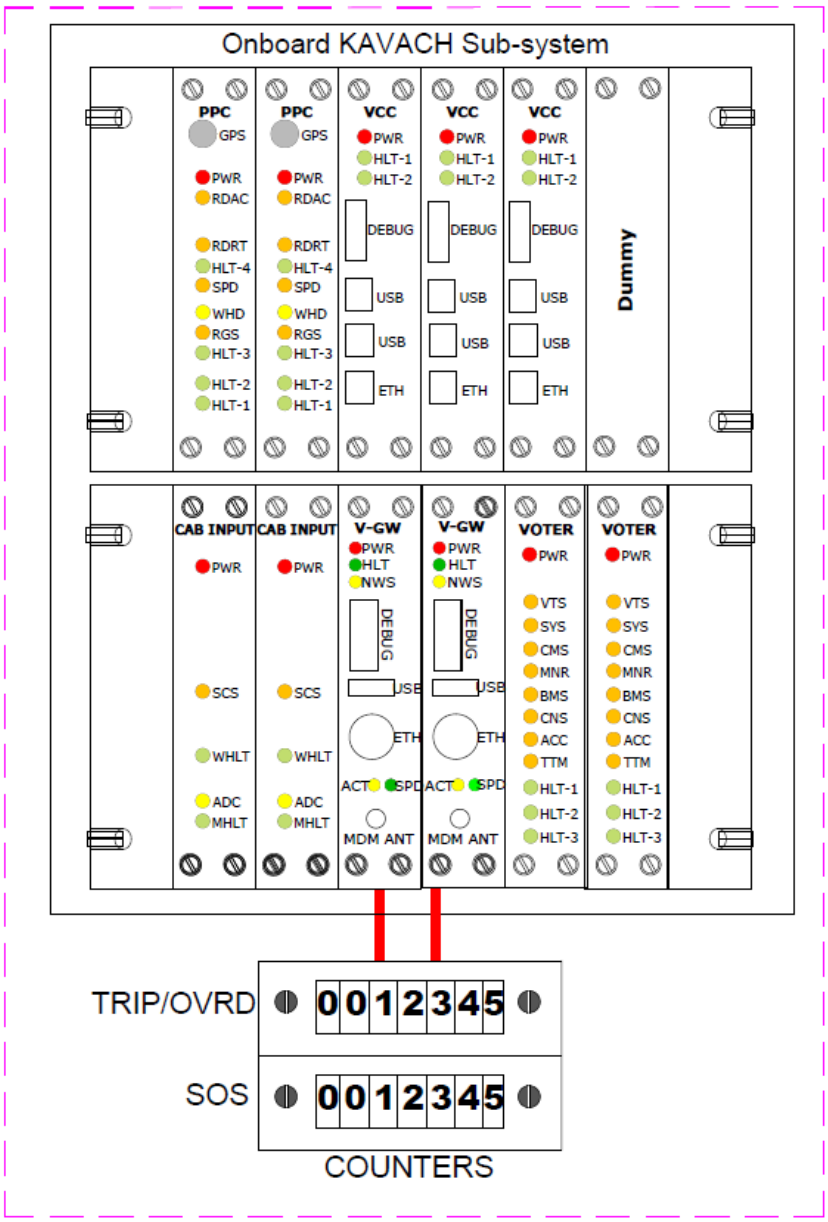

Figure 15 : Counters on Onboard KAVACH

Figure 16 : Counter on BIU

4.15 ETHERNET COMMUNICATION :

The Error log data of Onboard KAVACH can be downloaded to a Laptop or Desktop units.The Ethernet interface for communication is shown in the following figure:

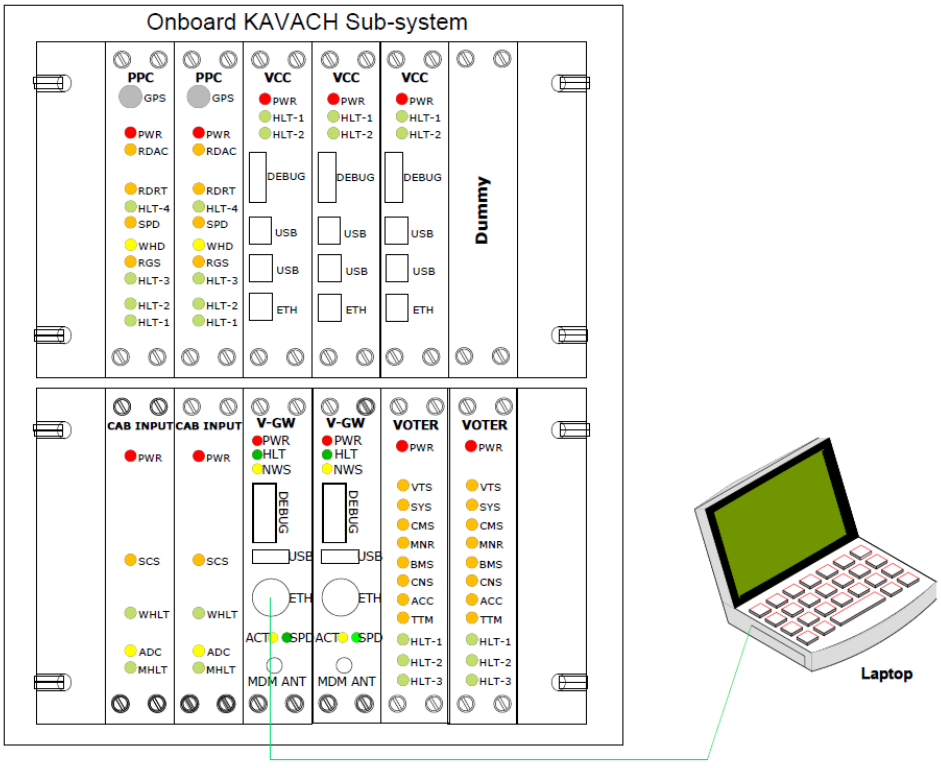

Figure 17 : Ethernet connectivity

5 AVAILABILITY, RELIABILITY AND REDUNDANCY :

Availability,reliability and redundancy is achieved in Onboard KAVACH as follows :

- All the peripheral devices are interfaced with Peripheral Processing Card (PPC), and there are two Peripheral Processing Cards (PPC) one PPC card is active, and another is available as the hot standby module

- There are two Radio modems and both are active to increase the availability
- There are two GPS modules with a separate antenna to increase the availability
- There are three Vital Computer cards to implement 2oo3 design
- There are two Voter cards for voting purpose. One Voter card is active, and another Voter card is available as hot standby
- There are two VGW cards.One card is active, and another card is available as hot standby.
- There are two Digital Power supply modules (DPS), both are active to maintain redundancy
- There are two Cab Input cards ,both are active to maintain redundancy

6 COMPLIANCE AND SAFETY :

The KAVACH subsystems comply with RDSO specifications RDSO/SPN/196/2012 dated 17/05/17 for functional and safety requirements. KAVACH subsystems comply with RDSO/SPN/144/2006 for environmental and other requirements.

The complete KAVACH system is designed to and assessed as Compliant with a Safety Integrity Level 4 (SIL 4) as defined by EN 50126, EN 50128, EN 50129, EN 50159 EN 50124-1 and EN 50121-4 CENELEC standards.

Signature: DLRaju
DLRaju (May 4, 2025 21:59 GMT+5.5)
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Title: Sr.Engineer

Signature: JWSNV Prasad
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Signature:
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Title: Safety Manager

Signature: Rajasekhar K
Rajasekhar K (May 5, 2025 12:27 GMT+5.5)
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5 53 76 0020_Onboard Kavach User Manual

Final Audit Report 2025-05-05

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