



सत्यमेव जयते

**SPECIFICATION FOR  
GPS Based Portable System for  
Acceleration Measurement at Axle Box Level**

**Version 1**

**SPECIFICATION NO. TM/IM/340**

**TRACK MACHINE & MONITORING DIRECTORATE**

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## 1.0 Scope

- 1.1 This document sets forth general, operational, technical and performance requirements for GPS Based Portable System for Acceleration Measurement at Axle Box Level
- 1.2 Whenever this specification is referred by number only, without mentioning the year of issue, the latest issue of the specification is implied.

## 2.0 Objectives of the specification

- 2.1 This specification lays down the requirements and tests for GPS Based Portable System for Acceleration Measurement at Axle Box Level
- 2.2 GPS Based Portable System for Acceleration Measurement at Axle Box Level covered in this specification shall be of robust, rugged and compact construction and shall be easily mountable on any inspection coach.
- 2.3 GPS Based Portable System for Acceleration Measurement at Axle Box Level shall be capable of recording vertical and lateral acceleration at axle box level on both left and right side of axle on straight, curves and station yard track.
- 2.4 GPS Based Portable System for Acceleration Measurement at Axle Box Level shall be of natural air cooled type and shall be suitable for use on Railway Rolling Stock.

## 3.0 Terminology & Abbreviations:

Abbreviation	Full Form/ Description
AC	Alternating Current
DC	Direct Current
LED	Light Emitting Diode
RI	Ride Index.
IMU	Inertial Measurement Unit
GPS	Global Positioning System.
TP	Telegraph Pole
KM	Kilometer

## 4.0 General Requirements

- 4.1 System shall be universally suitable for all types of sections of Indian Railways like single line, double line, twin single line, multiple lines etc.

- 4.2 System shall be suitable for installing on axle box of all types of passenger coaches e.g. ICF all coil coach, LHB Coach etc.
- 4.3 System shall be capable of working on electrified and non-electrified sections of Indian Railway Track
- 4.4 System shall be capable of deterring location of acceleration peaks and speed with the help of GPS.
- 4.5 The system shall be capable to run from the 110 volt AC power supply available in ICF/LHB coaches for charging of Laptop and Mobiles.
- 4.6 System shall be suitable for train speeds up to 160 KMPH.
- 4.7 System shall be well protected against any electromagnetic interference. No false peaks should be reported if walky-talky equipment is operated in the inspection room of the coach.

## 5.0 Functional requirements

### System shall be capable of performing following functions

- Measurement of vertical and lateral acceleration on both side of axle box on user selectable band pass filter in the frequency range of 0.3 Hz to 48 Hz at various speeds.
- Storage of vertical and lateral acceleration at axle box level at user selectable distance and on various track features stored in a track location file along with speed. Data shall be stored in ASCII file in CSV format.
- On line display and printing of maximum value of vertical and lateral acceleration peaks occurring at axle box level for both left and right side of axle for every 50 meter and on various track features stored in a track location file.
- On line display and printing of SD value of vertical and lateral acceleration for every 200 meter of block. The last block of the kilometer may be more or less than 200 meter. If the distance in last block of kilometer is more than 250 meter SD value of length in excess of 200 meter will be reported in a new block. If the distance in last block is more than 200 meter but less than 250 meter the SD for total length will be reported in the last block.
- On line display and printing of Average speed for block of every 200 meter length in a kilometer.

## 6.0 Technical Requirements

- 6.1 GPS Based Portable System for Acceleration Measurement at Axle Box Level will be based on Lap Top PC with Inertial Measurement Units consisting of MEMs based accelerometers & Gyros and GPS. A portable printer is connected to Laptop for printing of on line results.
- 6.2 The minimum technical requirements of Laptop PC, IMUs, GPS and device/card for data communication are furnished below:

### 6.2.1 Laptop PC

- Intel© core TM i5 2520M v Pro processor or equivalent having Mobile Computing Platform
- 4GB RAM
- intel® HD 3000 graphics Robust magnesium alloy display case or equivalent
- shock - protected HDD/SSD
- USB 3.0 and serial port

### 6.2.2 IMUs

The IMUs used are Micro Electronic Mechanical System (MEMS) type with digital output and consists of a tri-axial gyroscope and a tri-axial accelerometer to give out put in three perpendicular axis i.e. x, y, z IMUs used shall be capable to measure acceleration up  $\pm 18g$  in the frequency range of 0 to 330 hzs

### 6.2.3 Digital data communication Device/Card

USB port compatible Digital data communication device shall be used for transmitting data from IMUs and GPS to Processing and display unit. The device/card shall be capable of providing I2C and SPI connectivity with eight SPI chip selects and eight general-purpose DIO channels

### 6.2.4 GPS

At least 5Hz GPS having following features shall be used in the system.

- GPS smart antenna receiver included an embedded antenna and GPS receiver circuits.
- MediaTek MT3329 solution i.e. an all-in-one single chip GPS solution
- 5Hz output
- 57600bps TTL serial interface
- 3.3V @ 41mA
- 66 Channel GPS
- Fast TTFF at low signal level
- Up to 10Hz update rate
- Capable of SBAS (WAAS, EGNOS, MSAS)
- Built-in micro battery to preserve system data for rapid satellite acquisition
- LED indicator for fix or no fix
- Compact in size and weighs just a few ounces.

### 6.2.5 Odometer

An optical odometer of at least 1000 pulses per revolution shall be installed on one of the axle of coach for determination of location of peak from previous kilometer and average speed for every block of 200 meter and for whole kilometer. The speed and location calculated using odometer will be used to verify the speed and location determined using GPS data

## Printer (Optional)

For on Line Printing of exception reports one minimum 40 column Dot Matrix Printer shall be provided

## 7.0 Software Requirements

### 7.1 On line software

A user interactive and tailor made online software for real time data acquisition and online analysis and reporting of results shall be developed and installed in the Laptop. **Software shall be capable to perform the following function.**

- **Facility to input following initial parameters for identification of recorded data**
  - Railway
  - Division
  - Section
  - Sectional Speed
  - Route tape of Track feature file name
  - Train No.
  - Coach No.
  - Route electrified or not
  - Start Kilometer
  - Threshold values for peak information
- Acquisition and storage of raw vertical and lateral acceleration data in time domain at every 10 m Sec.in the frequency range of  $\pm 330$  Hzs.
- Acquisition and storage of vertical and lateral acceleration data in space domain with user selectable band pass filter in the frequency range of 0 to 50 Hzs at user selectable sampling interval.
- Acquisition and storage of vertical and lateral acceleration data in space domain with user selectable band pass filter in the frequency range of 0 to 50 Hzs at various track features stored in a track location file or punched manually from a dedicated Keypad
- Display of acceleration data acquired in space domain on user selectable sampling interval in graphical form in a split window on Laptop.
- On line display and printing of exception report as per the format to be supplied at the time of award of work. The exception report will contain the following information
  - Worst peak for every 50 meter length of track
  - No. peaks in a kilometer above three pre-selected limits
  - SD value for every 200 meter length of track
  - Average speed for every 200 meter length of track
  - RI for every 200 meter length of track
  - Vertical and Lateral acceleration peak on track features along with distance from previous kilometer.

- Each sample will be tested for peak. If sample is a peak it will be stored in a buffer for RI computation. All the peaks on a 200 meter length will be used for RI computation by using following formula:

$$R.I. = 0.896 \times \frac{\sum_{i=1}^n \{ b_i^3 \times F(f_i) \}}{10 \times n}$$

Where n = no. of completed half waves (cycles)

$b_i$  = Peak value of amplitude for the  $i^{th}$  half-wave

$f_i$  = Frequency of the  $i^{th}$  half wave =  $1/(2T_i)$ ;  $T_i$  = Time of  $i^{th}$  half cycle

$F(f_i)$  = Corrector factor for the  $i^{th}$  half wave.

Correction factors for various frequency values are as follows:

For vertical mode 0 for $f < 0.5$ Hz $0.325 f^2$ for $0.5 < f \leq 5.4$ Hz $400/f^2$ for $5.4 \leq f \leq 20.0$ Hz 1 for $> 20$ Hz	For lateral mode 0 for $f < 0.5$ Hz $0.8 f^2$ for $0.5 < f \leq 5.4$ Hz $650/f^2$ for $5.4 \leq f \leq 20.0$ Hz 1 for $> 20$ Hz
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## 7.2 Offline Software

A user interactive and tailor made offline software to perform the following functions from the stored raw data shall be developed and installed on the Laptop PC

- Display and printing of graphical output of vertical and lateral acceleration on a user selectable band pass filter in the range of 0 to 50 Hz along with speed.
- Display and printing of exception report as per the format to be supplied at the time of award of work. The exception report will contain the following information
  - Worst peak for every 50 meter length of track
  - No. peaks in a kilometer above three pre-selected limits
  - SD value for every 200 meter length of track
  - Average speed for every 200 meter length of track
  - RI for every 200 meter length of track
  - Vertical and Lateral acceleration peak on track features along with distance from previous kilometer.

## 8.0 Documents required from supplier

Manufacturer shall provide Operating and Maintenance manual consisting of following details:

- Brief description of the system with suitable block diagram
- Installation and maintenance guide.

- iii) Static calibration procedure, Diagnostic procedure, system commands including troubleshooting charts.
- iv) User's Manual for operating the system & offline analysis of acquired data

## 9.0 Accessories

### 9.1 Tools to be supplied

- a) Tool kit required for fixing IMUs on axle box, GPS and maintenance and repair of system, as recommended by OEM

### 9.2 Spares to be supplied

- a) One each for all leads and sensors used
- b) As recommended by OEM

## 10.0 Guarantee/Warranty

All the material supplied should have a warranty for at one year from the date of commissioning.

## 11.0 Tests & Verification:

### 11.1 Dynamic Calibration:

The transducers used in the system shall be calibrated from a certified laboratory and frequency of calibration shall be specified in the manual. The tachometer will be calibrated in the field by moving the coach for a premeasured distance and setting the tacho factor.

### 11.2 Makers test certificate for outsourced item

- a) Test and Dynamic calibration certificate of system as per clause 11.1.
- b) Test and calibration certificate for transducers.
- c) Test certificate for Tachometer.
- d) License of Windows Operating system
- e) License of MS office
- f) License of Antivirus software of reputed supplier with two years subscription

### 11.4 Acceptance test

- The system will be tested in field for repeatability of acceleration peaks in space domain at same speed in the range of 80 to 120 Kmph in steps of 10 Kmph.
- The location of acceleration peaks recorded by GPS will be verified using tachometer with in a accuracy of  $\pm 5.0$  meter