USER MANUAL

FOR

STATIONARY KAVACH

Document Number : 5 53 76 0002

Version: 1.0

Date Published: 25 - 04 - 2025

Prepared by

HBL Engineering Ltd

Hyderabad

DOCUMENT DATA SHEET

Title of the Document	File Name	Pages	Figures	Tables
User Manual for Stationary KAVACH	User Manual for Stationary KAVACH	30	11	-

Prepared by	Validated by	Reviewed by	Approved by
M.Jagruthi M.Jagruthi (May 4, 2025 18:25 GMT+5.5)	JVVSNV Prasad		Pradeep Kongalla Pradeep Kongalla (May 4, 2025 20:15 GMT+5.5)
M.Jagruthi	JVVSNV Prasad	Hemant Sagade	K.Pradeep Kumar

Abstract

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

DOCUMENT CONTROL SHEET

#	Name	Function	Level	Signature
1	K.Pradeep Kumar	IV&V - QA Head	Approve	
2	Hemant Sagade	Safety Manager	Review	
3	JVVSNV Prasad	Senior Manager - Engineering	Validate	
4	M.Jagruthi	Engineer-Engineering	Prepare	

CHANGE HISTORY

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

REFERENCES

#	Document Name	Document Number	Version Number/Year	Source
A	Safety and Reliability Requirements of Electronic Signaling Equipment	RDSO/SPN/ 144/2006	Rev 2	RDSO
B	RDSO Specification for Train Collision Avoidance System	RDSO/SPN/ 196/2020	4.0 Amdt-3	RDSO
C	Railway Applications - Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)	EN50126-1&2	1999 (with corrigendum 1-28 Feb 2007), Feb 2007	CENELEC
D	Personnel Safety Instruction Manual	5 16 76 0014		HBL
E	**Stationary** KAVACH Power Supply Connectivity Diagram	5 16 49 0**xxx**		HBL
F	**Stationary** KAVACH inter connectivity diagram	5 16 49 0**xxx**		HBL
G	Maintenance Activities for **Stationary** KAVACH, issued by CoE	IRISET/CoE/KAVACH/Misc dated 31-01-2024		HBL

GLOSSARY OF TERMS

#	Abbreviation	Meaning
1	2oo3	Two Out Of Three
2	CAN	Controller area network
3	CENELEC	European Committee for Electro Technical Standardization
4	CTC	Centralized traffic control
5	CTF	Control Table File
6	DC	Direct Current
7	DPS	Digital Power Supply
8	EI	Electronic Interlock
9	EMI/EMC	Electromagnetic interference/Electromagnetic compatibility
10	FIU	Field Interface Unit
11	FLF	Field layout file
12	FSC	Field interface Unit - Scanner Card
13	GPS	Global Positioning System
14	GSM	Global System for Mobile Communications
15	HLT	Health
16	HRC	High rupturing capacity
17	IB-HUT	Intermediate Block HUT
18	IBS	Intermediate block station
19	IPS	Integrated Power System
20	KMS	Key management system
21	LCD	Liquid Crystal Display
22	LC	Level crossing
23	LED	Light-emitting diode
24	MCB	Molded circuit breaker

#	Abbreviation	Meaning
25	MHz	Megahertz
26	Modem	Modulator- demodulator
27	NMS	Network Management System
28	OFC	Optical Fibre Cable
29	PPC	Peripheral Processing Card
30	PSR	Permanent speed restriction
31	PWR	Power
32	RDAC	Radio is active (LED indication on PPC module)
33	RDSO	Research Designs and Standards Organization
34	RDRT	Radio reception and transmission (LED indication on PPC module)
35	RF	Radio Frequency
36	RFID	Radio Frequency Identification Number
37	RIU	Remote interface unit
38	RRI	Route Relay Interlocking
39	RS232	Recommended Standard 232
40	RS485	Recommended Standard 485
41	Rx	Receive
42	SIL	Safety integrity level
43	SIM	Subscriber identification module
44	SLF	Station Layout File
45	SM	Station Master
46	SM-OCIP	Station Master Operation Cum Indication Panel
47	SMS	Short message service
48	SOS	“Save our souls” a distress message
49	SPAD	Signal passing at danger

#	Abbreviation	Meaning
50	SPN	Specification
51	SRPS	Station radio power supply
52	STC	Station TCAS Configuration
53	S2S	Station to Station
54	TB	Terminal block
55	KAVACH	Train Collision Avoidance System
56	TSR	Temporary speed restriction
57	Tx	Transmit
58	U	A rack unit abbreviated as “U” (The standard rack of 19 inches and U is 1.75 inches)
59	V	Volts
60	VC	Vital Computer
61	VGW	Vital Gateway

TABLE OF CONTENTS

LIST OF FIGURES

1 STATIONARY KAVACH OVERVIEW MANUAL:

Stationary KAVACH can be of three types, namely Station KAVACH, IBS KAVACH and LC-Gate KAVACH. All KAVACH units are microcontroller-based systems. The purpose of these systems is to prevent train collisions in block sections and on running lines at stations and also prevent Signal Passing at Danger (SPAD). The Stationary KAVACH system will communicate with Onboard KAVACH through radio over the air.

Stationary KAVACH gets the information of position, speed, and direction of movement from Onboard KAVACH over radio communication.The Stationary KAVACH system will acquire the status of all signal aspects, berthing track circuits and points of its yard, and calculate the movement authority for locos and transmit this information over the radio to the Onboard KAVACH for supervising of train movements.

In the event of emergencies, the Stationary KAVACH sends an SOS message to Onboard KAVACH for applying brakes, thereby preventing collisions.

Stationary KAVACH is ground-based equipment. The Stationary KAVACH is part of the automatic train protection system and is responsible for communicating the field status and also continuous updation of the movement authority for the safe movement of KAVACH fitted trains. This equipment constitutes more than one subsystem, which are interconnected through the communication network.

A. Stationary KAVACH unit is installed in relay room of the station and comprises of :

a. Power supply sub-system (PDU)

b. TCAS Repeater Relay Rack

c. KAVACH sub-system

d. FIU sub-system

e. GPS - GSM Antenna

f. Station OFC Termination Panels

B. The following are installed in Station Manager’s Room :

g. SM-OCIP

h. SM-OCIP OFC Termination Panels

C. The following are installed in Radio Tower Unit

i. Radio modems

j. RF antennae(Tx and Rx)

D. The following are installed on Track side

- RFID Tags

Field inputs like all Signals, Points, Track circuits, Berthing tracks from the EI/PI panel are wired to the FIU subsystem via TCAS Repeater Relay Rack.The Radio antennae are installed on the top of the 30/40 Mtrs tower and connected to the Radio Modems. The Radio Modems, GPS receiver and SM-OCIP are connected to the KAVACH sub-system. RFID tags with tag data are fixed on the sleepers in both station and block sections.

2 SYSTEM OPERATION :

The Stationary KAVACH scans the status of all the field inputs and transmits to the Onboard KAVACH sub-system.On the other hand, Onboard KAVACH reads the RFID tags, computes its current absolute location, train direction and transmits to the Stationary KAVACH on Radio.

Based on the status of the field inputs and the Onboard KAVACH location, the Stationary KAVACH calculates the Movement Authority for the Onboard(s) considering their absolute position and the routes that are set for the locos traveling in the Station vicinity.

It also derives the current signal aspect and next signal aspect considering the current status of all the inputs. Also, when the route is set for the Loop Line, the Stationary KAVACH prepares the information about turn out speed, turn out distance and release distance.

In addition to this, the Stationary KAVACH provides the necessary information required to compute the train length of a train passing through the Station by checking the sequence of states of track circuits as the train passes over them. Stationary KAVACH communicates all this information to the Onboard KAVACH using the Station Radio Modem. This information can be received by all the Onboard(s) that are within the vicinity of the station.

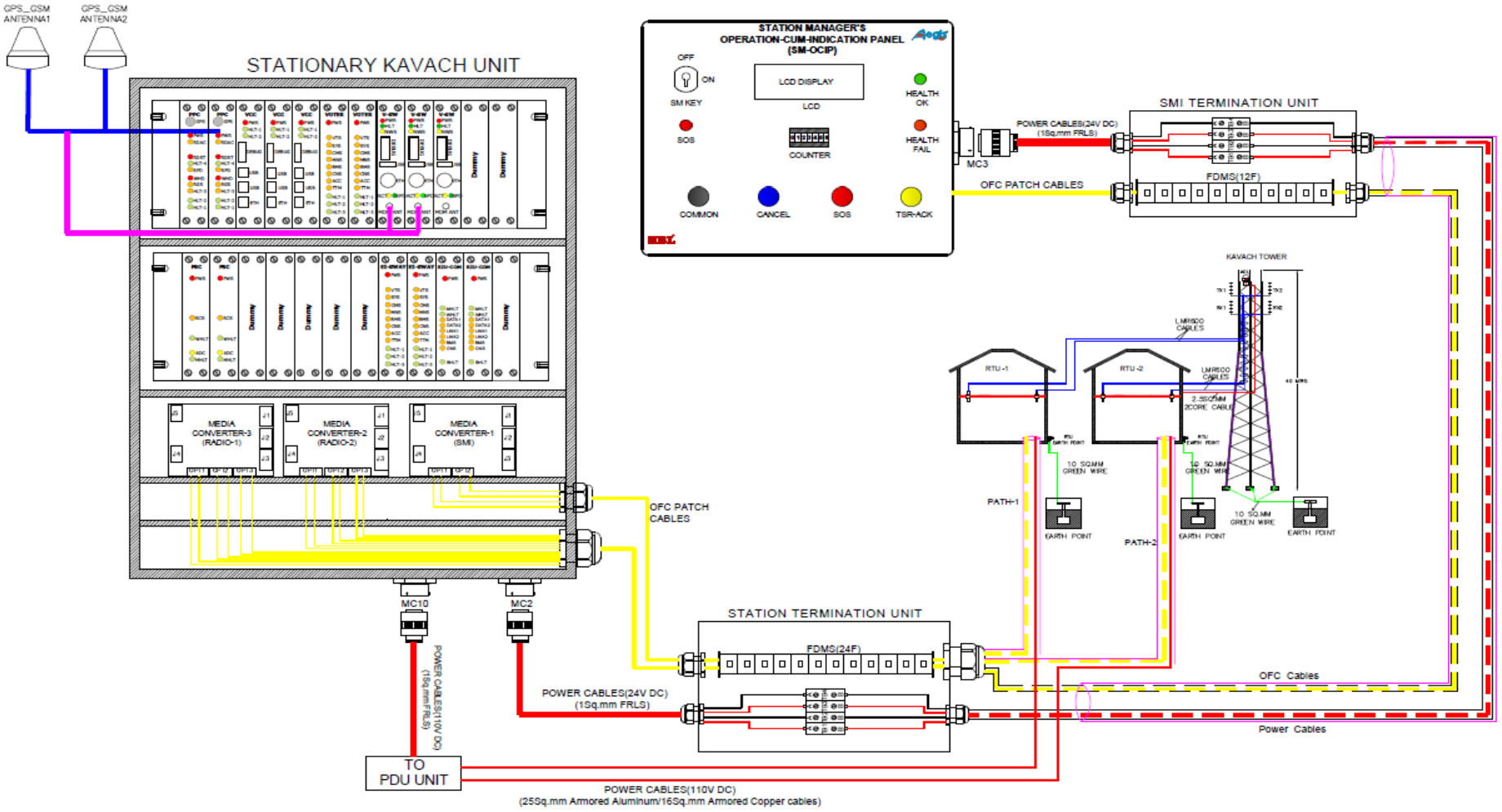

Figure 1 : Stationary KAVACH Overview

3 MODULES AND CONNECTIONS :

The Stationary KAVACH is divided into sub-systems and are divided into modules.Each card is housed in a cassette as a module.The modules are placed in 19” 4U sub-rack and these sub-racks are placed in an enclosure to form the Stationary 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 Stationary KAVACH are connected through the MIL grade connector to achieve proper connectivity.

4 INPUT AND OUTPUT CONNECTIONS OF STATIONARY KAVACH SYSTEM :

- **The input connection for the Stationary KAVACH unit are :**

a) 110VDC Power Supply from the Power Distribution Unit

b) Relay inputs from RRI/PI panel via TCAS Repeater Relay rack to FIU sub-system

c) GPS Antenna connection with LMR 200 cable

d) GSM Antenna connection with LMR 200 cable

e) RF Antennas(Tx & Rx) connection with LMR 600 cable

- **The output connection for the Stationary KAVACH unit are :**

a) SM-OCIP connection via SM-OCIP OFC Termination panel

b) Radio modem connection via Station OFC Termination panel

c) S2S Ethernet connection via network routers/optical modems

d) NMS Ethernet connection to NMS server via network routers

4.1 POWER SUPPLY SYSTEM :

The 110VDC power supply is taken from IPS room and is connected to Power Distribution Unit.Stationary KAVACH and Radio Tower Unit works on 110VDC power supply connected from Power Distribution Unit.TCAS Repeater Relay rack works on 24VDC power supply.

Each incoming 110V DC power supply is protected against short-circuit using HRC Fuses and MCBs. Also,diode protection is provided to prevent reverse polarity connection.

The incoming 110V DC power supply is fed to EMI/EMC Filter before connecting to the respective KAVACH subsystem.

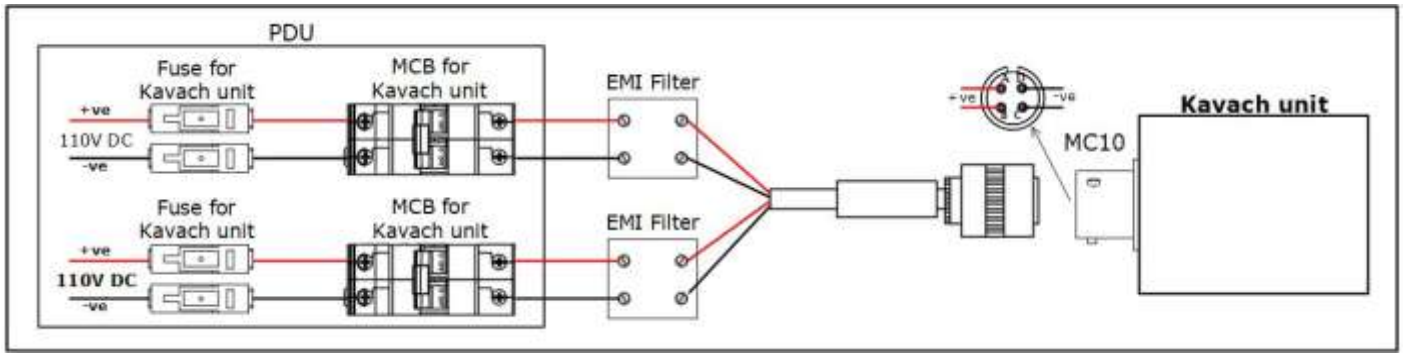

Figure 2 : Power Supply System

In the KAVACH/IB/LC 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/IB/LC sub-system comprises of following modules :**

  A. Peripheral Processing module

  B. Vital Computer module

  C. Voter module

  D. Vital Gateway module

- **Field Interface Unit (FIU) sub-system comprises of following**

  E. FIU-Termination module

  F. Scanner module

  G. EI Gateway module

  H. RIU Communication module

- **Other :**

  I. Digital Power Supply

  J. RS485 - OFC Converter

  K. RTU - OFC Converter

4.3 MODULES HOUSING :

The housing will accommodate the sub-systems in 19” 4U sub-rack.There is a separate 19” 4U sub-rack for the KAVACH sub-system and FIU sub-system.The arrangement of sub-rack is given below:

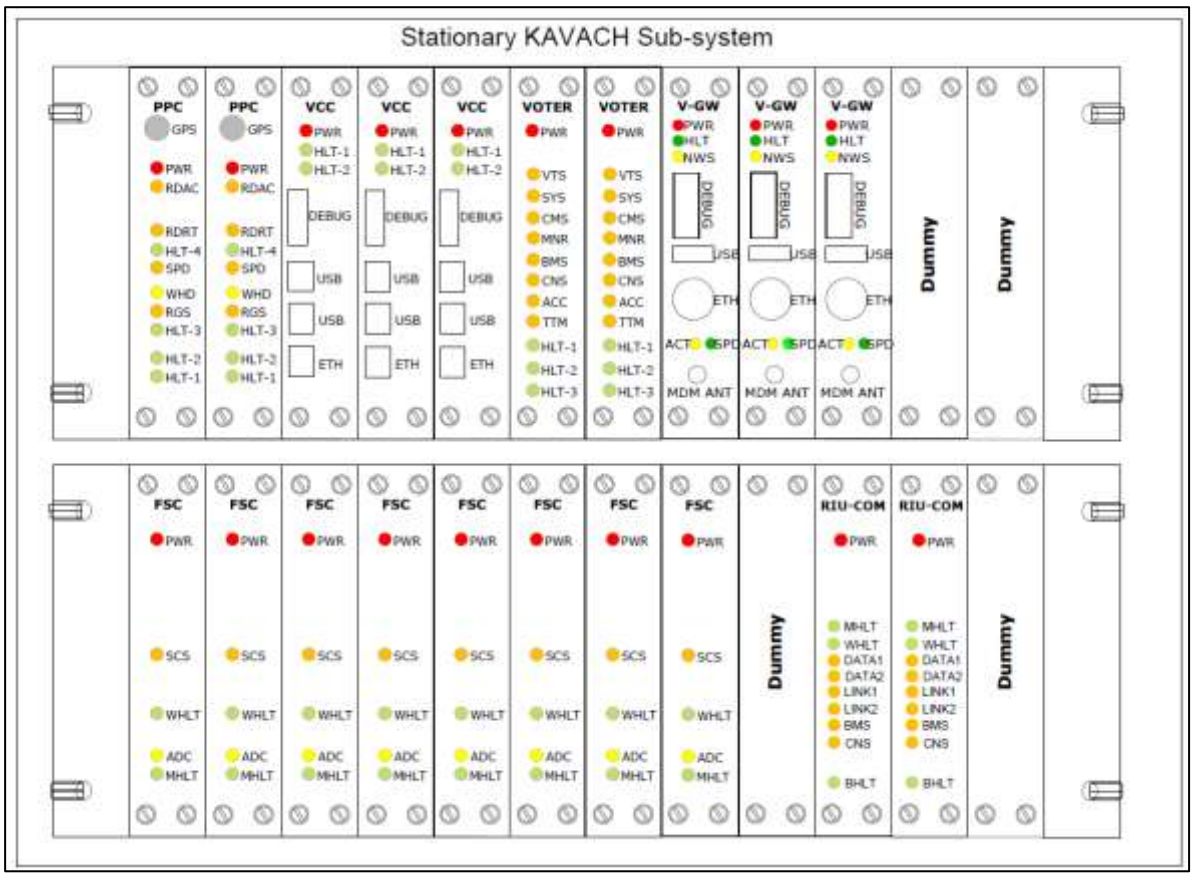

Figure 3 : KAVACH & FIU Sub-rack unit

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 and GPS module. 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

Note: SPD and WHD LED indications on the PPC module are applicable only for Onboard KAVACH PPC module.

B. Vital Computer Card(VCC)

In Stationary 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)

Stationary 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.

Three VGW modules are placed in Stationary KAVACH,out of which:

- Two are responsible for Station-to-Station communication(S2S) and KMS.For availability, two VGW modules work in hot standby configuration.
- One for NMS

Diagnostic LED indications for Vital Gateway card (V-GW) 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. Field Termination Card(FTC)

The Field relay contacts from TCAS Repeater Relay rack are connected to FTC available on the Stationary KAVACH.The maximum field input capacity of Stationary KAVACH is 128 inputs.

F. FIU Scanner Card(FSC)

The FIU Scanner can accept either front or back contact of the relay in the RRI panel. Two FIU Scanner modules are used for the same set of 32 field inputs to increase the availability of the field-input interface.Eight FIU Scanner modules shall read 128 field-inputs.Each field-input connected to the FIU Scanner module is scanned and sent to the Vital Computer modules on System Bus, which is a dual isolated CAN Bus.

Diagnostic LED indications for FIU Scanner (FSC) are as follows:

#	LED	Description
1	PWR	24V DC Available
2	SCS	Field Input scanning
3	WHLT	Micro-controller2 health status
4	ADC	Scanner card address status
5	MHLT	Micro-controller1 health status

G. RIU Communication Card(RIU-COM)

The RIU Communication reads additional field inputs from the remote units available at Goomty/Location Box through OFC network via OFC Rack and send to the Vital Computer modules on System Bus.For availability, two RIU-COM modules work in hot standby configuration.

Diagnostic LED indications for RIU Communication are as follows:

#	LED	Description
1	PWR	24V DC Available
2	MHLT	Micro-controller1 health status
3	WHLT	Micro-controller2 health status
4	DATA1	Data status through Link1
5	DATA2	Data status through Link2
6	LINK1	OFC-Link1 status
7	LINK2	OFC-Link2 status
8	BMS	Bus Master Status
9	CNS	CAN bus status
10	BHLT	Micro-controller3 health status

H. Digital Power Supply Card(DPS)

The input power supply to the Stationary KAVACH unit is 110V DC. The Stationary 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 SM-OCIP UNIT :

The Station Master Operation Cum Indication Panel (SM-OCIP) is installed in the Station Master's room and it is connected to the Stationary KAVACH through dual RS485 interface via SM-OCIP OFC Panel.The SM-OCIP is installed in a convenient place from where it is easily operated and accessed.

The Station Master can generate and cancel SOS messages during emergencies. The SM-OCIP comprises of LCD to show the messages. Push-button switches are provided for generating SOS, and for acknowledging messages.SM-Key is provided to lock the operations on the SM-OCIP by the Station Master. The SM-OCIP also has LED indications for indicating the health of the system and SOS status .

The SM-OCIP displays the messages received from the Stationary KAVACH. The Panel wiring is done in such a way that the Push buttons used to perform SOS related operations gets activated only when the SM's Key is turned to ON position.

The SM-OCIP also accommodates a seven-digit non-resettable electro-mechanical counter on the panel. The counter will increment whenever KAVACH generates SOS.

The details are as follows:

#	Switch Name	Colour	Description
1	COMMON	Black	Common switch pressed along with SOS/CANCEL
2	CANCEL	Blue	To cancel the command given through previous switch operation
3	SOS	Red	To generate SOS
4	TSR-ACK	Yellow	For TSR acknowledgment - Future purpose
5	SM-KEY	---	To lock the SM-OCIP panel

There are three LEDs on the SM-OCIP :

#	LED Name	Color	Description
1	HEALTH OK	GREEN	KAVACH healthy status
2	HEALTH NOT-OK	RED	KAVACH unhealthy status
3	SOS	RED	SOS is generated

The arrangement between SM-OCIP and the Stationary KAVACH is as follows:

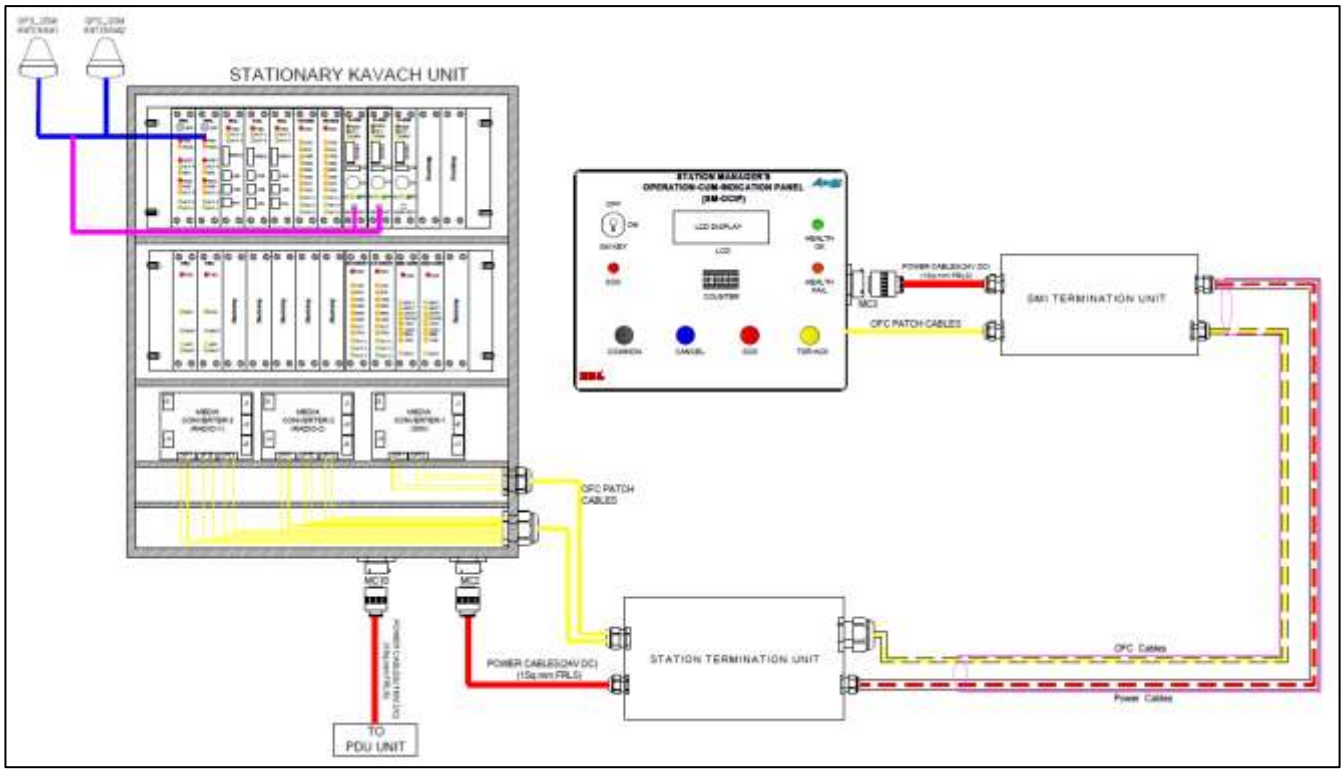

Figure 4 : SMOCIP Connectivity

4.6 RADIO MODEM :

The Radio Tower units are installed on the Radio tower.The Radio modems are available in the Radio Tower unit.The communication between the Radio modems and the Stationary KAVACH system is through OFC network.

The Station TCAS Radio communication arrangement is as follows:

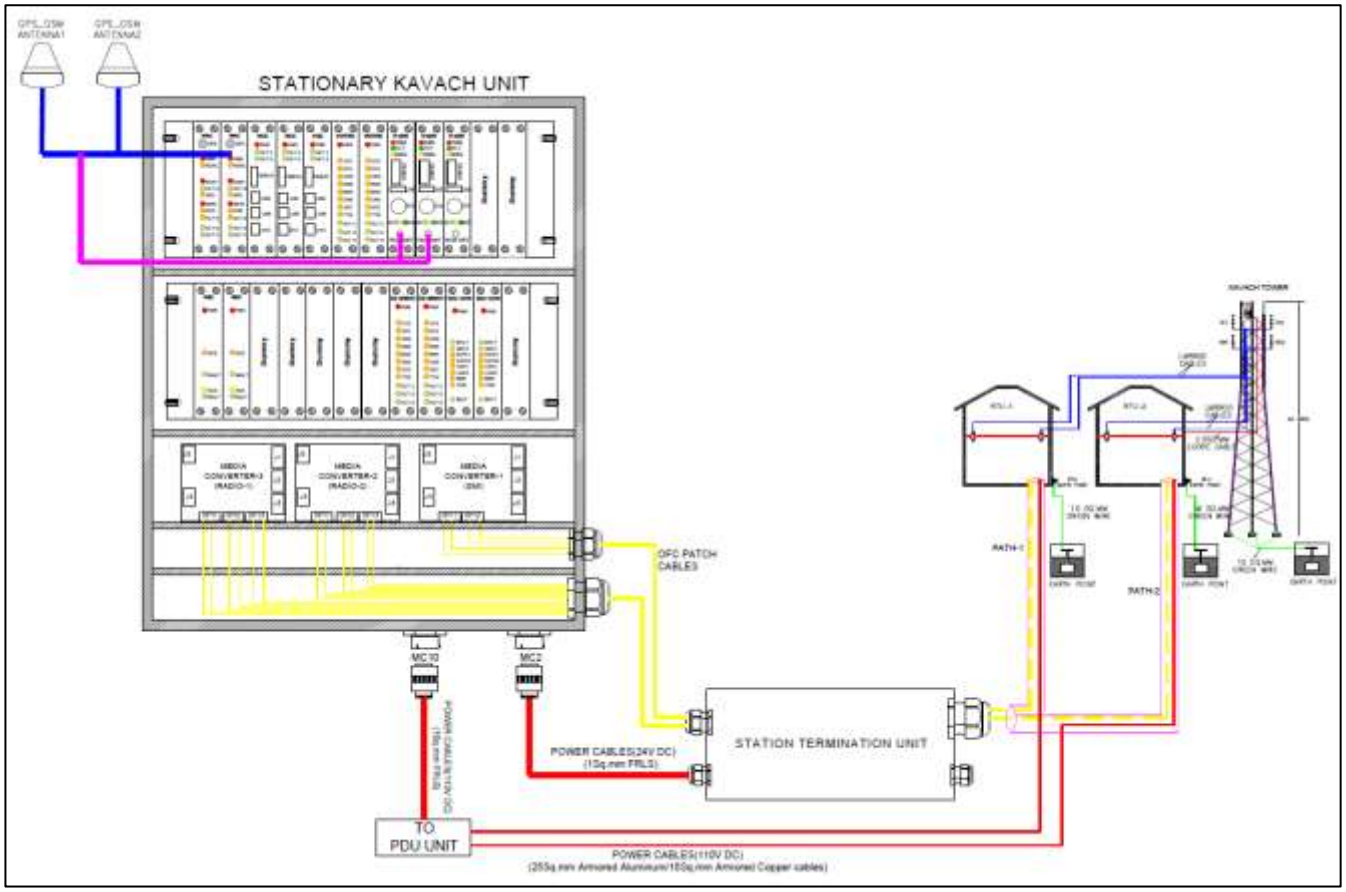

Figure 5 : Radio modem connectivity with Stationary KAVACH

4.7 RF ANTENNAES :

The Stationary communication system for Station/IBS/Level Gate unit shall provide communication coverage at least in the communication mandatory zone for the Stationary KAVACH.

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 6 dB

The RF Antennas are installed to the Radio Tower.The RF Antenna connection is shown below:

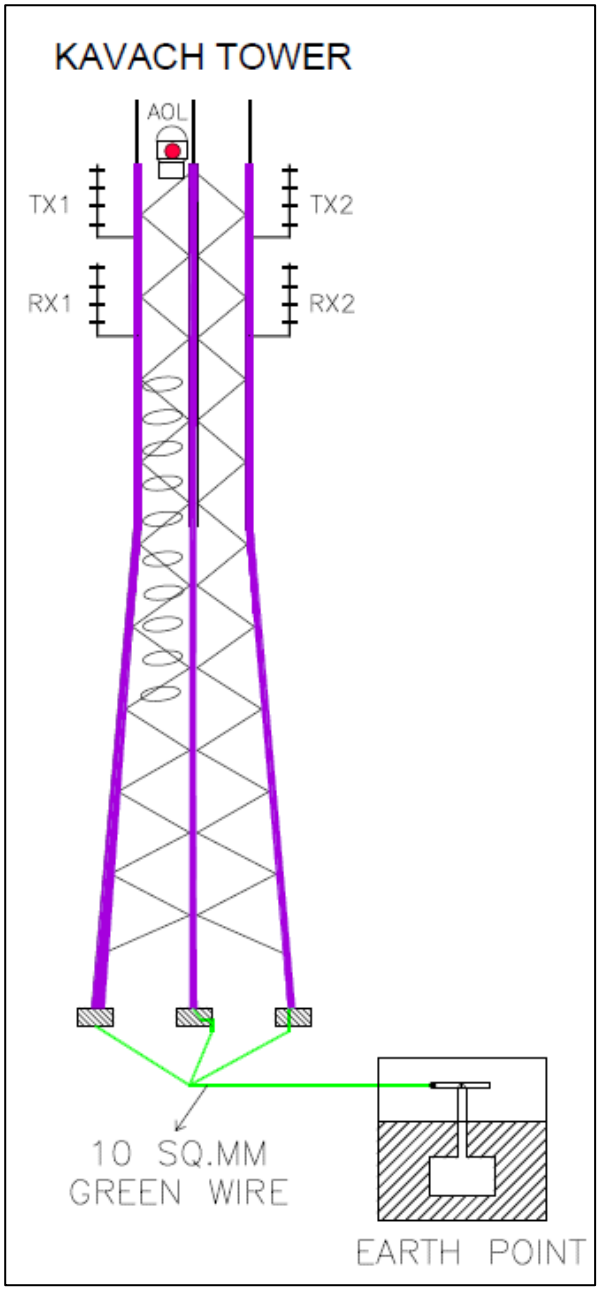

Figure 6 : RF Antennas connectivity

4.8 ETHERNET COMMUNICATION :

The Ethernet interface for communication is available on Vital Gateway module of the KAVACH system. In the Stationary KAVACH unit, the communication with NMS Server and neighboring Stationary KAVACH is achieved on the Ethernet interface.

The Error log data of the Stationary TCAS unit can be down-loaded to a Laptop or Desktop units through Ethernet communication interface.

The Ethernet interface for communication is shown below:

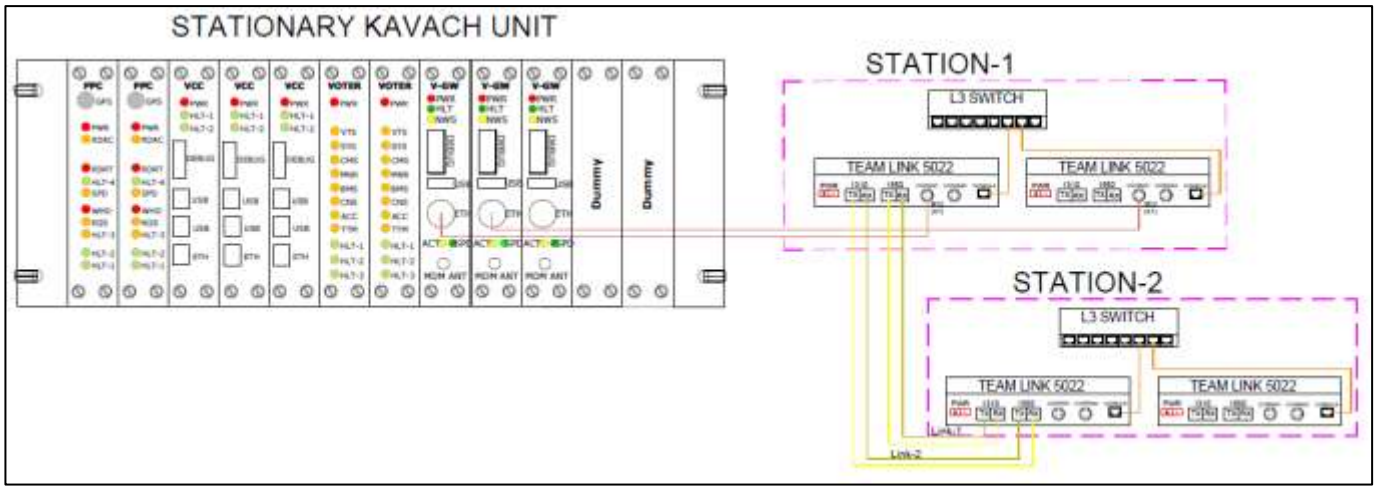

Figure 7 : Ethernet connectivity for S2S communication

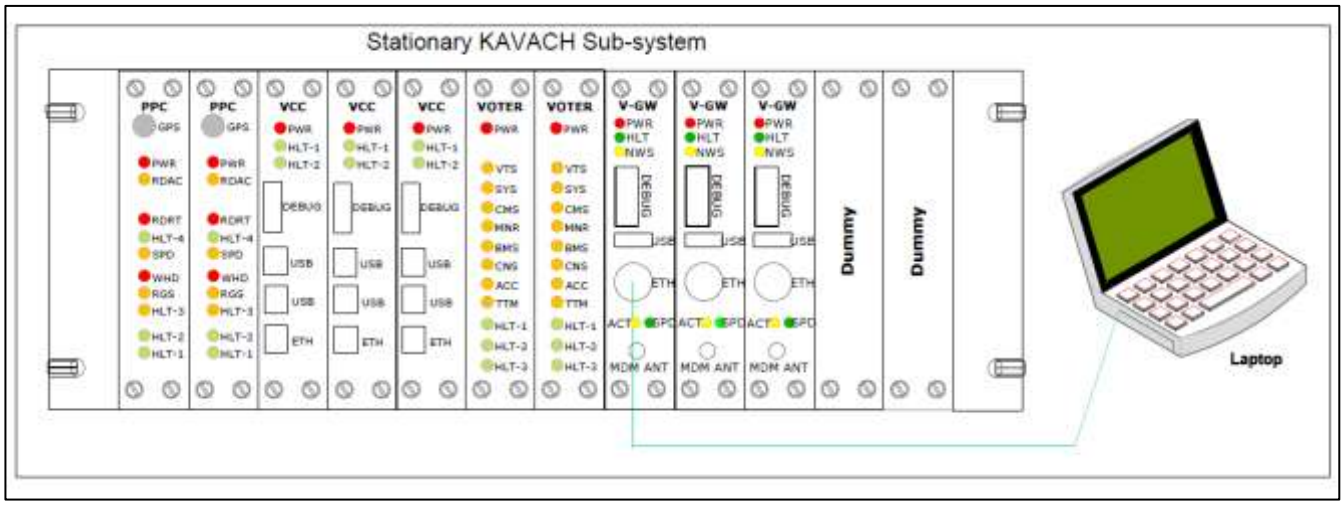

Figure 8 : Ethernet connectivity for Log downloading

4.9 COMMUNICATION WITH EI :

Apart from RRI / PI field inputs, Stationary KAVACH supports EI inputs.EI Gateway module is capable to handle the Station inputs I.e 2048 inputs.For availability, two EI modules work in hot standby configuration.

Diagnostic LED indications on EI card are as follows:

^

#	LED	Description
1	PWR	24V DC Available
2	VTS	Field 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

The Electronic interface(EI) with Stationary KAVACH is shown below:

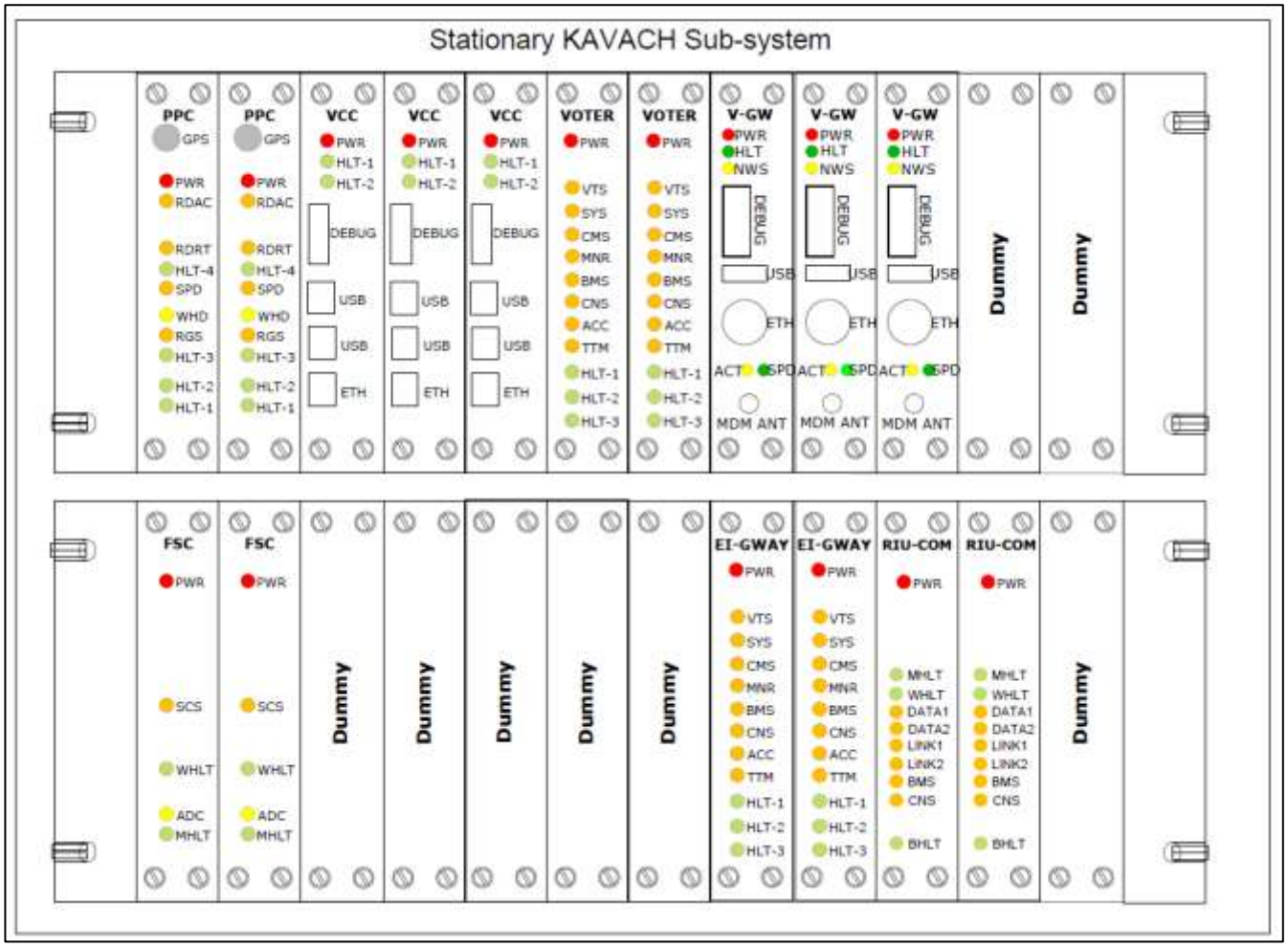

Figure 9 : EI connectivity

4.10 COMMUNICATION WITH RIUS :

Stationary KAVACH is adapted for auto section working by gathering the information of signals in the auto sections through remote Interface Units (RIUs). RIU is same as FIU with an addition of communication modules to communicate the line side signal and other filed gear information to station KAVACH over OFC.

The connectivity of RIUs with station KAVACH is as shown below.

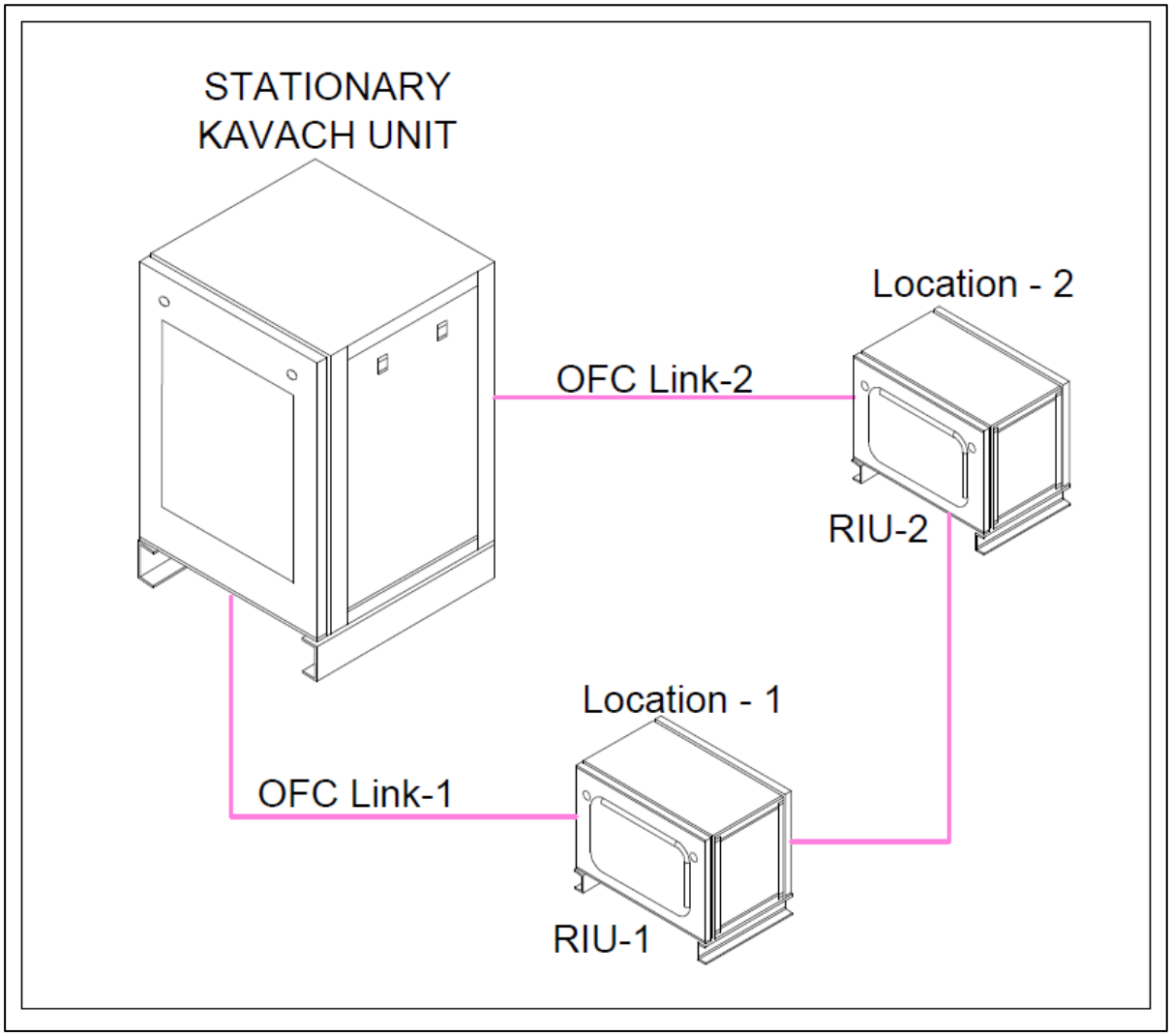

Figure 10 : RIU Connectivity

In Stationary KAVACH Host RIU communication modules are deployed.

The host RIU communication modules are housed in inside the Stationary TCAS enclosure.

The status of relays of RRI panel available in remote locations shall be scanned by Remote Interface Unit (RIU), known as REMOTE-RIU and shall be communicated over optical fiber channel to the Remote Interface Unit (RIU), known as HOST-RIU installed in stations. The HOST-RIU shall transfer the status of relays, received from REMOTE-RIU, to the Station KAVACH unit over CAN-Bus.

4.11 GPS & GSM ANTENNA :

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

GSM Antennas are connected to S2S Vital Gateway card(V-GW).

The connectivity is shown in the following figure:

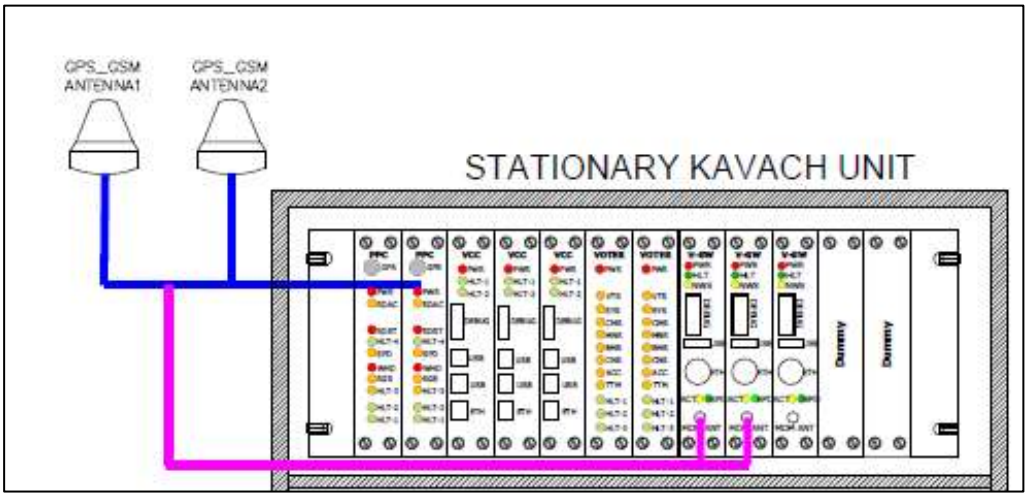

Figure 11 : GPS & GSM Antenna connectivity

5 AVAILABILITY, RELIABILITY AND REDUNDANCY :

Availability, reliability and redundancy is achieved in Stationary 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 for S2S communication.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 FIU Scanner along with two FIU Termination cards both are active to maintain redundancy
- There are two EI Gateway cards for Electronic Interlocking inputs.One card is active, and another card is available as hot standby.
- There are two isolated RS-485 interfaces to SM-OCIP module to maintain availability as redundant communication channels

6 COMPLIANCE AND SAFETY :

The KAVACH subsystems comply with RDSO specifications RDSO/SPN/196/2020, Version V4.0, 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: M.Jagruthi
M.Jagruthi (May 4, 2025 18:25 GMT+5.5)
Email: jagruthi.m@hbl.in
Title: Engineer

Signature: JWSNV Prasad
Email: prasad.jagatha@hbl.in
Title: Sr.Manager

Signature: 
Email: hemant.sagade@hbl.in
Title: Safety Manager

Signature: Pradeep Kongalla
Pradeep Kongalla (May 4, 2025 20:15 GMT+5.5)
Email: pradeep.kongalla@hbl.in
Title: IV&V and QA Head