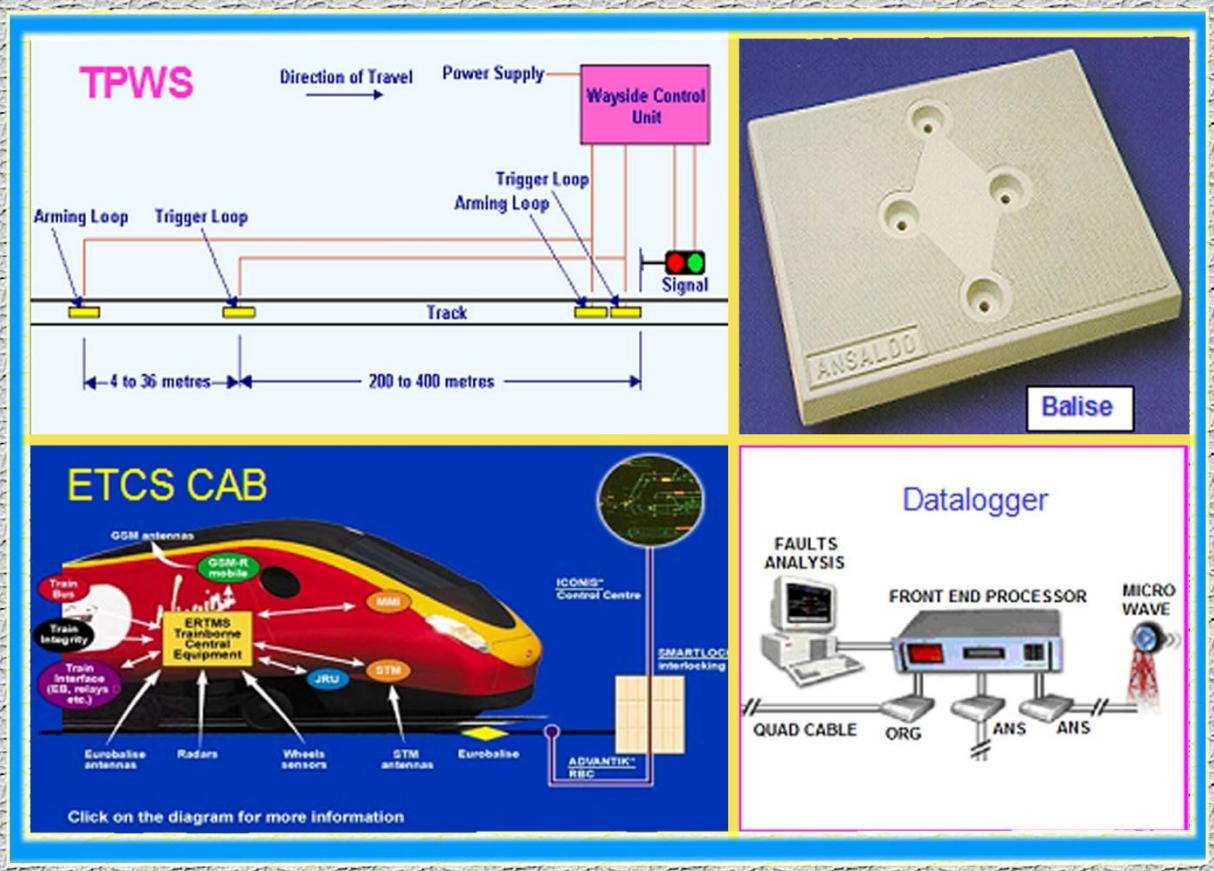
इरिसेट IRISET

S 28

DATA LOGGER, TPWS, TCAS, AWS AND ETCS



Indian Railways Institute of
Signal Engineering and Telecommunications

SECUNDERABAD - 500 017

S 28

DATA LOGGER, TPWS, TCAS, AWS & ETCS

VISION:	TO MAKE IRISET AN INSTITUTE OF INTERNATIONAL REPUTE, SETTING ITS OWN STANDARDS AND BENCHMARKS
MISSION:	TO ENHANCE QUALITY AND INCREASE PRODUCTIVITY OF SIGNALLING & TELECOMMUNICATION PERSONNEL THROUGH TRAINING

The Material Presented in this IRISET Notes is for guidance only. It does not over rule or alter any of the Provisions contained in Manuals or Railway Board's directives

INDIAN RAILWAYS INSTITUTE OF
SIGNAL ENGINEERING & TELECOMMUNICATIONS
SECUNDERABAD - 500 017

Issued in March 2014

S-28

DATA LOGGER, TPWS, TCAS, AWS & ETCS

CONTENTS

Checked By	IES5, IES7, SSE (D), LS2, PS2
No. of Pages	106
Date of Issue	March , 2014
Version	A3

Incase of any suggestions please write to LS2/PS2 or mail to LS2/PS2 at email address ls2@iriset.indianrail.gov.in/ ps2@iriset.indianrail.gov.in

CHAPTER 1: DATA LOGGER

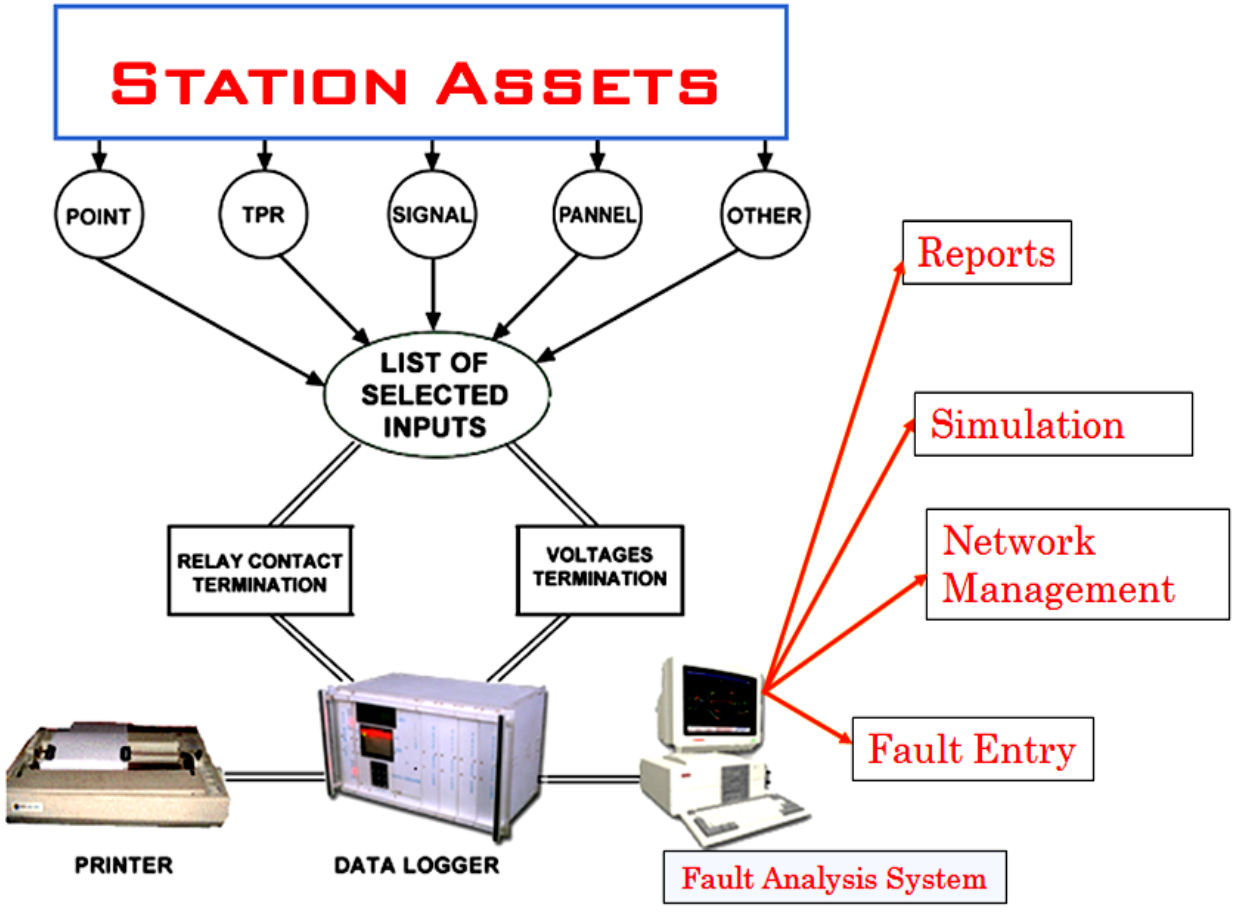
1.1 INTRODUCTION

Data logger is a Microprocessor based system, which helps in analysing the failures of relay inter locking system (PI & RRI) / Electronic Interlocking system (EI). This is like a black box, which stores all the information regarding the changes that take place in relays , AC / DC Voltages and DC currents along with date and time. The same information / data can be transferred to the computer to analyse further “on line" / “off line” analysis of stored data. A print out also can be obtained through a printer by connecting directly to the Data logger unit.

The data of Relay contacts is considered as digital inputs and the data of voltage levels / currents is considered as Analog inputs**.**

Data loggers are mandatory for all new relay interlocking (PI/RRI) , EI installations and it is also recommended to provide in all existing PIs / RRIs.

To increase the line capacity, mechanical signaling installations are upgraded to PI / RRI or EI. Due to complexity in the circuits and wiring sometimes it is very difficult to rectify the failures. As Data logger can monitor these systems with real time clock it can be used as a vital tool for accident investigation. Data loggers are provided at Stations / yards, whereas in Auto Section & IBH, Mini Data logger, called as Remote Terminal Unit (RTU), is used.



1.2 ADVANTAGES OF DATA LOGGERS

(a) Data logger helps in monitoring typical failures such as intermittent, auto right failures.

(b) It helps in analyzing the cause of accidents.

(c) It helps in detecting the human failures / errors such as :

(i) Drivers Passing signal at Danger (SPAD).

(ii) Operational mistakes done by operating staff Signal & Telecom interferences in safety circuits.

(iii) Engineering and Electrical department interferences / failures.

(iv) It helps as a “Diagnostic tool” in preventive maintenance of signaling gears.

(d) Data loggers can be connected in network. Networked Data loggers help to monitor the PI/RRI/EI remotely

(e) Failure reports can be generated remotely with help of Data logger network

(f) On line and Off line track simulation is possible.

(g) Speed of the train on point zones can be calculated.

(h) Age of the equipment in terms of number of operations etc can be assessed .

RDSO specification for Data logger is IRS:S-99/2006. As on date maximum number of Data loggers provided in Indian Railways are of EFFTRONICS make.

1.3 COMMON EQUIPMENT FOR ALL DATA LOGGERS ARE GIVEN BELOW:

(a) CPU card .

(b) Digital and Analog input cards.

(c) Local terminal.(PC).

(d) communication links.

(e) Printer.

Potential free contacts of relays are used for monitoring digital inputs through Digital scanner cards and AC/DC bus bar voltages are used for monitoring Analog inputs through Analog scanner cards in all data loggers.

Digital and Analog inputs are connected to the CPU card. The CPU card consists of memory IC’s. Memory IC’s are programmed as per requirement of the signal engineers.

The data collected by the Data logger can be used for failure analysis, repetitive discrepancies, and for accident investigations.

1.4 STUDY OF EFFTRONICS DATA LOGGER (IRS: S-99/2006)

1.4.1 Technical details

(a) 24V DC Power Supply.

(b) Total Storage Capacity of 10 Lakh events.

(c) In-built Temperature sensors.

(d) Internal Buzzer for alarming during failures.

(e) Real Time clock with internal battery backup with data retention up to 10 years.

(f) 512 LED matrix to indicate the status of Digital inputs .

(g) Seven segment LCD screen (2x24 alpha numeric characters) to display the status of digital/analog signals, Time, Temperature etc.,

(h) Using the keyboard, various functions can be viewed in the LCD screen .

(i) Max Digital Inputs 4096.

(j) Max Analog Inputs 96.

(k) Digital Input Scanning Time is 16 millisecond.

(l) Analog Input Scanning Time is less than 1 Sec.

Fig: Efftronics Data logger system

1.4.2 Hardware (Equipment)

Data logger system consists of:

(a) CPU Module.

(b) Digital input cards.

(c) Dual modem card.

(d) Digital Scanner units (DSU)

(e) Analog Scanner units (ASU)

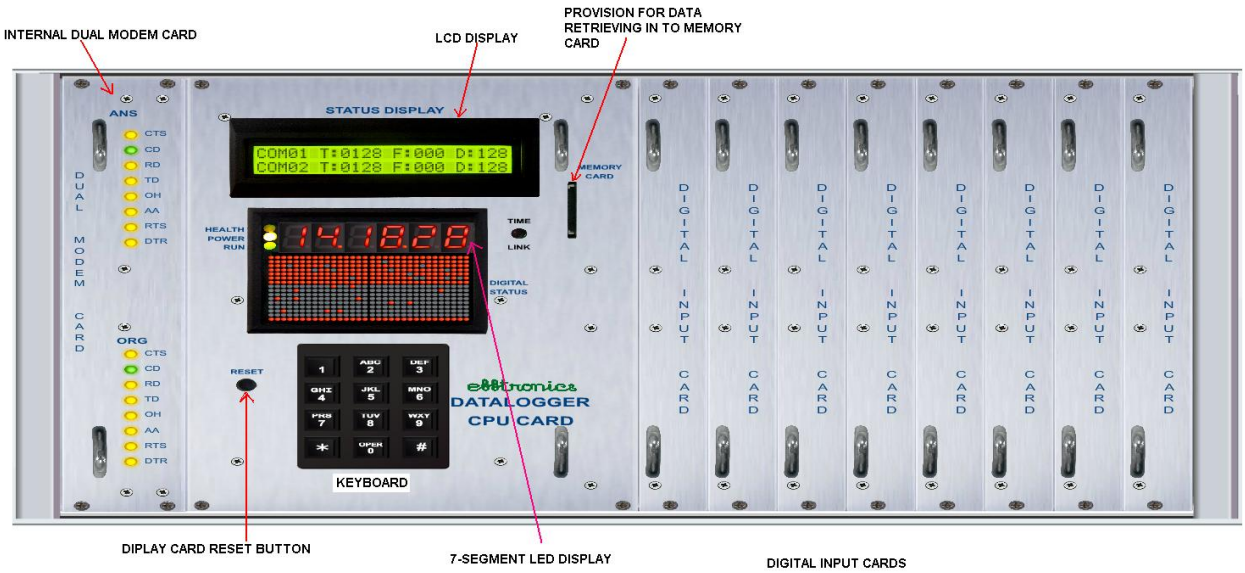


Fig: Efftronics Data logger CPU card file

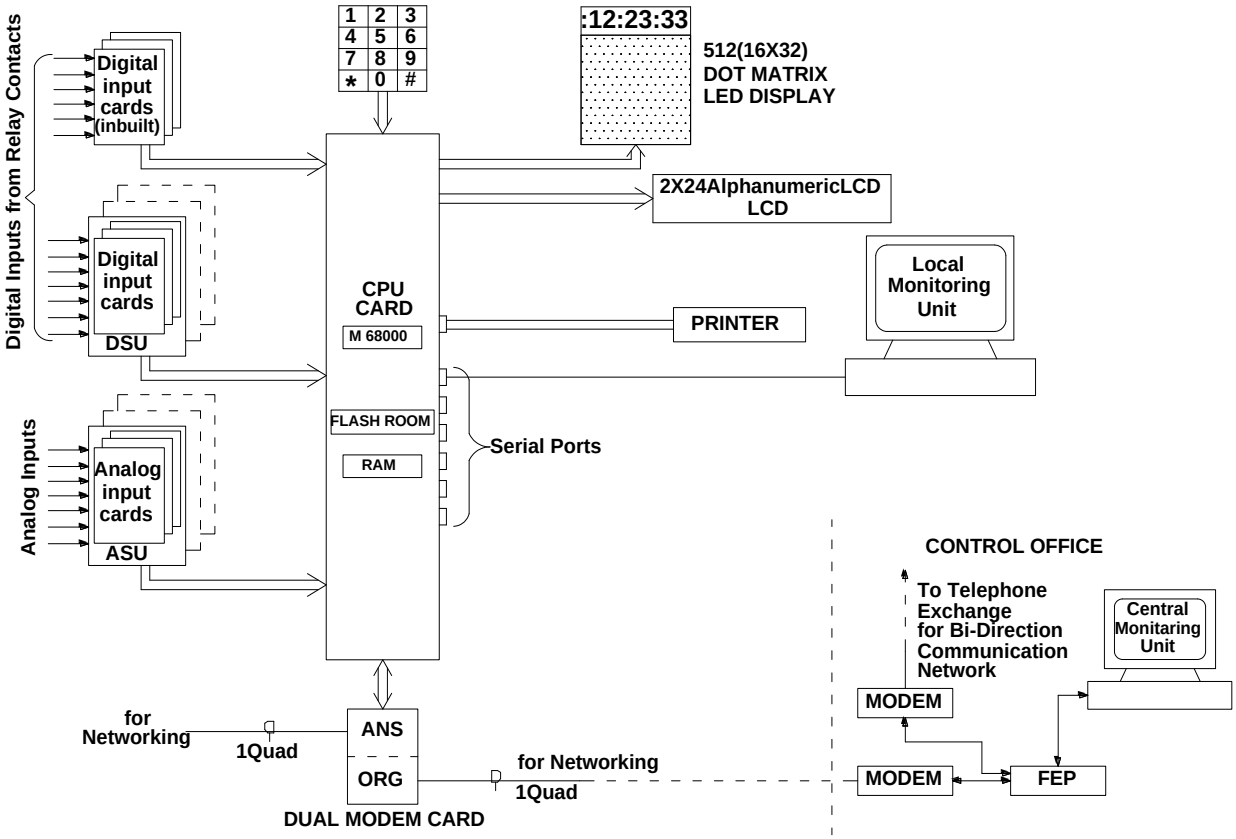


Fig: FUNCTIONAL DIAGRAM OF EFFTRONICS DATA LOGGER

1.4.3 CPU Module

CPU Module is the heart of the Data logger and it does all the major functions. Motorola 68000 processor, capable of working at 20 MHz speed, is used in CPU module. It contains NAND flash memory, which can store up to 10 Lakhs packets. It has Real Time Clock for keeping time. It continuously scans (check) the Digital input cards (inbuilt), Digital Scanner Units and Analog Scanner Units. i.e., it scans digital signals (Relay operations) for every 16-milli seconds and scans analog signals (i.e. AC/DC voltages & DC currents) for less than 1 second.

CPU Module continuously scans (checks) the DSUs and ASUs. Each input connected to digital scanner units are optically isolated by Opto couplers. When CPU card scans the digital inputs, it compares with the previous stored data and if there is any change from the previous status then only that data will be stored (the status / conditions of relay) with date and real time. A maximum of 10 Lac events can be stored in memory on first in first out basis so that latest data is available in the system. There is no loss of data from Data logger memory in case of power supply failure of Data logger.

It has two dip switches, one for configuring Data logger ID and the other for configuring the number of digital inputs.

The Data logger ID can be configured using the 8-way dip switch, as follows:

- Data logger identification number always starts from “65”.
- If any switch is in the direction “ON” (it is marked on the DIPSWITCH) which indicates LOW, otherwise it is “HIGH”.
- Different combinations of the dipswitch settings will give the different identification numbers.

CPU Module has 16 ports for serial communication, out of which:

- 3 ports are dedicated to Display card, Serial printer, and Memory card.
- 4 ports are generally used as Answering, Originating, T- Network port, and Debugger port.
- 6 ports are used for connecting Analog Scanner Cards.
- 3 ports are used for Remote Terminal Units/Electronic Interlocking system/Point machine health monitoring unit /IPS.

Display Card (DIS) is the part of the CPU module and it acts as interface between user and the Data logger. Hence it is also known as User interface card. It houses LCD (Liquid Crystal Display) - 2X24 display, 7-Segment LED block, Processor status LEDs, Dot matrix LED block, Keypad, Display Reset button, and MMC card insertion slot. User can perform various operations through this card. The 7-Segment LED screen displays current time of data logger. Real time clock is provided by DALLAS 1286 chip. This IC comes with internal battery backup.

LED Indications for Processor Health Status

Three LEDs are provided on front side of display card (below LCD panel) to indicate the health status of processor to the user. Normally, all the three LEDs should be continuously ON.

1. Health LED indicates whether the 68000 processor has booted (started execution of code) or not.
2. Power LED indicates whether power supply to CPU module is ON or not.
3. Run LED indicates whether the 68000 processor is in running state or not.

Fig: LED INDICATIONS on CPU Card

Sl. No	Health LED	Power LED	Run LED	REMARKS
1	ON	ON	ON	CPU module running normally
2	OFF	ON	ON	Processor boot failed
3	ON/OFF	ON	OFF	Processor is in halt state
4	---	OFF	---	Power supply not turned ON. Check power supply to Data logger

LED Block Display

Online status of each digital input is indicated by one LED on the LED block display on the facial of Data logger. LED is lit when the contact being monitored (either front or back) is closed.

Display Card RESET Button

On the front side of display card, RESET button is provided (indicated as Display Card RESET Button) for refreshing of display when the display hangs. Resetting display does not have any effect on the operation of CPU module, and hence it is safe to use.

Provision for DATA retrieving in to External Memory Card

Flash Memory Chip is used for data backup of about 10 Lakhs events. User can see the flash Memory Chip status. User can copy the files from Flash Memory to External Memory Card by inserting it into the slot by the side of LCD display.

DSU Ports (Digital Scanning Unit Ports)

Seven no. of DSU ports are provided in the CPU module. Each DSU port receives digital input data of 512 inputs from one Digital Scanner Unit .

ASU Ports (Analog Scanning Unit Ports)

Six nos. of Analog Input ports are provided at the rear of CPU module to connect 6 Nos. of ASUs. Each Analog Input port receives input data of 16 analog channels from one Analog Scanning Unit.

Relay Control Port

It is possible to control 8 miniature relays inside the data logger through commands from Central Monitoring Unit (CMU). Signals to control these relays are conveyed through Relay Control Port. These relay contacts can be used for controlling the power equipment, generating alarms etc. Provision to connect external devices to these relay outputs has been provided on the adapter PCB. The devices should be connected to the relay controls as per the numbers provided on the adapter PCB. Each control can sink or source 100 m. amps of current.

1.4.4 Digital input cards (in-built)

This system is provided with 8 nos. of digital input cards as inbuilt cards, connected to the same mother board on which processor card is fixed. Maximum 64nos. of digital inputs can be connected to each digital input card. The potential free relay contact, may be front or back contact, terminated at the Tag Block from the relay of signals, tracks, points, Buttons etc. and are subsequently connected to Digital input cards through Flat Ribbon Cable (FRC) connectors. These in-built digital input cards can monitor a total 512 nos. of relays status. In the figure, Input1 (A1, A2) contact is open (front contact) and Input2 (B7 & B8) contact is closed (back contact). Wires from all the relay contacts, those are to be monitored by data logger, are terminated on Intermediate Tag Block (ITB). For this purpose 16/0.2 wires are used for Q-series (metal – carbon) relays and 0.6mm single strand wires are used for metal to metal contact relays. Single strand multi core indoor cables are used for ITB to DTB (Digital Tag Block) wiring. Flat Ribbon Cables are used for DTB to Data logger wiring connections. As per latest RDSO Guidelines in addition to SSI Protocol converter vital input and vital output relays of EI are to be wired in the Data logger .

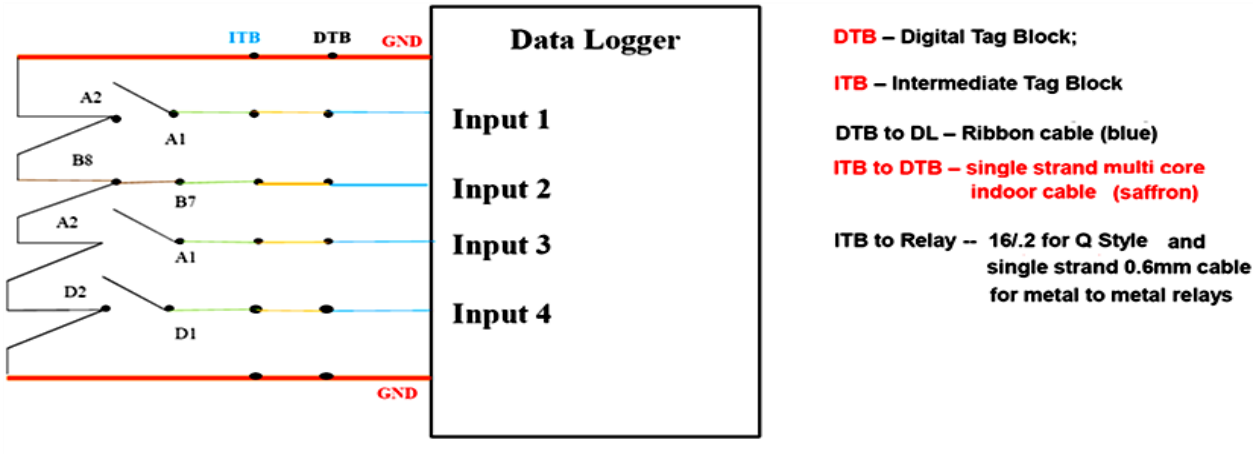


Fig: Digital Input Connections to Datalogger System

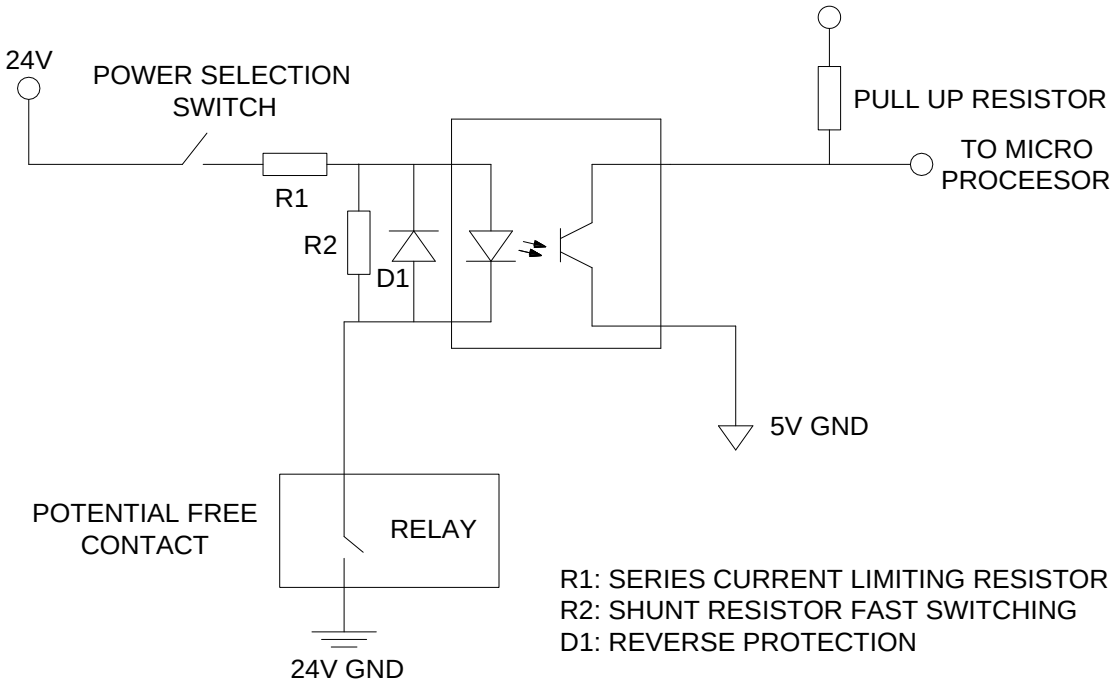


Fig: Digital Input Monitoring

1.4.5 Digital Scanner Unit (DSU)

If we want to monitor more than 512 relays status then it is required to provide Digital Scanning Units (DSUs) externally to the Data logger system. These DSUs are required to be connected to the digital input ports of Data logger system. Maximum 7 nos. of DSUs can be connected to the Data logger system and each DSUs is connected to one no. of digital input port of Data logger. Each DSU is provided with 8 nos. of digital input cards. Each digital input card can able to read the status of 64 nos. of relays. Digital input capacity of each DSU is 512. From 7 nos. of DSU ports 3584 digital inputs data is received by processor. 512 inputs are monitored directly through the mother board connection to the processor. Thus 4096 inputs are monitored by one processor (Data logger). So, Digital input capacity of the system is 4096. All these digital inputs are scanned at rate of 16 m.sec.

1.4.6 Analog Scanner Unit (ASU)

ASU contains maximum 2 nos. of Analog input cards. Each input card can be connected with 8nos. of Analog inputs. Total input capacity of the ASU is 16 analog input channels. Each scanning unit is connected to the processor by one serial port. 6 Nos. of Analog Input ports are provided at the rear of CPU card to connect 6 Nos. of ASUs. Thus 96 analog inputs can be monitored by Data logger. All these analog inputs are scanned at a rate of less than 1 sec.

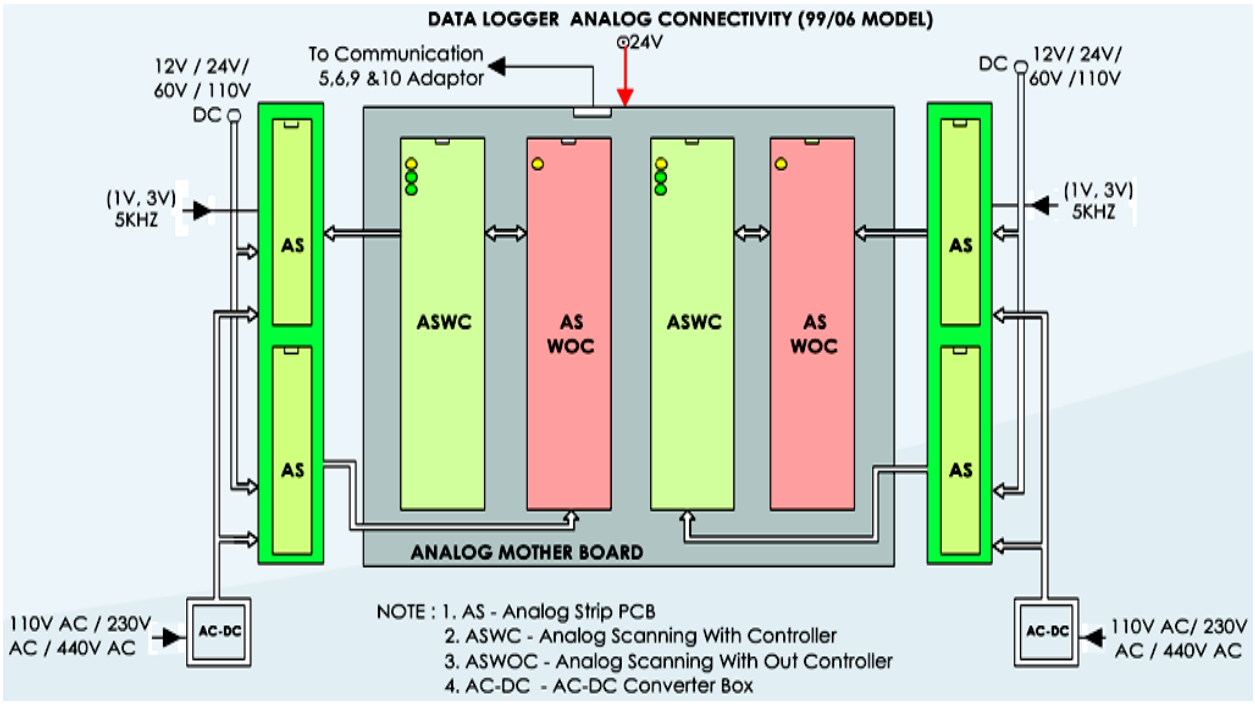


Fig: Diagram of Analog Scanner Unit

Analog Scanner Unit is provided in the analog euro rack. It has two cards.

Card 1: Analog scanner card with controller, which supports 1-8 channels.

Card 2: Analog scanner card without controller, which supports from 9-16 channels.

To support a scanner card without controller, it is mandatory to have a scanner card with controller in every set.

The LED indications are provided on the 'Analog Scanner Card with Controller' for failure identification.

Green LED-TX: Data transmission to Data logger

Yellow LED-Rx: Data receiving from Data logger.

Both TX and Rx LEDs should blink continuously if the data is transmitting to Data logger. In case if any abnormality is found in the LED indications please continue further checking. Serial communication cable (Between analog cards and Data logger) is connected. The input fuse is provided in scanner card with controller.

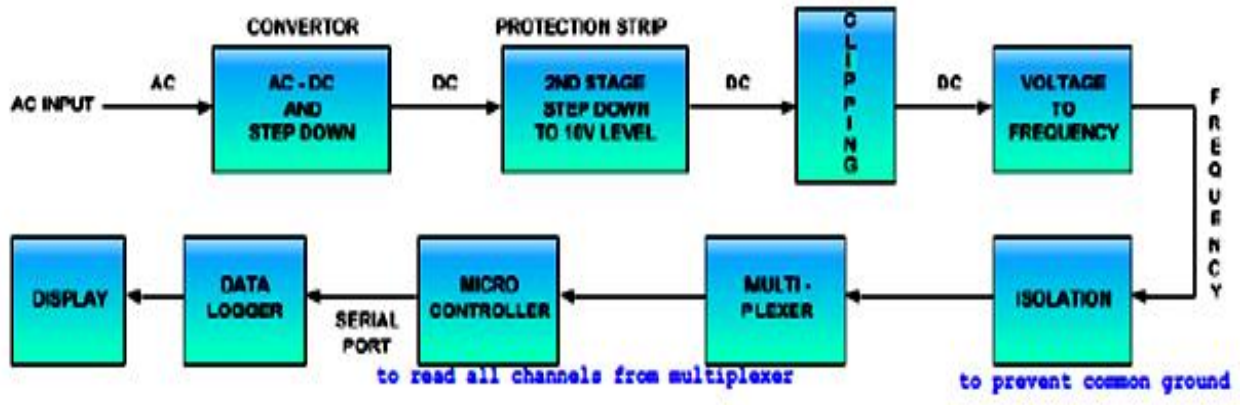


Fig: Analog inputs processing

1.4.7 Printer port

A serial printer port (9-pin D connector) is available on adapter card of the Data logger. To this port a serial printer can be connected.

1.4.8 Internal modem card / Dual Modem card (in-built)

To enable long distance communication, Data logger has an internal dual modem card, arranged vertically in Euro rack. The upper modem is called Answering Modem and the lower modem is called Originating modem. With two modems, each Data logger can connect to two adjacent Data loggers, to form a ring structured network. This helps Data logger to send data in two directions of the network. Communication is carried over analog voice channel. Quad cable/OFC voice channel is used for inter-modem communication. The modem to line speed is 14.4 Kbps (Kilo bits per sec) and Data logger to Modem speed is 57.6 Kbps. There is a provision to connect two more modems externally to the Data logger.

States of modems can be known from the LED Indications on the modems. From the indications it is possible to find out whether the medium is faulty or modem is faulty.

CTS Clear To Send
CD data Carrier Detect
RD Receive Data
TD Transmit Data
OH Off Hook
AA Auto Answer mode
RTS Request To Send
DTR Data Terminal Ready

Fig: Indications on Dual Modem card

CTS (Clear To Send)	LED 'ON' – MODEM READY TO TRANSMIT
CD (Data Carrier Detect)	LED 'ON' – MODEM DETECTS VALID REMOTE MODEM This LED is normally 'ON' and it's 'OFF' state indicates that the Modem is not in link at the other end.
RD (Receive Data)	LED 'ON' – RECEIVE DATA FROM REMOTE MODEM
TD (Transmit Data)	LED 'ON' – RECEIVE DATA FROM LOCAL DL
	'TD' (Transmit Data)and 'RD' (Receive Data) LED's will frequently blink indicating the proper data transfer and receiving condition.
OH (Off Hook)	LED 'ON' – MODEM PICKUP THE LINE. It Indicates that the modem is working. It should be normally 'ON' LED 'OFF'– MODEM HANGS-UP. It indicates that the Modem is in Hang condition. Modem should be Reset.
AA (Auto Answer mode)	LED ON – Auto Answer mode
RTS (Request To Send)	LED ON – Request from DL for data transmission
DTR (Data Terminal Ready)	LED ON – DATA LOGGER IS READY TO SEND THE DATA

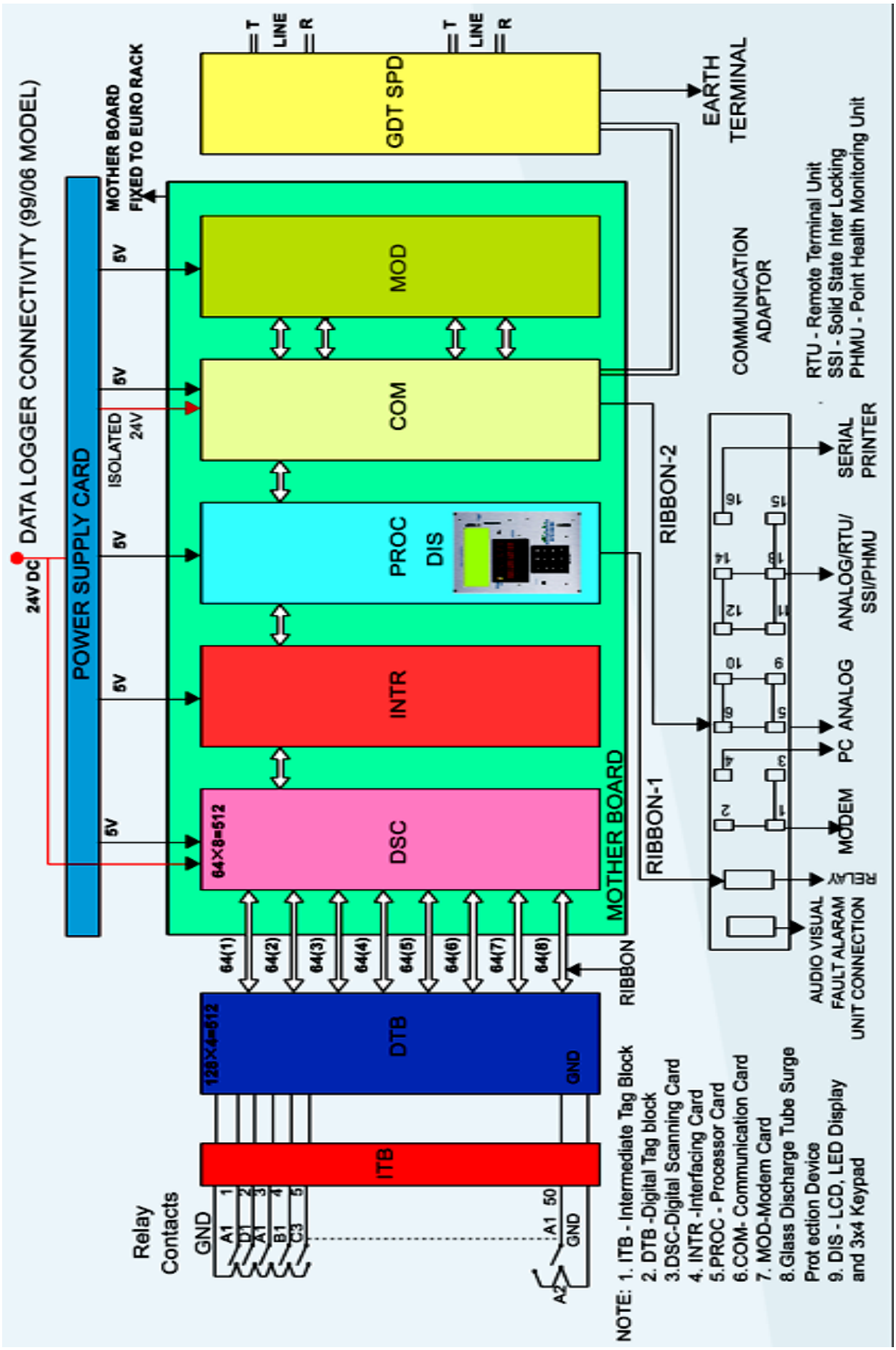


Fig: Efftronics Data logger connectivity diagram (99/2006 Model)

1.4.9 Intermediate Tag Block (ITB):

The relay contacts are terminated on this block. It supplies inputs and common ground to Digital Tag Block of Data logger.

1.4.10 Digital Tag Block (DTB):

It gives provision for termination of digital input lines on Data logger. Each tag block can host 128 inputs. These tag blocks are connected to digital scan cards through motherboard. These are fixed to the side walls of the Data logger housing.

1.4.11 Interfacing card (INTR):

Interfacing card acts as a gate between CPU card and digital scan cards. It contains multiplexers, which helps in selection of digital scan cards by CPU card for reading inputs.

1.4.12 Communication Card (COM):

It contains the required circuitry for RS-232 and isolated current loop communication.

1.4.13 Surge Protection PCB (GDT SPD):

- For surge protection, Gas Discharge Tubes (GDT) and Resettable fuses are used in Line Protection PCB.
- The Gas Discharge Tubes are connected across the communication lines and ground.
- When any surge occurs, it is discharged through the Gas Discharge tubes to ground.
- This protects modem and Data logger from damage due to surges in communication lines.
- Resettable fuses are used in Line protection PCB, to allow automatic breaking and making of circuit.
- The Resettable fuses trip when a surge occurs, thereby isolating the communication lines from the Data logger.
- After the surge, the resettable fuse comes back to normal (conducting) state.

1.4.14 Minimum configuration & Upgradability:

Minimum no. of Digital inputs is 512 and it is upgradable to 4096 digital inputs.

Minimum no. of Analog inputs is 32 and it is upgradable to 96 analog channels.

1.4.15 Steps for up-gradation of Digital Inputs:

Incorporate additional hardware:

- For first 512 additional inputs:
  - 1 Digital Motherboard
  - 8 digital input cards
  - 4 digital tag blocks are required additionally

  This additional hardware can be housed in the empty space in the analog euro rack.
- For further up to 1024 additional inputs one more euro rack also is required apart from other cards.
- For inputs beyond 2048 inputs one more housing rack is required.
- 2nd housing rack can accommodate another 2048 digital in puts in two euro racks.
- Configure DIP switch settings to appropriate value for appropriate digital inputs on processor card.
- Configure appropriate digital inputs for that station in NMDL software.

1.4.16 Steps for up-gradation of Analog Inputs:

Incorporate additional hardware:

- For every 32 additional inputs
  - 1 analog motherboard
  - 2 with-controller analog scanner cards
  - 2 without-controller analog scanner cards
  - 4 Analog protection strips
  - 3 AC to DC convertor cards are required additionally.

  An additional Euro rack is required to connect the additional hardware.
- It is possible to connect 1024 digital inputs (or) 64 analog inputs (or) 512 digital inputs and 32 analog inputs, to an additional Euro rack.

1.4.17 Power supply

Normally 24V DC supply with battery backup is required for the system working. The system working voltage range is -30% to +20% of 24V DC. Railways will provide 24V DC input supply.

Power supply arrangement with Battery charger:

- 230V AC input to the battery charger of Data logger should be protected with Class B & C Surge Protection device.
- AT Supply or Stand by diesel generator supply also is to be extended to the battery charger of Data logger.
- Battery charger earth terminal should be connected to Data logger rack with 64 strand 31SWG Copper cable.
- Ensure that all terminals are tightened, practically no voltage drop shall be observed between the battery and Data logger power supply input terminal, since battery is provided within the Data logger rack.
- Voltage limits at Data logger terminals: 24V – 28V DC
- Switch off the charger when it is in float mode. After 15 minutes measure the voltage. Practically no voltage drop shall be observed.
- Ensure that the earth resistance is less than 2 Ω.

Power supply arrangement with IPS (Integrated Power Supply):

- If IPS is available, then power supply of Data logger may be taken from IPS.
- When DC–DC converter is connected, ensure that the 24 V DC supply wires connected between the DC–DC converter output terminals and the Data logger terminals are not run parallel to other power supply wires. There shall not be any joints in the power cable.
- Separate DC–DC converter module shall be used exclusively for Data logger.
- Voltage limits at DL Terminals: 24 V–28 V DC
- Rating of DC–DC converter shall be
  - 5 A up to 1024 inputs
  - 10 A for 1025 to 2048 inputs
  - 15 A for 2049 to 4096 inputs

- Type of wires used for various connections
  - Battery charger body to earth terminal : 64 strands 31 SWG copper wire
  - Battery charger OUTPUT terminal to DL power supply input : 28 strands 31 SWG copper wire
  - Battery charger to battery: 28 strands 31 SWG copper wire
- Inter-battery connection: 64 strands 31 SWG copper wire230 V AC supply extended to the PC has class B & C protection.
- Power supply availability: DG set supply and AT supply where provided is also to be extended to the PC.
- UPS capacity may be decided based on power supply availability at the station to avoid abrupt shut down of the system which may corrupt the software.
- The minimum power back-up of UPS should be 6 Hrs. The same should be verified quarterly.

1.4.18 Earthing and Surge protection

- The earth connectivity cables are to be connected with 10 sq.mm multi strand copper cable for protecting the Data logger and it also mainly connected for:
  - Data logger euro rack to the frame
  - Within the frame of the Data logger
  - Data logger frame to earth terminal in the room
- Ensure that the earth resistance is less than 2 Ω.
- Ensure that the Quad cable (where provided) armor and screen are earthed.

1.4.19 Input requirements

Relay inputs (digital inputs) and analog inputs (voltages, currents etc.,) are required to be connected to the system as per the requirements of RRI / PI / SSI as the case may be.

Some of the inputs to be monitored is given below:

(a) Digital inputs:

(i) **Field inputs:** All TPRs, NWKRs, RWKRs, ECRs, Crank Handle relays, Siding, Slot, LC gate control relays etc.,

(ii) **Control Panel inputs:** All button / Knob, SM's Key relays.

(iii) **Internal relays:**

British system: All HR, DR, HHR, WNR, WRR, ASR, UCR, RR, LR, UYR, TLSR, TRSR, TSR, JSLR, JR, etc.,

SIEMENS system: Z1UR, Z1UR1, GZR, ZDUCR, ZU(R)R, ZU(N)PR,G(R)R, G(N)R, U(R)S, U(N)PS, UDKR, DUCR, U(R)LR, UYR1, UYR2, G(R)LR, GR1, GR2, GR3, GR4, OVZ2U(R)R, W(R/N)R, (R/N)WLR, Z1NWR, Z1RWR, Z1WR1. WKR1, WKR2, WKR3, etc.,

(b) Analog channels

(i) 230 V AC (for power supplies in the power panel),

(ii) 110V AC (for Signal and Track transformers),

(iii) 110V DC (for Point operation),

(iv) 60V DC (Siemens relays),

(v) 24V DC (Q-series relays),

(vi) 24V DC (for Block, Axle counters),

(vii) 24V/12V DC (for indication)

(viii) 20A (for point operation current),

(ix) 1.0V AC, 5KHz (for Axle counter channels), etc.

1.4.20 Software Modules of Data loggers

(a) Network Management of Data loggers (NMDL).

(b) Reports.

(c) Fault Entry.

(d) Track Offline Simulation.

1.4.21 NMDL Software features

(a) Online Relay Status

(b) Online Faults - To view information of various Online Faults, as they occur in the stations where the Data loggers are connected.

(c) Online Simulation - Graphical view of relay operations, train movements, etc**.**

(d) Remote monitoring of stations with the help of NETWORKING.

1.4.22 Software objectives

(a) Predictive Maintenance.

(b) Easy identification of failures.

(c) Crew discipline.

(d) Train charting.

1.4.23 The Data logger equipment is capable of generating following exception reports:

(a) Battery Low voltage.

(b) Battery charger defective.

(c) Under wheel flashing of points.

(d) Signal lamp failure.

(e) Blanking of signals.

(f) Route section not released after passage of train due to track circuit failure.

(g) Point failure point detection not available after set time period.

(h) Track circuit failure.

(i) Fuse blown OFF.

(j) Timer not properly set for 120 Sec.

(k) Sluggish point operation.

(l) Signal cable low insulation.

(m) Route not set when operations valid.

(n) Push button stuck.

(o) Signal over shoot.

(p) Wrong operation.

(q) Axle counter RX low level.

(r) Bobbing of track, point, signal, crank handle, Level Crossing or Ground frame repeater relay.

(s) Point repeated operation.

(t) Non-sequential shunting of tracks.

1.4.24 The Fault Analysis Unit (FAU or CMU) is capable of generating following additional exception reports:

(a) Emergency Cancellation of route

(b) Panel failure due to power failure

(c) Late start of a train (train operation)

(d) Late operation of signals with respect to local trains (train operation)

(e) Route failure online indication with analysis of the stage at which it had failed.

(f) Non-signal movement (train operation)

(g) Total on time of lamp (to assess working life of signal lamp)

(h) Total number of operations of the relay (to assess life of relay)

(i) Emergency Point operation

(j) Emergency Route Release

(k) Emergency Sub-Route Release

(l) Overlap Release

(m) Emergency Crank Handle Release

1.4.25 VARIOUS FAULT LOGICS USED IN RAILWAYS

Sl No	FAULT NAME	FAULT DESCRIPTION
1	SIGNAL BOBBING	The time difference between ECR (UP to DOWN to UP)is in between 500 ms to 2 seconds which should be taken as 1 count and for satisfying the fault logic 2 to 3 counts should happen within 10 seconds
2	TRACK BOBBING	The time difference between TPR (UP to DN to UP)is in between 50 ms to 1second which should be taken as 1 count and for satisfying the fault logic 2 to 3 counts should happen within 10 seconds.
3	Point Bobbing	The time difference of (NWKR/RWKR) (Up to Down to Up) is in between 500 ms to 2 seconds which should be taken as 1 count and for satisfying the fault logic 2 to 3 counts should happen within 10 seconds with TPR up.
4	Point failure	When WNR or WRR picks UP it has to wait for 20 seconds, if NWKR or RWKR is not picking UP then it should trigger this message.
5	POINT LOOSE PACKING	With TPR is Down, the time difference of (NWKR/RWKR) (Up to Down to Up) is in between 250 ms to 2 sec.
6	Timer Setting less	The TIME difference between JSLR UP and NJPR UP is less by more than 10% (less than 108 seconds for 120 seconds timer) of the prescribed time.
7	Timer Setting more	The TIME difference between JSLR UP and NJPR UP is greater by more than 10% (more than 132 sec. for 120 sec. timer) of the prescribed time.
8	Check the charger	The difference between present voltage and previous voltage is greater than 5% and it should continue beyond that range for at least 30 seconds and LVR relay is UP.
9	Blanking of Signals	Concerned LVR (AC power supply for signal available) relay is UP and all ECRs are DN for that particular signal for more than 20 seconds.
10	Fusing of Signal Lamp	Concerned LVR (AC power supply for signal available) relay is UP a. Yellow (three aspect):- After HR picks up and DR is DN, if HECR is not picked UP within 10 seconds. HR is triggering signal. b. Green (three aspect) :- After HR and DR pick UP, if DECR has not picked UP within 10 seconds. HR and DR is triggering signal. c. Red:- After HR/DR is DN, if RECR has not picked up within 10 seconds. HR/DR is triggering signal. d. Yellow/Green (two aspect):- After HR/DR picks UP, if HECR/DECR has not picked UP within 10 seconds. HR/DR is triggering signal.

Sl No	FAULT NAME	FAULT DESCRIPTION
11	TRACK CIRCUIT FAILURE	T1,T2,T3 are Sequential Tracks. a. When T2 is Down. b. T1 and T3 Up. c. The Time difference between T1 Up and T2 DN is more than 5 sec. d. The time difference between T3 UP and T2 DN is more than 5 sec. e. T2 is not bobbing and is DN for more than 10 seconds.
12	POWER SUPPLY FAILURE	LVR is DN for more than 100ms.
13	POWER SUPPLY RESTORED	LVR is UP for more than 100ms.
14	SIGNAL FLYING BACK TO DANGER	a. UCR UP and b. RECR UP and c. HR DN and d. TSR Up or (TSR DN and control track UP or Approach track UP)
15	Route section not released	Previous route section released, sequential route release relays of route section UP but sectional route release relay not picked UP.
16	Sluggish Operation of Point	After WNR/WRR picks UP, NWKR/RWKR picks UP after a delay of 10 to 20 seconds.
17	Picking UP of Track Circuit when adjacent Track circuits are DN	T1,T2,T3 are consecutive Tracks circuits in sequence a. T1 and T3 are DN and b. T2 is Up and not bobbing and remains continuously UP for more than 10 seconds.
18	Route getting released without all the sequential route relays in the route picking UP	a. ASR UP and b. Concerned route TSSLR DN or TPZR DN or TLSR DN or TRSR DN and c. Emergency Route cancellation, NJPR DN.
19	Block getting released without picking up of sequential train arrival relays	Block clearing relay picks Up without picking UP of sequential track relay. NOTE: This will require change in wiring of block instrument so that the pickup contacts of block TAR is brought outside the block instrument.
20	Advanced Starter OFF without LINE CLEAR	HR up and Concerned LCPR is down.

Sl No	FAULT NAME	FAULT DESCRIPTION
21	Late Start of Train	a. Berthing track DN and b. HECR/DECR UP and c. Signal replacement track DN and d. Time difference between time of occurrence of **b** and **c** is more than time defined by user.
22	Over speeding of Train	T1,T2 and T3 are track circuits in sequence. Length of T2 is fed in the logic option a. Counter starts when T2 goes DN with T1 already DN b. Counter stops when T3 goes DN with T2 already DN c. Time interval between (a)and (b) is less than length of T2 divided by maximum permissible speed by more than10%
23	Clearing of Signal without route locking	a. HECR/DECR UP and b. ASR UP
24	Signal Assuming Green Aspect with one or more Points in route in reverse condition	a. DECR UP and b. RWKR of any Point in the route UP
25	Home/Main Line starter signal assuming green aspect with advance starter danger	a. Home signal DECR UP or Main Line Starter DECR UP and b. Advance Starter RECR UP
26	Point BURST	If the train arrives on the track 2 proving the sequence of track1 DN and the Point setting in the un-favorable position and then the NWKR/RWKR both are DN for 20 seconds.
27	Check for passing of defective/danger signal	a. When track 2 DN after • Track 1 is DN • RECR UP. b. The time difference between T2 DN and T3 UP is more than 5 sec. c. The time difference between T2 DN and RECR UP is more than 5 sec. d. T2 is not bobbing and is DN for more than 1.2 seconds.
28	REAR-END Point not set against Occupied line.	'At the time of Point zone track(input1)(trig) UP, Platform track (input2) is Down and track Before Point zone track (input3) UP and after time interval either of other Platform tracks(input4) are UP then check the corresponding back end points.
29	FRONT-END Point not set against Occupied line	'At the time of Point zone track(input1)(trig) UP, Platform track(input2) is Down and track before Point zone track(input3) is UP and after time interval either of other Platforms tracks(input4) are UP and Starter HR(input5) is Down and Starter Control track(input6) is UP then check the corresponding Front end points.

1.5 OPERATIONS OF DATA LOGGER

Switch on the power supply switches provided on the rear side of Data logger unit and observe the LCD panel and SIX 7 segment LED display on front view of the DTL.

LCD display will show :

Efftronics (P) Ltd Networked Data logger System.

All the operations (Software) can be performed using the LCD and keyboard.

When the data logger is switched on it will be in self-diagnosis mode for some time and finally, a screen similar to the one below will appear. This screen is called **"Default Display".**

COM01	**T:0128**	**F:0000**	**D:0128**
COM02	**T:0128**	**F:0000**	**D:0128**

Here T, F, D indicates the total records sent from COM Port - 1, total fail records received by COM Port - 1, and total pending packets to transmit from COM Port – 1 respectively on first row of LCD display. Similarly for COM Port – 2 in second row.

The following procedure will give the present status of the digital input on the LCD screen. Press '*' key at 'Default Display Menu'. Then the following menu will be displayed and it is called as "Main Menu".

1. DATALOGGER	**2. RELAY HUT**
3. FLASH MEM	**4. MEM CARD**

At main menu, press key '1' for selecting the data logger options. Now the following screen will be appeared on LCD screen.

1.TIME	**2.PGE**	**3.DGT**	**4.ANG**
5.FALT	**6.PRN**	**7.TMP**	**8.PWD**

Choose the options for the required software operations.

Example : Digital Input Status Through LCD display

Now press the key '**3**' to select the 'DGT' (digital) option. Then the following screen will appear on the LCD panel.

1.ALL	**2.TPR**	**3.PNT**	**4.ROUT**
5.BTN	**6.SLT**	**7.SIG**	**8.RLAY**

By selecting the required category of digital input, the status of the corresponding signals will be displayed on the LCD.

1. ALL: Will indicate the status of all digital inputs.
2. TPR (TRACK PROVED RELAY): Will indicate the status of all the TPR's connected to the Data logger.
3. PNT (POINTS): Will indicate the status of all the POINTS connected to the Data logger.
4. ROUT (ROUTE RELAYS): Will indicate the status of all ROUTE relays connected to the Data logger.
5. BTN (BUTTON): Will indicate the status of all the BUTTON relays connected to the Data logger
6. SLT (SLOTS): Will indicate the status of all the SLOT relays connected to the Data logger
7. SIG (SIGNALS): Will indicate the status of all the SIGNALS connected to the Data logger
8. RLAY (RELAY): Will indicate the status of all other inputs, which are configured as relays

After entering into the required option, press the '#' key to view the status of next relay or press '0' key to view the status of previous relay inputs.

By selecting the required category of digital input, the status of the corresponding signals will be displayed on the LCD

Example: Digital Input Status (ON Line/OFF Line Mode) report print out taking.

Connect printer port with printer. Switch 'ON' the supply to the printer.

User can get the online information of the change in digital inputs status by using the printer option. Here it should be noted that only the changed input status would be recorded or printed. If the digital inputs status is not changing then its status will not be printed. To get the printout in online mode follow the instructions below.

In main menu, press key "1" for selecting the data logger options. Now the following screen will appear on the LCD.

1.TIME	**2.PGE**	**3.DGT**	**4.ANG**
5.FALT	**6.PRN**	**7.TMP**	**8.PWD**

For selecting PRINT option press the key '6'. Then LCD displays the following screen. This is called "PRINTER MENU"

PRINTER IN OFF LINE MODE

ONLINE (0) **USER (1)**

Press ' 0 ' key to change it to the ONLINE mode, then the following screen will appear

PRINTER MODE IS CHANGED….

PRINTER IN ONLINE MODE

Now printer will start printing the latest changes in the status of the Digital inputs and Analog inputs provided printer is ready to print.

To get the digital inputs status and analog voltages in off-line mode there is only one option and that is taking “printouts”.

The OFF-LINE printing is well organized in the DL99/06 MODEL. In this model user can even print a single input status or faults of one type (digital or analog).

For this, all the events for printing are mainly divided into two categories. They are

1. DIGITAL
2. ANALOG

In DIGITAL, it was again divided into two types. They are

1. DIGITAL INPUT (RELAYS STATUS)
2. DIGITAL FAULTS

All the DIGITAL INPUTS are divided into 7 types

1. TRACKS
2. POINTS
3. ROUTS
4. BUTTONS
5. SLOTS
6. SIGNALS
7. GENERAL RELAYS

Thus, If the time interval entered for off line printing is valid, then the following screen will appear.

1. ALL	**2. DIG**	**3. ANA**
9. PRNT	**0. BACK**	***. MAIN**

Key “1” - for selecting digital, analog events and faults printing.

Key “2” - for selecting digital events printing.

Key “3” - for selecting analog events printing.

Here, for printing the digital inputs, press key “2”. Then the following screen will be appeared.

1. ALL	**2. DIGIPS**	
3. DIGFLT	**0. BACK**	***. MAIN**

Key “1” for selecting both digital inputs status and faults printing.

Key “2” for selecting digital inputs status printing.

Key “3” for selecting digital faults printing.

Here, for example, for printing the digital inputs, press key “2”. Then the following screen will be appeared.

1. ALL	**2. TPR**	**3. PNT**
#. NEXT	**0. BACK**	***. MAIN**

For selecting the other group input for printing, use key “#” or “0”.

For example, if the user wants to print the status of a track input. Then the user has to follow the procedure given below.

Press key “2” at the above screen. Now the display should be as below.

1. ALL	**2. SOME**
0. BACK	***. MAIN**

Key “1” - for selecting all TRACK inputs.

Key “2” - for selecting only selected TRACK inputs.

If we Press key “2” for selecting few TRACK inputs, then the following screen will be appeared.

DIGITAL INPUT NAME		**-S**	**1. S/D**
#. NEXT	**0. PREV**	**9. END**	***.MAIN**

Here, in first row, signal name and its selectivity (i.e. whether it is already selected or not) will be displayed.

Press Key “1” for selecting the input if the input is not selected earlier or for deselecting if it is already selected.

Keys “#” & “0” are for next and previous digital inputs viewing in this type.

Press key “9” for end of selection of inputs for printing. Now the display on the screen will be as shown below.

1. VIEW	**2. PRINT**
3. EDIT	***.MAIN**

Key “1” for VIEWING the selecting inputs for printing.

Key “2” for printing the selecting inputs.

Key “3” for editing the selecting inputs for printing.

Key “*” to go to main menu

Press key “2” for printing the selected inputs. Now the screen will be as shown below.

PRINTING	**IS**	**IN**	**PROGRESS**
#. STOP			***.MAIN**

Key “#” for STOP printing.

Key “*” to go to main menu.

Note: Make sure that the printer is ready to print while going for off line printing. If the printer is not ready then the fallowing message will be displayed on the screen. And after some time, main display will be displayed.

PRINTER IS NOT READY

Same procedure has to follow for printing the digital faults, analog channel voltages, and faults of analog channels.

Example: **MODEM RESET through KEY BOARD:**

This option is to reset the modems port through the keyboard option. To do this press the key '#' key from the Default Display screen. Then the following screen will appear.

1.PKTS	**2.CONFIG**		**3.CD STAS**
4. CTR	**5.ADB**	**6.DCS**	**7.MDMR**

Now press the key'7' in order to select the 'MDMR' option i.e. Modem Reset option. When the key'7' is pressed the following screen will appear on the LCD.

	HWRST	**FOR**	**COM01**
KEY	**0: PREV**	**#: NXT**	**1: HRST**

Now select the required port, which has to be made reset and press the concerned number on the keyboard. If for example, the user wants to reset the modem connected to the PORT1, press the key '1' on the keyboard. Then the following screen will appear.

COM01	**MODEM**	**RESET**	**DONE**
KEY	**0: PREV**	**#: NXT**	***: MAIN**

It means that the concerned modem has been made reset.

Similarly reset the modems connected to other ports by pressing the corresponding key on the keyboard.

Note: The modem will be reset after one minute of pressing the key.

1.6 Data processing and Transmission:

- One digital data packet is generated by Data logger for one relay status change. One packet has 12 bytes.
- One analog data packet is generated by Data logger when the value changes beyond 5% of nominal value from previous recorded value or when the voltage varies beyond the selected range.
- Any packet generated is stored in the data logger memory. If it is in the network one by one the packets are sent to communication buffer memory. One communication buffer memory is there for each direction in the data logger.

- Main memory can store 10 Lakhs packets where as Communication Buffer memory can store only 128 packets.
- Copy of the Packet from buffer memory is sent to the next data logger. As soon as the acknowledgement packet is received packet in the buffer is discarded.
- If communication buffer is full then the packet is stored in main memory only. As and when space is available in the buffer memory a copy of the packet is moved from main memory to buffer memory.
- One train reception and dispatch creates about 100 digital data packets. For 100 trains in a day 10,000 packets are generated.
- For network of 30 Data loggers 3 Lakhs digital packets are generated per day.
- 5.5 V change in 110 V AC or DC supply, 1.2 V change in 24 V supply creates one analog packet (5% change of nominal value).
- Every 32 minutes status of all inputs are sent to central location by sending hour packets.
- If no packet is getting generated, once in a minute one time packet is generated by the data logger to convey that it is healthy. It is called TIME packet.

1.7 Protocol Converter Card:

Protocol converter card is required to be provided in Data logger system when the data logger has to monitor the data of Electronic Interlocking system in which RDSO standardized communication protocol is not used.

Protocol converter card:

- Supports interfacing of maximum 4096 inputs from Electronic Interlocking System.
- Accepts Two potential free contacts for identification of main & standby operation of Electronic Interlocking System.
- Two RS 232 ports for interfacing main and standby CPUs of Electronic Interlocking System.
- One current loop port for interfacing with Data logger.
- One RS-232 port for Diagnostic/configuration purpose.
- Internal RTC with battery backup.
- Provision for time synchronization of Protocol Converter with data logger at an accuracy of 150millisec.

1.8 REMOTE MONITORING OF STATIONS WITH NETWORKING OF DATA LOGGERS

The individual Data loggers of various stations can be interconnected through networking technology. The data of Remote Panel stations can be viewed in a Computer at the Central Monitoring Station. The data of the network is collected by the FEP (Front End Processor), which in turn is transmitted to the computer

Components of Network Management of Data loggers :

(a) Data logger at stations.

(b) MODEM and DATA Transmission medium

(c) Front End Processor (FEP)

(d) Central Monitoring Unit (CMU) /Computer

1.8.1 Data logger at stations

The data of the individual Data loggers of various stations can be seen from a centralized place by interconnecting them through networking technology. For this purpose dual modem card is provided in the station Data logger system. This enables bi-directional communication of data in the network. Data logger system is also provided with the facility of tri-directional communication network (T-Network) to avoid the delay in data transfer, in case of lengthy network. For this purpose an external modem is required to be connected to one of the COM port of the Data logger system.

1.8.2 MODEM and DATA TRANSMISSION MEDIUM

1.8.2.1 DATA TRANSMISSSION:

Data loggers can be networked in Uni-directional Mode or Bi-directional Mode or T - Network Mode. In case of loss of data, retransmission of data takes place.

(a) Uni-Directional Mode:

In this mode, each Data logger will send data in only one direction to the FEP. Hence, this Uni-directional mode network is not preferred.

(b) Bi-Directional Mode:

In this mode, each end of Network is connected to FEP and each Data logger can now transmit data in both the directions. Bi-directional Mode is advantageous, it enables the Data Transmission even in case of Network Failure in one direction.

(c) T - Network Mode:

If more no. of stations are in network i.e. if the network is too lengthy then T-network mode is preferred to minimise the data transmission delay.

1.8.2.2 COMMUNICATION

The communication protocol for transmitting data and command between Data logger and CMU is standardized by the RDSO and is given in the Specifications of Data loggers.

(a) The type of communication used in the network is dependent on the distance between the Data loggers.

(b) For shorter distances, Opto Converter Box (Opto isolated current loop communication) is used.

(c) For longer distances, Modem (Dial-up / leased) / Fiber Optic / Satellite / Microwave communication is used.

(d) If the serial communication is more than 50meters then line drivers shall be used up to 3Kms. 4wire leased line Modems shall be used if the serial communication is more than 3Kms.

1.8.2.3 Modems

Modems are used for DATA transfer between Data loggers and Front End Processor.These are configured to RS 232 Serial Communication.

Network is connected with two types of 4-wire modems:

(a) Internal modem card / Dual Modem card (in-built):

It is fixed in Data logger Euro rack itself. One card contains two modems. The top modem is called ANS (answer) modem and the bottom modem is called as ORG (originate) modem.

Note: *In case of networking of Data loggers, connect 'ANS' modem to the 'ORG' modem of one adjacent station and connect 'ORG' modem to the 'ANS' modem of other adjacent station.*

(b) External modems:

These are generally used at Data logger or FEP to connect the Data logger/FEP to Tri-directional network.

(i) To transfer Data from one Data logger to another Data logger / FEP Baud rate is 9600 bps.

(ii) These modems are 4-wire line communication.

(iii) To transfer the data from FEP to CMU (PC) the Baud rate is 57,600 bps.

There is no difference between these modems functionally.

1.8.3 FEP (Front End Processor) Euro Rack

FEP acts as a buffer between the Central Monitoring Unit (Computer) and the Network. It is provided at centralised place to retrieve data continuously from station Data loggers and store in memory and transfer to computer on request. It stores 10 Lac telegrams. It works on 24V DC.

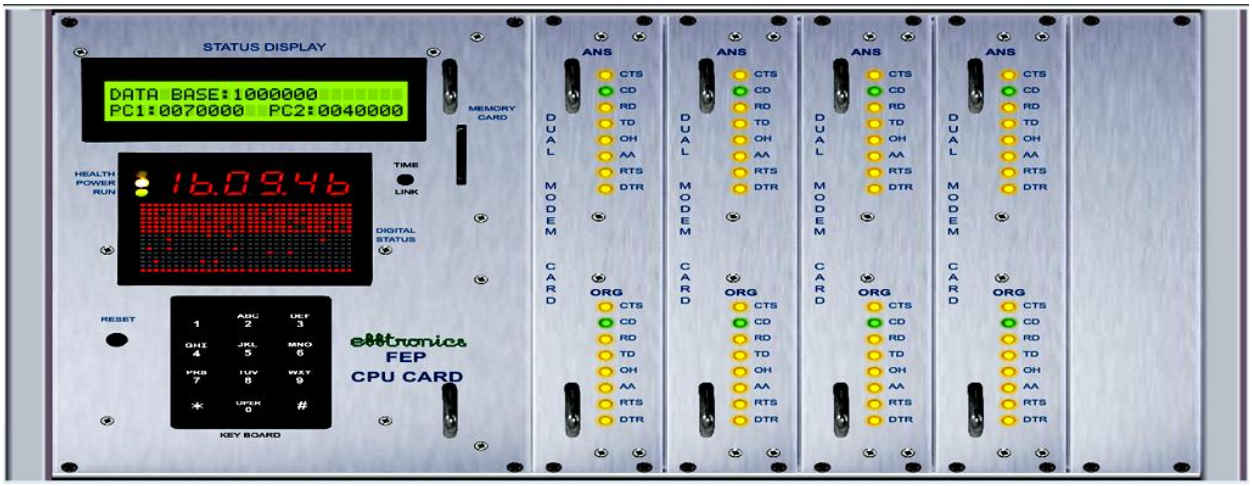


Fig : Front End Processor

Front End Processor consists of

- CPU Card
- Internal Dual Modem Cards (Answering and Originating) with LED Indications for Modem status
- Seven Segment LED Display
- Display Card Reset Button
- LCD Display
- Keyboard

It has 12 Nos. of RS-232 communication ports such as COM1, COM2, COM3, COM4, COM5 and so on. These COM ports are used for Fault Analysis System (FAS) i.e. Central Monitoring Unit (Computer) connection, GSM Modem connection, Internal dual modems and external modem connections for networking.

Basic functionality of FEP is to receive the data from Data logger network through network port and maintain data backup and communicate this data to CMU Software. User Interface with FEP consists of 5 basic modes.

1. Default Display Menu
2. Communication Status Menu
3. Port Status Menu
4. Diagnosis & Configuration Menu
5. Data Backup Menu

1.8.4 Central Monitoring Unit (CMU) / Computer

Central monitoring unit (Fault Analysis Unit) is a Personal Computer and its minimum configuration shall be specified by RDSO from time to time. System Software Windows XP/Vista/Windows7(OS), Norton/ Kaspersky (Anti Virus), Interbase where Server is not available (DBMS), Oracle where Server is available (DBMS) software are required to run Data logger System. It is provided with Graphical User interface (GUI) based software and it can retrieve data from all Networked Data loggers (up to 32) at various stations. It stores data in standard data base files. The CMU is capable of analyzing the data and generate reports, audiovisual alarms on defined conditions. This data can be compressed to take backup.

In central monitoring unit Software, used for analysis of data, prediction of faults etc., is written in a structured format so that purchaser can reconfigure it, if required. It displays the status of signaling gears at any selected time in graphic form for any selected station yard. It retrieves the stored data & simulates train movement. It sends commands to various Data loggers to activate audio, visual alarm or operate an electromagnetic relay.

CMU shares data available in it by other PCs through available local area network where this data can be used for train charting / passenger information purpose.

The system generates audiovisual alarm in ASM's/Signal Maintainer's room in the case of power supply failure (battery voltage low) or battery charger defective with acknowledgement facility.

(a) Each Data logger has its own identity code which will be transmitted along with data packet to central monitoring unit.

(b) Events recorded at each station are continuously transmitted to central monitoring unit. Response time of data transfer will not exceed 10 sec.

The CMU is capable of generating following additional exceptional reports:

(a) Emergency cancellation of route.

(b) Panel failure due to power failure.

(c) Late start of a train (train operation).

(d) Late operation of signals with respect to local trains (train operation).

(e) Route failure online indication with analysis of the stage at which it had failed.

(f) Non-signal movement (train operation).

(g) Total on time of lamp (to assess working life of signal lamp).

(h) Total number of operations of the relay (to assess life if relay).

(i) Emergency Point operation.

(j) Emergency Route release.

(k) Emergency Sub Route Release.

(l) Overlap release.

(m) Emergency Crank Handle release.

(n) Calling on operations.

(o) Slot operation.

(p) Historical relay of events in a yard in graphical manner.

(q) Circuit progression. Railway shall provide logic for the same.

(r) Any other exception report.

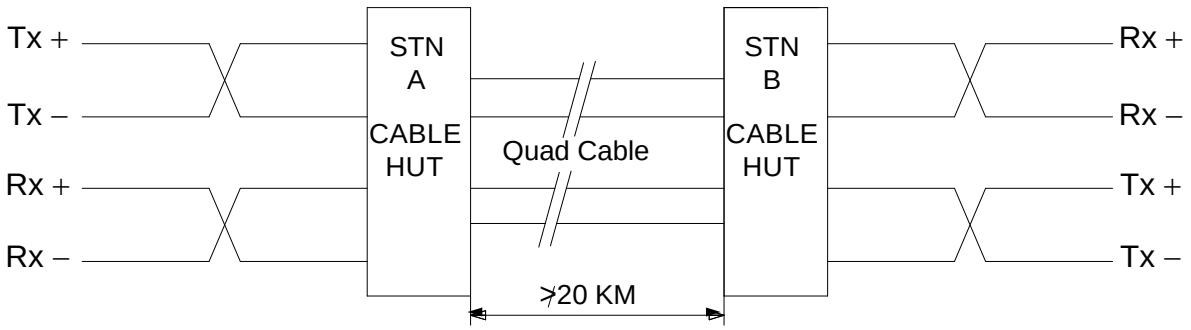
Exception conditions are stored in the Data logger chronologically and displayed one by one on the front panel through a toggle switch.

Data loggers of all stations send status report to the central monitoring unit and audiovisual alarm generated for the fault/alarm condition.

1.9 Use of data loggers for preventive maintenance:

With the help of current sensors (Track circuit monitoring equipment) provided at location boxes, track feed end currents, relay end currents and track feed charger currents are being monitored and will be communicated through wireless network from yard to relay room. This will in turn communicate with data logger in relay room to generate suitable data which will be further highlighted at Divisional HQ NMDL through pop-up screen in CMU. In this way measurements of track circuit parameters will be available at any given time which will improve Track Circuit maintenance. These experiments are under advanced stage of testing at Tenali station of BZA division of SCRly by M/s Efftronics. In a similar way the normal and reverse operation currents of point machines are being measured online. This data will give the performance of the point machine at any given time.

1.10 Cable connections between data loggers of two adjacent stations



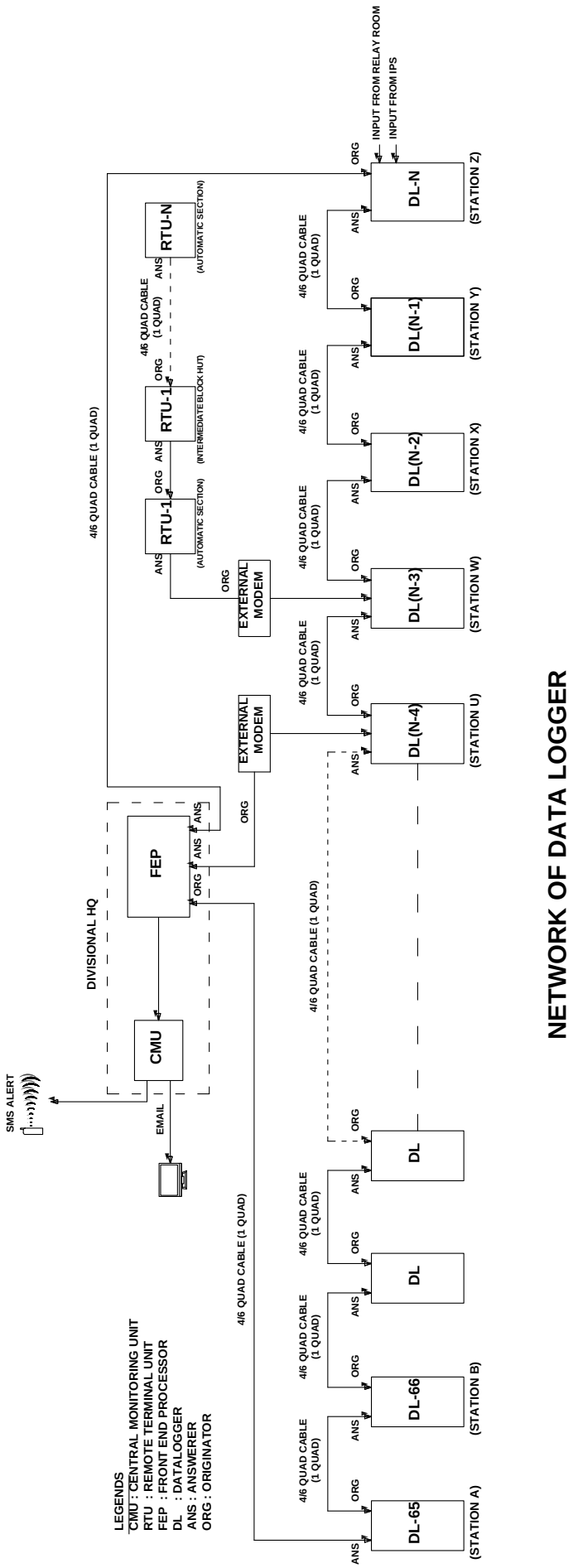
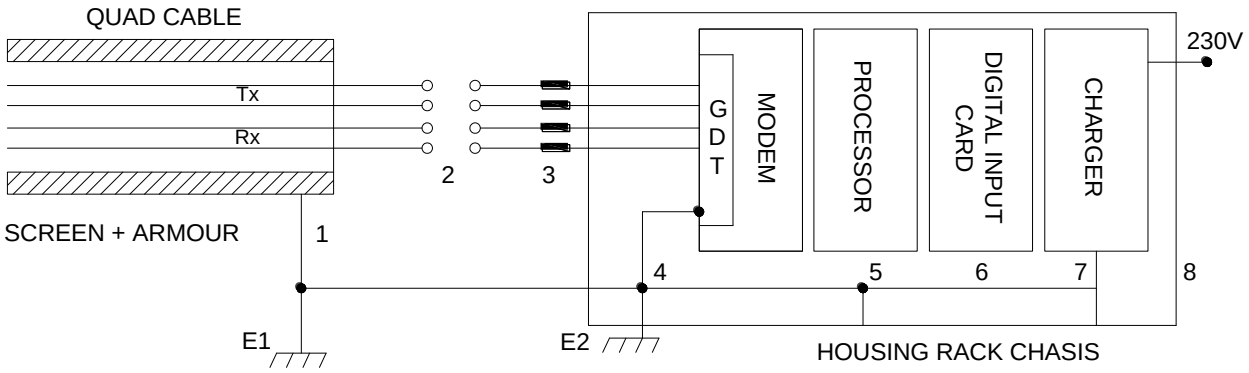


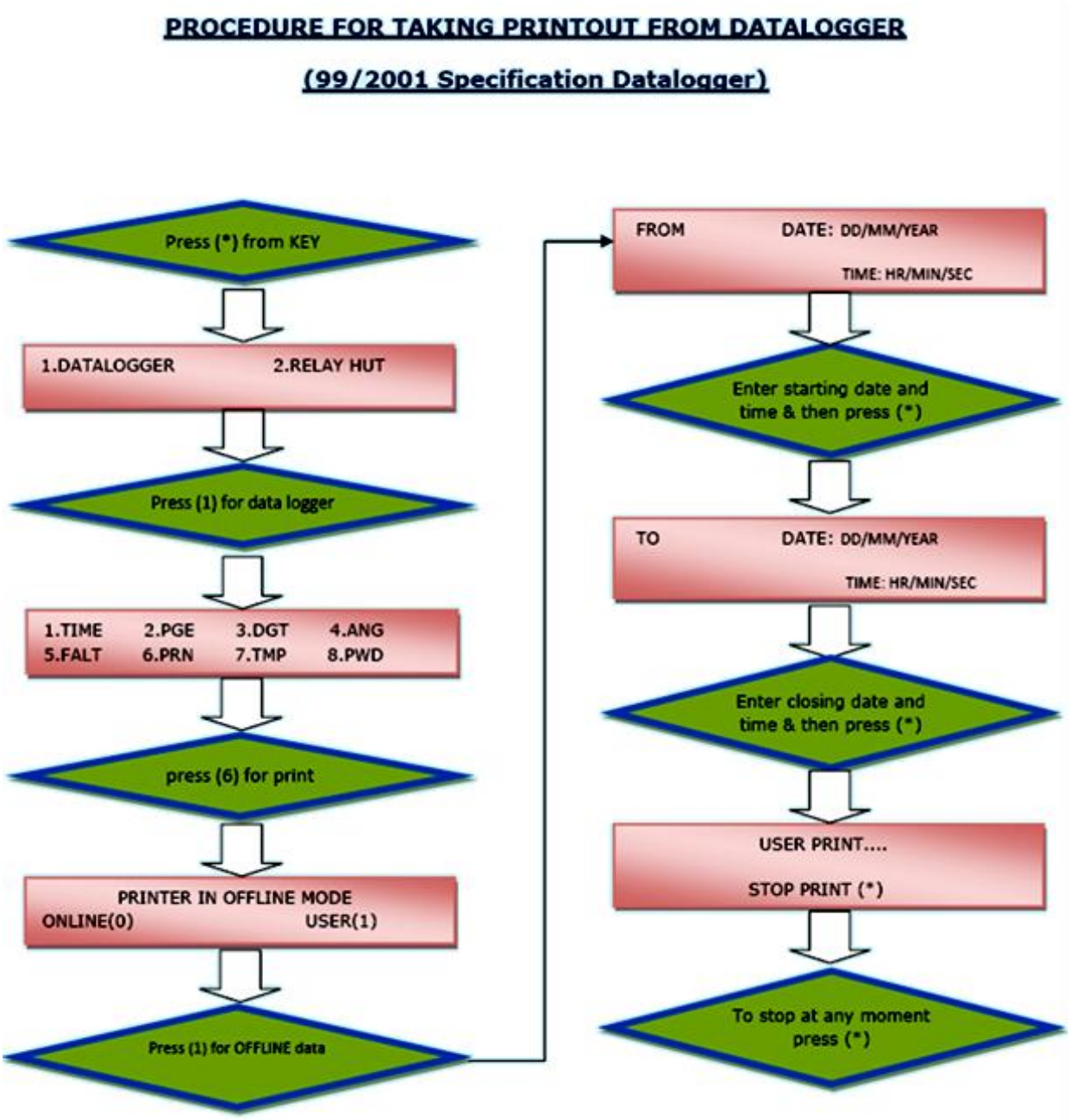
Fig :1.2 BLOCK DIAGRAM OF NETWORK MANAGEMENT OF DATA LOGGERS

1.11 SURGE & LIGHTNING PROTECTION AND EARTH ARRANGEMENT FOR DATA LOGGER :



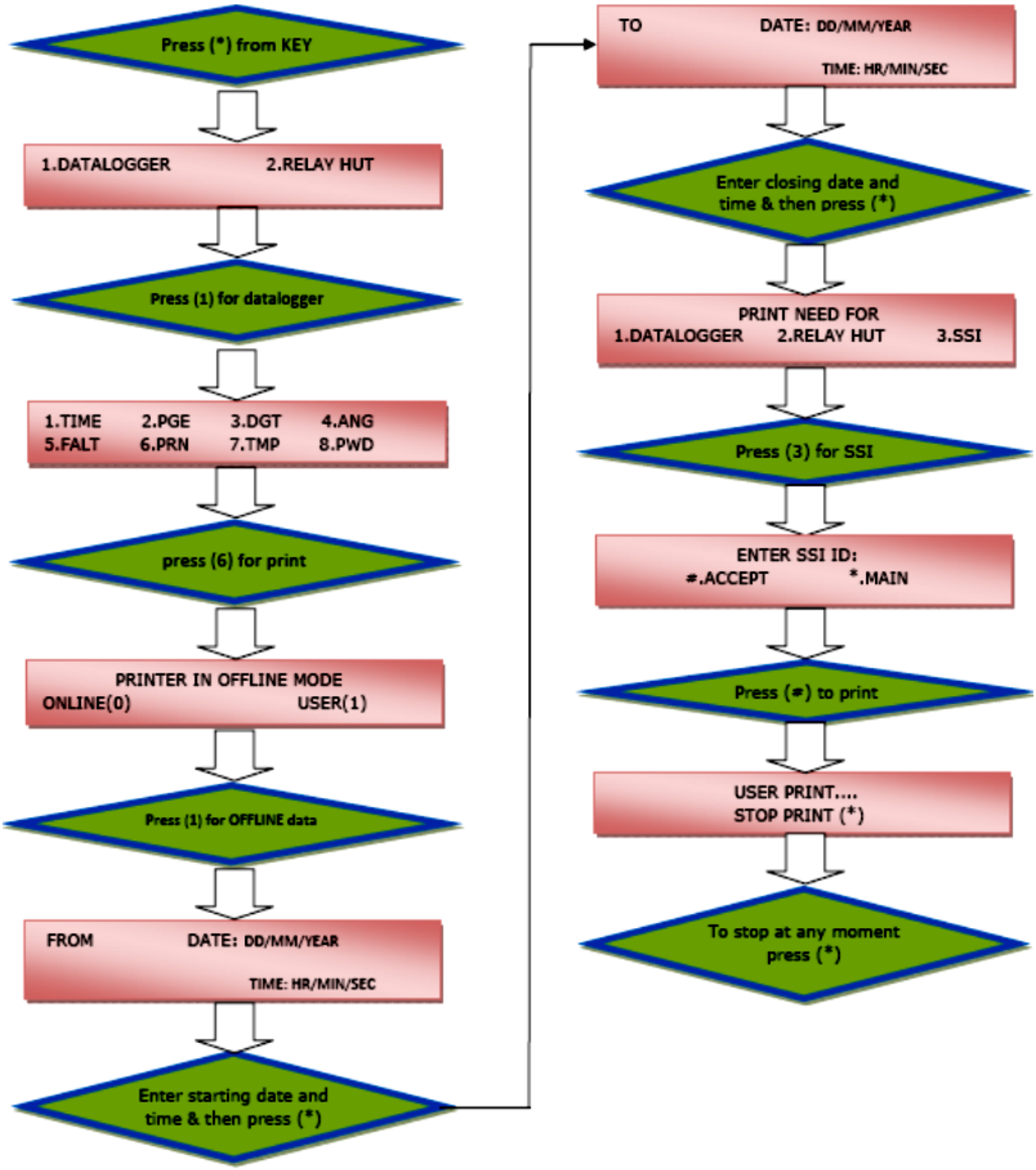
- Earthing of screen and amour of the quad cable to earth by soldering.
- Main cable termination shall be done by Soldering / crimping / Wago terminal - Avoid ARA terminal.
- Tail cable intermediate terminations - by Soldering only - Avoid ARA terminal.
- Extend Earth to Data logger's surge & lightning protection equipment i. e. GDT provided at the TX , RX cable connections to modem.
- Ensure Processor card chassis is connected to the data logger frame - which in turn is connected to earth as at 4 above.
- Ensure correct rating fuse at the input of each analog input.
- Ensure correct rating fuse of charger - extend earth to the chassis of the charger.
- Extend clean power (class B protected) to the charger -- Where feasible extend 24 V from IPS and remove the charger.
- E1 and E2 may be same earth or two separate earths.

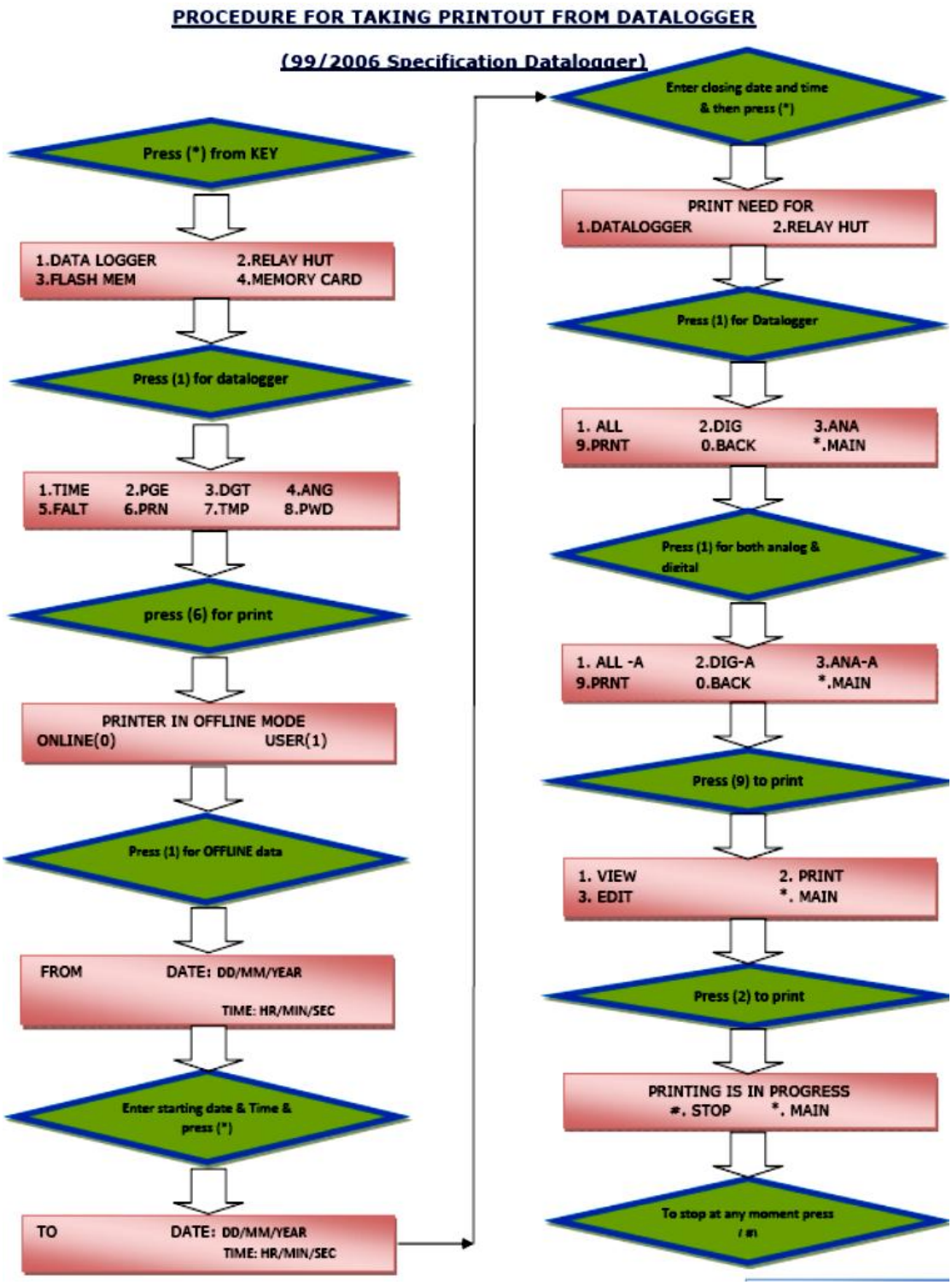
1.12 Procedure for taking data printouts from various versions of efftronics Dataloggers



PROCEDURE FOR TAKING PRINTOUT FROM SSI DATALOGGER

(99/2001 Specification Datalogger)





1.13 RDSO approved list of firms for manufacture and supply of electrical signalling items: As on January 2012

ITEM: Data logger system for railway S&T installations.

Spec No.: IRS: S-99/2006

APPROVED UNDER PART: I	APPROVED UNDER PART: II
Nil	1. M/s Crompton Greaves Ltd.,
	2. M/s. Sirveen Control System Pvt.Ltd.
	3.M/s HBL Power Systems Ltd

Note: *Please refer annexure – I for Pre-commissioning check list of data logger.*

CHAPTER 2 : TRAIN PROTECTION & WARNING SYSTEM

2.1 TPWS - A BACKGROUND

On the recommendation of CRS for a Safety provision similar to Auxiliary Warning System (AWS) of Western Railway, consequent of an accident on suburban section of Chennai in 11/94, the work of TPWS was sanctioned on Southern Railway. Railway Board issued specifications for an improved version of Train Protection and Warning System (TPWS) after detailed study TPWS specification is based on the proven European Railway Traffic Management System (ERTMS) Level-1 configuration. **It is commissioned in 2008 between Chennai – Gummidipundi (48 KM) for 150 signals and 82 EMU coaches.**

Level-1 configuration i.e. Line side signalling System uses balises for communication between trackside signal & on board side cab equipment.

Levels

Levels are nothing but the minimum operating relation between the Cab side equipment and the track side equipments.

Level definitions are principally related to the trackside equipment used, to the way trackside information reaches the on-board units and to which functions are processed in the trackside and in the on-board equipment respectively.

The definition of Levels depends upon:

(a) How the route is equipped Line side signalling or Cab side signalling

(b) Linking of Balise.

(c) The way by which information is transmitted to Cab side equipments.

The ERTMS/ETCS Levels

Level	Track side	On Board
Level–1	• Line side Signalling. • Authorization for run is given by balise	Continuous control of speed with intermittent transmission.
Level–2	• Authorization to run is given by radio(RBC) • Balise is used for location referencing. • Line side signal can be suppressed.	Continuous control of speed with continuous transmission.
Level–3	• Authorization to run is given by radio(RBC) • Possibility of moving block sectioning. • Absence of Track circuits.	• Continuous control of speed with continuous transmission. • Self train location. • Train integrity

2.1.2 TPWS –BENEFITS

(a) Allows safe movement of trains under its supervision.

(b) Automatic Train Protection and prevents collision.

(c) Assures higher level of safety during train operations.

(d) Facility to run the train at maximum permitted speed by providing the indication to the driver 500 meters in advance of signal and higher average speed of train.

(e) Facilitates normal operation of train in dense foggy condition where visibility is near zero.

2.1.3 BENEFITS TO DRIVERS

(a) Aids the driver by various information as under on the Driver Machine Interface (DMI) fixed in front of him.

(b) Permitted speed, Actual speed , Target distance & Target speed.

(c) Modes of operation (Unfitted, Full supervision, Staff responsible, On sight etc.)

(d) Level of operation (One or Zero).

(e) Over speed indication by visible/audible warning in two stages.

(f) Service and Emergency brake indication.

2.2 TPWS – MAIN COMPONENTS

2.2.1 On Board

(a) Driver Machine Interface (DMI)

(b) On Board Computer (OBC)

(c) Balise Transmission Module (BTM)

(d) Wheel sensors

(e) Antenna

2.2.2 Track Side

(a) Line-side Electronic Unit (LEU)

(b) Balise

Basic Architecture of TPWS System is shown in fig.No:2.1

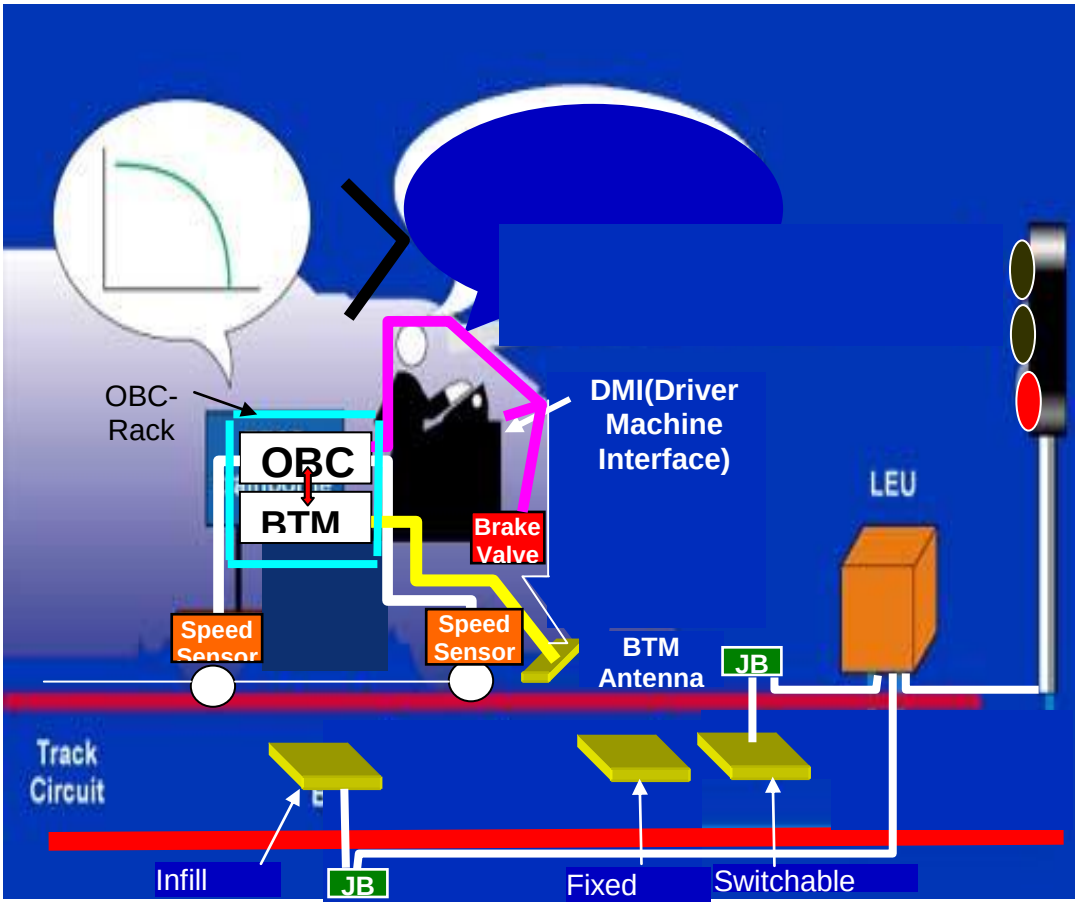


Fig. No: 2.1 Basic Architecture of TPWS System

2.3 ON BOARD SUB SYSTEM

2.3.1 On board Equipment Functions

(a) Reception of movement authorities and track description.

(b) Selection of the most restrictive speed.

(c) Calculation of dynamic speed profile.

(d) Comparison of the actual speed with the permitted speed & brake commanding when required.

(e) Cab signaling to the driver.

2.3.2 On Board Equipment consists of

(a) On Board Computer (OBC).

(b) Antenna.

(c) Balise Transmission Module (BTM).

(d) Driver Machine Interface (DMI).

(e) Wheel sensors.

2.3.3 Input data to be fed to On Board Equipment through DMI

(a) Length of train, wheel diameter, deceleration factor.

(b) Maximum permitted speed of train.

2.3.4 Displays

(a) Over speed, Brake Target Distance, Numerical Actual Train Speed indications

(b) Mode Information (UN/SR/FS/OS), Level information (1 or 0)

(c) Visual & audible warnings, Brake intervention SB or EB

(d) Acknowledgements

2.3.5 ON BOARD COMPUTER (OBC)

(a) Reading of Balise.

(b) Processing track messages.

(c) Speed sensing.

(d) Speed and position control.

(e) Braking management.

(f) ERTMS levels & modes.

(g) Display/controls with driver.

(h) Record data.

(i) Power 110 V DC, 270 W.

2.3.6 ON BOARD WHEEL SENSORS

(a) Installed on two different axles of driving cab.

(b) Provides continuous information regarding actual speed, the inputs for distance traveled and orientation of train.

(c) Input for detection of slip & slides thereby correct evaluation of distance traveled.

2.3.7 ON BOARD BALISE TRANSMISSION MODULE (BTM)

(a) Reads the message packets from Euro-balises through antenna.

(b) Decodes the message packets.

(c) Transmits the decoded packets to On Board Computer (OBC).

(d) Antenna interface.

(e) Power: 24 V DC, 200 W.

2.3.8 ON BOARD ANTENNA

(a) Picks up message packets from Balises through air-gap.

(b) Transmits the messages to Balise Transmission Module(BTM).

(c) Bimodal, reads FSK Balise and ASK 180- and 12-bit balise.

2.3.9 Description of On Board Equipment

The on board sub system is consists of BTM (Balise Transmission Module) antenna fitted at the bottom of the cab, mounted in the LT room of the cab, two wheel Sensors are fitted on to axles, OBC (On-Board Computer) installed in the LT room of the Cab & DMI (Driver Machine Interface) mounted in front of the driver.

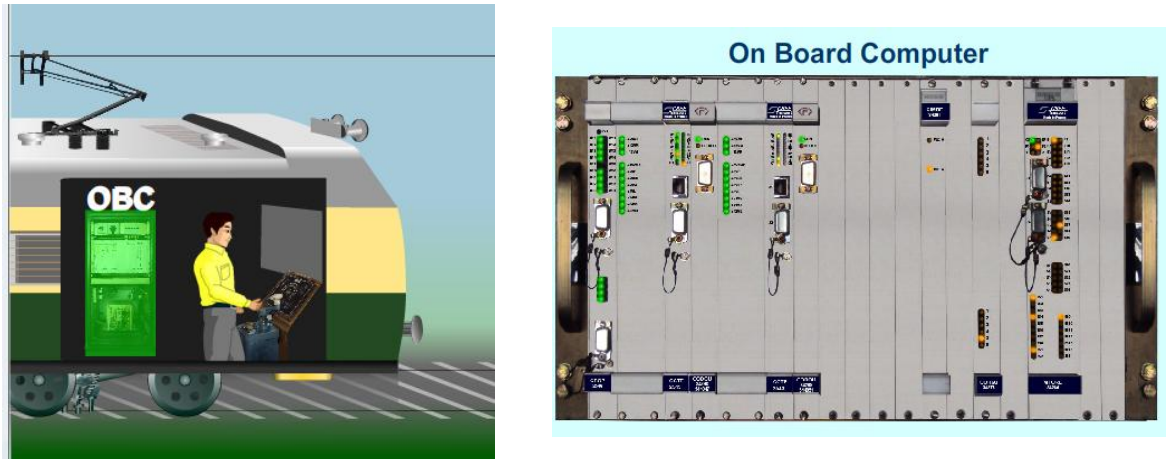


Fig. No. 2.2 On Board Computer

On Board Computer (OBC):

- On Board Computer is based on 2-out of-2 / 2-out of 3 architecture on Indian Railway 2-out of-2 is being used.
- On Board Computer is composed of 8-types of boards/cards, out of which 3-cards i.e.
  - CCTE (Compact Processing Board for Safety Critical Computer)
  - ACSDV (Power Supply Module) and
  - CODOUH (Odometer Interface Card)
- These cards are duplicate to achieve 2-out of-2 architecture.
- One I/O board called as short MTORE (Module for hardwired digital inputs and outputs).
- 2 numbers of processor cards called the CCTE board.
- 2 numbers of wheel sensor interface and processing cards (CODOUH).
- 2 numbers of power supply board called ACSDV board.
- One memory card for storing the configuration details called CBOP board (Plug card: Memory Card holding information necessary to the initialisation).

- One memory board for storing train data called CBAT card provided in rear of CBOP card of On Board Computer (Plug Card: Memory Card containing Train and Odometer data).
- One card having a set of relays called COR6U board (6 Unit Relay Commutation board).
- One safe output board called CIMRE board (European Rail Traffic Management System Train Interface board) for generating the vital output i.e. the brake command outputs.
- All the above cards are wired in a rack.
- The input to ACSDV card is 24 V DC. Each ACSDV card is fed through 110 V DC to 24 V DC-DC Converter.

Functions of On-board Computer:

- Reading of Balise.
- Processing track side messages.
- Odometry (Speed Sensing).
  - **Calculation of Speed:** The system shall accurately calculate the train speed duly accounting for wheel slip/skid corrections.
  - **Calculation of speed profile:** On board computer shall calculate the static and dynamic speed profile for the track section ahead based on data received from balise and data available on board of the train characteristics.
  - **Calculation of permitted speed:** Based on all relevant data (available with on board & as received from balise), the TPWS shall calculate permitted speed, warning speed, a service braking curve and an emergency braking curve for the train for all locations on the section.
  - **Release Speed:** A release speed allows the train to approach the target (i.e. stop signal at ON) with such speed so as to ensure that the train stops before reaching the danger point (overlap distance beyond the stop signal at ON) upto which train movement is considered safe, based on data received.
- Display/controls with driver.
- Braking management i.e.
  - Service Brake
  - Emergency Brake
  - Records data.

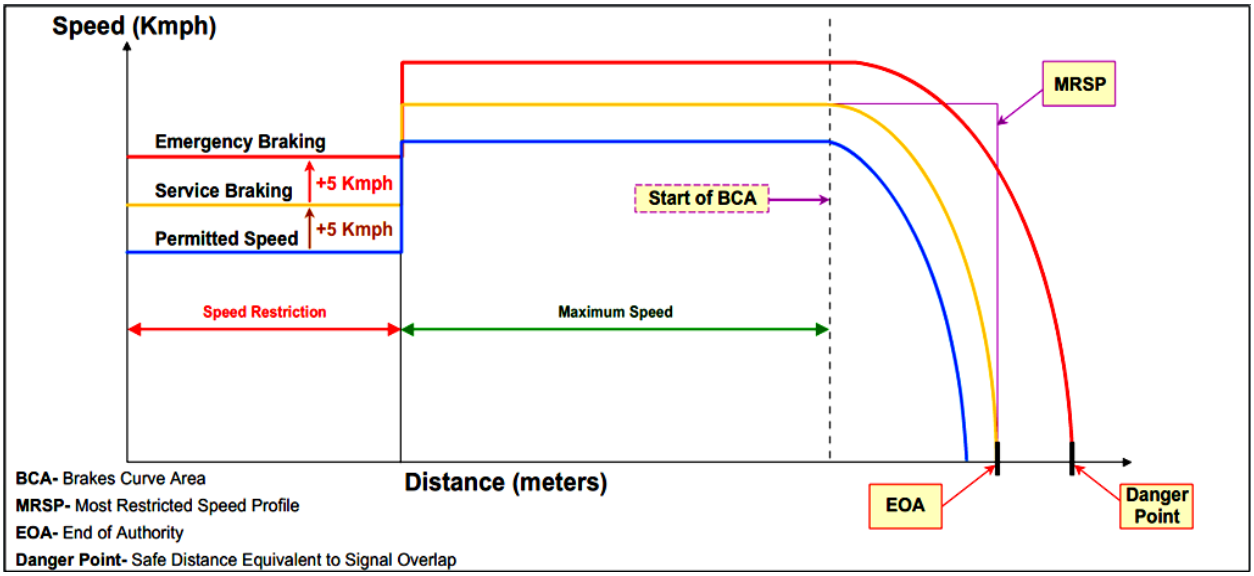


Fig. No. 2.3

Balise Transmission Module (BTM)

Balise Transmission Module (BTM) generates 27MHz signal for transmission through antenna. It also decodes the messages received from trackside through antenna & sends it to OBC. OBC takes the input from BTM & speed sensor, analyses the data & generates signals for application of Service Brake / Emergency Brake depending the requirement. In addition OBC generates visual & audible indication for the driver (Like current speed, Level information, Mode information, failure information, Target speed, Distance to brake, over speed warning, Service brake indication, emergency Brake indication etc). All the indications are displayed on DMI in the form of standard symbols. ETCS type DMI is having a set of touch screen buttons for various controls & data entry.

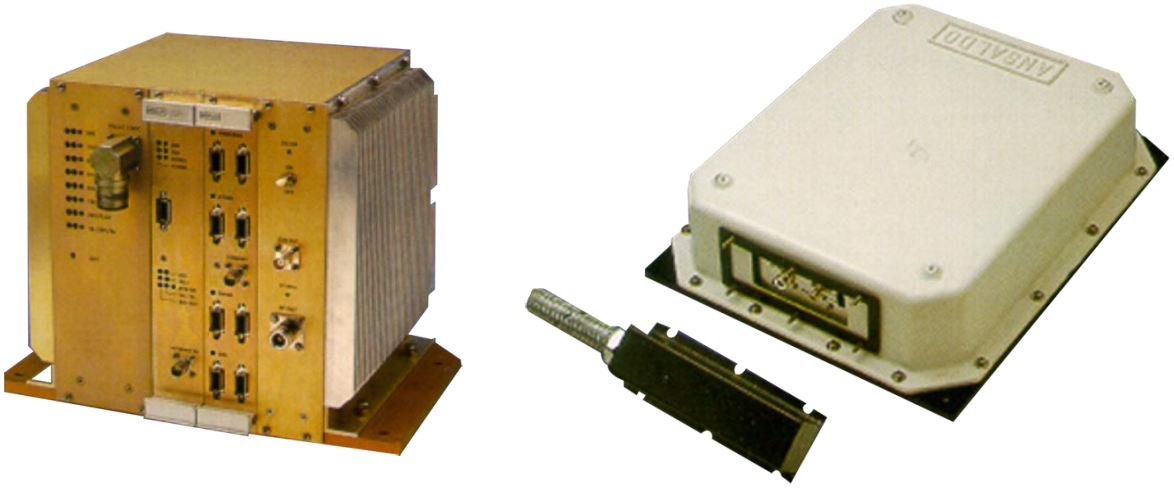


Fig. No. 2.4 Balise Transmission Module & Antenna

The simplified DMI is an LED based display unit. The buttons are hardwired push buttons. The icons used are exactly the same as that for CENLEC DMI.
It shows the following indications:

Driver Machine Interface (DMI):

1. Maximum permissible speed of the section.
2. Actual speed of the train.
3. Target Distance-It indicates that the remaining distance to brake target, when the train is in Brake Curve Area(BCA)
4. Level of Working: Unfitted mode and Level-1.
5. Full Supervision (FS) mode: When the track and train data are available then the system assume with full supervision mode.
6. Brake Application:
    a. Service Brake application.
    b. Emergency Brake application.

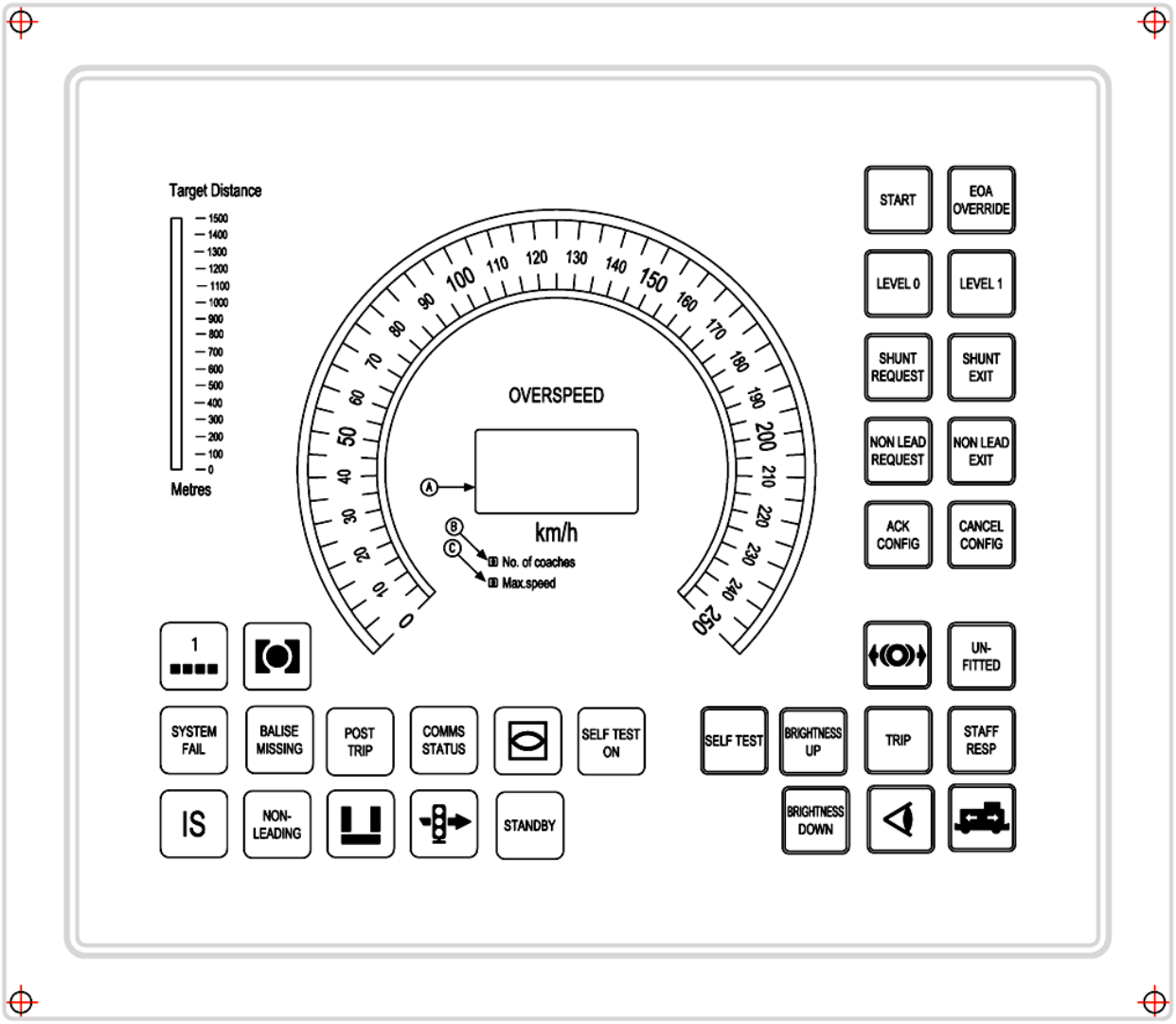


Fig. No. 2.5 SDMI as per RDSO Specification Number RDSO/SPN/183/2010

Wheel Sensors

It provides continuous information regarding actual speed, the inputs for distance travelled and orientation of movements. Provided on two different axles of the driving cab, there by correct the evaluation of distance travelled due to slips and slide movements of the wheels.

Fig. No. 2.6 - Wheel Sensor

Brake Interface:

For service brake intervention, the signal from OBC is fed to coils of the existing relays (Holding & Application relays) used for EP (Electro-Pneumatic) brake application of the EMU motor Coach through the contacts of safety relay (M/s leach make).

For Emergency brake two solenoids are provided, One solenoid is for cutting off the MR (Main Reservoir) pressure during application of EB & the second is for dropping of pressure in Brake pipe (BP). These solenoids are being provided on the branched brake pipe tapped from the existing brake pipe. Normally solenoid-controlling MR is kept in open condition whereas solenoid controlling the BP pressure is kept in closed condition with 110V DC coming through contacts of a safety relay (M/s Leach make). During application of EB command from OBC the supply to safety relay is cut-off there by opening BP solenoid & closing MR solenoid and hence resulting in application of EB. During application of SB (Service Brake) or EB (Emergency Brake) traction power is cut-off.

Both these solenoids are having bypass manual cocks to bypass the respective solenoids incase of failure. In case of failure, the cock provided in parallel with the MR solenoid should be kept in open position & the cock provided in series with the BP solenoid should be kept in closed position. This will result in pneumatic isolation of the system in case of system failure.

Isolation:

Electrical isolation is achieved by turning the **Isolation** rotary switch to bypass position. In this position the circuit between the EB safety relay & solenoid is cut off. This switch also cuts off the supply between SB safety relay and holding & application relay. Through a set of contacts of rotary isolation switch traction supply is made permanently through & 110Vdc is directly extended to BP solenoid to keep it energized. In case failure of solenoids, pneumatic isolation can be achieved using cocks as discussed in the previous para.

2.4 Track Side Sub System

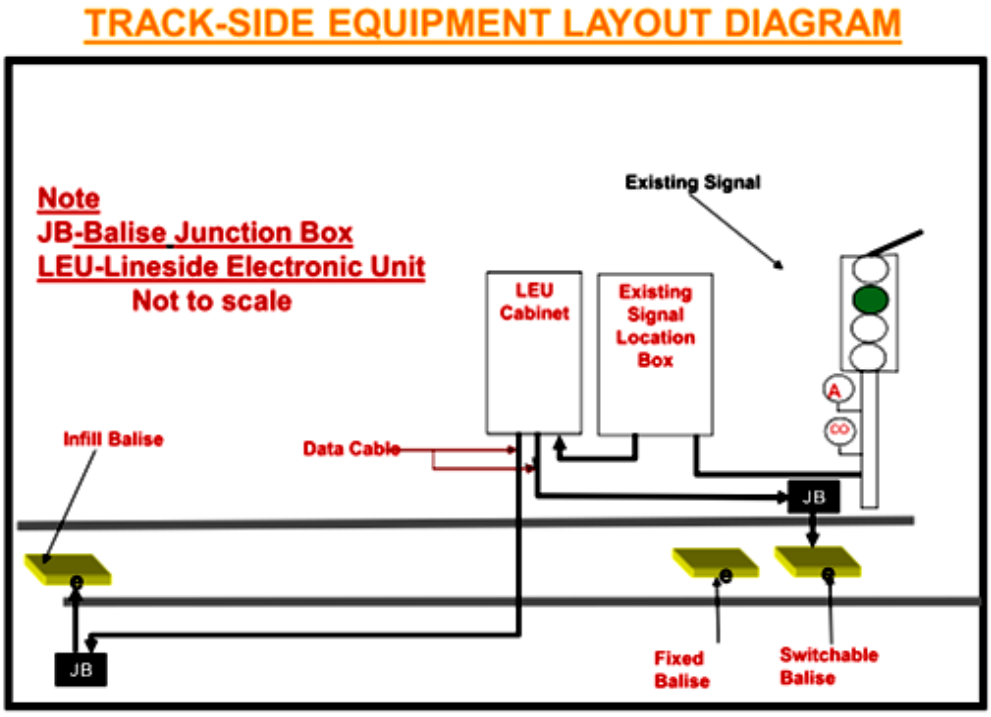


Fig. No. 2.7

2.4.1 Functions of Track Side Sub System

(a) Determines movement authorities according to the underlying signaling system of Railway.

(b) Transmits movement authorities and track description to the train.

2.4.2 It consists of

(a) Line-side Electronic Unit (LEU)

(b) Track-side balise.

2.4.3 Input data to be fed to Track Side Sub System

(a) Inter Signal distances.

(b) Aspect Control Chart details.

(c) P-way section gradient.

(d) Sectional speed.

(e) Permanent speed restrictions etc.

2.4.4 TRACK-SIDE BALISE

Balise is a transmission device which can transmit track side information(aspect of signal),in the form of telegrams (messages)to the on board cab equipment, by using magnetic transponder technology. In European countries balise is called by the name Euro Balise .

(a) Transmits Telegrams from LEU to on-board equipment while an active EMU driving cab passes over it.

(b) Air gap Interface.

(c) Transmission 27.5 MHz downlink signal and 4.234 MHz (+/-282.24KHZ) uplink signal.

(d) FSK transmission 565.4 KHz.

(e) Upto 1023 bit telegrams.

All the balises are linked (Linking information) in which the Id of the next balise & the distance to that balise is fed. This linking information helps in odometric correction & in finding out missing balises. In case of missing switchable balise “SB” (Service Brakes) will be applied. In case of missing infill balise there will be no action.

All the balises are linked in which the identification (Id) of the next balise & the distance to that balise is fed. This linking information helps in odometric correction & in finding out missing balises.

Balise is composed of two loops (one for transmission & another for reception) along with other circuitry. The entire assembly is hermitically sealed. Balises are fixed on the sleeper through which all the trackside information (telegrams stored in LEU) are transmitted to OBC using magnetic transponder technology. In this technology, the balise becomes active due to the magnetic waves (at 27.5 MHz) received from the on board antenna fitted at the bottom of the cab. Once active, it transmits the necessary telegram to On Board through Air gap using FSK modulation with 4.234 MHz centre frequency & deviation of 282.24 KHz.

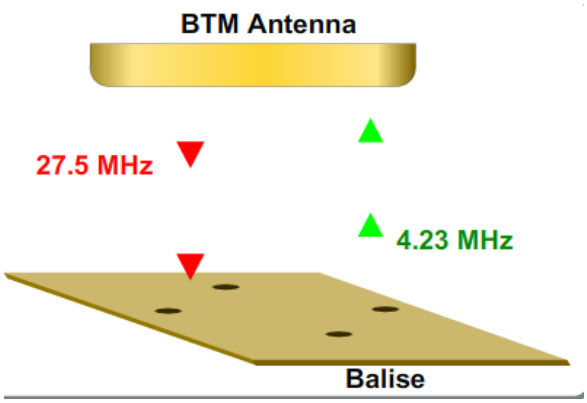


FIG.NO.2.8 TRACK-SIDE BALISE TRANSMISSION AND RECEPTION.

Types of Balise:

1. Switchable Balise This Balise is connected to the Signal through LEU (Line side Electronic Unit) for transmitting the Signal aspect information .And is provided at the foot of the Signal.

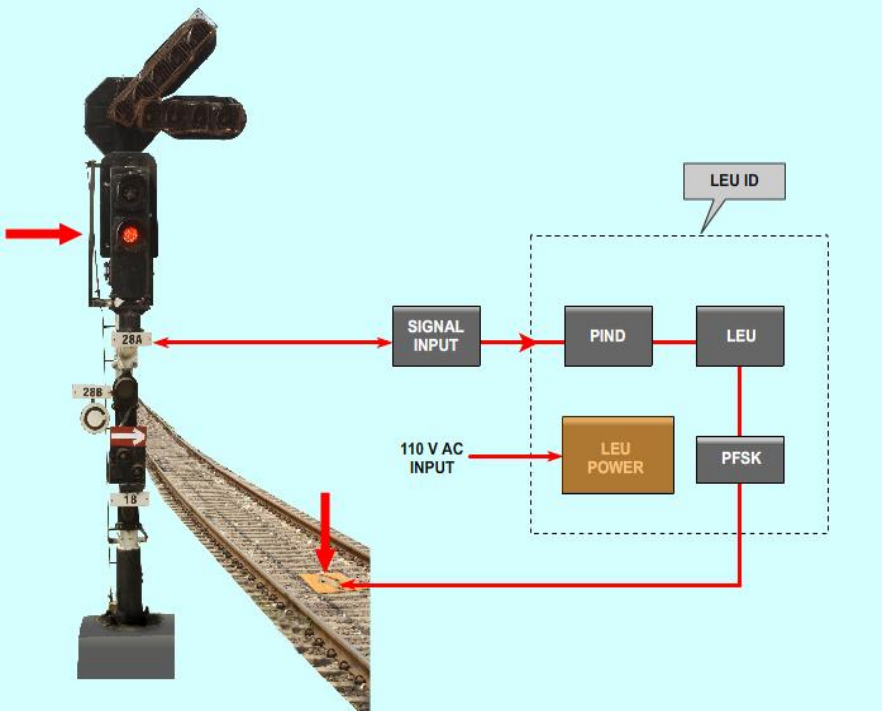


Fig. No. 2.9

2. **Infill Balise:** For the main line, additional balises are placed usually at 500 m in rear of the signals (connected through data cable) these balises are called **infill balises**, which are provided to transmit the information regarding change of aspect of signal in advance there by increasing the line capacity, as well as Updation and reduction in movement authority.

3. **Fixed Balise:** There are some balises, which are not connected to the signals. These balises are called **fixed balises**. Basically these balises are used to establish co-ordinate system of the balises for the On Board Computer. Fixed balises are also utilized for repositioning purpose when the train is dealt on calling on signals for knowing the correct road on which the train is going, as no route information is available to the system when Calling On signal is cleared. Also used to

   - Checked entry and exit.(Terminal Platforms)
   - Checked changes in the levels i.e. Level O to Level 1
   - Checks Start and End of TPWS Sections.

Repositioning Requirements:

At the start of Signal A, an linking information will be sent for Balise group (B1_B3) i.e linking distance .The Movement authority to the destination Signal (C1_C3) will be updated with respect to the length of track.

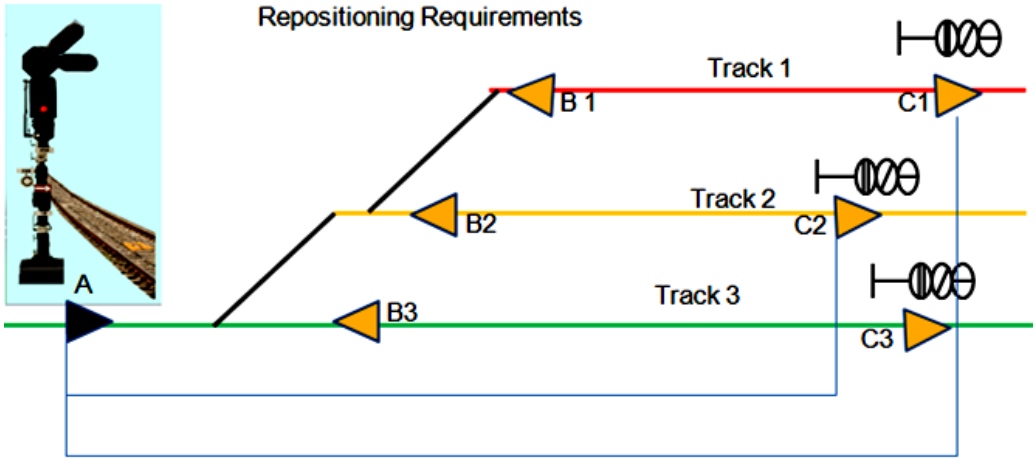


Fig. No. 2.10

Telegram: Telegram is a set of well defined packets, configured in LEU,One telegram is also stored in Switchable Balise which is called as default balise telegram use during the communication loss between LEU and Balise. Default Balise telegram is always a restrictive message. There are a total of 38 packets for track to train transmission.

Telegrams are prepared on the basis of base table which contains the following information

(a) Survey reports of inter signal distance.

(b) Signal Interlocking plan for Aspect Control chart and gradients.

(c) Permanent speed restrictions if any.

(d) Each telegrams has unique ID.

(e) Size of the telegrams is 1023 bits.

(f) Uplinks 4.23 MHz FSK transmission

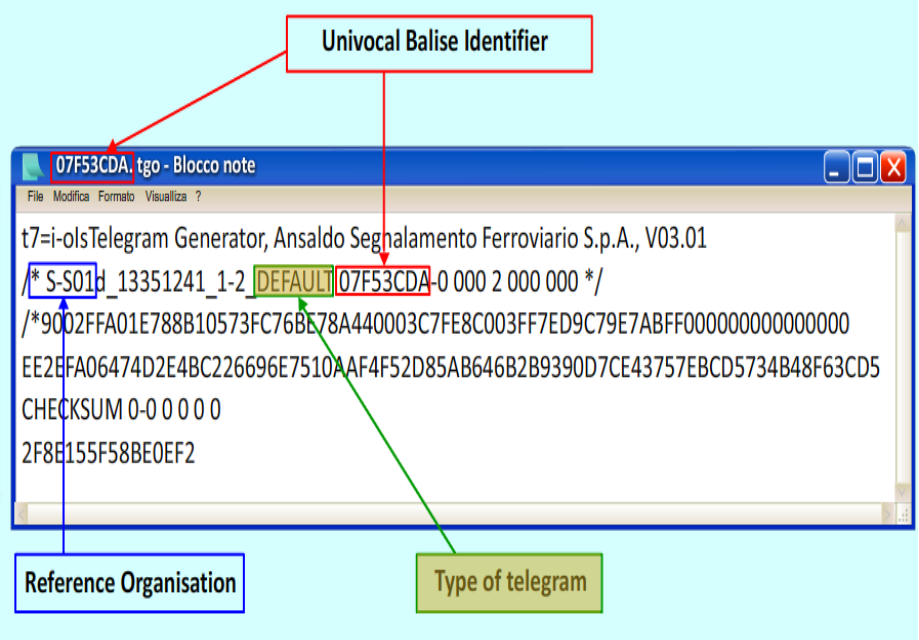


Fig. No. 2.11

2.4.6 Description of Track Side Sub System

For implementing level – 1, LEUs (Line side Electronic Unit) & Balises are installed as part of trackside sub system.

The LEU is composed of LEU ID module which is the processor module, having 2 out of 2 architecture, one PIND (Digital Input Protection) board which is used for the input over voltage and surge protection and one PFSK (FSK Module) board which is used for output over voltage /surge protection. The signal aspects are interfaced to LEUs using one Front Contact (FC) of ECR/ ECPRs of each aspect. In one LEU module, 10 FC of ECR can be wired as input & to each LEU four separate balises can be connected as output. The LEU module works on 48V DC, which is supplied by a 110V AC/48V DC converter. 110V AC/24V DC converter supplies the 24V DC required for ECR front contact sensing. 110V AC is extended from signal supply available in the signal location. A set of telegrams is stored in LEUs, which are communicated to the OBC (On Board Computer) through balise depending upon the aspect of the signals. All the information is passed from trackside to the On board in form of telegram. A telegram is a set of well-defined packets. There are a total of 38 packets for track to train transmission.

ARCHITECTURE OF L.E.U.

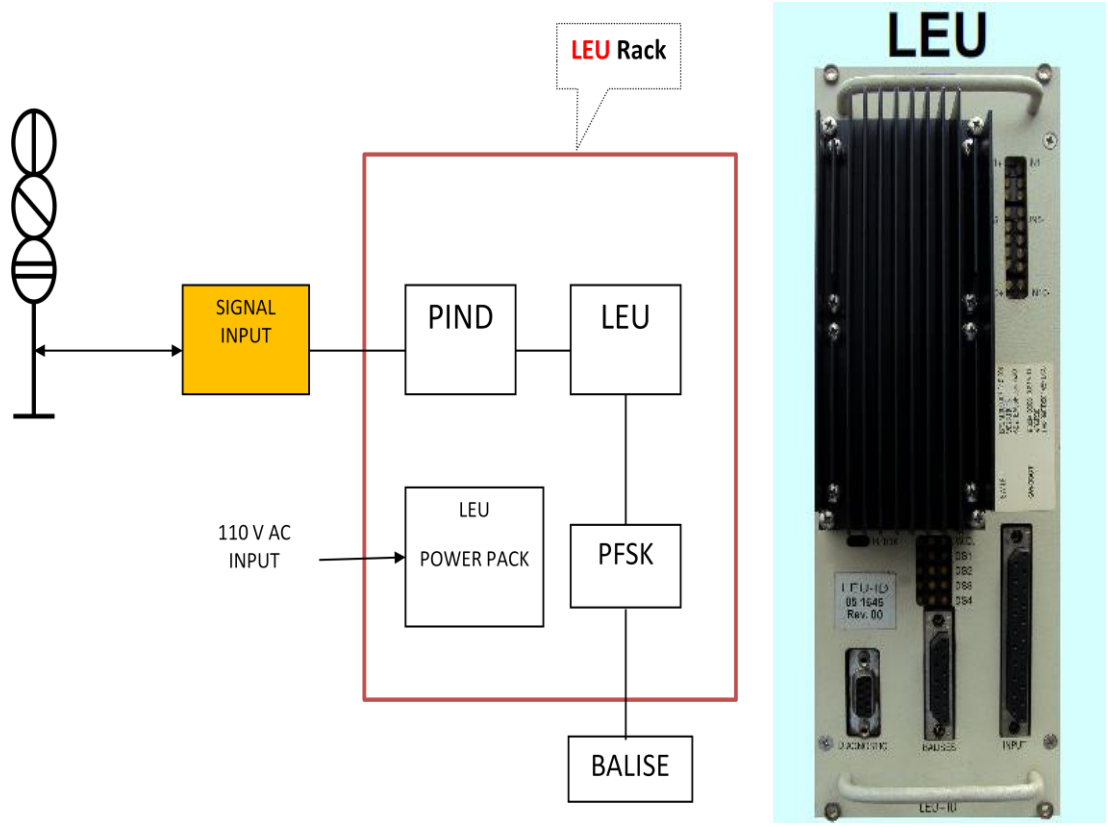
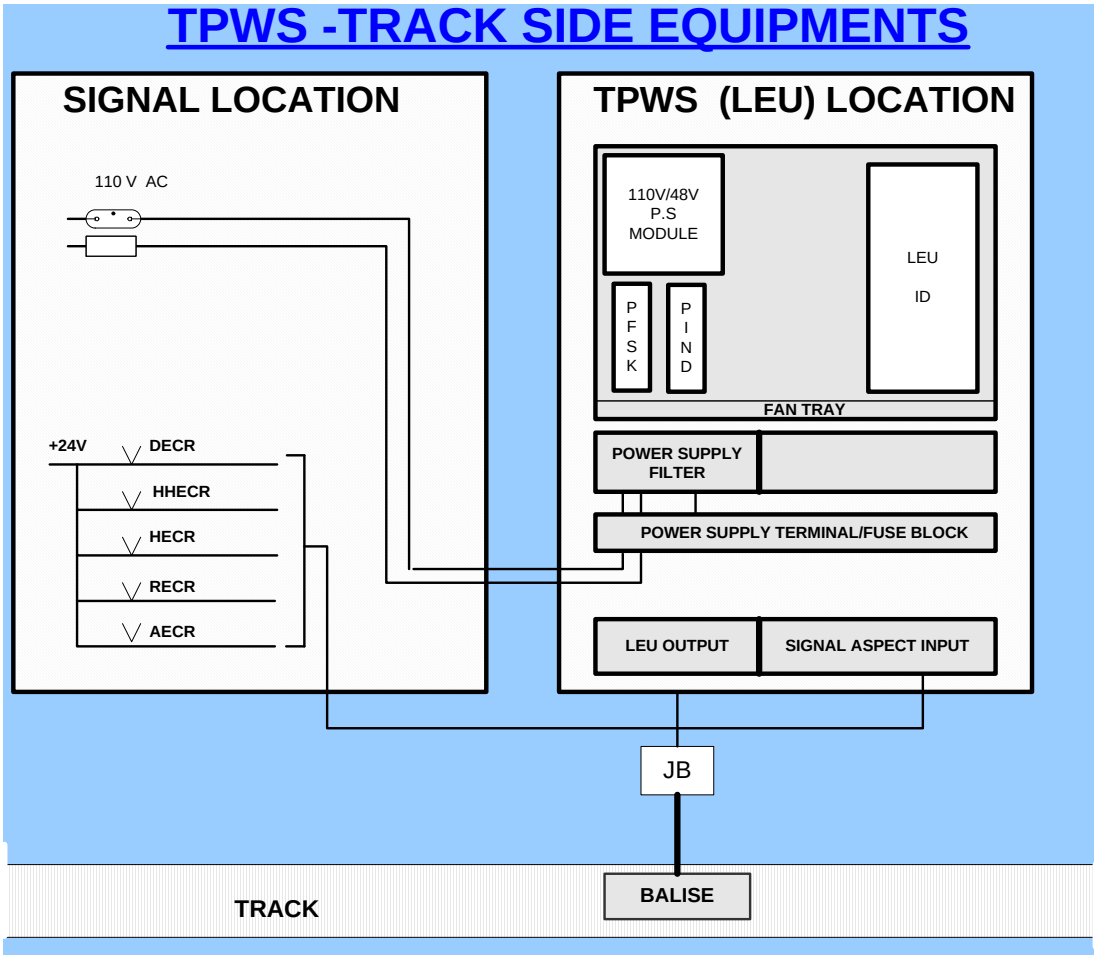
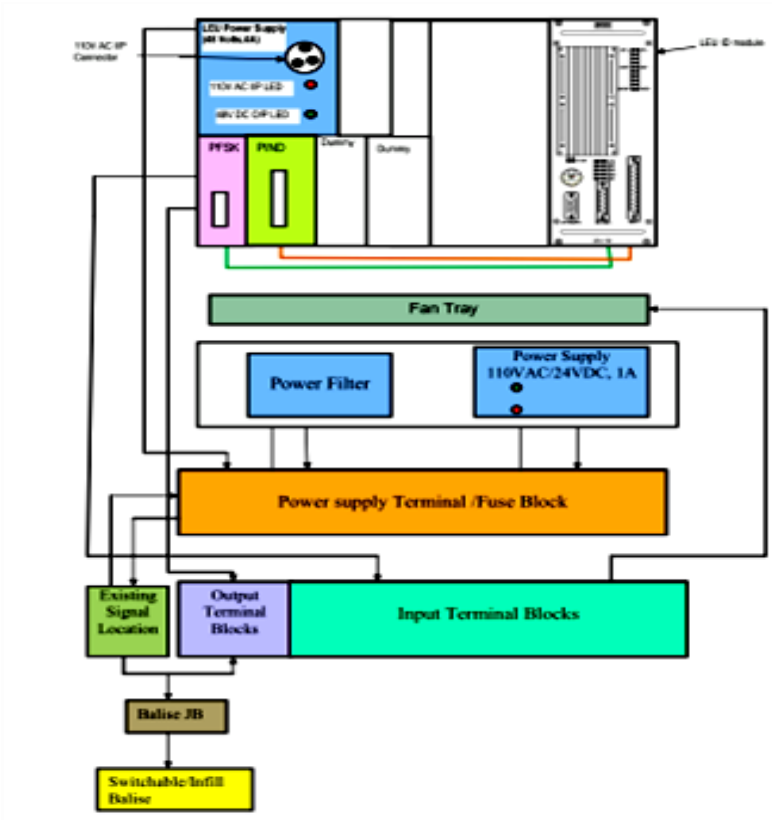


Fig.No. 2.12 ARCHITECTURE OF L.E.U.





LINE SIDE ELECTRONIC UNIT

Fig. No. 2.13 & 2.14

LINE SIDE ELECTRONIC UNIT

Following LED indications and ports are provided for the proper working of Line side Electronic Unit:

1. ECR's Input Indications LED:

LEU can read maximum 10 numbers of signal inputs from ECR's (Line Proving Relays) and their corresponding indications are provided on the LEU LED indication panel which can be used to check the correspondence of concern signal input with respect to the signal aspect lits at site.

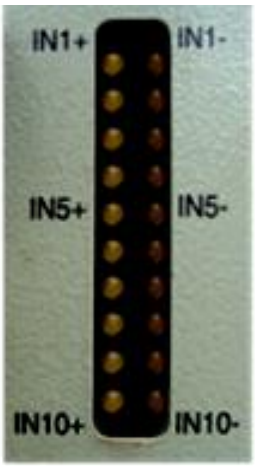


Fig. No. 2.15

2. Maintenance LED's:

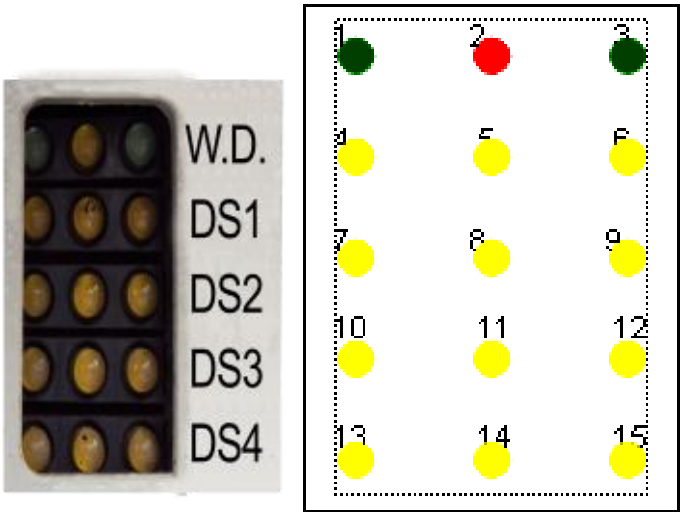


Fig. No. 2.16

15 numbers of LED organized in a 3 x 5 matrix. These LED indications provides information's about the status of Line side Electronic Unit.

- LED 1 – When this LED lits in green colour indicates that the LEU is powered.
- LED 2 – Indicates the redundant configurations of the LEU.
- LED 3 – Indicates the status of watch dog (WD).
  - When lits in green colour it,
    - indicates watch dog (WD) is active.
    - indicates the working of LEU is normal.

- When this LED is OFF, it indicates
  - watch dog is hit and
  - LEU has failed.

- LED 4, 7, 10 and 13 – When lits it indicates the status of four FSK channels.
  - When LED 4 lits, indicates channel 1 is active.
  - When LED 7 lits, indicates channel 2 is active.
  - When LED 10 lits, indicates channel 3 is active.
  - When LED 13 lits, indicates channel 4 is active.
- LED 5 – Indicates that the encoder emits the default telegram to the balise.
- LED 6 – Flashes for 5 seconds were indicates the changes of telegrams from the previous telegrams transmitted.
- LED 8 – Indicates the healthiness of the digital input connected to the LEU module.
  - When lits, indicates that one or more digital inputs are unstable.
  - When this LED is OFF, it indicates all digital inputs are stable.
- LED 9 – Indicates the connection to the other device.
  - When lits, indicates one or more remote LEU are not connected.
  - When this LED is OFF, it indicates that all remote LEU are connected.
- LED 11 – Indicates the type of LEU used.
  - When lits, it indicates that the LEU module is LEU-ID type otherwise it is LEU-IS type (not used in Indian Railways).
- LED 12 – Indicates the startup stage of the LEU module.
  - When lits, indicates that the LEU module is on startup stage and does self-test and verifies the configuration.
  - When this LED is OFF, it indicates the LEU module is online.
- LED's 14 & 15 (always OFF) – They are not used and reserved for future use.

➢ **System Healthy Indication LED:**

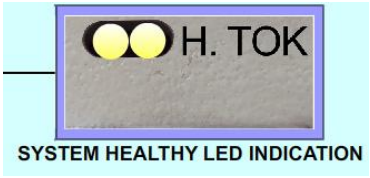


Fig. No. 2.17

- When lits, it indicates the healthiness of the system.
- When the LED is OFF, system is failed.

DIFFERENT PORTS

Following ports are provided on the LEU module for interfacing to the peripheral module of LEU and for diagnostic and programming of LEU.

- PIND Module
- PFSK Module
- Diagnostic Port

PIND Module Connector:

This module is an interface between ECR's contact to LEU and can read up to 10 input channels.

To provide digital signal inputs from PIND module to LEU this interconnection is provided

PFSK Module Connector:

This module is an interface between LEU and balise.

To provide output for the PFSK module the interconnection is provided through interface cable between LEU and PFSK module.

Diagnostic Port:

This port is used for uploading of LEU programming and analysis of LEU data through PC-SAM software via maintenance PC.

Fig. No. 2.18

2.5 TPWS BRAKE MANAGEMENT

2.5.1 Type of Brake Condition

(a) Service Brake.

(b) Emergency Brake.

2.5.2 Service Brake

(a) First level of brake intervention before Emergency Brake during speed monitoring.

(b) Automatic intervention while Exceeding the max. permitted speed by 5 KMPH after intermittent audiovisual warning.

(c) Roll away and Roll back is sensed by wheel sensors. If the direction is in neutral position, it restricts forward or reverse movement of the train within 2 meters. Thus it prevents the train from moving in unwanted direction especially useful in sections with steep gradients.

(d) Balise missing: When balise missing is noticed, one of the brakes is applied to bring the train to a halt.

2.5.3 Emergency Brake

(a) Passing of Signal at "ON" (Red aspect).

(b) Automatic intervention while Exceeding the max. permitted speed by 10 KMPH after continuous audiovisual warning.

(c) System failure or power down of the system.

(d) Passing over un-authorized balise.

(e) Exceeding Release speed.

2.5.4 Brake Activation

(a) Brake Activation may be Service Brake or Emergency Brake.

SB (Service Brake)			**EB** (Emergency Brake)	
1	On Over speeding (If actual speed > Permitted Speed + 5 KMPH)		1	On Over speeding (If actual speed > Permitted Speed + 10KMPH)
2	Permanent Speed Restriction.		2	Tripping.
3	Temporary Speed Restriction.		3	Release speed protection.
4	Missing Balise.		4	In case of failure of SB.
5	Roll away protection.			

(b) Generates various Indications on DMI (Ref: 2.7)

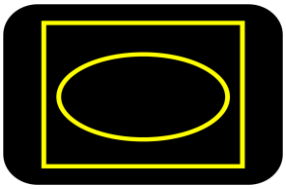
(c) Generates Audible Alarm on over speeding.

(d) Generates intermittent alarm when the actual speed exceed the Permitted Speed by more than 5 KMPH & continuous alarm if the actual speed exceed the Permitted Speed by more than10KMPH.

2.6 Modes of Operation of System

The SRS (System Requirement Specifications) version 2.2.2 specifies 16 modes of operation of on board equipments. At any point of time the On Board equipment has to be in any one of the modes. There are well-defined procedures for transition from one mode to another. Out of these 16 modes, 1. FS 2. OS 3. SR 4. SH 5. UN 6. SB 7. TR 8. PT 9. SF 10. IS and 11. NP are only applicable for SR projects.

1. Full Supervision (FS) Mode:



- TPWS on board equipment will be in Full Supervision (FS) mode when all train and track side data is available on board.
- Full Supervision cannot be selected by driver, but shall automatically enter into Full Supervision mode when all necessary conditions are met.

In FS mode, TPWS on board equipment supervises train movements against dynamic speed profile.

2. ON Sight Mode:

- On Sight (OS) mode enables the train to enter into a track section that could be previously occupied by another train or obstructed by any kind of obstacle.
- On Sight mode cannot be selected by driver but shall come from track side only.
- On Sight mode can be used to pass auto signals at ‘On’.
- Once entered into On Sight mode on board shall stay in On Sight mode up to the foot of next stop signal (i.e. next switchable balise group).

On board equipment monitors train against dynamic speed profile and On Sight mode ceiling speed limit.

3. Staff Responsible Mode:

- Yellow acknowledgement button with LED indication. Loco Pilot can move the train TPWS equipped area under his own responsibility.

4. Service Brake Intervention Mode:

- Red acknowledgement button with LED indication. It indicates the service brake application.

5. Emergency Brake Intervention Mode:

- Red acknowledgement button with LED indication.
- It indicates the emergency brake application. Emergency Brake intervention is registered in the form of counter.

6. End of Authority Mode(EOA) and Pass Signal with Authorization Mode

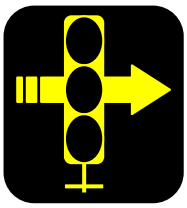
The On Board equipment shall allow the driver to select the n “EOA OVERRIDE” button only when

- The train speed is under the maximum speed limit.
- The current mode is
  - Full supervision
  - On Sight
  - Staff responsible
  - Shunting
  - Post trip or standby
  - Unfitted

Note : End of Authority mode can be used under specific degraded situation i.e.

- Signal failure, track circuit and point failure and authorized as per GR&SR.

7 .Pass Signal with Authorization Mode:



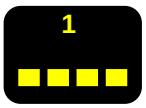
- After the train has stopped, Loco Pilot will press the EOA override button (as per rule).

Authorization mode icon yellow with steady lit appear on the Driver Machine Interface.

8. Balise Missing Mode:

- Red with steady lit.
- This icon will come when on board computer detects default balise information (balise missing) in case of communication failure or if the Balise Transmission Module antenna cannot detect the balise after travelling a specified distance as programmed in on board computer.

9. **Intermittent Transmission Level-1 Mode:**



10.Unfitted Mode

If only horizontal bar is lit, it indicates “ETCS Level-0”

11.Trip mode:

Red Acknowledgement button with LED indication.

The ‘TRIP’ icon will flash in red colour when the train passes the End of Authority, the on-board computer has activated Emergency Braking.

Note: No brake release is possible in ‘TRIP’ mode.

12. Post trip mode:

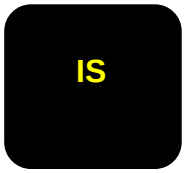
- Upon seeing the ‘TRIP’ flashing icon, the driver has to acknowledge the TRIP icon.
- ‘TRIP’ icon will extinguish after acknowledgement and ‘POST TRIP’ icon will be lit in yellow colour.

- In POST TRIP mode, the on-board equipment shall release the Emergency Brake command and shall let the driver to start the train again.
- Once the Emergency Brake is released the train can either be started in shunt mode or in SR (Staff Responsible) mode.

13. System Fail :

- Red steady indication.
- This mode will come in case of any vital system failure and Emergency Braking applied by the on board computer.

14. Isolation



- Yellow steady indication.
- This mode will come when the TPWS system is isolated.
- Electrical isolation between TPWS system and train equipment is achieved by turning the isolation rotary switch to bypass position.

* * *

CHAPTER 3 : Train Collision Avoidance System (TCAS)

TCAS has been aimed as an Automatic Train Protection (ATP) System having capability to prevent train accidents caused due to Signal Passed at Danger (SPAD) by train, disobedience of train speed restrictions etc. by Automatic application of the brakes should Train Driver fails to do so. It would, in addition, also avoid certain other collision like scenarios even in case of non-interlocked or non-signaled territory.

Advantages of TCAS:

1) It also provides assistance to Loco Pilots by means of real-time display of signaling related information such as Movement Authority, Target Speed, Target Distance, and Signal Aspects etc. in Loco Pilot's cab.

2) This includes key features of Anti Collision Device (ACD) and TPWS at much lower cost.

3) TCAS does not suffer from the issues like need of customization of braking model etc. of TPWS for use on any specific Railway.

4) It can be used with various different types of signal interlocking.

5) Unlike TPWS, TCAS provides continuous update of Movement Authority and thus obviates undue operational constraints and does not need to address the safety issues associated with 'Release Speed' on approach to a signal at danger.

Limitations of existing Train Protection Systems

1) Indian Railways version of **Auxiliary Warning System (AWS)** has been in use on Mumbai Suburban as a simple system fulfilling its limited objective effectively. It has outlived and needs to be modified as system does not detects the absence of Track Magnets.

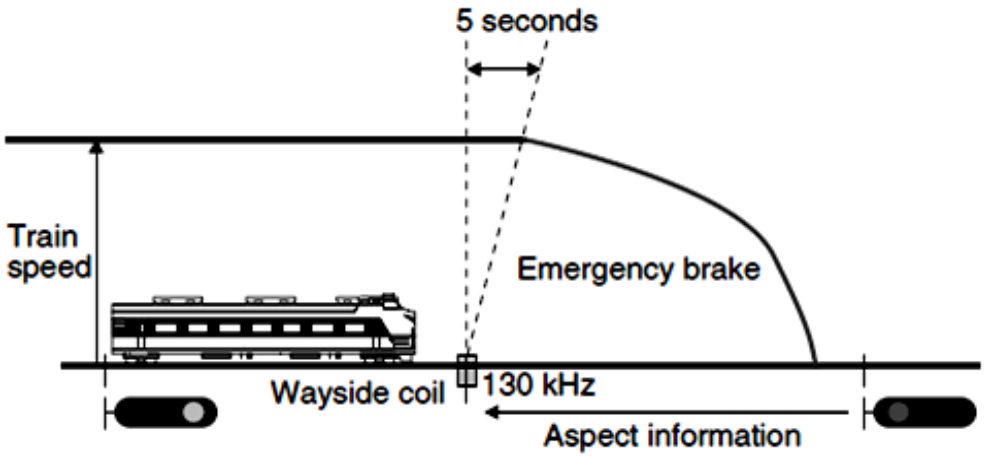


Fig. No. 3.1

2) GPS based Anti-Collision Device (ACD) has been provided on approximately 1700 Route-km of NF Railway (Extreme North-East Part of India). This is based on detection of various collisions like scenarios on the basis of locations determined through GPS. This is low cost but a non-failsafe solution as it is not capable of providing protection against SPAD (Signal Passing at Danger). Furthermore, it requires numerous Radio Repeaters in block sections.

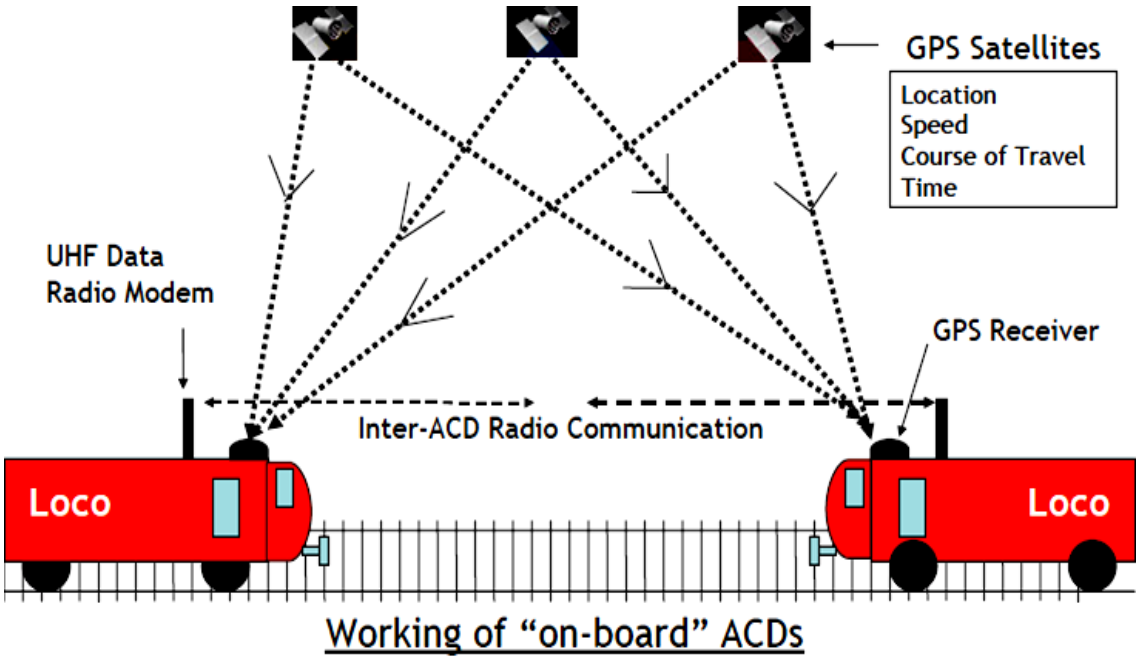


Fig. No. 3.2

3) **ETCS (European Train Control System) Level-1 based TPWS**, a SIL-4 (highest Safety Integrity Level) ATP System, has been provided as pilot project on Indian Railway on around 300 Route-km section and further work is in progress.

Despite being high cost solution, ETCS Level-1 TPWS is not capable of providing continuous update of Movement Authority which is desired to manage the high dense and high speed Operations. This inherent design limitation also ceases ability to stop the train prior to Signal at Danger (Red), i.e. the effect is more pronounced in context of Indian railways as it has mixed traffic of numerous small control centres in form of small stations with its own Signal Operator. There is wide variation in braking characteristics on Indian Railways and it may not be fully deterministic even through elaborate inputs from Loco Pilot at the start of mission.

ETCS Level-2 TPWS is not suitable for Indian Railways presently since it would need large scale modification even in present interlocking which have yet to complete their lives. Moreover, ETCS Level-2 is extremely high cost system and consumes lot of resources such as GSM-R channels etc.

Requirements of ATP System for Indian Railways

95% of Indian Railways is presently Non-automatic Absolute Block System with each interlocking having individual Signal Operator. Speeds in near future are not likely to exceed 200 kmph. The requirements for IR include key features of ETCS and ACD:

- Prevention of SPAD
- Speed Control for Permanent & Temporary Speed Restrictions.
- facility of SOS.
- Continuous Update of Movement Authority.
- Reasonable cost.
- Limited trackside passive equipment.

Train Collision Avoidance System (TCAS) has been envisaged as a low cost Automatic Train Protection (ATP) System for speeds upto 160 / 200 kmph.

Any ATP System needs following real-time information as minimum, which are achieved in TCAS in following manner:

Requirement	Mechanism in TCAS
Location of Trains	Distance traversed beyond a RFID tag on Track Sleeper (Rail-road Tie) through Tachometer
Extraction of dynamic Signalling information	By Interfacing to interlocking
Transfer of Signalling related information to Train	Radio Communication among various Stationary & Train units through dynamic TDMA. Stationary units are allocated timeslots according to Topography and their size. Mobile units i.e. trains are assigned slots dynamically. This provides efficient utilization of channels.
Knowledge of Braking Characteristics of Train	Crude but adequately reasonable braking characteristics are determined by carrying out Brake Test at the start of mission. Adaptive braking logic to control brakes seamlessly based upon deceleration and closed loop control.

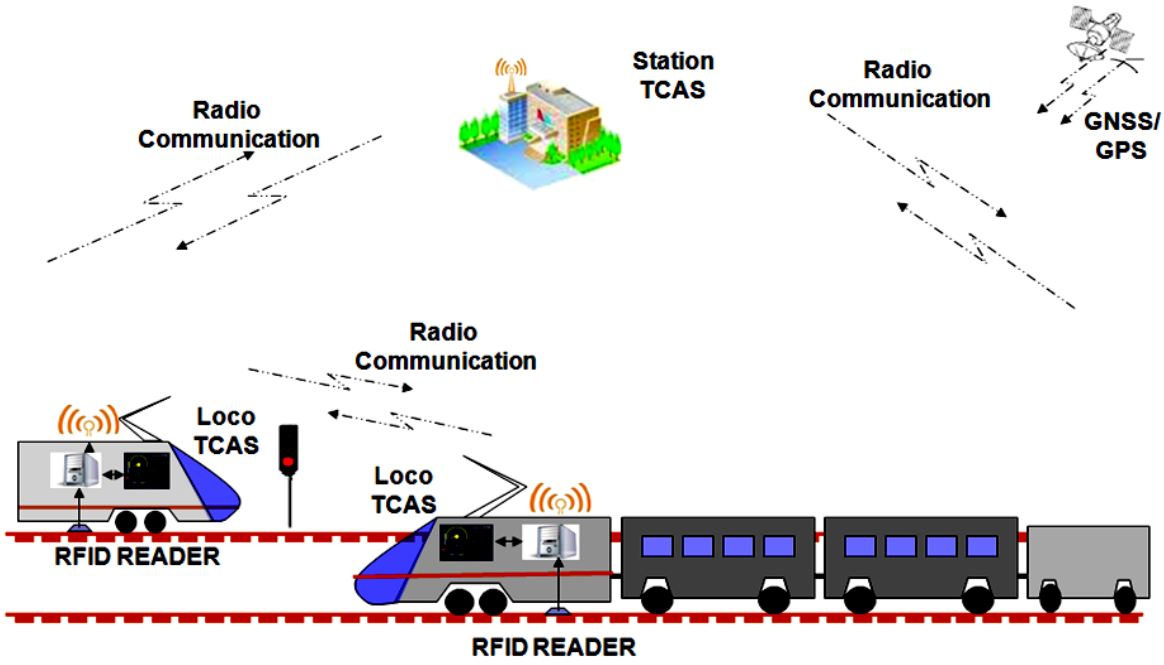


Fig. No. 3.3

As mentioned above, TCAS is based on the determination of location of Trains through distance traversed from RFID tags installed on track and transmission of signaling related information from Stationary Unit such as Station Interlocking. The train unit shall deduce its 'Movement Authority' i.e. distance to the approaching signal at Red and 'Target Speed' for 'Target Distance'. The Stationary Unit shall also disseminate the information of trains to all other trains in vicinity through radio signals. The information is used to determine whether unsafe situation has resulted, in which brake application is necessitated, but the Crew has either failed to do so or is not in position to do so. In such case, automatic brake application shall take place. It has got other features too such as facility of Auto & Manual generation of SOS from Station as well as train.

The present low cost design is suited for Absolute Block Signalling for 160/200 kmph speeds. Minor design modifications shall render it to be suitable for Automatic Signalling as well.

Main components of TCAS:

TCAS consists of Station Equipment, Loco Equipment and RFID tags on Track.

Fig. No. 3.4

TCAS –Schematic Arrangements.

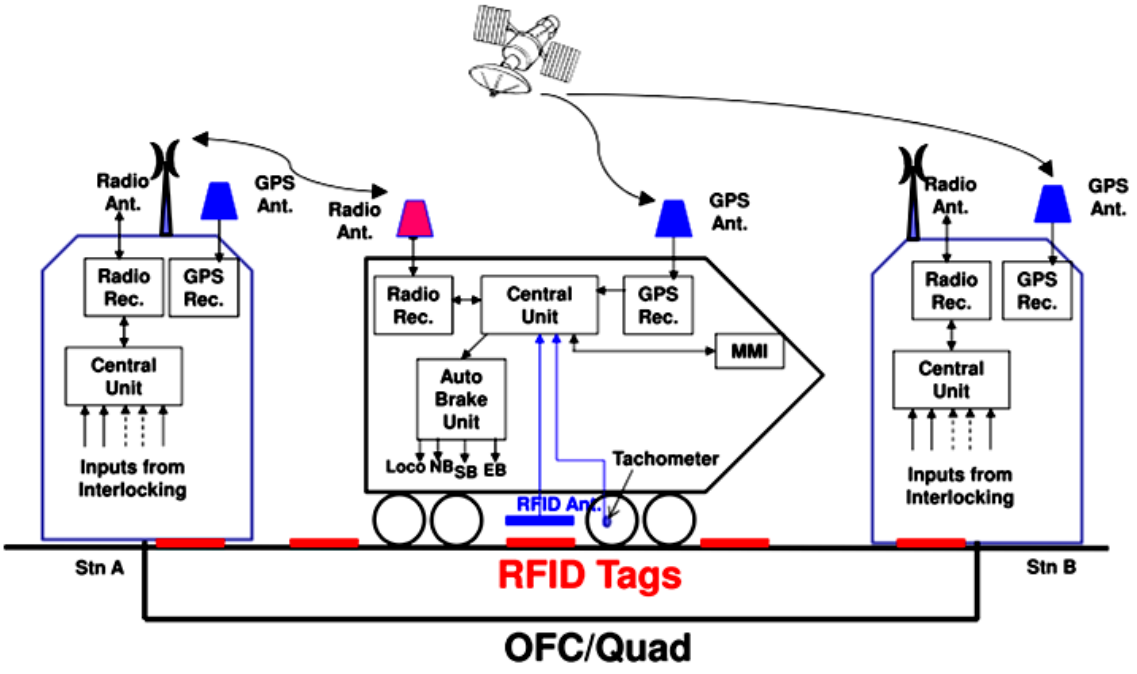


Fig. No. 3.5

RFID Tags Deployment

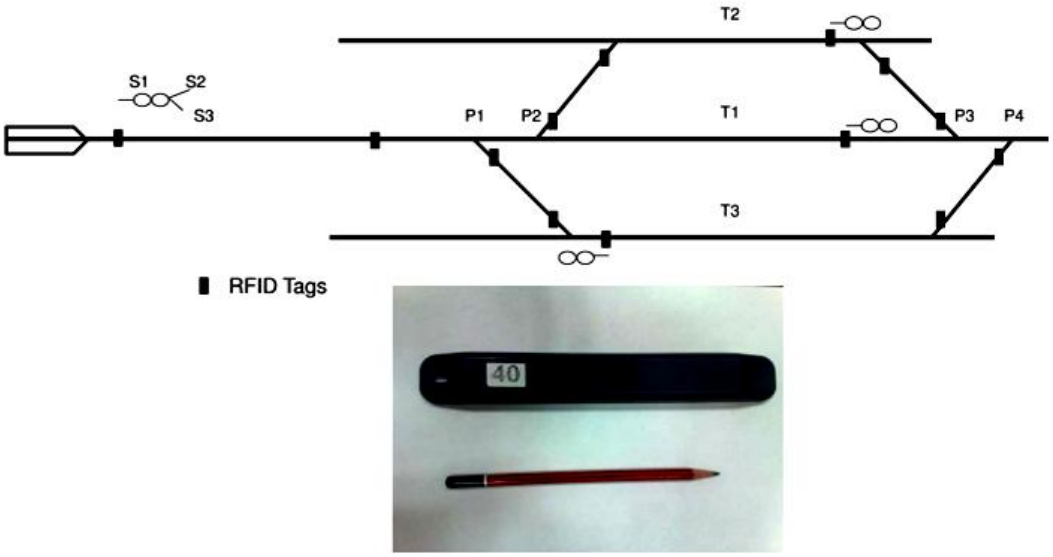


Fig. No. 3.6

Stationary TCAS Unit:

This shall be provided at Stations, Intermediate Block Locations (IBS) and mid-section interlocked Level Crossing Gates to cover all the trackside signals. This shall be interfaced with interlocking equipment to acquire real-time dynamic information related with signaling such as various signal aspects. It has database of static signaling related information such as location & details of RFID tags, Speed Restrictions in its database. It is interfaced to interlocking for the purpose of extracting dynamic signaling information such as aspects of various signals. It gets real-time information regarding Locations, Speed etc of various trains in its jurisdiction through UHF Radio Communication. On the basis of this information, it detects any emergency situation and can direct the command to Loco to take action to stop.

Fig. No. 3.7

RFID tags on Track Sleepers or Rail-Road Ties:

These provide site specific static information to Locomotive. Apart from acting as Location references, these relieve the Radio Channels and provide immediate information such as crossing the signal etc. to Loco Unit.

Fig. No. 3.8

Loco TCAS Unit :

Loco TCAS Unit receives Signal Aspects, Movement Authority etc. from Stationary TCAS Units. It gets some information from RFFID tags installed on track through RFID Antennae and Reader. It transfers the ID of last RFID tag crossed, current Location of Train, speed etc. to Stationary Unit. It can detect emergency situation on its own or can get this information from Stationary Unit. In case, Loco Pilot fails to takes action of application of braking in time, Loco TCAS Unit automatically applies the brakes to prevent untoward situation. For example, in case of finding the train running too fast towards a Signal at Danger to result in SPAD, it shall provide protection through automatically application of brakes much in advance. Loco Unit also has a Driver Machine Interface which provides real-time information to Driver such as Signal Aspect, Movement Authority, Distance to Signal on approach, Target Speed, Target Distance, Speed Dial, Concerned RF Field Strength Indicator etc. Loco Pilot can invoke overrides, specific modes and initiate SOS through this DMI.

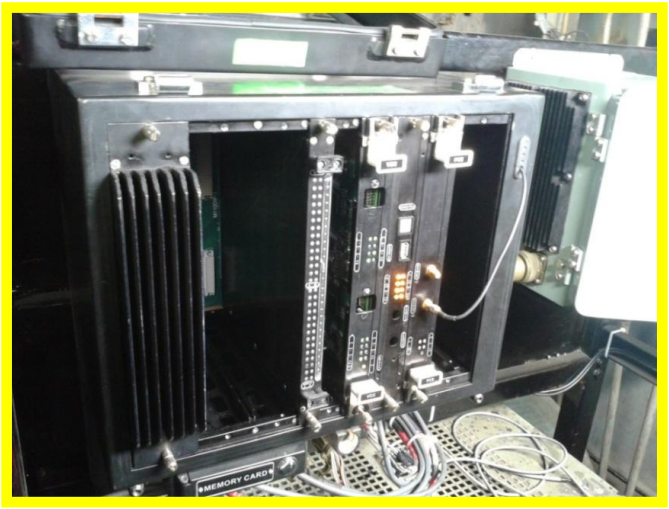


Fig. No. 3.9

Fig. No. 3.10

OFC /QUAD LINK:

(a) Adjoining Stations, L.C. Gates and IBH are connected through OFC Link.

(b) Information regarding exit of train from station section to block section is detected And communicated to adjoining station

Assessment of Braking Characteristics :

Braking characteristics of any specific train are assessed by “Brake Test” at the start of mission. These Parameters are used to determine the spot where from the braking by Loco TCAS unit need to commence. Frequent placement of RFID tags in the vicinity of Signal on approach shall enable Locomotive unit to dynamically adjust braking effort for stoppage of train.

Determination of Train Length :

Station Interlocking and Locomotive units together determine train length. The determination is crude but within tolerances to determine substantial change in configuration.

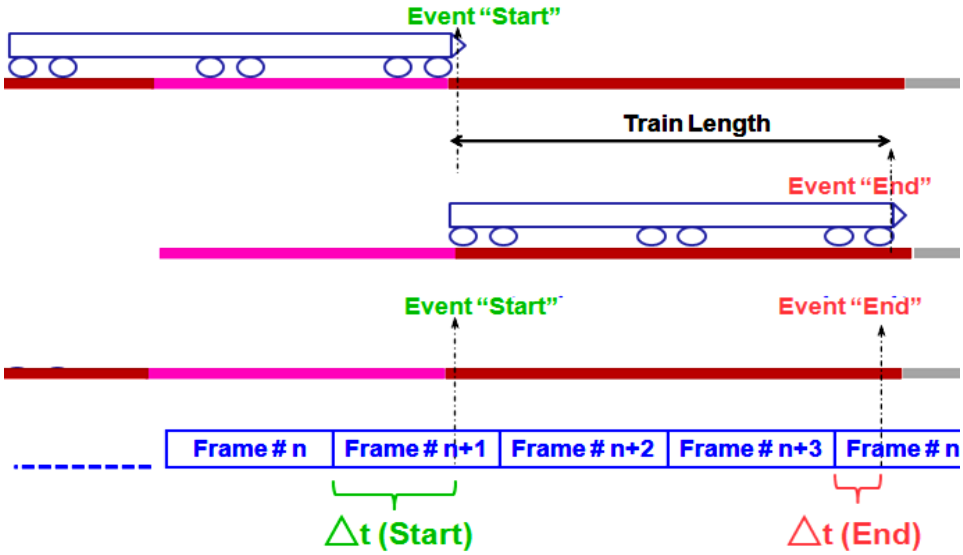


Fig. No. 3.11

Loco Unit memorizes its position along the track in FIFO manner. Train Detection mechanism of Interlocking detects Time Stamps of ‘Start’ & ‘End’ events and Station TCAS units passes on the information to Loco Unit. Loco unit registers locations pertaining to ‘Start’ and ‘End’ events. Difference between two locations is Train Length.

Radio Communication for TCAS:

Presently, Full Duplex UHF Radio Communication is being used for transfer of information between Stationary and Locomotive units. Stationary Units normally transmit on frequency channel f1 and receive on f2. Locomotive Units normally transmit on frequency channel f2 and receive on f1. In emergency situation, Locomotive shall additionally transmit on f1 in a timeslot and tune back to receive on f1. Transmission by Locomotive on f1 in case of emergency situation shall enable other trains in vicinity to get the immediate message without routing through Stationary Unit.

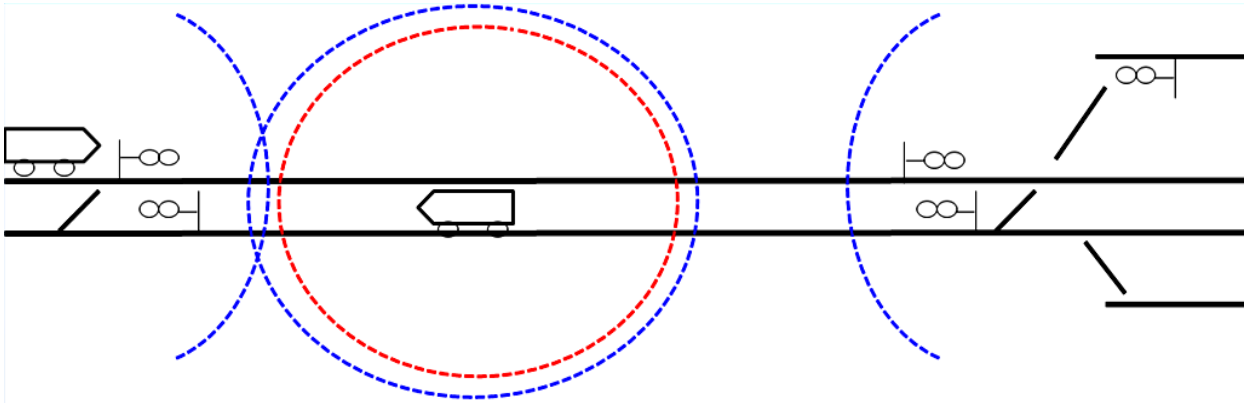


Fig. No. 3.12

In Absolute Block Territory, Signals are located in the vicinity of Stations or interlocked LC Gates or IBS only. Therefore, the requirement of communication range between Stationary Unit & Loco Unit for the purpose of transmission of signalling information is limited to approach of outermost signals i.e. ~ 3.5 km.

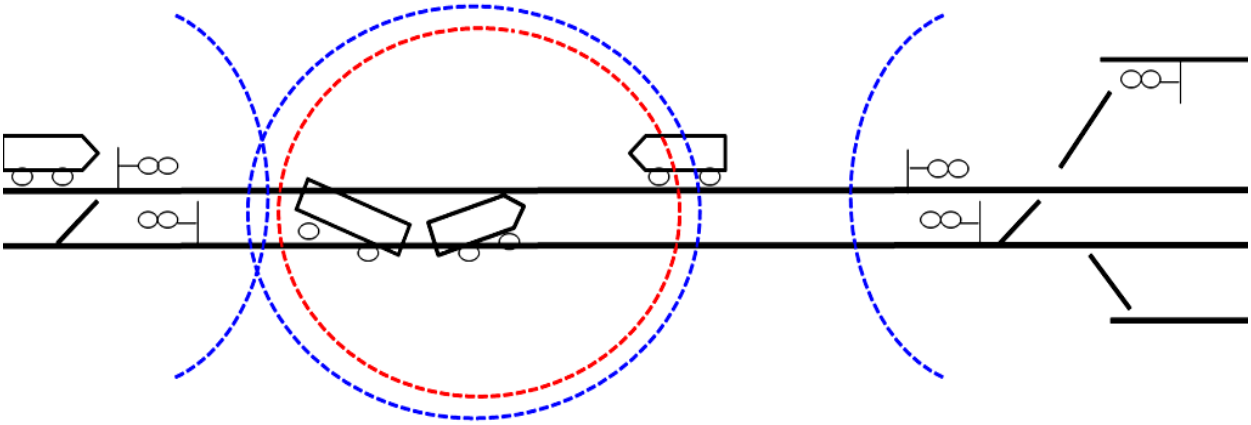


Fig. No. 3.13

However, transmission of emergency messages such as “Infringement / Side Collision Message” etc. by derailed Train on both the frequencies shall enable these messages to be received by both – other locomotives as well as stations.

Applications of TCAS

Dynamic TDMA for enhanced Communication Efficiency:

In order to efficiently utilize the scarce communication resources, specifically designed dynamic TDMA with preconfigured Stationary (f1) timeslots with explicit dynamic reservation of Locomotive (f2) timeslots by Stationary to mobile trains has been employed. In order to further enhance the throughput, multiple frequency configuration can be adopted in future.

The RF Field Strength from various Stationary units shall be dynamically kept at optimum level so as to provide reliable communication in desired zone and also to obviate interference to the adjacent stationary TCAS unit with same timeslot. In order to reduce the interference, adjacent stations shall be configured in different timeslots and same timeslot shall repeat quite far away.

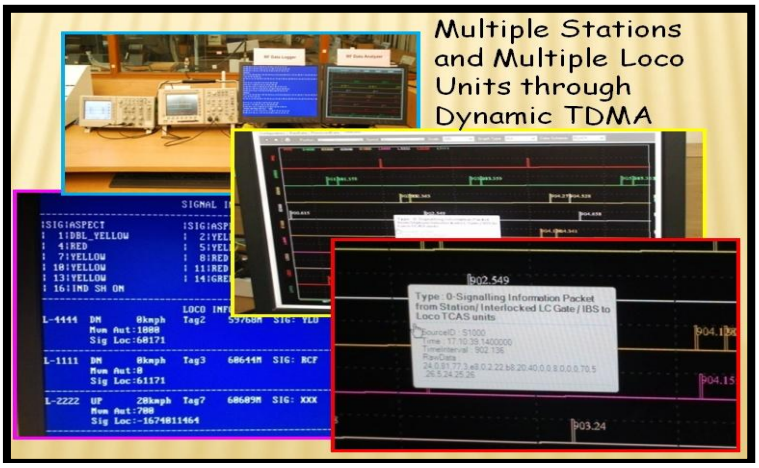


Fig. No. 3.14

Summarizing salient features of TCAS:

- Unlike ETCS L-1, TCAS is based on continues real-time update of signal aspect or 'Movement Authority (MA)' which is quite suitable to requirements of operations in countries like India.
- Due to above continuous MA update feature, it is able to restrict the train before signal at Red itself instead of braking it in Overlap as is necessitated by ETCS Level-1.
- Operational Convenience to Loco Drivers – no need to feed train configurations such as braking characteristics, train length etc.
- Retaining specific needs of Indian Railways which are fulfilled by other indigenous system ACD –provides protection in case a train derails and infringes adjacent tracks
- Quite Cost-effective – doesn't need Mobile Radio, Active track balise

Comparison of ETCS & TCAS Features:

Feature	ETCS Level-1	ETCS Level-2	TCAS (IR-ATP)
Cab Signalling	Yes	Yes	Yes
Line side signal	Required	Optional	Required
Continuous supervision	Yes	Yes	Yes
Continuous update of Movement Authority	No	Yes	Yes
Suitable for Auto signal	Yes	No	Not presently
Collision prevention (without help of Signalling, with the help of absolute location)	No	No	Yes
SOS feature	No	No	Yes
SIL-4	Yes	Yes	Yes
Invulnerability to theft (No costly trackside devices)	No	Yes	Yes
Easy to operate	No	No	Yes
Cost	High	Very High	Low

Various Field & Lab Trials for Development:

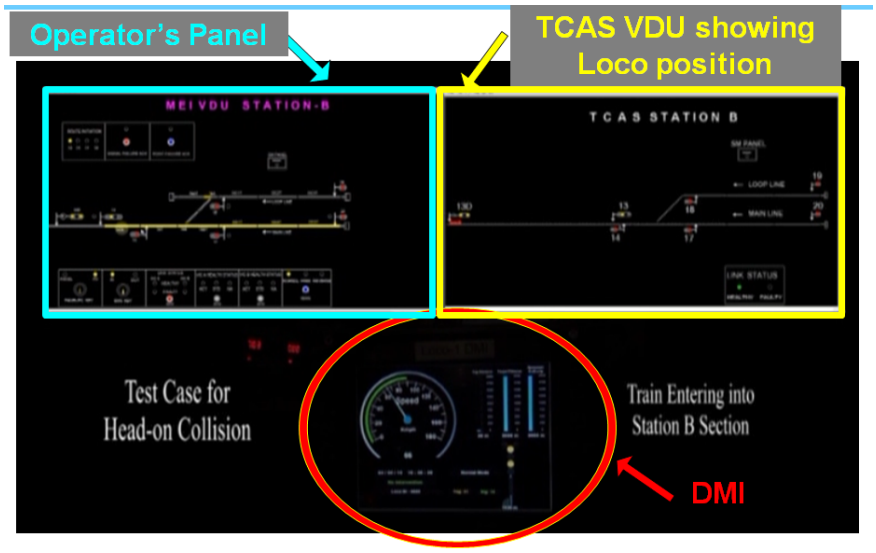


Fig. No. 3.15 Lab Simulations

First Field Concept Trial had been carried out in October'2012. In this field trial, equipments were installed at two stations interlocking and two trains. In this field trial, demonstration of following was included:

- Detection and Prevention of SPAD including put back signal to danger on approach
- Immediate extension of Movement Authority on delayed clearance of Signal on Approach.
- In Cab Display of Signal Aspect
- Loop Line Speed Control
- Detection and Prevention of Head-On Collision
- (without help of signaling, with the help of absolute location)
- Detection and Prevention of Rear End Collision
- (without help of signaling, with the help of absolute location)
- Station – Station Communication for Block Protection
- Station Generated SOS
- Loco Generated SOS
- Brake Test
- Train Length Measurement

Fig. No. 3.16

Further, the field demo of the TCAS model with dynamic TDMA, which does not require any storage of sectional data on Locomotive, was made in August'2013 end.

Fig. No. 3.17 Using Real-time Data-logger for diagnosis during field trial

The development of TCAS is being carried out as a multi-vendor interoperable product. In September'2013, field demo of interoperability at preliminary level was demonstrated in which Loco TCAS Unit of one Make was able to interact with Stationary Unit of other Make and was able to correctly display Movement Authority, Signal Aspect, Target Distance, Target Speed, Distance to Signal on Approach, RF Field Strength Level Indicator etc. and vice versa.

Display on DMI during Field Trials:
Movement Authority, Speed, Aspect, Distance & details of Signal on Approach, Target Speed for Speed Restriction on Loop Line etc.

Fig. No. 3.18

As such, It can be seen that this low cost ATP system for speeds of upto 160 / 200 kmph is not resource intensive and covers all key ATP features. The development of TCAS by RDSO in association with multiple sources from Indian Industry is at advanced stage. Involvement of multiple agencies for the objective of an interoperable product shall obviate the situation of monopoly. Development is yet to be completed. It is expected that the development of TCAS product in form suitable to be put into operational use, shall be completed by February'2014.

*** * * ***

CHAPTER 4 : AUXILIARY WARNING SYSTEM

1 Objectives of AWS system

(a) Bring train to halt in case of SPAD (signal passing at danger).

(b) Prevent over speeding of train.

(c) Audio visual assistance to the driver about speed and aspect of signal etc.

(d) Check vigilance/alertness of driver and reduces speed by applying breaks if driver is not responding.

(e) Supervise train in terms of speed limits.

(f) Monitor the speed of train with respect to signal aspect.

IRS Specification : IRS S: 38 – 70 (Automatic Warning System)

2 Major equipment of AWS system

(a) Track equipment :

(i) Opto coupler card (Electronic equipment, an interface between the signal to collect the signal aspect information).

(ii) Track magnet (balise / beacon/ transmitter) to gather the collected information and transmit the information to the CAB (coding).

(b) Cab Equipment :

(i) Engine magnet to collect the information transmitted from the track side.

(ii) Microprocessor (INTEL 8085) based system to process and issue various commands /indications.

(iii) CAB display unit / Drivers Indication Panel, to display various indications of signal aspects, speeds and counters to register responses by the driver.

(iv) Brake Actuating Unit (BAU), to apply brakes (service, emergency) as needed.

(v) Tacho-Generator unit, to monitor speed of the train.

(vi) Isolating switch unit, to isolate AWS in case of malfunctioning / defect.

(vii) Hooter and Buzzer

(viii) Break Actuating Unit.

3 TYPES of AWS systems

Depending upon the way the information is transferred between the cab and the track the systems are classified as:

(a) Intermittent

(b) Continuous

3.1 Intermittent

Here the information is provided only at designated places (signals or in-between desired locations) , the update of information also takes place at these locations / spots only. This means the train has to travel on the basis of the previous data until the next infill / transmitter. No advantage of less restrictive conditions after the train has passed over the infill point. This may result in slowing down of the train needlessly in particular cases. System is not being upgraded by OEM. Here the speed & distance profiles are preprogrammed into the Cab-equipment. Though it obviates the need for calculating speed in real time, they allow optimal train running only if all trains have the assumed performance characteristics.

3.2 Continuous

In this, the system updates information to the train immediately. Hence any change or deviation from schedule can be updated immediately. This also includes any change in running speed and alteration in route ahead. This reduces delay and improves the line capacity. A train that has passed caution aspect can respond immediately to the early clearance of the next signal. This implies that it need not continue to obey the earlier information until it reaches the next information place, as it happens in case of intermittent systems. The system needs more equipment to carry out the requirements.

3.3 Discussion on the above systems

The complexity of mixed traffic which may need various speed profiles and may not always work at the pre-programmed speed profiles as in intermittent systems. The continuous system is costly and it may not be needed for all 24 hours. Also the present level of traffic may not justify the need of a continuous system. It is also to be noted that conversion from intermittent and continuous is not cost effective. (It is very complex to update information in dense traffic areas on Multiple parallel running lines (Hexaple) like Mumbai Suburban Section) The intermittent system does not immediately respond to aspect clearing ahead, which means the train continues to move at a speed more restrictive than required for safety.

4 AWS System installed in Mumbai suburban section

4.1 Various measures are taken to improve railway traffic in respect to safety and flexibility. Misinterpretations of signal aspects by the train driver and false reactions due to bad visibility because of rain, fog or smoke as well as the incapacity of the driver can endanger human life and goods. Auxiliary Warning System, therefore, can be considered as an essential link within the chain of safety provisions. So, **it was introduced in 1986 in Mumbai suburban section.**

4.2 The enhancement of operational tasks arising out of higher running speeds, increased number of signal aspects, variable target distances, information with respect to speed and the demand for continuous monitoring of the train made necessary development of a reliable track to train communication for transmission of information for which AWS has been introduced.

AWS transmits data regarding aspect of the signal from trackside at significant locations like distant signals, auto signals or at the beginning of speed restrictions to the vehicle in order to control and implement the required train performance.

With these data, it is possible to:

(a) Advise the driver about the condition of section ahead of him.

(b) Give visible and audible warnings.

(c) Continuously monitor the maximum stipulated speed and the braking procedure.

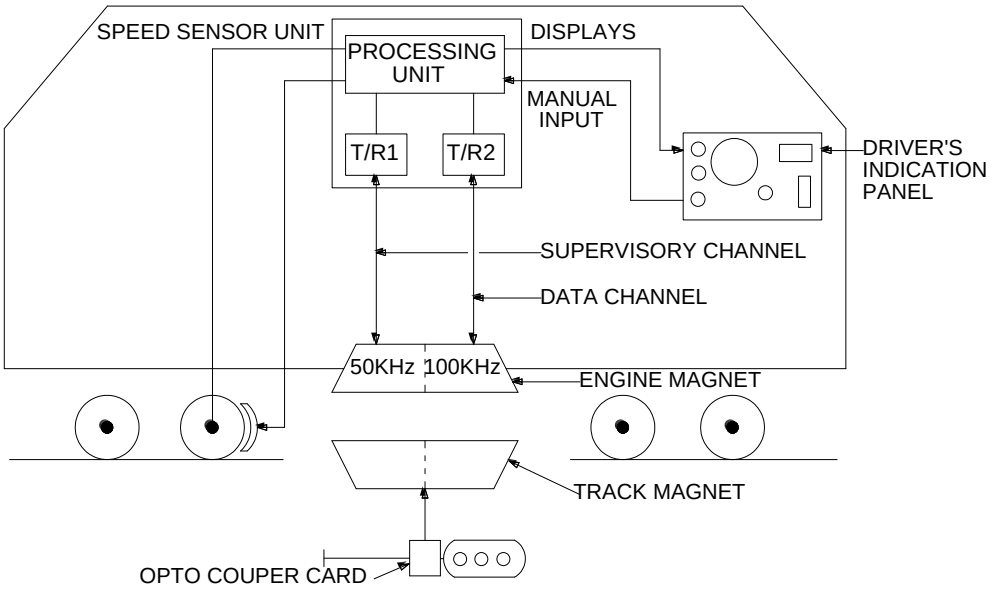


Fig. No. 4.1 ZUB100 AWS System

Block Diagram

Frequency Division Multiplex Transmission System

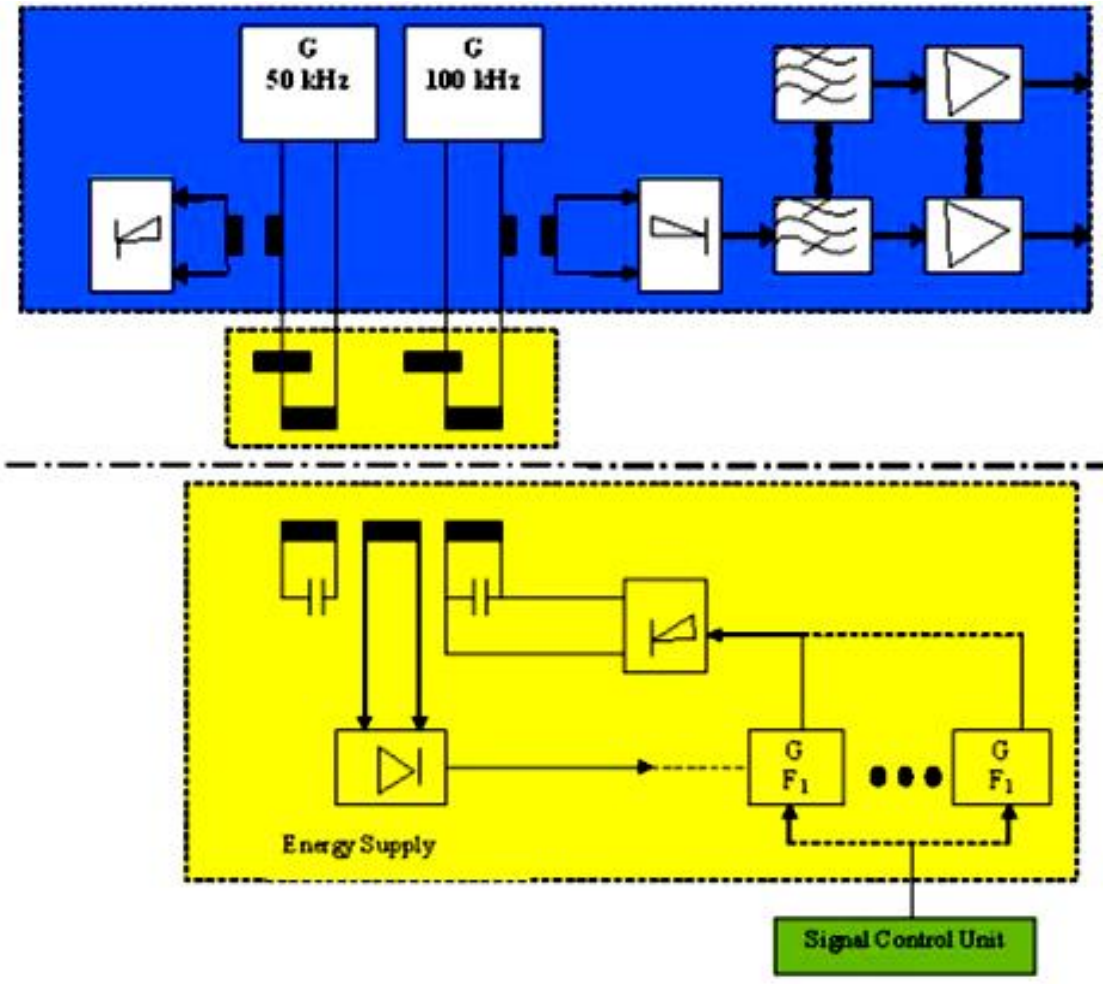


Fig. No. 4.2

4.3 General Principle of operation (SIEMENS ZUB100 AWS)

(a) AWS consists of

(i) On-board equipment

(ii) Track side equipment

(b) The cab-borne equipment consists of transmitting and receiving devices. It is connected with the cab-borne coil (Engine Magnet) which is mounted to the vehicles bogie to receive the track side data- An axle mounted speed sensor (Tacho generator) supplies the information about the distance covered and the actual speed. A display unit provided on board contains the elements of manual inputs (vigilance button, signal failure by-pass button, reset button, counters) and different visual indications and a Hooter. The Brake functions interface unit acts directly on the braking and Throttle system.

(c) The track side equipment consists of track magnet installed at the signal and some selected location inside the track and is controlled by signal aspects through an interface Opto coupler card.

(d) Trackside to vehicle data transmission is achieved by inductive Magnetic coupling through two resonance circuits installed in the track side as well as cab-borne coils; which monitor each other's function. One tuned circuit operates with 50 KHz and acts as a checking (Pilot) circuit. The second tuned circuit which acts as data transmission circuit, operates with 100 KHz and is modulated with selected audio frequencies depending on the signal aspect which is lit. Audio frequencies received after de-modulation by the engine are amplified and are transferred for further processing to effect the required train control.

(e) The system uses 2 of 7 frequencies for encoding signalling information. Maximum no. of encoded information is 21. ($7C_2 = \frac{7 \times 6}{2 \times 1} = 21$)

5 The working of various sub-systems

5.1 Track Magnet and Signal Interface

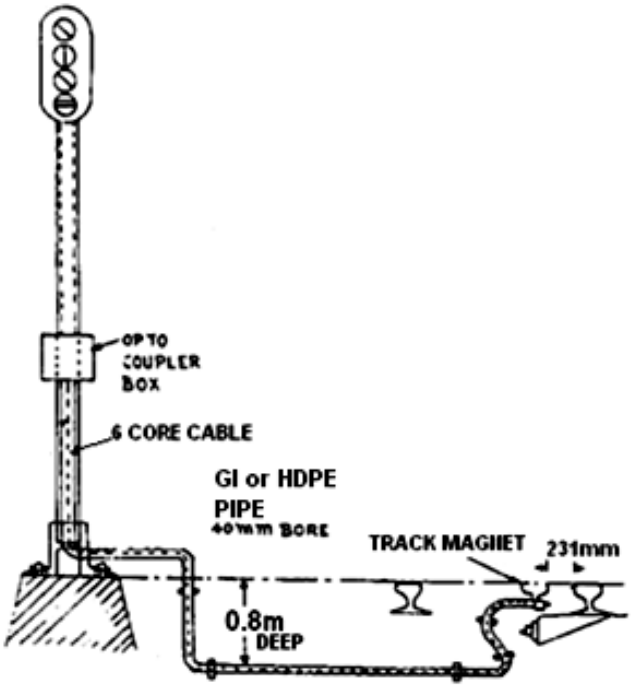


Fig. No. 4.3 Track Device Installation Details

This part of the AWS equipment interfaces with the signals. The details are shown in Fig.3. As could be seen from the Fig 2, on the signal post, there is an Opto Coupler Card which monitors the output voltage on the secondary of the signal transformer feeding the signal bulb (voltage range 8 to 20V AC and current 2 mA). From this, the Opto Coupler Card senses which signal aspect red, yellow. double yellow or green is active at a particular instant. Similarly it can also monitor functions like calling ON signals, 'A' markers, shunt signals and route indicators. For auxiliary signals the Opto Coupler Card works at 110V AC (75-120V AC). After deciding which of the signal aspects is getting a voltage. the Opto coupler card conveys this information switching two frequencies from FI to F5 by giving a loop between the terminal No.6 and any two of the remaining 5 terminals namely 1 to 5. Thus the Opto coupler will be giving a loop through Opto-Coupler IC on two circuits through the connecting cable between Opto coupler and the Track Magnet.

5.2 The details of Opto coupler card are given in (Fig 3). Wherever the signal has to control the intermediate magnet in rear, a special type of opto coupler is to be used. In such cases three extra output terminals are brought out. This selects F6 and any one out of F1 and F2. Thus, F1F6 is selected when the signal is off and F2F6 is selected when the signal is 'ON'. The auxiliary output (3 core) is connected by cable from opto coupler to intermediate magnet in rear. The main track magnet is installed between two rails on Right Hand Side of train movement by clamping it on RHS of the Rail sleeper at the rail height at the foot of the signal post. It is installed at a distance of 231mm from the right hand side of the rail in the direction of the movement of train. (The Track Magnet is tried to be installed within at least 3 sleepers away from the nearest rail joint. The track magnet is a passive device and does not require power supply.

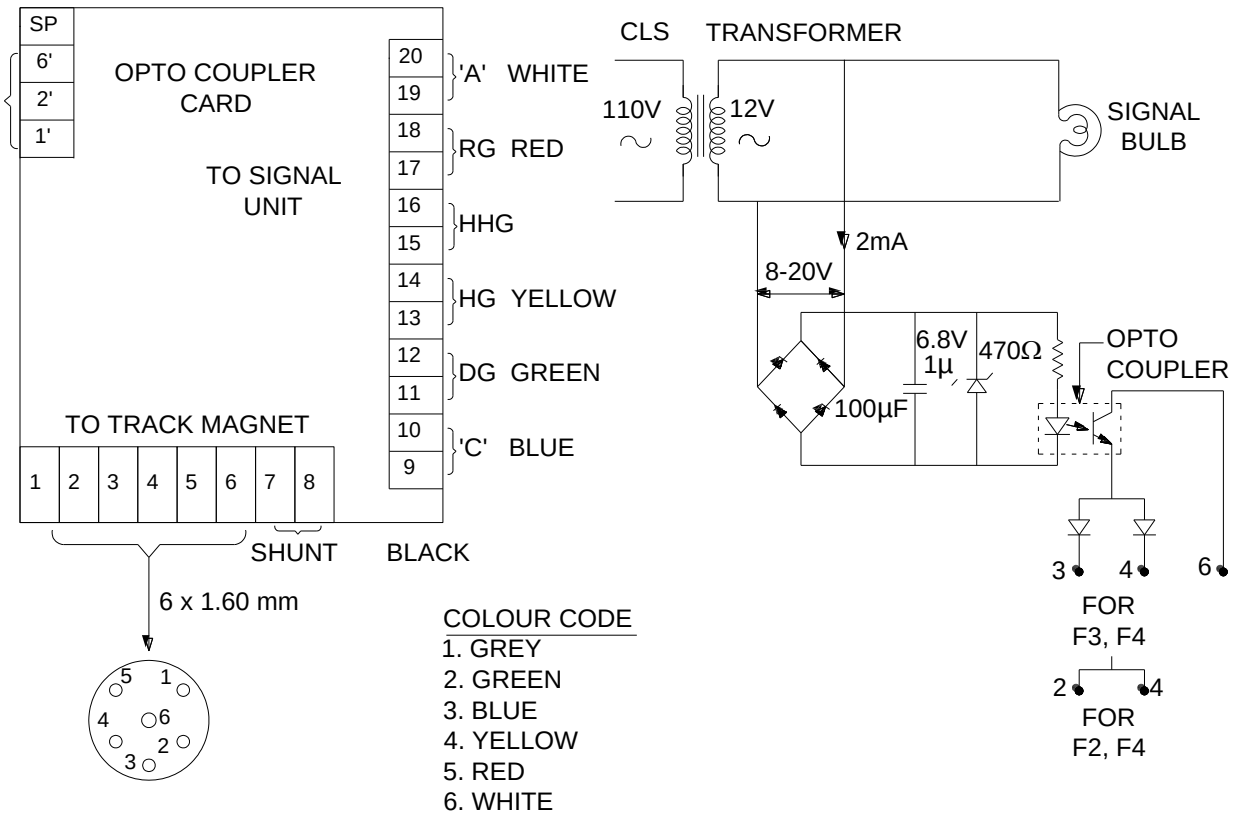


Fig. No. 4.4 OPTO COUPLER CARD DETAILS

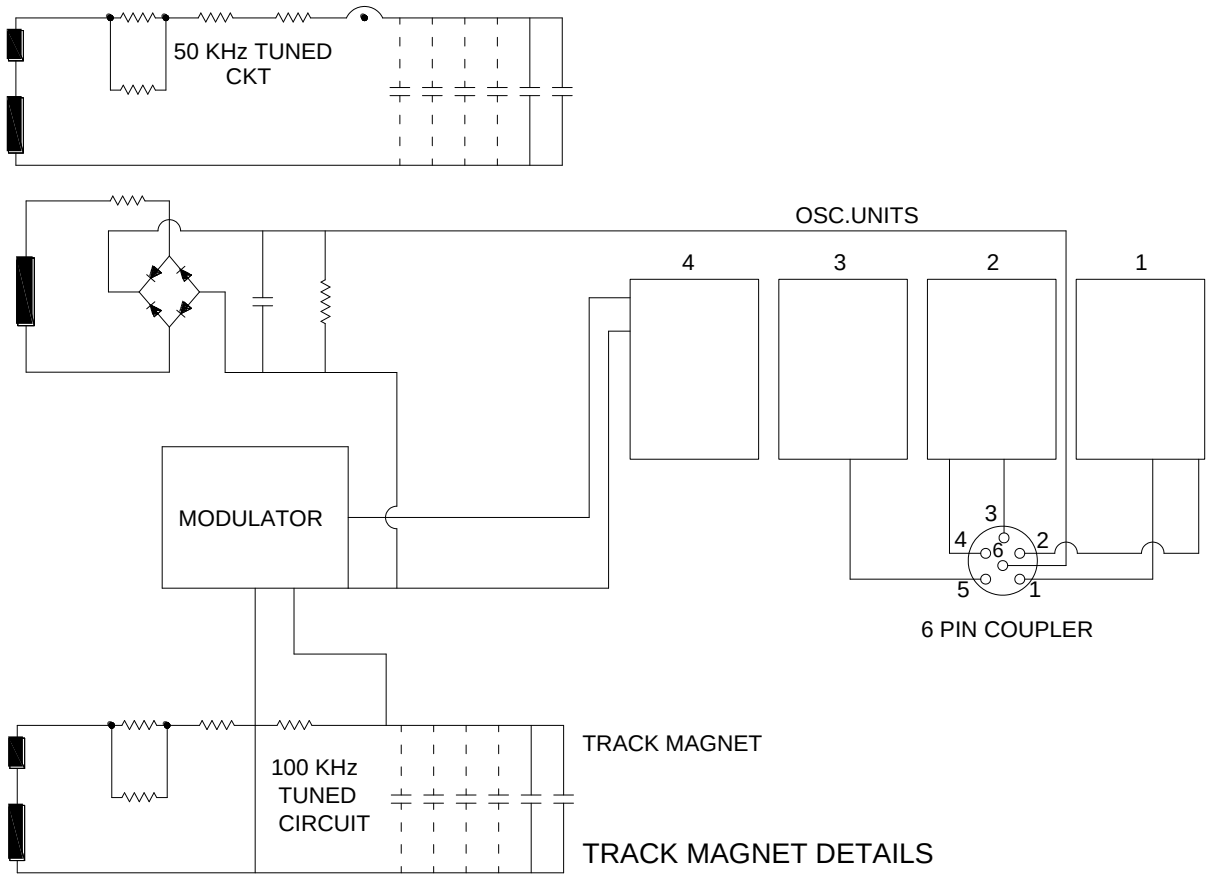


Fig. No. 4.5

Components distribution in Track Magnet is given in Fig.2.4. It picks up its power supply from the engine equipment while the engine coil passes over the track magnet. As already explained, out of the oscillators F1 to F5, the circuit will be completed at any one time for two oscillators depending upon the loop given by opto coupler which in turn depends upon the aspect being displayed at the signal. Two different frequencies are switched on whenever the power supply for the track magnet is available when the engine magnet passes over it and thus a resonated carrier frequency of 100 KHz transmitted by the engine equipment (called data channel) is modulated by the two track frequencies and again picked up by engine and demodulated. The audio frequencies are once again re-generated in the engine equipment and processed by the microprocessor based cab equipment which determines the follow up action to be taken depending upon the information received from the track magnet. For any information from track to train, two audio frequencies are selected out of F 1 to F7 and this gives maximum capacity of 21 possible information from track to train.

5.3 The track magnet also has a 50 KHz tuned coil which acts as pilot circuit and the engine equipment has got corresponding 50 KHz coil and 100 KHz oscillator. Whenever the engine passes over track equipment, due to Magnetic coupling between the two 50 KHz tuned circuits, there will be a dip in 50 KHz carrier level in the engine equipment. This is interpreted by the engine equipment to indicate the presence of a track magnet. The engine equipment should always get a dip on 50 KHz (to indicate the presence of track equipment), otherwise it does not considers the information as valid information, which is received through 100 KHz information on data channel and applies brakes immediately. Similarly, if the 50 KHz shows a dip and there is no information on 100 KHz data channel then the engine equipment senses that something is wrong with track equipment and applies brakes. Thus, the 50 KHz senses a supervisory (or pilot) channel. However if the entire track magnet is missing including the 50 KHz tuned coil, this cannot be detected by engine equipment.

5.4 Different types of Opto coupler cards are used depending upon the type of signal to which it is to be connected and also depending upon whether it has got auxiliary aspects as well. Apart from this, for the signals which have to control the intermediate and additional magnet in rear a different type of Opto coupler card is required. Regarding caution aspect, there are two types of Opto coupler cards, one having frequency combination of F1, F4 which is suitable if inter-signal distance is less than 700m and another having frequency combination F2, F4 which is suitable if inter-signal distance is more than 700m. Therefore, according to inter-signal distance between the signal and signal in advance, the type of opto coupler is to be decided.

5.5 The various frequencies used in the track magnet for the purpose of frequency modulating 100 KHz carrier and the combinations of these frequencies for conveying different signal aspects to the engine equipment are as shown below:

F1	2800 Hz	Field tolerance - 45Hz / + 55 Hz
F2	3600 Hz	
F3	4400 Hz	
F4	5200 Hz	
F5	6000 Hz	
F6	6800 Hz	
F7	7600 Hz	

5.6 For an information transmission, any two out of these seven frequencies are used. As such, there can be 21 combinations but only 9 are used. The frequency combinations used in CCG-VR AWS is (Church gate - Virar section).

1	F3F4	-	Green and Double Yellow.
2	F1F4	-	Yellow (Inter Signal distance < 700M or > 700M with route).
3	F2F4	-	Yellow (Inter Signal distance > 700M).
4	F1F5	-	Permissive Red.
5	F1F2	-	Absolute Red.
6	F1F6	-	Release of Brake Curve (used at Addl. magnet).
7	F2F6	-	No change in earlier information (used at Addl. magnet).
8	F5F6	-	Reduced braking distance after second next signal.
9	F3F5	-	End of AWS section.

5.7 There are two types of track magnets, namely, Type-A and Type-B. Type-A is generally used along with the main line signals and it is also used as intermediate magnet in-between two main signals wherever the inter-signals' distance is more than 700m. If it is used along with main signals, type-A magnet has got frequencies F1 to F5 and if It is used as additional magnet, it has got frequency F1 F2 / F6. Apart from this, there is another type of magnet called Type-B magnet is generally used for reduced inter signal distance, end of AWS section, speed restrictions etc., and this need not be connected to a signal. Therefore, it does not require Opto coupler card to control it. It is permanently set to give only two frequencies.

There are three types of Type-B magnets, namely.

B I - Having F1 F2, which is used for applying emergency brake for testing purposes when the EMU comes out of car shed.

B II - Mounted 'a' mts away in rear of the signal and its fixed frequency is F5F6 and denotes that the braking distance available is less (d) from the signal in advance.

Detailed arrangement of placement of track magnets A & B under this requirement is given in Fig. Below.

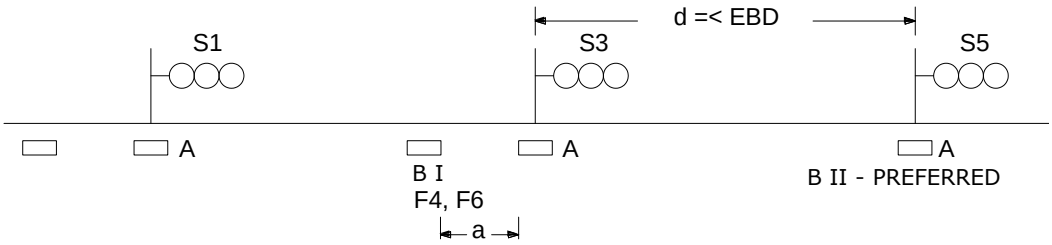


Fig. No. 4.6

Sl. No	Inter signal distance 'd' in meters	Distance of additional magnet in rear of signal magnet 'a' in meters
1	375 ± 12.5	15 ± 0.3
2	350 ± 12.5	17.5 ± 0.3
3	325 ± 12.5	20 ± 0.3
4	300 ± 12.5	22.5 ± 0.3
5	275 ± 12.5	25 ± 0.3
6	250± 12.5	27.5 ± 0.3
7	225± 12.5	30 ± 0.3
8	200± 12.5	32.5 ± 0.3
9	175± 12.5	35 ± 0.3
10	150± 12.5	37.5 ± 0.3
11	125± 12.5	40 ± 0.3
12	100 ± 12.5	42.5 ± 0.3
13	75± 12.5	45± 0.3

PLACEMENT OF TRACK MAGNETS

B III - The last type of B-type magnet is permanently tuned to F3F5 to indicate that the AWS section is over and there is no more speed restriction on passing signal at caution.

5.8 Engine Equipment

(a) The schematic diagram of driver's display and control panel and the processor is given in Fig.1.9.

(i) From this it may be seen that there is a reset button which is to be operated (only in standstill condition) whenever the train is to be restarted after emergency brake application has been imposed by AWS. This operation is also counted by the EBC counter.

(ii) There is an SFBB button to be pressed whenever an absolute stop signal is to be passed at danger. This operation is also counted on the SFBC counter. This button is to be pressed when the train is within 100 m in short of the stop signal at danger, which is to be passed at 'ON'.

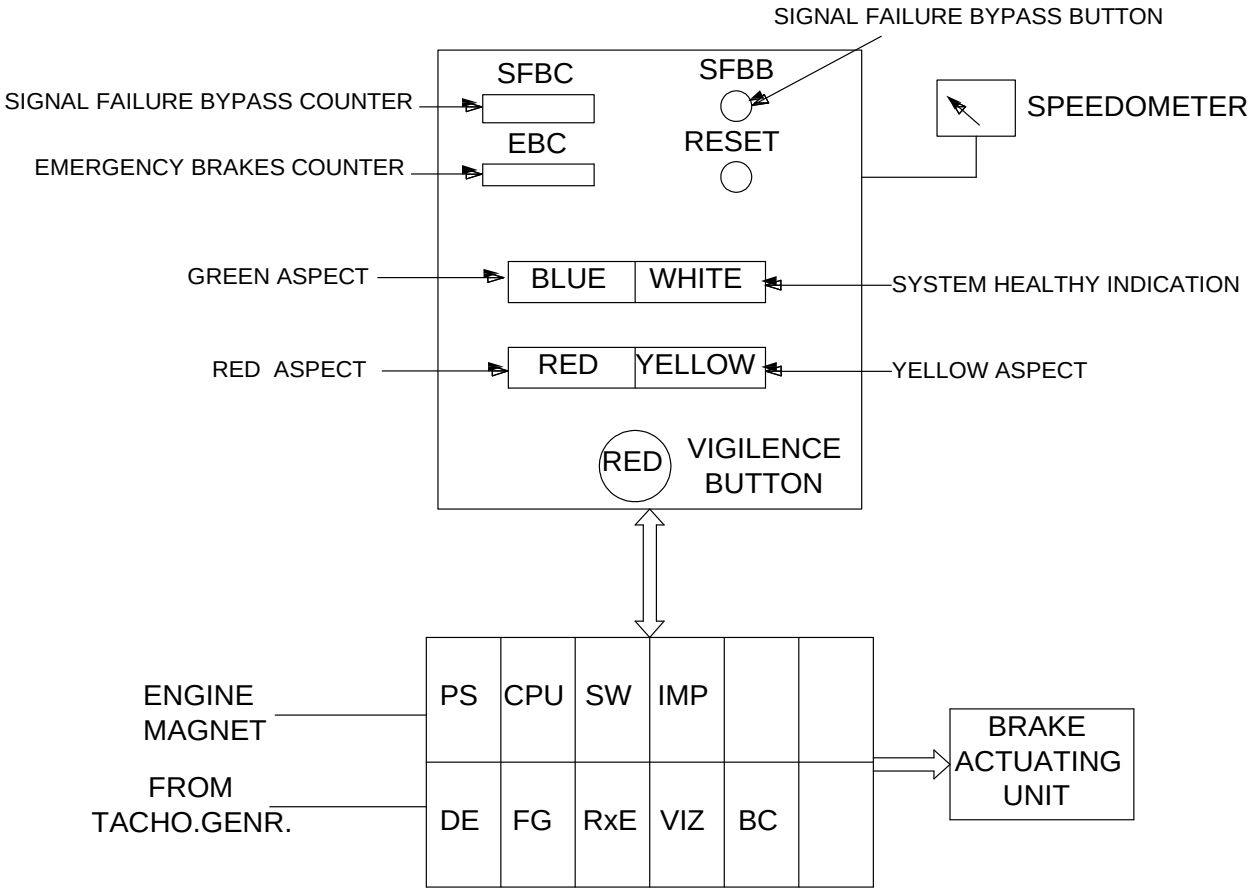


Fig. No. 4.7 DRIVER'S DISPLAY AND CONTROL PANEL

PS - Power Supply

DE - Distance Evaluator.

CPU - Microprocessor 8085.

FG - Frequency Generator 50/100 1 KHz.

SW - Switching Card.

RxE - Receiver & Evaluator.

IMP - Impulse Card - Clock.

VIZ - Vigilance Card.

BC - Brake Card.

(iii) There is also a vigilance button, which is required to be pressed within 4 seconds whenever Hooter sounds after any vigilance required aspect .

(iv) There is a buzzer, which operates whenever the signal passed is double yellow or green.

(v) Regarding indication lamps there are three different types, of which white indicates normal working. Flashing white indicates fault in the cab equipment, (or CPU starting / resetting under progress), blue is also normally on and flashes in case of any fault in power supply, speed check or speed evaluation equipment and goes off for 5 seconds when the train is passing the signal at green or double yellow. Steady yellow appears whenever the train passes a signal at caution and starts flashing roughly 290 m after passing the signal

displaying caution aspect or if the inter-signal distance is more than 700 m. after passing 290 m beyond the intermediate magnet at ‘caution' by a train (the train speed would have been reduced to 38 KMPH within this distance). Likewise steady red indicates emergency braking or passing a permissive red signal at on. Flashing red indicates service braking or pressing of SFBB button in standstill condition. Driver should start the train only if blue & white indications are steady.

(vi) There is another control switch for switching on supply to the master controller and this cannot be switched off when the train is in running condition. Before switching off master supply, it is also to be ensured that AWS isolation switch is in the "on" position.

(vii) The isolation switch is a sealed switch, which is to be used in case of erratic functioning of AWS resulting in unwarranted brake application. The driver should open the seal and operate to 'off position and try to run the train. After doing so, if it is not possible to run the train, then he should isolate the feed cut-off magnet valve and exhaust magnet valve by operating two cocks provided for the same. Whenever isolation switch is switched off, it is also counted by a counter.

(viii) Whenever the train is at stand still by pressing vigilance button for 10 seconds the driver can affect the functional test of the indication panel. On pressing this for 10 seconds the red, blue and yellow indications on the driver's panel are steady and white starts flashing. When the button is released the Hooter and buzzer sounds for 1.2 seconds each.

(b) The action to be taken by the driver while passing the different signal aspects are summarised below:

OPERATIONAL CHART

Signal Aspect	Action to be taken by	INDICATIONS		Whether to acknowledge
		Visual	Audible	
Green	None	Blue lamp goes off for 4 Sec.	Buzzer * Sounds	No
Double Yellow	None	Blue lamp goes off for 4 Sec.	None	No
Yellow (Inter- Signal distance <700m)	Press vigilance button within 4 Sec. When Hooter sounds.	Yellow steady & fast flashing after 290 m.	Hooter sounds	Yes
Yellow (Inter-Signal >700m **)	Press vigilance button within 4 Sec. When Hooter sounds.	Steady yellow at intermediate magnet if the signal ahead is still on' which becomes flashing at 290m from the additional magnet by which time the train speed should have been reduced to 38 KMPH.	Hooter sounds	Yes

** in such cases additional magnet is fitted at a distance of 400m in rear of the signal in advance.

* Buzzer can be dispensed if necessary.

Signal Aspect	Action to be taken by	INDICATIONS		Whether to acknowledge
		Visual	Audible	
Permissive Red	Stop dead in rear of signal within 100m. Observe GR/SR and proceed. Press vigilance button within 4 Sec. When Hooter sounds.	Red lamp Steady	Hooter sounds	Yes
Absolute Red (on authority 369.3B)	Stop dead in rear of signal within 100m. After receiving authority to pass signal at danger press SFBB button and note SFBC counter reading. Press vigilance button within 4 Sec when Hooter sounds.	Red lamp fast flashing	Hooter sounds	Yes

(a) It is a microprocessor based equipment based on 8085 microprocessor. Basically this has got processing unit, driver's indication and control panel, and brake control unit which controls train brakes (emergency and service braking).

(b) It has speed sensor unit, which is useful in monitoring train speed and also for sensing direction of movement. In case of reverse movement of more than 2m, it applies brakes automatically. The speed control unit ensures that the speed is maintained within the range of 5 KMPH of the stipulated maximum speed permitted by the signal aspect.

(c) Whenever speed exceeds 1 KMPH above the maximum permissible, the intermittent Hooter sounds indicating that driver has to reduce the speed, whenever he exceeds by more than 5 KMPH service brakes are applied, when he exceeds by more than 10 KMPH emergency brakes are applied.

(d) It can be seen that the engine equipment has a 50 KHz oscillator which is used as a pilot circuit for monitoring presence of track magnet as already explained and it also has a 100 KHz oscillator which acts as data circuit to be modulated by the audio oscillator inside the track magnet.

(e) The on-board equipment also has 100 KHz demodulator, band pass filters which takes out individual frequencies F1 to F7 present in the signal transmitted by the track magnet to the engine magnet.

(f) The demodulated signals are given to the processing unit which decodes them and controls the various displays to the driver as explained in earlier and follow up action by the driver as required. In case the driver does not follow these instructions the equipment controlling the braking system of the train resorts to either service braking or emergency braking as warranted. The train restarts only after reset button is pressed by the driver.

(g) Whenever the track magnet is not functioning properly or is functioning erratically it may lead to unnecessary brake application on EMUs. To prevent this, track magnet is to be covered by a appropriate size tin sheet.

(h) To check up the proper working of the track magnet, a track magnet check device is available. This is a battery operated equipment and monitors, the track magnet working. It is possible to verify which two audio frequencies are being transmitted from the track to the train and also to read the level of 50 & 100 KHz carriers transmitted from the track side equipment. By changing the signal aspect it can be verified whether the track magnet and the opto coupler are correctly responding and transmitting the appropriate combination of two audio frequencies.

6 The essential features of this AWS system are

(a) No track circuits involved in the track to train communication. No mechanical components.

(b) No requirement of power supply in the field. Suitable for speeds up to 250 KMPH.

(c) Air gap 175 mm (permitted range is 175 mm to 225 mm) with a lateral deviation of ±10 mm between track and engine magnets.

(d) Immune to electro- magnetic interference.

(e) Fail safe monitoring.

(f) Small and compact in size.

7 Differences between AWS and TPWS

Sl. No.	AWS	TPWS
1	Track Magnet missing will not be detected and no action will be initiated.	Balise missing is detected and Service / Emergency breaks will be applied.
2	Audio frequency signals are used with 100KHz carrier for sending the track side data to cab equipment.	1023Bit Telegram messages are used with 4.2MHz carrier for sending the track side data to cab equipment..
3	Two audio frequencies are being used out of 21 combinations for transferring the track side data to cab equipment. ($7C_2$)	1023 bit coded telegram messages are used.
4	It senses the signal aspects directly by reading the voltage at signal lamp.	It senses the signal aspect through ECR front contact.
5	Comparatively it is very cheap.	It is approx. twenty times costlier.
6	It displays actual speed of the train.	It displays distance travelled along with the actual speed of the train.
7	Speed sensor is connected only to the front axle of the engine.	Speed sensors are connected to the front back axles of the engine. So that wheel slipping is detected.
8	Not suitable for ERTMS Level 2 & 3 applications.	Suitable for ERTMS Level 2 & 3 applications.

The speed of 38kmph has been chosen because if at this speed an EMU overshoots a signal at Danger, it can come to a standstill within 120 mtrs. (signal overlap) , with available braking power.

- Signal aspect is RED : Speed is limited to 15km/h.
- Signal aspect is Yellow : Speed is limited to 38km/h.
- Signal aspect is Green or Double Yellow : Speed is limited to 70km/h.

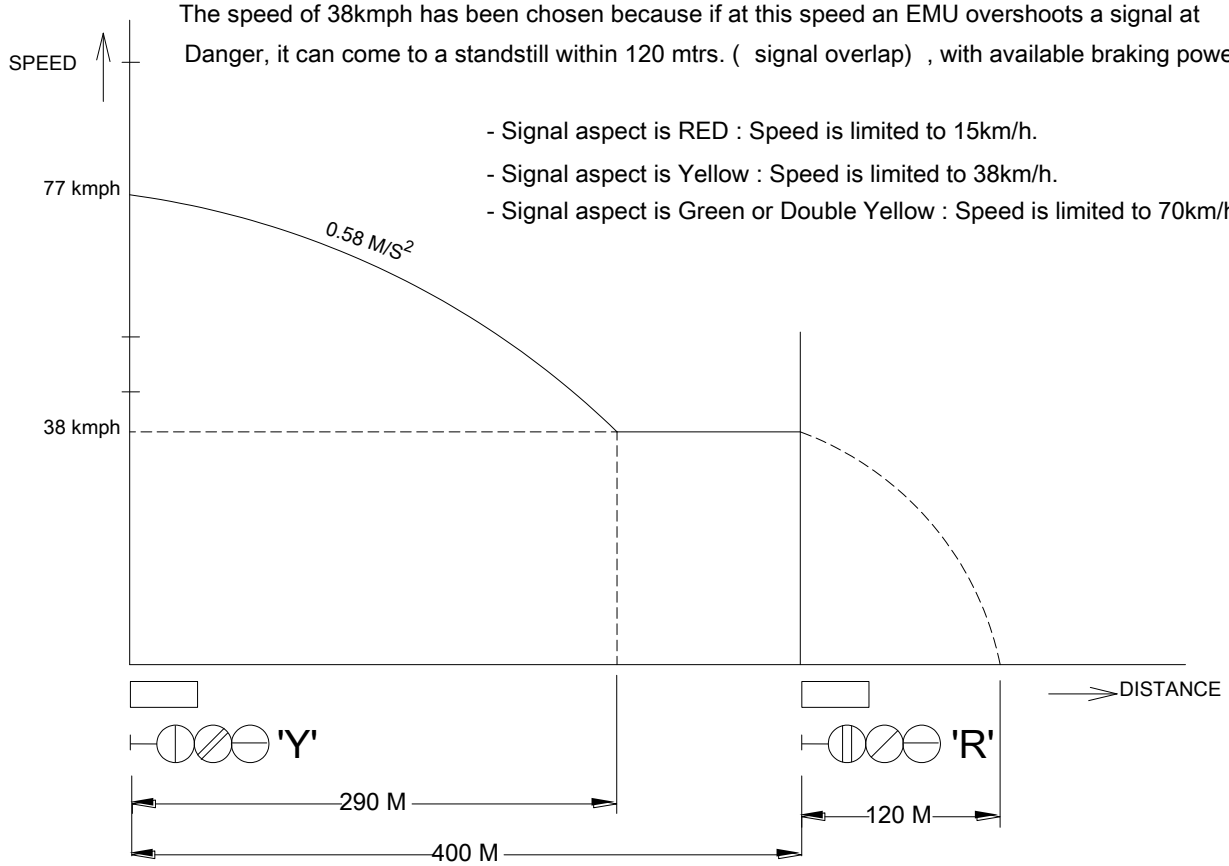
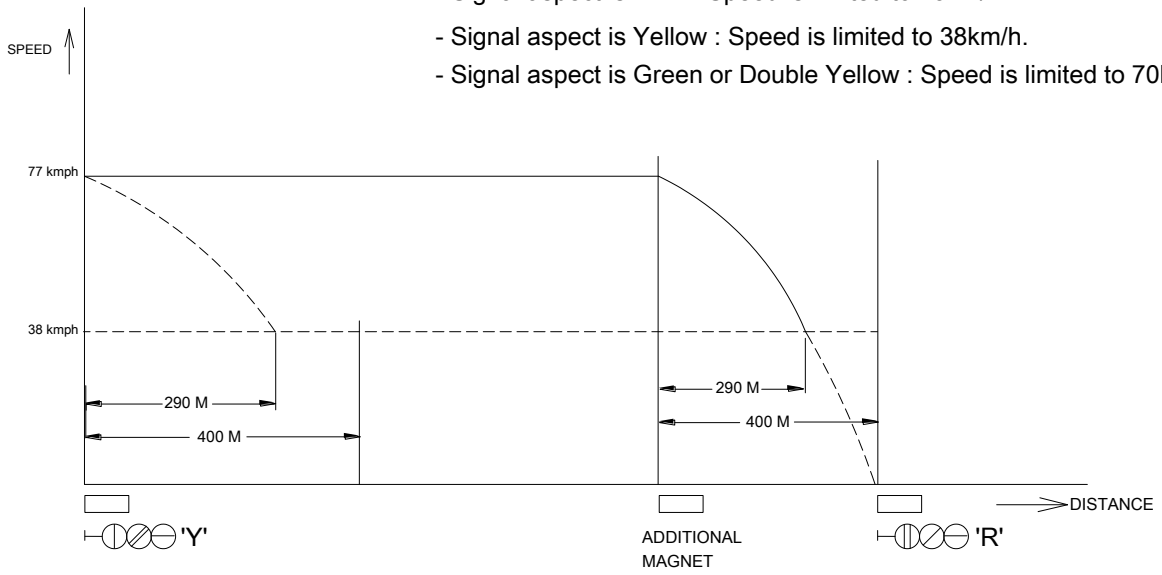


Fig. No. 4.8 BRAKE CURVE FOR A.W.S. ON 'YELLOW' ASPECT

The speed of 38kmph has been chosen because if at this speed an EMU overshoots a signal at Danger, it can come to a standstill within 120 mtrs. (signal overlap) , with available braking power.

- Signal aspect is RED : Speed is limited to 15km/h.
- Signal aspect is Yellow : Speed is limited to 38km/h.
- Signal aspect is Green or Double Yellow : Speed is limited to 70km/h.



LEGEND

ORIGINAL BRAKE CURVE

MODIFIED BRAKE CURVE

BRAKE CURVE ON 'Y' ASPECT WITH PROVISION OF ADDITIONAL MAGNET & SOFT WARE CHANGE

Fig. No. 4.9

* * *

Annexure - I
Pre-Commissioning check list of Data loggers

Pre-commissioning check list of Data loggers

Ref: RDSO Letter No.: STS/E/DATA LOGGER dated: 29-10-2010.

S.No.	Activity	Expected result	Result
1.	**Power supply**		
1.1	Class B & C Protected AC 230 V is extended to the charger	Yes	
1.2	AT Supply or Stand by diesel generator supply also is extended to the charger	Yes	
1.3	Charger body earth terminal connected to Data logger rack by 64 strand 31 SWG Copper cable	Yes	
1.4	Ensure that all terminals are tightened – practically no voltage drop shall be observed between the battery and Data logger since battery is provided within the data logger rack – minimum 24 V shall be available at the data logger. Maximum shall not exceed 28 V	Voltage limits at DL Terminals: 24 V – 28 V	Voltage: ---- V
1.5	When DC – DC converter is connected, ensure that the 24 V DC supply wires connected between the DC – DC converter output terminals and the Data logger terminals are not run parallel to other power supply wires. There shall not be joints in the power cable. Separate DC – DC converter module shall be used exclusively for data logger as recommended by RDSO. Rating of DC – DC CONVERTER shall be: 5 A up to 1024 A inputs, 10 A for inputs from 1025 to 2048 and 15 A for 2049 to 4096 inputs.	Voltage limits at DL Terminals: 24 V – 28 V	Voltage: ---- V Current: ---- A
1.6	If IPS is available power supply of Data logger may be taken from IPS	Voltage limits at DL Terminals: 24 V – 28 V	Voltage: ---- V Current: ---- A
1.7	Switch off the charger when it is in float mode. After 15 minutes measure the voltages at the battery terminal and DL input terminal.	Practically no voltage drop shall be observed	Voltage: ---- V Current: ---- A

1.8	Type of wires used for various connections a) Battery charger body to earth terminal – 64 strands 31 SWG copper wire. b) Battery charger output terminal to DL input – 28 strands 31 SWG copper wire. c) Battery charger battery – 28 strands 31 SWG copper wire. d) Inter-battery connection – 64 strands 31 SWG copper wire.		
2	**Earth and surge protection**		
2.1	Ensure that the following cables are connected to ensure earth connectivity for protecting the data logger. a) Data logger euro rack to the frame. b) Within the frame of the Data logger. c) Data logger frame to earth terminal in the room(equi-potential earth bar); 10sq.mm Multi strand copper cable d) GDT earth terminal to the DL frame earth terminal	Yes	
2.2	Use screened cable between the modem of the data logger and the OFC room. Earth the screen of the cable at both ends.	Yes	
2.3	Measure the earth resistance. Ensure it is less than 2 ohms	Less than 2 ohms	
2.4	Ensure that the Quad cable (where provided) armor and screen are earthed and the earth resistance is less than 2 ohms.	Less than 2 ohms	
3	**Communication Medium and induced voltages**		
3.1	**Galvanic isolation of data logger with transmission line**: Where Quad cable communication is used between stations – provide 1: 1 isolation transformer at the communication room to ensure galvanic isolation between the line and the equipment. This is to protect the data logger from induced surges in the block section.	Yes	
3.2	Ensure surge protection equipment is connected between modem and transmission line – nearer to the modem.	Yes	

3.3	Use twisted screened cable of not less than 0.5 mm diameter only to wire between the Data logger and the communication room in one single piece without intermediate terminations. Where intermediate termination is unavoidable use crimping or soldering of conductors. Do not terminate the cable; do not use communication links.		
3.4	Measure the loop resistance and insulation resistance of the main cable and tail cable. **Loop resistance** – 56 ohms/loop km for 0.9 mm cable. **Insulation resistance** – more than 10 mega ohms/km. **Attenuation** – less than 0.5 db/km.		Loop resistance: ---– ohm Insulation resistance: ---– ohm Attenuation: –--- db/km Distance: --- km
3.5	**Induced voltages:** i. Voltage between the communication cable conductor and earth shall not be more than 5 V AC. ii. Voltage between the two conductors of communication cable shall not be more than 1 V AC.	i. Less than 5 V AC ii. Less than 1 V AC	
3.6	Tests to be conducted on voice channel extended through Primary MUX of OFC: i. 4 Wire loop test: loop the TX and RX pairs at other end station – feed 0 db signal to TX pair at this end station – the level of the signal shall be 0 db at RX pair at the same station. ii. Feed tone to TX pair and, measure at RX pair the signal strength – it shall be less than -25 db (minus twenty five db) iii. Check 2 Mb error counter of P MUX – it shall show zero. iv. Check that the Optical signal strength is within the limits specified by STM1 equipment. v. Measure the parameters of copper quad cable used between OFC room and data logger. Ensure it is within the limits mentioned at 3.4 above.	i. Loss shall be zero with 4 wire loop test. ii. Leakage between TX and RX due to hybrid shall be less than 25 db. iii. Quality of E1 channel shall be such that it shall show zero error in the counter of P MUX.	

4	**Data logger and Wiring**		
	Ensure all digital inputs required for simulation and fault logics are wired. If there is deviation – reasons for deviation may be recorded (inadequate capacity of data logger, non-availability of spare contacts) Ensure wiring of potential free contacts of IPS as digital inputs	Yes	
4.1	Validation of digital and analog inputs completed jointly with railways as per the pro-forma and document jointly signed	Yes	
4.2	Validation of Map completed by observing on line	Yes	
4.3	Validation of fault logics completed	Sample / full	
4.4	Input wiring done with ground wire looping and bunched the wires neatly	Yes	
4.5.1	Ensure connection between Data logger to Data logger or Data logger to FEP is in both directions with 4 wire leased line modems.	Yes	
4.5.2	Observed the modem indications and ensured that the indications are as given in installation manual.	Yes	
4.5.3	Ensure data transmission from both ports (answering and originating ports by observing Transmitting count incrementing and pending count decrementing in the LCD display)	Yes	
4.5.4	Ensure resetting of both modems from data logger key board	Yes	
4.6	Down load the final data base into the data logger through flash RAM on line down load exe and verify the correctness by taking print from data logger	Yes	
4.7	At least 6 serial ports shall be provided for communication with other data loggers, CMU, RTU, EI, IPS etc.	Yes	
4.7	Whether dot matrix printer is provided with data logger	Yes	
4.8	Printer tested jointly with railways by taking both online printing and offline printing print by giving command from Data logger	Yes	

Check list for CMU

S.No.	Activity	Expected result	Result
1	**FAS(PC) and Printer**		
1.1	AC 230 V supply extended to the PC has class B & C protection	Yes	
1.2	Power supply availability: Diesel stand by generator supply and AT supply where provided is also extended to the PC.	Yes	
1.3	**UPS:** capacity may be decided based on power supply availability at the station to avoid abrupt shut down of the system which may corrupt the software. i. Ensure Maximum power non-availability duration in one incidence (i.e. continuously) is less than the UPS standby time. Record the time at this station ii. Record the power non-availability duration at the station for the whole day iii. Input voltage is within the limits (230 +/- 10%) when UPS is charging its battery – no abnormal voltage drop The minimum power back-up of UPS should be 6 Hrs. The same should be verified quarterly.	i. Maximum power non-availability duration in single occasion ii. Maximum power non-availability per day	
1.4	Ensure Loading of latest updates of antivirus software, NMDL install shield, Windows OS	Yes	
2.0	**Software** – ensure loading of (i) Dataskel.GDB file in C:\NMRH\SKEL (ii) STATION NAME.DAT file in C:\NMRH\CHART (iii) (ID of data logger) Faultentry.TXT file in C:\NMRH\FAULT	Yes	
3.0	Check inputs data entry duplications and non operating inputs with the help of NMDL software	Yes	
4.0	**PC configuration (Recommended)** Processor: CORE 2 DUO or better RAM capacity: 2 GB or better Hard disc capacity: 160 GBX2 having disk mirroring feature. Serial ports: 2 or more Windows 7 or XP OS SPIKE GUARD Protection	Yes	

S.No.	Activity	Expected result	Result
5.0	Whether Inkjet / Laser printer is provided with CMU. Printer tested jointly with railways.	Yes	
6.0	Ensure connection of ISOLATION BOX in between data logger and FAS PC	Yes	
7.0	Ensure that all fault logics as recommended by RDSO are entered in the local PC (FAS) Reasons for deviation may be recorded (non-availability of inputs; logics not applicable, logics not feasible)	Yes	
8.0	Test on line and off line simulation of yard diagrams for all the stations connected in network.	yes	

* * *

ANNEXURE - II
European Rail Traffic Management System(ERTMS) / European Train Control System (ETCS)

1. Introduction

ERTMS is the European Rail Traffic Management System, a signalling and train control system promoted by the European Commission (EC) for use throughout Europe, which is required for full compliance with the High Speed and Conventional Interoperability Directives. Its key characteristics are that it provides Automatic Train Protection (ATP), to ensure trains operate within safe limits and speeds at all times; and cab signalling, providing safe movement authority directly and continuously to the driver through the desk display.

2. The **ERTMS/ETCS** (European Rail Traffic Management System/European Train Control system) has two sub-systems.

(a) The trackside subsystem.

(b) The on-board sub-system.

2.1 The trackside subsystem

The trackside sub-system can be composed of:

(a) Balise.

(b) Line-side electronic unit.

(c) The radio communication network (GSM-R).

(d) The Radio Block Centre (RBC).

(e) Euro loop.

(f) Radio infill unit.

(a) Balise:- The balise is a transmission device that can send telegrams to the on-board subsystem. The balises provides the up-link, i.e. the possibility to send messages from trackside to the on-board sub-system. The balises can provide fixed messages or, when connected to a line side electronic unit, messages that can be changed. The balises will be organised in groups, each balise transmitting a telegram and the combination of all telegrams defining the message sent by the balise group.

(b) Line-side electronic unit:- The line side electronic units are electronic devices, that generate telegrams to be sent by balises, on basis of information received from external trackside systems.

(c) The radio communication network (GSM-R):- The GSM-R (Global System for Mobile communication-Railways) radio communication network is used for the bi-directional exchange of messages between on-board sub-systems and Radio Block Centre or radio infill units.

(d) The Radio Block Centre (RBC):- The RBC is a computer-based system that elaborates messages to be sent to the train on basis of information received from external trackside systems and on basis of information exchanged with the on-board sub-systems. The main objective of these messages is to provide movement authorities to allow the safe movement of trains on the Railway infrastructure area under the responsibility of the RBC.

(e) Euroloop:- The Euroloop subsystem operates on Level 1 lines, providing signalling information in advance as regard to the next main signal in the train running direction. The Euroloop subsystem is composed of an on-board functionality and by one or more trackside parts.

(f) Radio infill unit:- The RADIO IN-FILL subsystem operates on Level 1 lines, providing signalling information in advance as regard to the next main signal in the train running direction. The RADIO IN-FILL subsystem is composed of an on-board functionality and by one or more trackside parts (named RADIO IN-FILL Unit).

2.2 The on-board sub-system

Depending of the application level, the on-board sub-system can be composed of:

(a) The ERTMS/ETCS on-board equipment.

(b) The on-board part of the GSM-R radio system.

(c) Specific Transmission Modules for existing national train control systems.

(a) The ERTMS/ETCS on-board equipment:

The ERTMS/ETCS on-board equipment is a computer-based system that supervises the movement of the train to which it belongs, on basis of information exchanged with the trackside sub-system. The interoperability for the ERTMS/ETCS on-board equipment is related to the functionality and the data exchange between the trackside sub-systems and the on-board sub-system and to the functional data exchange between the onboard sub-system and the driver; the train; the specific transmission modules (STM's).

(b) The on-board part of the GSM-R radio system:

The GSM-R on-board radio system is used for the bi-directional exchange of messages between on-board sub-system and RBC or radio infill unit.

(c) Specific Transmission Modules (STMs) for existing national train control systems:

The device which allows the ERTMS/ETCS onboard equipment to utilise the transmission system of the national system is called STM (specific transmission module).

Figure-1 shows the architecture of ERTMS/ETCS.

3. ERTMS / ETCS Levels

The different ERTMS/ETCS application levels are a way to express the possible operating relationships between track and train.

Level definitions are principally related to the trackside equipment used, to the way trackside information reaches the on-board units and to which functions are processed in the trackside and in the on-board equipment respectively.

For the purpose of a consistent specification a level 0 has been defined. This level is used for operation on non-equipped (unfitted) lines or on lines, which are in commissioning.

ERTMS/ETCS can be configured to operate in one of the following application levels

(a) ERTMS/ETCS Level '0'

Train equipped with ERTMS/ETCS operating on a line without ERTMS/ETCS or national system or with the ERTMS/ETCS systems in commissioning.

(b) ERTMS/ETCS Level 'STM'

Train equipped with ERTMS/ETCS operating on a line equipped with a national system to which it interfaces by use of an STM.

(c) ERTMS/ETCS Application Level '1' with or without infill transmission.

Train equipped with ERTMS/ETCS operating on a line equipped with Eurobalises and optionally Euroloop or Radio infill.

(d) ERTMS/ETCS Application Level '2' with train location and train integrity proving performed by the trackside.

Train equipped with ERTMS/ETCS operating on a line controlled by a Radio Block Centre and equipped with Eurobalises and Euroradio.

(e) ERTMS/ETCS Application Level '3'

Similar to level 2 but with train location and train integrity supervision based on information received from the train.

Levels 1, 2 and 3 are downwards compatible. This means that a level 3 equipped train is able to operate in level 1 and 2 and a level 2 equipped train in level 1. Operation under STM is not part of the downward compatibility chain.

4. ERTMS/ETCS Application Level '0' :

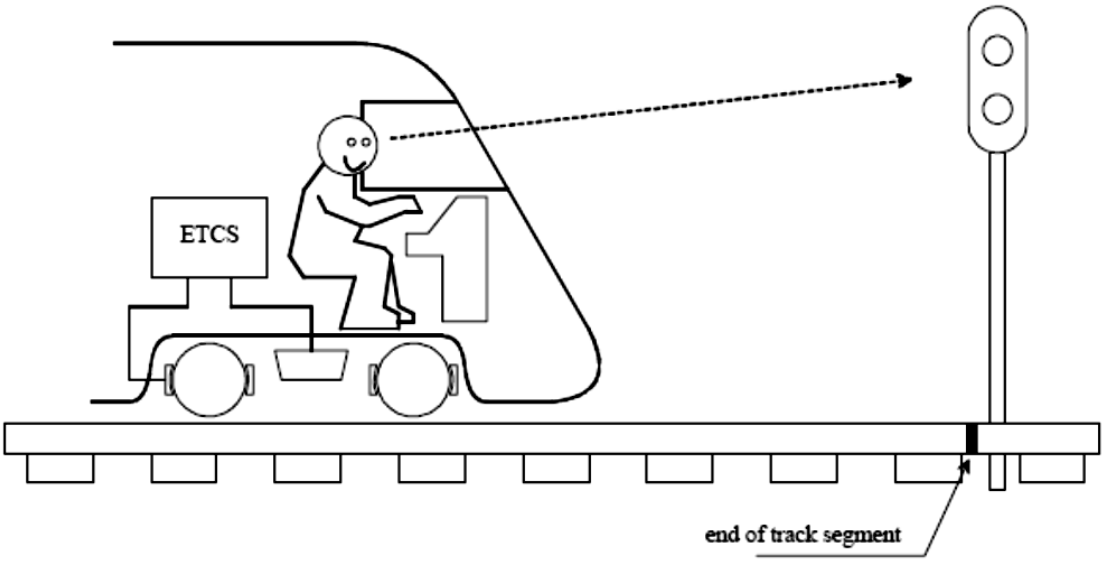


Figure 2: ERTMS/ETCS Application Level '0'

(i) Level 0 covers operation of ETCS equipped trains on lines not equipped with ETCS or national systems or on lines which are in commissioning, e.g. where trackside ERTMS/ETCS infrastructure may exist but has to be ignored.

(ii) In Level 0 line side optical signals or other means of signalling external to ERTMS/ETCS are used to give movement authorities to the driver.

(iii) ERTMS/ETCS on-board equipment provides no supervision except of the maximum design speed of a train and maximum speed permitted in unfitted areas.

(iv) Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.) and are outside the scope of ERTMS/ETCS.

(v) Level 0 uses no track-train transmission except Eurobalises to announce/command level transitions. Eurobalises therefore still have to be read. No balise data except certain special commands are interpreted.

(vi) No supervisory information is indicated on the driver MMI (Man Machine Interface) except the train speed. The maximum permitted speed is only displayed temporarily and on driver request. Train data has to be entered in order not to have to stop a train at a level transition to ERTMS/ETCS equipped area and to supervise maximum train speed.

5. ERTMS/ETCS Application Level 'STM' (Specific Transmission Module):

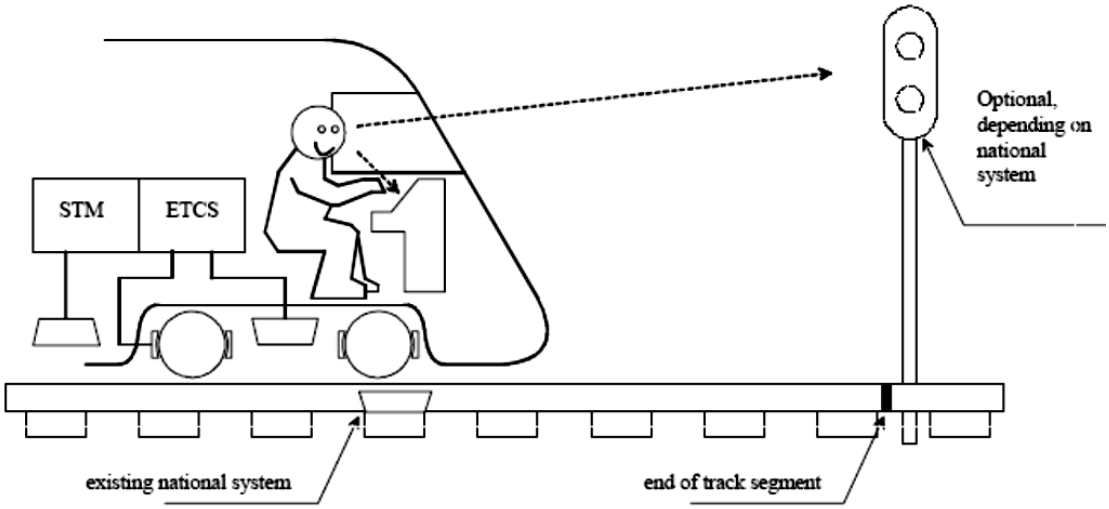


Figure 3: ERTMS/ETCS Application Level STM

(i) Level STM is used to run ERTMS/ETCS equipped trains on lines equipped with national train control and speed supervision systems.

(ii) Train control information generated trackside by the national train control system is transmitted to the train via the communication channels of the underlying national system and transformed onboard into information interpretable by ERTMS/ETCS.

(iii) Line side optical signals might be necessary or not, depending on the performance and functionality of the underlying systems.

(iv) The device which allows the ERTMS/ETCS onboard equipment to utilise the transmission system of the national system is called STM (Specific Transmission Module).

(v) Train detection and train integrity supervision are performed by equipment external to ERTMS/ETCS.

(vi) Level STM uses no ERTMS/ETCS track-train transmission except to announce/command level transitions and specific commands related to balise transmission. Euro balises therefore still have to be read. No data except level transition commands and certain special commands are interpreted.

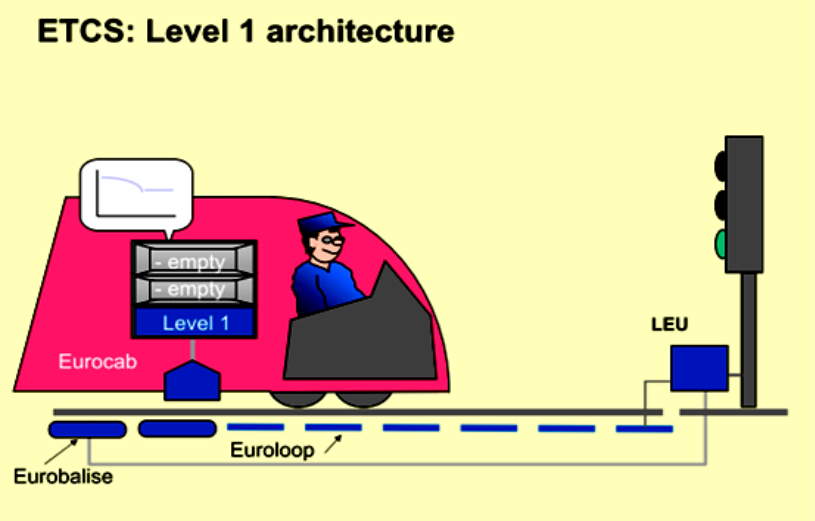
(vii) The information displayed to the driver depends on the functionality of the underlying national system. The active STM is indicated to the driver as part of that information. Full train data has to be entered in order not to have to stop a train at a level transition position and to supervise maximum train speed.

(viii) Each combination of national trackside systems shall be combined externally to the ERTMS/ETCS Onboard system and shall be regarded as one STM level.

(ix) The reuse of ERTMS/ETCS Onboard functionality can be different depending on the configuration of a specific STM.

(x) Access to ERTMS/ETCS Onboard supervision functions is supported.

5. ERTMS/ETCS Application Level '1' :



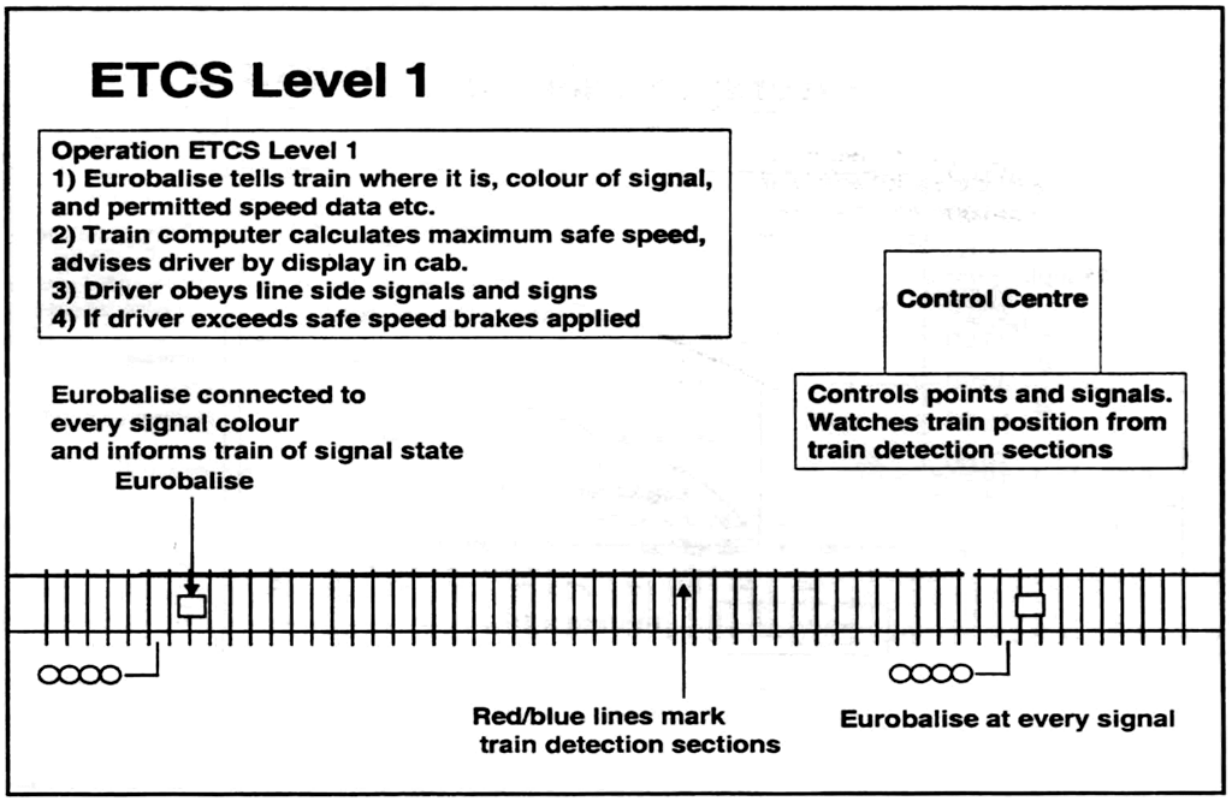


Figure 4: ERTMS/ETCS Application Level 1 without infill function

(i) ERTMS/ETCS Level 1 is a spot transmission based train control system to be used as an overlay on an underlying signalling system.

(ii) Movement authorities are generated trackside and are transmitted to the train via Euro balises.

(iii) ERTMS/ETCS Level 1 provides a continuous speed supervision system, which also protects against overrun of the authority.

(iv) Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.) and are outside the scope of ERTMS/ETCS.

(v) Level 1 is based on Eurobalises as spot transmission devices.

(vi) The trackside equipment does not know the train to which it sends information.

(vii) If in level 1 a line side signal clears, an approaching train cannot receive this information until it passes the Eurobalise group at that signal. The driver therefore has to observe the line side signal to know when to proceed. The train has then to be permitted to approach the stopping location below a maximum permitted release speed.

(viii) Additional Euro balises can be placed between distant and main signals to transmit infill information, the train will receive new information before reaching the signal.

(ix) Line side signals are required in level 1 applications, except if semi-continuous infill is provided.

(x) Semi-continuous infill can be provided using Euro loop or radio in-fill. In this case, the on-board system will be able to show new information to the driver as soon as it is available and even at standstill.

(xi) Euro loop or radio in-fill can improve the safety of a level 1 system as they allow the operation without release speed.

7. ERTMS/ETCS Application Level '2' :

(i) ERTMS/ETCS Level 2 is a radio based train control system which is used as an overlay on an underlying signalling system.

(ii) Movement authorities are generated trackside and are transmitted to the train via Euro radio.

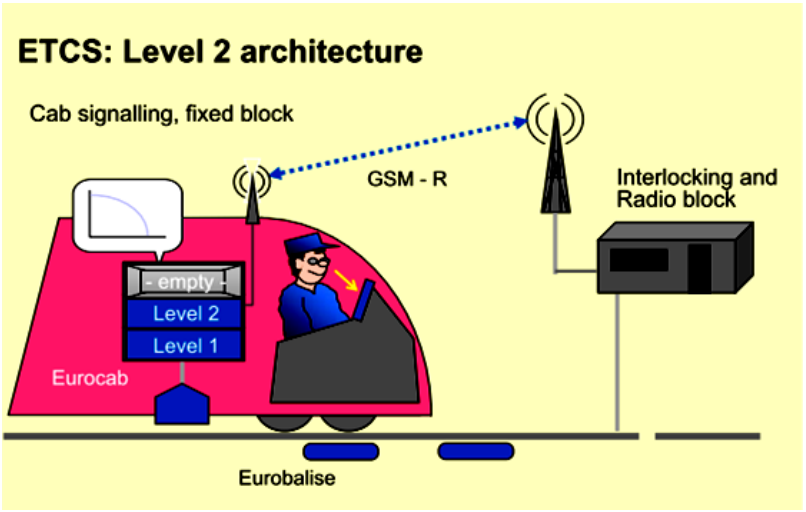
(iii) ERTMS/ETCS Level 2 provides a continuous speed supervision system, which also protects against overrun of the authority.

(iv) Train detection and train integrity supervision are performed by the trackside equipment of the underlying signalling system (interlocking, track circuits etc.) and are outside the scope of ERTMS/ETCS.

(v) Level 2 is based on Euro radio for track to train communication and on Euro balises as spot transmission devices mainly for location referencing.

(vi) The trackside radio block centre which provides the information to the trains knows each ERTMS/ETCS controlled train individually by the ERTMS/ETCS identity of its leading ERTMS/ETCS on-board equipment.

(vii) Line side signals can be suppressed in Level 2.



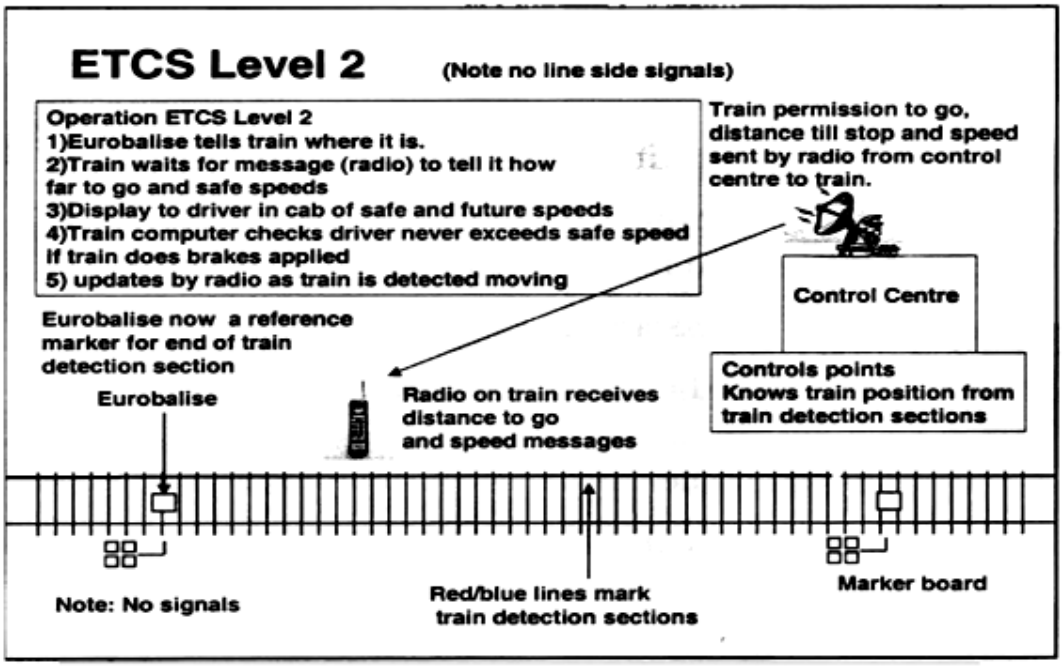


Figure 6: ERTMS/ETCS Application Level 2

The track side equipment consists of a Radio Block Center (RBC) and fixed Eurobalises installed in the track. For bi-directional communication between the ETCS train borne unit and RBC, GSM-R (Global System for Mobile communication-Railways) will be used. An ETCS train running in the RBC area keeps a continuous connection to the RBC.

8. ERTMS/ETCS Application Level '3' :

(i) ERTMS/ETCS Level 3 is a radio based train control system.

(ii) Movement authorities are generated trackside and are transmitted to the train via Euro radio.

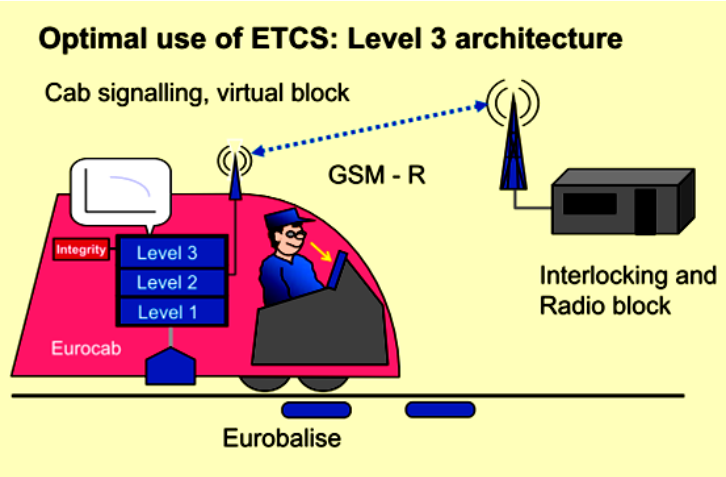
(iii) ERTMS/ETCS Level 3 provides a continuous speed supervision system, which also protects against overrun of the authority.

(iv) Train location and train integrity supervision are performed by the trackside radio block centre in co-operation with the train (which sends position reports and train integrity information).

(v) Level 3 is based on Euro radio for track to train communication and on Euro balises as spot transmission devices mainly for location referencing.

(vi) The trackside radio block centre which provides the information to the trains knows each train individually by the ERTMS/ETCS identity of its leading ERTMS/ETCS onboard equipment.

(vii) Line side signals are not foreseen to be used when operating in Level 3.



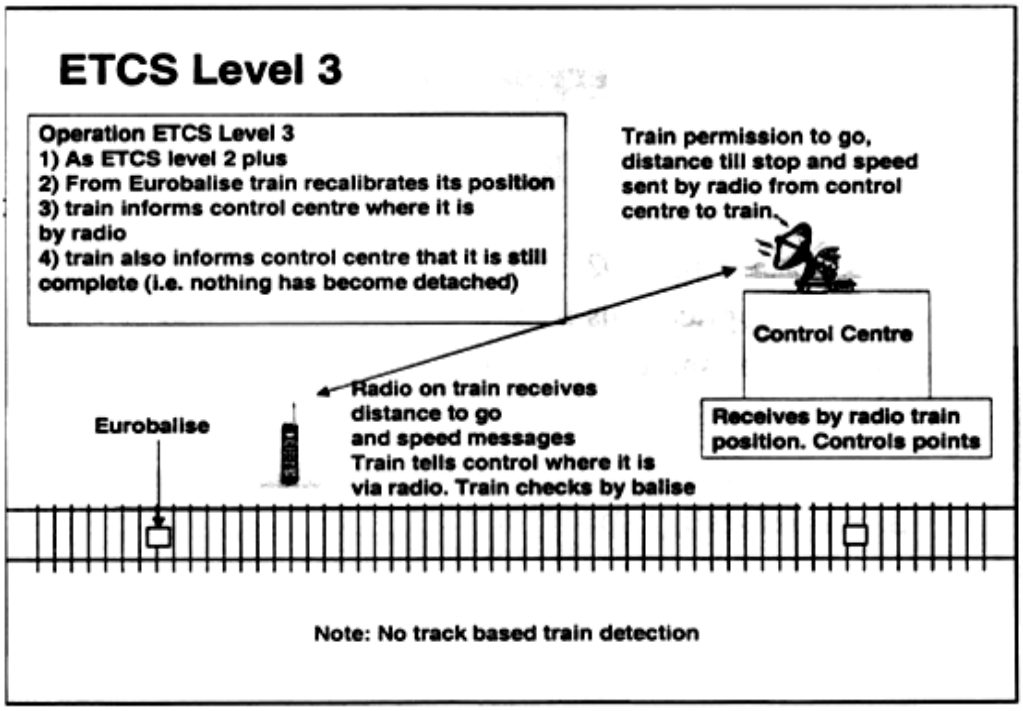


Figure 7: ERTMS/ETCS Application Level 3

Level 3 can be used

- On lines where there are no train detection device on the track.
- When moving block is requested, to improve line capacity.
- On lines where some trains might not short circuit the track circuit.

Note: For further details on 'ETCS LEVELS' please refer the following book available in IRISET Library.

" ETCS FOR ENGINEERS"

Author :Peter Stanley; Institution of Railway Signal Engineers

Publisher: Hamburg Eurail press 2011.

3.2 An overview of ERTMS/ETCS Application levels:

	Signalling			Telecom		
ECTS level	**Train Detection**	**Type of Signals**	**Movement Authority**	**Communication – Means**	**Communication- One way / Both ways**	**Train Control**
Level 0	Track Circuits, Axle Counters	Line side	Fixed block		No Track-Train transmission except to announce/command level transitions.	No supervision of speed except maximum design speed of a train and maximum permitted speed in unfitted areas.
Level STM	Track Circuits, Axle Counters	Line side signals may not be necessary.	Fixed block - through Balise	Through Balise	No Track-Train transmission except to announce/command level transitions.	Supervision of maximum train speed.
Level 1	Track Circuits, Axle Counters	Line side	Fixed block - through Balise	Through Balise	**Track side :** has no knowledge of Train. **Train :** Receives preprogrammed Track Data through Balise	Continuous speed supervision system Balise / Loop or Radio in-fill
Level 2	Track Circuits, Axle Counters	Line side / Cab	Fixed block . through RBC	Radio. Balise - KM Marker	**Track side** : has knowledge of train characteristics. **Train :** Receives track data.	Radio Based Train control system with continuous speed supervision. Balise / Loop / RBC
Level 3	On board Integrity Systems	Only Cab Signaling	Moving Block through RBC	Radio Balise - KM Marker	Both way communication from and to Radio Block Center.	Radio Based Train control system with continuous speed supervision.

* * *

Annexure – III : ANTI COLLISION DEVICE

1 Anti Collision Device (ACD)System

ACD was developed by Konkan Railway Corporation Ltd.(KRCL) and Installed in Konkan Railway. Northeast Frontier Railway (NFR) also installed Anti-Collision Devices (ACD) on trial basis.

Popularly known as Raksha Kavach, Train Collision Prevention System (TCPS), the Anti-Collision Device is a micro processor based Networked control system providing a non-vital safety shield over existing signal based protection systems. It prevents high speed collisions or minimize the damage caused by collisions between trains and between trains and Road vehicles

The ACD system includes a variety of networked ACDs mentioned below.

(a) LOCO ACD

(b) GUARD ACD

(c) STATION ACD

(d) MANNED Level Crossing Gate ACD:

(e) UN-MANNED Level Crossing Gate ACD:

(f) ACD 'REPEATER'

(g) TID (Track Identification) assigning ACDs

Apart from interfacing with existing Signalling system, ACD utilises the following 3 features for its functioning .

(a) Track Identification (TID) Track ID is assigned as UP line, DN line, etc on which train is running for distinguishing each track to enable risk assessment.

(b) Global Positioning System (GPS) for determination of train location, speed, course angle of travel and time.

(c) Radio communication: ACDs communicate with each other through radio modems within a radius of up to 3KM. If two ACD units are within a predefined distance and deemed to be at a risk of collision, the ACD system activates automatic braking operation to prevent collisions.

ACD assists the driver as a companion to prevent any accident like situations by p**erforming the following functions.**

(a) Prevention of Head-on/ Rear-end / Side Collision between ACD trains/ACD locomotives in block section.

(b) Prevention of collision in station area, due to fouling of lines having different TID's in station area.

(c) Detection of Train Parting / Jumbling.

(d) Station approach warning to the drivers.

(e) Speed Limit imposition

(f) For manned gates , if approaching Loco ACD detects 'Gate Open' condition, the speed of the train / loco is regulated. For unmanned gates, aapproach warning for Road Users at level crossings equipped with ACD.

(g) SOS functions.

(h) Event logging.

2 Networked ACD

It is a network of different types of ACD units, namely Loco ACD, Guard ACD, Station ACD, Level Crossing Gate ACD, Loco shed ACD, TID assigning ACD and Repeater ACD. Each ACD is an intelligent microprocessor based system, which uses a GPS receiver (for Loco and Guard ACDs), data radio modem for communication with other ACD units and interfaces with track circuits and point status inputs, speedometer, self-propelled vehicles and other external devices, on need basis. The arrangement of 'Networked' ACD system is as under:

'ACD' Network (Raksha Kavach) – An Overview

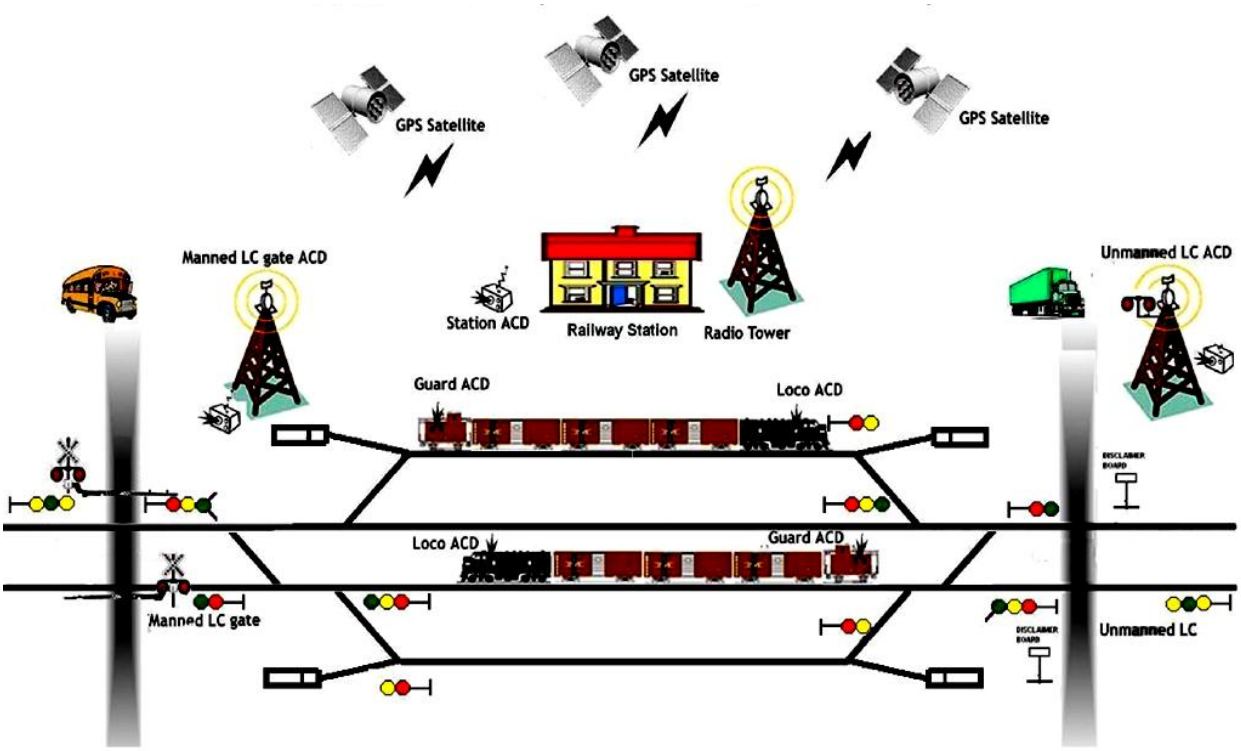


Fig. No. 1

3 Loco ACD

Loco ACD is provided in the Locomotive of the train with **Automatic Braking Unit (ABU).** The basic components of Loco ACD are - **GPS Receiver, Radio Modem, Central Control Unit and Locomotive Interface.** The GPS Receiver provides the vital information of its own location on the earth; in addition, it gives angle and speed with time stamp. The sensitivity of GPS is not adequate to distinguish between two parallel tracks, hence deviation count is done to establish the track ID in loco. Thus track ID may be modified after adopting input from existing track circuit advised through station ACD to loco ACD. If the track ID is not established or if the trains proceeds with an incorrect track ID, it is slowed down to 25KMPH on approaching other train within 3Kms. and if they cross without event, the correct track Ids are allocated. The Radio Modem transmits and receives information through UHF Radio for taking decisions based on the information received from other Loco/Guard/Station ACDs. The Central Control Unit takes decision depending on various inputs received from GPS Receiver, Radio Modem and gives different commands like application of brakes through ABU, Audio-Visual indication etc. Two nos. of Driver's Console are connected with the Loco ACD for ease of operation during normal train working.

Loco ACD is **'permanently'** fixed in Locomotive for:

(a) Auto-application of Brakes, whenever a 'collision-like' situation is perceived

(b) Alerting driver on 'Station Approach'

(c) Alerting driver of 'Train Parting', through generation of 'Auto-SOS'

(d) Alerting driver when the train is dispatched on 'Wrong' Track

(e) Stopping of other Train(s) in case of emergency, by pressing 'SOS' button

(f) Alerting the driver and regulating the train speed to 25KMPH, when it detects (through the Loco ACD of other train) that it has stopped in mid-section

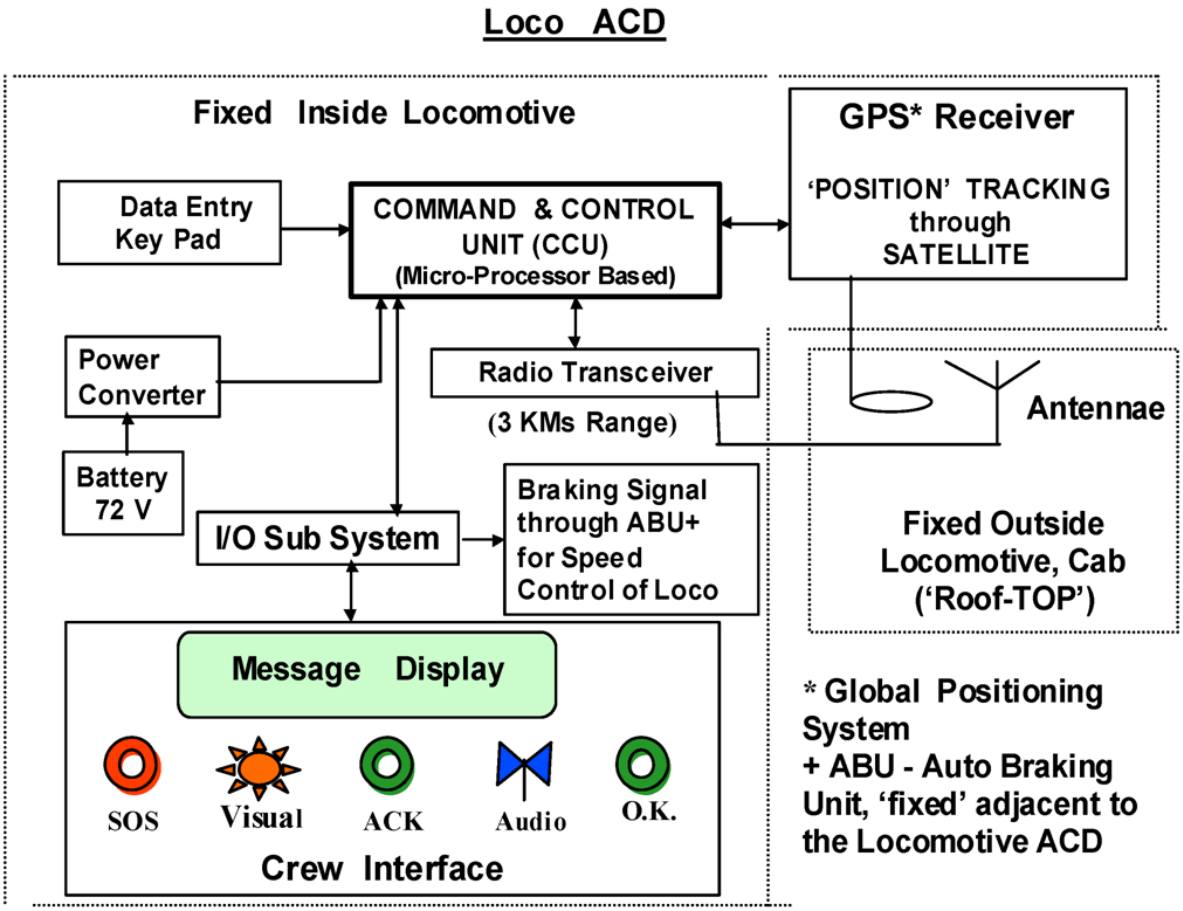
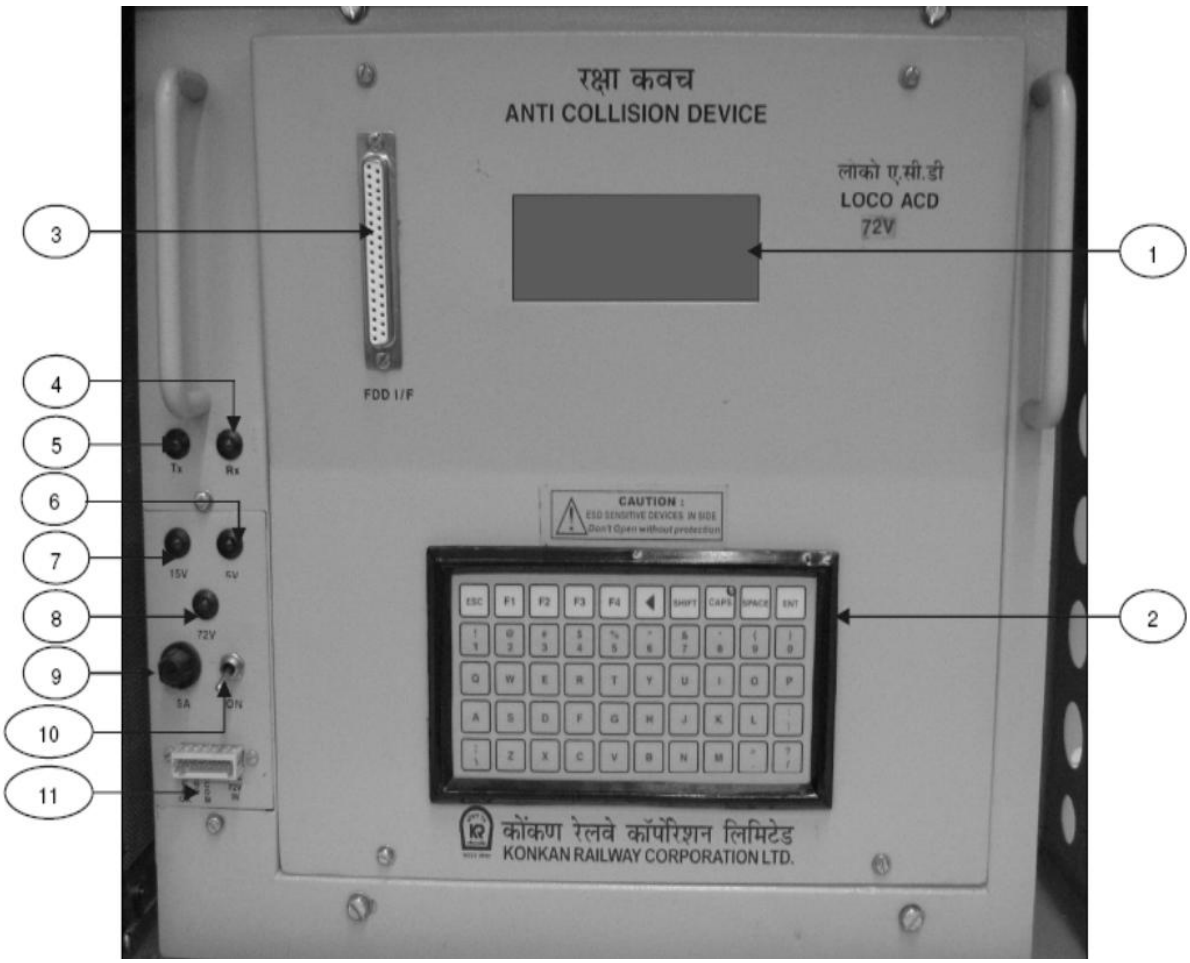


Fig : 2 Functional diagram of LOCO ACD



ID	Abbreviation	Description
1	LCD	Liquid Crystal Display
2	KEYPAD	50 Keys Key Pad
3	DATA PORT	Data Terminal for connecting Floppy Disk Drive
4	Rx LED	Data Packet Receiving indication
5	Tx LED	Data Packet Transmission indication
6	5 V	5 V Voltage supply indication
7	15 V	15 V Voltage supply indication
8	72 V (110V for electric locomotive versions)	72 V (110V) Voltage supply Indication
9	5A	5 Amps Fuse
10	On/Off Switch	Switch for switching ON/Off the ACD
11	Connector	Interface Connector to Driver Console

Fig :3 Loco ACD Front Panel

3.1 The different types of LED indications and buttons provided on Loco ACD are as under

(a) LED Indications **:**

(i) **SOS** – This 'emergency' (**S**ave **O**ur **S**oul) 'flashing' indication **appears** whenever the Loco ACD either receives or transmits **SOS** condition and becomes steady after 'ACK' button is pressed. It **disappears** when 'ACK' button is pressed TWICE.

(ii) **Train Parted** – This indication **appears** whenever the distance between Loco and Guard ACDs of the same train in the Block section, is more than 1000m. It **disappears** when the relative distance between these two ACDs becomes less than 1000m.

(iii) **TID Failure** – This indication appears after the loco ACD crosses last stop signal of any station. It **disappears** only when driver of that train presses 'Normalcy' button within 60 (Sixty) seconds.

(iv) **Station Approach** – This 'driver alert' flashing indication **appears** whenever the loco ACD is about 2 Kms away from FSS (First Stop Signal), becomes steady after driver presses 'ACK' button and **disappears** after the Loco crosses the FSS.

(v) **Train Ahead** - This indication **appears** when Loco ACD detects a train moving ahead of it with 'same' Track ID, within a distance of 2 Kms. It **disappears** when the relative distance between these two ACDs becomes more than 2 Kms.

(vi) **Fail** - This ACD Fail indication to indicate to the driver that he NO more enjoys the ACD protection, **appears** when Loco ACD failure or by-passing of ABU (Auto-Braking Unit) is detected during the routine 'self-test' at a regular interval. It **disappears** when the ACD detects 'System O.K.' during its routine 'self-test'.

(b) 'Audio' buzzer to draw the attention of the driver will follow all the above '**visual'** indications. The buzzer will stop, moment the 'ACK' button is pressed.

(c) Buttons:

(i) **'ACK' Button** – This button is used for acknowledgement of audio buzzer, which follows the 'Visual' indications, described above.

(ii) **'SOS' Button** – This button is used for radiating 'SOS' signal whenever a 'collision-like' situation arises

(iii) **'Normalcy' button** – This button is used for radiating 'normal' condition of train after confirming that

- There is **no** infringement to adjacent track where the train has stopped in block section **or**
- The **Track ID** being displayed on the LCD panel of the Loco ACD is 'matching' with that of the Track on which the train has been despatched from the station.

(d) 'Brake Test' button - This button is used for checking the 'effectiveness' of application of both 'Normal' and 'Emergency' brakes, whenever needed, through Auto-Braking Unit of Loco ACD. This button is effective only when the train speed is not exceeding 35 KMPH.

4 Station ACD

Station ACD is provided at the station for:

(a) Differentiating 'Station Area' from the 'Block Section'

(b) Permitting 'shunting' movements in the 'Station Area'

(c) Storing yard layout and interfacing with signalling circuits of the station area for ensuring 'despatch' of trains in Block Section with 'correct' Track ID

(d) Stopping of other Train(s) in case of emergency, by pressing 'SOS' button

4.1 The different types of LED indications and buttons provided on Station ACD are as under

(a) LED Indications**:**

(i) SOS – **This** 'emergency' (**S**ave **O**ur **S**oul) 'flashing' indication **appears** whenever the Station ACD either receives or transmits **SOS** condition and becomes steady after 'ACK' button is pressed. It **disappears** when 'ACK' button is pressed TWICE.

(ii) TID Failure – This indication **appears** on receipt of 'TID Failure' flag from any Loco ACD that is approaching its Station Area.

Further, it **disappears** when, **either**

- the Station Master enters 'correct' TID in Loco ACD **or**
- the Station ACD NO more receives the 'TID Failure' flag from the Loco ACD concerned, for a period of at least 60 (Sixty) seconds

(iii) Fail - This ACD Fail indication to indicate to the Station Master that his station NO more enjoys the ACD protection, **appears** when Station ACD failure is detected during the routine 'self-test' at a regular interval. It **disappears** when the ACD detects 'System O.K.'

(iv) Train Fouling - This indication **appears** to indicate to the Station Master that one of the trains is 'fouling' the adjacent track in the Station Area. It **disappears** when the 'Train Fouling' status is no more being radiated from Loco and/or Guard ACD of the Train concerned for a period of at least 60 (Sixty) seconds.

(b) 'Audio' buzzer to draw the attention of the Station Master will follow all the above '**visual'** indications. The buzzer will stop, moment the 'ACK' button is pressed.

(c) Buttons:

(i) 'ACK' Button – This button is used for acknowledgement of audio buzzer, which follows the 'Visual' indications, described above.

(ii) 'SOS' Button – This button is used for radiating 'SOS' signal whenever a 'collision-like' situation arises.

5 Guard ACD

'Portable' Guard ACD is provided in Guard Van/SLR for

(a) Detecting the 'train parting'

(b) Stopping of other Train(s) in case of emergency, by pressing 'SOS' button.

(c) Providing 'limited backup' for Loco ACD, in case it detects that its Loco ACD is no more 'radiating' any information.

(d) Ensuring 'Guard Alert' at an interval of every 15 minutes and alerting the driver of the same through 'Audio' indication along with the message display on LCD panel of to its Loco ACD

5.1 The different types of LED indications and buttons provided on Guard ACD are as under

(a) LED Indications**:**

(i) SOS – This 'emergency' 'flashing' indication **appears** whenever the Guard ACD either receives or transmits **SOS** condition and becomes steady after 'ACK' button is pressed. It **disappears** when 'ACK' button is pressed TWICE.

(ii) Train Parted – This indication **appears** whenever the distance between Loco and Guard ACDs of the same train is more than 1000m. It **disappears** when the relative distance between the two ACDs becomes less than 1000m.

(iii) Train Approaching - This indication **appears** when Guard ACD detects a train approaching it with its Loco ACD radiating the 'same' Track ID, within a distance of 2 KM. It **disappears** when the relative distance between the two ACDs becomes more than 2 KM.

(iv) Guard Alert - This 'Guard Alert' flashing indication **appears** at an interval of every 15 minutes and **disappears** after the Guard presses 'ACK' button.

(v) Fail - This ACD Fail indication to indicate to the Guard that he no more enjoys the ACD protection, **appears** when Guard ACD failure is detected during the routine 'self-test' at a regular interval. It **disappears** when the ACD detects 'System O.K.'

(vi) Battery Low - This indication **appears** to 'alert' the Guard for initiating action to replace the discharged battery. It **disappears** when the ACD detects 'Battery O.K'.

(b) 'Audio' **buzzer** to draw the attention of the Guard will follow all the above '**visual'** indications. The buzzer will stop, moment the 'ACK' button is pressed.

(c) Buttons:

(i) 'ACK' Button – This button is used for acknowledgement of audio buzzer, which follows the 'Visual' indications, described above.

(ii) 'SOS' Button – This button is used for radiating 'SOS' signal whenever a 'collision-like' situation arises.

The 'Networked ACD' system monitors the normal train working, either in Mid-section or in Station Area and acts to 'stop' or 'regulate' the trains whenever collision-like situations are perceived.

6 Essential difference between Anti-Collisiondevice (ACD) and Train Protection Warning System(TPWS)

Sl. No.	A C D	T P W S
01	ACD is basically a Telecom system based on data communication between UHF transmitters fitted on trains.	It is basically a signaling system where the signal aspects are transmitted to the train for determining its permissible speed and actuation of brakes, if necessary based on signal aspects and current speed.
02	ACD is not a fail-safe device as if there is a break in communication between two approaching trains due to any reason; it will not lead to stopping of trains.	This is a fail-safe system and stops the train, in case of any defect in the track-side or on-board side equipment on the trains and failure of communication between on-board and track side equipment.
03	For the system to effectively function, a train has to be provided with two ACDs one fitted in the Loco and other in the Brake Van.	As far as TPWS, on-board equipments are concerned, it need be provided only in the Loco or Motor Coach of the train and no equipment is required in the Brake Van.
04	As far as track side equipments are concerned, it requires 'station ACDs', 'LC gate ACDs' and other special ACDs like 'Repeater ACDs', 'Bahar Line ACDs' etc.	The Track side equipment consists of Line Side Electronic Units (LEU) which is connected to the signal aspects and Balises fixed in the centre of the track in front of the signals.
05	The trains location system based on GPS adopted for ACD is not very effective due to the inadequate resolution of the GPS as well GPS shadow zones along the track.	No such difficulty is encountered here as the train is located based on the Balises fixed on the track.
06	In order to overcome the ineffectiveness of GPS, it has now been decided that the ACD will also use signaling inputs like point indications and track circuit indications, thereby ACD will not be effective during NI working in yards as claimed earlier.	TPWS, it is a proven system working on high speed networks in European Railways and no major design modifications are required for adoption on Indian Railways.
07	Visibility of signals to the driver continues to remain essential.	Since aspect of signals are communicated to the on-board system by Balises and permissible speeds are always indicated, visibility of signals become less important and drivers can operate trains even during low visibility conditions confidently.
08	Speed control on account of permanent speed restrictions and on loop lines not available.	Speed control available over permanent speed restricts and loop lines.

Sl. No.	A C D	T P W S
09	Can control speed of train if manned gate is open.	For manned interlocked gates this system can also prevent trains from running into road traffic if gate is open. Presently not possible to control speed of trains if non interlocked gates are open
10	Can give road warning for unmanned LC gates. However this feature has not been found reliable due to thefts and has now been dropped in N F Railway.	Presently the feature to provide road warning when a train is approaching is not implemented.
11	If communication between trains works satisfactorily, can prevent head on & rear end collisions and side collisions on account of derailment in mid sections.	By preventing over running of movement authority, it can prevent all types of collisions except perhaps the side collisions on account of derailment in mid sections
12	Can detect parting of trains	No such feature available.

Train Collision Avoidance System (TCAS) with RDSO/SPN/196/2012 Version 3.0 (Draft) will be introduced in place of ACD. Aim of this system is to prevent train collisions in block sections and on running lines at stations and also prevent Signal Passing at Danger (SPAD).

* * *

REVIEW QUESTIONS

CHAPTER-1

SUBJECTIVE :

1. Explain the Data loggers and their networking.

State True or False

1. Data logger records analog & digital inputs of an Interlocking system with reference to date and time. (T)
2. In EFFTRONICS Data logger, capacity of each Digital input card is 64 inputs. (T)
3. In EFFTRONICS Data logger, each DSU is provided with maximum 4 Nos of digital input cards. (F)
4. In EFFTRONICS Data logger, all Digital inputs are scanned at the rate of 30m.sec. (F)
5. In EFFTRONICS Data loggers, all the Analog inputs are scanned at the rate of 16 m. sec. (F)
6. In EFFTRONICS Data loggers, DSU is required only when the system is required to be connected with more than 1024 relays. (F)
7. Data logger Digital input capacity is 4096. (T)
8. Minimum number of Analog channels is required to be provided with Data logger system is 32. (T)
9. FEP is required at centralised place for networking of Data loggers. (T)
10. Modems are required at stations and also at centralised place for networking of Data loggers. (T)
11. In EFFTRONICS Data loggers, NMDL software is required for analyzing the ON LINE Faults or ON LINE data. (T)
12. Data logger stores 10 Lakh events. (T)

CHAPTER-2

SUBJECTIVE:

1. Briefly explain the TPWS with the help of functional diagram.

State True or False

1. TPWS enables automatic train protection and prevents collision, like situation. (T)
2. In TPWS, external power supply is not required for Balise. (T)
3. Telegrams are normally configured in L.E.U. (T)
4. Default Balise telegram is provided in Balise. (T)

5. Infill Balise is used for updation and reduction in movement authority. (T)
6. Fixed Balise can be utilised for Relocation of movement authority. (T)
7. LEU can read 10 ECRS contacts. (T)
8. LEU can operates 4 Balise up to a distance of 5 KM. (T)
9. PIND module is use as interface between LEU to ECR contacts. (T)
10. PFSK is a protection module between Balise to LEU. (T)

CHAPTER-3

1. Draw and explain the Schematic Arrangement of TCAS?
2. Explain the function of RFID in TCAS working?

CHAPTER-4

1. Explain the working of Auxiliary Warning System(AWS)?
2. Explain the working of Additional Track magnet?
3. Explain the working of Opto coupler Cards?

* * *