INDIAN RAILWAYS
CHITTARANJAN LOCOMOTIVE WORKS
CHITTARANJAN

Technical Specification
For
Upgradation Kit for
IGBT Based Integrated converter with Traction Converter and 2x750kVA Hotel Load Converter for WAP-7 Locomotive

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Revision History

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ABBREVIATIONS

The following abbreviations are used in these Specification

Abbreviations	Full Name
AAR	Association of American Railroad
AC	Alternating Current
AF	Audio Frequency
ASIC	Application Specific Integrated Circuit
ATP	Automatic Train Protection
BS	British Standards
CBC	Centre Buffer Coupler
CLW	Chittaranjan Locomotive Works
DC	Direct Current
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
EN	Euro Norm (European Standard)
EPDM	Ethylene Propylene Diene Monomer
EVA	Ethylene Vinyl Acetate
FEM	Finite Element Method
GPS	Global Positioning System
GSM	Global System for Mobile
GSM-R	Global System for Mobile - Railways
HT	High Tension (Voltage) (according to Indian Electricity Rules)
IC	Integrated Circuit
IEC	International Electro technical Commission
IEEE	Institution of Electrical and Electronic Engineers
IGBT	Insulated Gate Bipolar Transistor
IR	Indian Railways
IRS	Indian Railway Standards
IS	Indian Standard
ISO	International Standards Organization
Kmph	Kilometers per hour
LED	Light Emitting Diode
MCB	Miniature Circuit Breaker
MMD	Maximum Moving Dimension
MMI	Man-Machine Interface
MMIS	Maintenance Management Information System
MSU	Motor Suspension Unit
OHE	Over Head Equipment
PCB	Printed Circuit Board
RAMS	Reliability, Availability, Maintainability and Safety
RDSO	Research Designs & Standards Organisation

SI	Systeme Internationale
UHF	Ultra High Frequency
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
VHF	Very High Frequency
VCU	Vehicle Control Unit
VCD	Vigilance Control Device

Definitions

In these Specifications and Standards, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

Term	Definition
Agreement	shall mean the Procurement cum Maintenance Agreement for Electric Locomotives;
Bo-Bo	shall mean one unit of the Locomotive consisting of two bogies, with each bogie having two wheels with two independent traction motors and the traction motor drive coupled to each wheel;
BG	shall mean 1676 mm Broad Gauge used in IR;
Co-Co	shall mean one unit of the Locomotive consisting of two bogies, with each bogie having three wheels with three independent traction motors and the traction motor drive coupled to each wheel;
C&M 1 volume 1	shall mean Civil and Mechanical Engineering Report Number 1 Volume 1, issued by RDSO;
Indian Railways Schedule Of Dimensions	shall mean Indian Railways Schedule of Dimensions for broad gauge, revision 2004;
IP	shall mean degree of protection provided by enclosures according to IEC 60529;
L-10	shall mean life of bearing in accordance with 1SO 281;
Man Machine Interface (MMI)	shall mean the interface between the system or equipment and the human interfacing with that equipment;
Ti	shall mean the temperature index of the insulation system;
Transmission and Suspension System	shall mean system comprising traction gears, gear case, traction rod arrangements (if any), primary and secondary suspension springs and dampers with bogie frame;
WiMax	shall mean the telecommunication technology, based on the IEEE 802.16 standard that provides wireless data, from point-to-point links to full mobile cellular type access; and
Others	any capitalized term used herein not specifically defined shall have the meaning ascribed to such term in the Agreement.

Chapter-1

General Description, Operating and Environmental Conditions

1.1 Introduction

1.1.1 Indian Railway is manufacturing WAP-7 locomotive equipped with standalone 2x500kVA IGBT based Hotel Load Converter. Further IR is willing to upgrade the Hotel Load Converter output to 2x750KVA to cater the requirement of complete AC rake of 24 coaches with sufficient margin. Due to space limitation and air-cooled technology used in standalone HLC, it is not possible to augment 2x750 kVA rating in the existing envelop of HLC. Hence this specification aims to develop an Integrated Converter approach in which the HLC shall be feed through common DC link of traction converter part of Integrated Converter. This scheme will have following advantages:

i) No separate HLC winding will be required in transformer. This will help in design transformer in same envelop and weight limitations.

ii) Rectifier side modules of HLC shall not be required, hence size of HLC part will be optimized and be possible to fit in the available envelop size in locomotive.

iii) Since it will be integrated converter, hence water cooling of integrated converter shall be extended to HLC inverter modules also, hence will eliminate requirement of air cooling. The existing space available for HLC can be utilized. Requirement of side wall cutting and provisions of filter shall be eliminated.

iv) Controller size of complete integrated converter shall be optimized as compared to two separate controllers for HLC and Traction Converter part of Integrated converter. Also faults of HLC will also be recorded in DDS data and can be accessible with use of RMS system.

v) One of the major limitations of switching OFF and ON of HLC output at Neutral section shall be eliminated. Logic of catering HLC power through making TMs in regeneration shall be used.

1.1.2 In existing WAP7 locomotive, the traction converters, auxiliary converters, VCU, DDU and Speed Sensor are being provided as per RDSO specification of Drive Propulsion Equipment no. RDSO/2008/EL/SPEC/0071, Rev. '5' issued in June' 2016.

1.1.3 The environmental and service conditions, performance requirements and technical requirements are specified in these Specifications and Standards.

1.1.4 The design and manufacture of the upgraded equipment shall be based on the requirements set out in these Specifications and Standards and in accordance with Good Industry Practice.

1.1.5 The Contractor shall demonstrate, to the satisfaction of the IR, that the sub-systems proposed to be used in the Locomotives are based on proven technology and design. For the avoidance of doubt, the IR may require the Contractor to conduct such tests and trials as may be necessary to establish the reliability and efficiency of such technology and designs in accordance with the Good Industry Practice.

1.1.6 Due consideration shall be given at design stage to ambient conditions of dust, moisture, high temperature and vibrations prevalent in India, as specified in the clause 1.4 of Specifications and Standards.

1.2 References to various standards

1.2.1 The standards applicable and relevant to the complete Locomotive and to the various subsystems and systems shall be:

(i) IEC publications;

(ii) EN;

(iii) UIC;

(iv) AAR

(v) IEEE;

(vi) BS;

(vii) IS; and

(viii) Any other standards referred to in these Specifications and Standards.

In the event of any contradiction in the aforesaid standards, the following standards shall have priority in the order listed:

(i) Standards mentioned in Specifications and Standards set forth herein;

(ii) EN/IEC/UIC/AAR; and

(iii) IS.

For avoidance of any doubt, in case of any conflict between the requirements of these standards, the stipulations of these Specification and Standards shall have precedence.

1.2.2 The design of the upgraded equipment, system and sub-systems thereof shall comply with the following standards:

1.	Electric traction — rolling stock — test methods for electric and thermal /electric rolling stock on completion of construction and before entry into service	: IEC 61133
2.	Electronic equipment used on rail vehicles	: IEC-61287
3.	Specific rules concerning the electronic control part of converters	: IEC-60571
4.	Electronic converter fed alternating current motors	: IEC 60349 -2
5.	Railway application - rolling stock — Part 1 combined testing of inverter fed alternative current motors and their control system	: IEC 61377-1
6.	Guide for the evaluation and identification of insulation systems of electrical equipment	: IEC 60505

7.	Electric railway equipment-train communication network	: IEC 61375-1
8.	Rotating electrical machines: Functional evaluation of insulation systems	: IEC 60034-18
9.	Railway applications — electromagnetic compatibility — Part 3-2: rolling stock — Apparatus	:EN 50121-3-2/ IEC 62236-3-2
10.	Railway applications – electromagnetic compatibility — Part 2: emission of the whole railway system to the outside world	:EN 50121-2/ IEC 62236-2
11.	Railway applications — compatibility between rolling stock and train detection system	: EN 50238
12.	Transformer and chokes	: IEC 60310
13.	Transformer oil	: IEC 60296
14.	High voltage AC circuit breaker	: IEC 60077-4
15.	Rules for pantograph of electric rolling stock	: IEC: 60494 Pt.I
16.	Relays, Contactors and switches	:IS 3231, IEC 60337, 60947
17.	Cables	:IEC 60228, IS 10810
18.	Lightning arrestor	:IEC 60099-4, IS 3070 Pt. II
19.	Railway applications - rolling stock equipment- shock and vibration test	: IEC 61373
20.	Programming languages for PLC	: IEC 61131
21.	Railway applications — electric equipment for rolling stock	: IEC 60077
22.	Electronic equipment used on rail vehicles	: IEC 60571
23.	Power converter installed on board rolling stock- Part 1: Characteristics and test methods	: IEC 61287-1
24.	Power converter installed on board rolling stock- Part 2: Additional technical information	: IEC 61287-2
25.	Railway application - rolling stock protective provisions against electrical hazards	: IEC 61991

26.	Auxiliary machines	:IEC 60034
27.	Power factor correction	:IEC 60871
28.	Control cubicle	: IEC 60068
29.	Batteries	: IEC 60623
30.	Degree of protection provided by enclosures	: IEC 60529
31.	Rules for installation of cabling	: EN 50343
32.	AAR approved couplers and coupler yokes	: M-211
33.	Wheels	: IRS R-34
34.	Axle	: IRS R-43
35.	Railway applications, welding of railway vehicles and components	: EN15085
36.	Air brakes	:RDSO's specification No. 02-ABR-02
37.	Schedule of Dimension for broad gauge	:IR Schedule of Dimension for Broad Gauge, revision 2004
38.	Reliability of electronic component	: IEC 61709
39.	RAMS	:EN 50126/ IEC 62278
40.	Metallised carbon strip for pantograph	:RDSO's technical circular no. ELRS/TC/0071(Rev.'0')

1.2.3 The latest version of the aforesaid standards, which have been published at least 60 (sixty) days before the last date of bid submission shall be considered applicable.

1.2.4 Alternative Standards

The requirements listed in these Specifications and Standards are the minimum. The Contractor may adopt alternative internationally recognized codes, standards and specifications if it can demonstrate to the Government that such alternative is superior or more pertinent to the Locomotive than the standards specified in these Specifications and Standards. The Contractor shall seek the prior approval of the Government for any alternate standards proposed to be used.

1.3 Power Supply System

1.3.1 Power supply system for 25 kV AC OHE:

1.3.1.1 General	The power supply system adopted is 25 kV, 50Hz, single phase AC, 25 kV being the nominal voltage of the system. The design calculations and guaranteed performance will be based on voltage of 22.5kV.
1.3.1.2 Variation in voltage of supply	17.5kV to 30kV Occasional max. -31 kV Occasional min. - 16.5kV
1.3.1.3 Variation in frequency	± 8%
1.3.1.4 Stagger of the contact wire	± 200 mm on straight track. Up to 300 mm on curves.
1.3.1.5 Types of Neutral sections	(i) 41 min length having insulated over lap on both end and neutral wire in between which is not earthed; and (ii) Short neutral sections of approx. 4.61 m and 9.6 m length having an insulated portion (of PTFE) on both sides and middle portion of neutral section which is solidly earthed. There shall be power interruptions at neutral sections varying from 12 seconds to 30 seconds.
1.3.1.6 Pantograph bounce	Up to 45 ms (limit of zero pressure contact).

Note: The occasional maximum and occasional minimum voltage may persist for 30 minutes.

1.4 **Climatic and Environmental Conditions:**

1.4.1 Maximum Atmospheric temperatures:	Under Sun: 75°C In shade: 60°C
1.4.2 Humidity	100% saturation during rainy season.
1.4.3 Reference site conditions	(i) Ambient Temp.: max. 50°C & min. -10°C (ii) The Contractor will indicate the expected temperature rise in the machine room under reference site conditions. (iii) Altitude: 1776 meter above mean sea level
1.4.4 Rainfall	Very heavy in certain areas (an annual rainfall of 11,872 millimeters (467.4 inch). The locomotive will be

	designed to permit its running at 10 kmph in flood water level of 102 mm above rail level with wheels in fully worn condition.
1.4.5 Solar radiation	1 kw/m^2
1.4.6 Wind speed	High wind speed in certain areas, with wind pressure reaching150 kg/m^2.
1.4.7 Atmosphere during hot weather:	Extremely dusty and desert terrain in certain areas.
1.4.8 Coastal area	Locomotive and equipment will be designed to work in coastal areas in humid and salt laden atmosphere with maximum pH value of 8.5, sulphate of 7 mg per litre, maximum concentration of chlorine 6 mg per litre and maximum conductivity of 130 micro Siemens/cm.
1.4.9 Vibration	The equipment, sub-system and their mounting arrangement will be designed to withstand vibrations and shocks encountered in service as specified in IEC: 61373 publications unless otherwise prescribed.

1.5 **Signal and Telecommunication Installations**:

1.5.1 The tracks over which the Locos will run may be equipped with 83-1/3 Hz track circuits as well as track circuits at higher frequencies. Similarly, other devices like axle counters, block instruments, point machines, etc., may also be employed. On the communication network, control circuits, teleprinter circuits, as well as VHF/UHF and micro-wave circuits are employed.

1.5.2 The harmonic currents injected in the overhead supply system (as also the track return current) can introduce voltage/current harmonics on power supply and can interfere with signal and telecom circuits. The design of the power electronics and control electronics provided on the propulsion system shall be such as not to cause levels of interference exceeding the levels specified below at any point for stages of operation of 100% down to 50 %, working in a train:

	Interference Current	**Limit**
1.0	Psophometric current	10.0A
2.0	DC component	4.7A
3.0	Second Harmonic component (100 Hz) and 83.33 Hz component	8.5A

4.0	1400 Hz up to 5000 Hz	400mA
5.0	>5000 Hz up to 32000 Hz	270mA
6.0	39500 Hz up to 43500 Hz	270mA

(Note: The measurement of the interference current shall be done in track return current circuit of the Locomotive.)

1.5.3 The Contractor shall undertake FFT (Fast Fourier Transformation) analysis of the total current from 1000Hz to 5000Hz and 5kHz to 500kHz separately to find out the frequencies which produce the highest currents within each bandwidth. In the frequency bands >32000Hz to <39500Hz and >43500Hz to 50000Hz the frequencies at which the current values exceed 270mA shall be identified. Test results shall be provided in a Type Test report.

1.5.4 If the interference limits for track circuits and axle counters as per EN 50238 are more onerous than those stated in Clause 1.5.2 of these Specifications and Standards. These limits as per EN 50238 shall be applied subject to provisions made in Clause 1.2.4 of these Specifications and Standards.

1.5.5 There will not be harmonic filter winding in the transformer in compliance to RDSO MS-504. Hence converters shall be designed accordingly.

1.6 **Other Important Requirements**

1.6.1 Submission of design details: The details of the design will be submitted to CLW in the course of the design process. These will be examined in consultation with the Contractor for approval. The most essential criteria to be met are as below:

The equipment shall be equipped with technology incorporating IGBTs and microprocessor control that has been applied and tested in rail traction applications with acceptable levels of performance. The details of such applications and user experience will be provided. The system design, sub-system design and the equipment design will be so upgraded as to meet the overall requirement of performance.

1.6.2 Subject to the above, the equipment will represent proven latest technology specially adopted for application and future domestic manufacture in India. However, the contractor needs to submit the manufacturing details of mechanical items during design evaluation stage.

1.6.3 Adequate margin will be built in the design, particularly to take care of the high ambient temperatures, dusty condition, high humidity, etc. prevailing in India.

1.6.4 Efficiency of equipment and reduced energy consumption, high power factor, reduced interference to signaling and telecommunication circuits will be important considerations, but next only to reliability.

1.7 Reliability, Availability, Maintainability and Safety (RAMS)

1.7.1 **General**

The Contractor shall design the equipments to ensure Guaranteed Reliability, Availability and high degree of Safety in order to provide a dependable service. The optimization of the system with respect to Reliability, Availability, Maintainability and Safety shall form an integral element of these Specifications and Standards.

The plan for Reliability, Availability, Maintainability and Safety shall conform to EN 50126/ IEC 62278. Reliability of electronic components shall conform to IEC 61709.

1.7.2 The Contractor shall develop RAMS targets for the sub-systems such as transformer, Integrated converter with Traction converter and Hotel load converter with common DC link, Auxiliary converter, electronics, OCU, Radiator, pumps etc. supplied and commissioned by them.

1.7.3 There shall be an efficient means of operation of the Locomotive after all failures in accordance with Good Industry Practice.

1.7.4 Components critical for safety shall fall into safe operating mode in case of malfunctioning. The system safety plan shall identify and list safety critical components and this list shall be updated periodically.

1.7.5 The Contractor shall establish and operate a detailed Reliability, Availability, Maintainability and Safety (RAMS) Assessment system in support of the design, manufacture and subsequent testing, commissioning, operation and maintenance of the equipments supplied and commissioned by them.

1.7.6 Safety Assessment shall be carried out and shall include the following principles:

(i) Degraded modes and emergency operations shall be considered as well as normal operations;

(ii) Safety risk assessment shall utilize more than one methodology to assess risks; and

(iii) Safety risk assessment shall include the consideration of dependent failures, in particular the traction power, braking and control systems.

1.8 Quality of Materials, Manufacturing Processes and Workmanship:

1.8.1 All materials (including surface coatings, metals, insulators, adhesives, fluids, grease etc.) used in the manufacturing of the equipment shall not give rise to health hazards for crew and staff. The materials shall also be suitable for standard repair operations such as those currently used by the Government (e.g. welding, cutting etc.) without the need for staff to be protected by other than standard means. Materials used for equipment shall be appropriate for achieving the Design Life of the Locomotive.

1.8.2 Materials shall be suitable for disposal without any special precautions.

1.9 Infringement of Patent Rights:

IR shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, use of similar components in the design and development of the

Locomotive and any other factor not mentioned herein which may cause such a dispute. The entire responsibility to settle any such disputes/matters lies with the Supplier.

1.10 Documentation:

Documentation supply shall be in two phases, first part to be supplied with the tender for evaluation of offer, while the second more onerous part shall be developed in the Project phase by the Supplier and shall be submitted during design stage as described in Special Conditions of Contract.

1.10.1 Following documents shall be submitted by the Contractor along with the offer for evaluation:

a. System design concept
b. Schematic Circuit diagram
c. Functional Description
d. Clause by clause compliance
e. Credentials with details of supply made of such/similar items
f. Salient features and advantages of the offered design/system
g. Details of technical support and training offered.
h. List of special tools, jigs and fixtures needed for assembly, testing/validation, commissioning, maintenance and repair along-with full technical specifications and probable suppliers.
i. Logistics proposed for warranty support within India over IR.
i. Declaration for long-term support by the Contractor.
k. Guaranteed values of efficiency of devices/sub-assemblies and assemblies
l. Expected efficiency with respect to vehicle load/speed along-with calculations
m. Technical details of the devices proposed to be used.
n. Cooling system design description and cooling fluid data
o. Schedule maintenance activities with periodicity.
p. The Contractor shall wholly and completely be responsible for the performance of the complete equipment.
q. IRIS/ISO 9001 certification.

1.10.2 Following documents shall be submitted by the Contractor during Project Phase (Concept & Detail Design stage):

a. Communication protocol and software structure description along with compatibility with the locomotive control system.
b. Mechanical interface diagram and compliance to existing equipment
c. Calculation and simulation results of system behaviour, including interference to the S&T track circuits and equipment
d. Data sheets for devices and other equipment proposed along with detailed description of supply proposed
e. Calculation to withstand short circuit current under fault conditions
f. Details of short time rating of the Integrated/individual Converter

g. Technical documentation explaining the complete scheme, characteristics, diagnostics, protection and control etc.
h. Detailed drawings of each system/sub-system with interface details.
i. Design calculations for selection of devices, cooling systems and various subsystems, establishing the adequacy of the components selected.
j. Complete BOM / technical specification of components with source of supply.
k. Mechanical drawings, mounting arrangement, weight, details of mounting accessories
l. Procedure for parameter alteration, software downloading, diagnostic uploading, analysis etc.
m. Maintenance, Trouble shooting and repair manual in soft form & hard copy.
n. All calculations evaluated on the basis of software simulations shall be supported by sample calculations.
o. 3D models of all the cubicles, compatible to NX platform.

1.11 The Contractor's responsibility shall be extended to the following:

The Contractor shall supply detailed instructions for proper installation of the equipment in the scope of this specification on locomotive. For this purpose, the supplier shall also depute his representative during installation and commissioning of the equipment, supplied against the specification. The supplier shall arrange to carry out detailed test & performance proving, jointly with CLW. The supplier shall also provide for special tools, testing jigs, and instruments, which may be required for troubleshooting and maintenance of the equipment supplied. The design shall be developed as per requirement given in the specification

Chapter-2

Performance Requirements

2.1 PERFORMANCE REQUIREMENTS

The upgraded locomotive shall be capable of the following performance:

2.1.1	Starting tractive effort under dry rail condition :	Not less than 360kN.
2.1.2	Continuous rated tractive effort:	Not less than 280 kN up to 90 kmph
2.1.3	Maximum operational speed with fully worn wheel:	140kmph
2.1.4	Maximum design speed with fully worn wheel	10% more than maximum operational speed
2.1.5	Continuous rated power:	Not less than 4.5 MW at wheel rim at all speeds between 70 and 140 kmph.
2.1.6	Dynamic brake	Max. possible without skidding over a Wide speed range
2.1.7	Regenerative brake effort	Brake effort should be same as existing WAP-7 loco
2.1.8	Capability to work in flood Water	The Locomotive shall be designed to permit its running at 10 Kmph in flood water level of 102 mm above rail level

2.2 **Train and Locomotive Resistance Data**: The train resistance and locomotive resistance data as followed by IR is as follows:

General: It is important to note that this data pertains to the existing system and for the existing generation of locomotives and rolling stock for speeds up to 120 kmph.

2.2.1 Train resistance (excluding locomotive)

(i) Mean starting resistance on level tangent track (including acceleration reserve): 5.0kg/tonne

(i) Mean running resistance on level tangent track (excluding locomotive up to 120 kmph): $Rf=0.6855+0.02112V+0.000082\ V^2$ (kg/tone)

"Rf" = the resistance in kg per metric tonne of freight train

"V" = The speed in kmph

2.2.2 Loco resistance as followed by IR is

(i) Starting resistance on level tangent track: 6 kg/tonne

(ii) Running resistance on level tangent track:

R_L=0.647+ 13.17/W + 0.00933 V + 0.057V^2 /WN [kg/Tonne]

"RL" = Resistance in kg/Tonne of locomotive

N = Number of axles

W = Axle load of the loco in tonne

V = speed in kmph

The compensation to be allowed for curve resistance is to be taken as 0.4 kg/tonne per degree of curvature.

During the detailed design evaluation stage the contractor shall submit the methodology to calculate the loco and train resistance at speeds above 120 kmph for different types of coaching stocks being used by Indian Railways.

2.3 Important Locomotive Parameters:

2.3.1	Axle load and weight of the locomotive	20.5 tonnes + 2% (Max.)
3.3.2	No. of axles	6
2.3.3	Weight	123 tonnes +1%
2.3.4	Buffing load	The locomotive shall withstand a static buffing load of 400 Tonnes at the buffers.
2.3.5	Unsprung mass	The maximum unsprung mass per axle shall be limited to 3.984 Tonnes.
2.3.6	Lateral forces	Lateral force at axle box level, lasting for more than 2 meters should not exceed 4 Tonnes at the maximum test speed of 155 kmph under specified track conditions. The measurement methods and parameters which have an influence on the lateral forces will be clarified by RDSO. Contractor shall make arrangement for measuring wheel along with the telemetry required for recording the lateral forces during the trials.
2.3.7	Dynamic augment	Dynamic augmentation at a test speed of 155 kmph shall be below 50% on track
2.3.8	Derailment co-efficient	Shall be less than 1.0.
2.3.9	Lateral and vertical acceleration in the driving cab and at a point as close to the bogie	<03g
2.3.10	Maximum ride index in the driving cab at floor level	3.75

2.4 Power

2.4.1 Power at wheel rim

2.4.1.1 The continuous power of the locomotive at wheel rim will be 4.5 MW under reference site conditions mentioned in clause 1.4 above.

2.4.2 Auxiliary Power

2.4.2.1 The Contractor will indicate total power required for Oil Cooling Unit (OCU) and other auxiliaries under scope of supply with breakup of power requirement. The Contractor will indicate the method used for determining power requirement for OCU and other auxiliaries. In case these are measured values, the Contractor will furnish detailed method employed for measurement of auxiliary power.

2.4.2.2 The auxiliaries shall be motor driven.

2.4.3 Efficiency:

2.4.3.1 Specific energy consumption at 50, 75, 100, 120, 140 kmph will be indicated. The curves for efficiency at the above speeds will be supplied during detailed design stage.

2.4.3.2 The efficiency of propulsion system, consisting of transformer, Integrated converter (line side converter and drive side inverter) of Locomotive shall not be less than 91% at full load. The efficiency of propulsion system shall be product of efficiency of transformer and Integrated converter measured at full load. In case the contractor proposes standalone auxiliary converters for supplies to auxiliary machines the efficiency of auxiliary converter shall not be less than 93% at full load. Efficiency at full load means, efficiency computed from parameters measured at conditions corresponding to full load and governed by IEC 60310 for transformer and IEC 61287-1 for Integrated converter and auxiliary converter.

2.5 The measurement methods and parameters which have an influence on the energy consumption will be based on mutual agreement. These parameters are:

i. train configuration;
ii. rolling resistance;
iii. profile and curvature;
iv. distance between stations;
v. required maximum speed;
vi. required acceleration;
vii. required deceleration (and in this way the participation of regeneration and of the mechanical brake);
viii. train pressure air consumption;
ix. hotel load consumption; and
x. driving/braking methods of the particular driver.

2.6 Adhesion Requirements

The design of the adhesion control shall be optimised for maximum utilisation of adhesion factor and shall be such that it is capable of generating the required starting tractive effort under dry rail conditions. Under dry rail conditions, the Locomotive shall be able to generate tractive effort during start and at low speeds corresponding to meet the requirement as per characteristics given in Para- 3.3.1.1 of this specification and standards. Adhesion of the locomotive should not be reduced by more than 20% of maximum dry rail adhesion during wet & contaminated rail condition. The adhesion control system shall be capable of giving high adhesion through a wheel slip control system through optimal exploitable creep force. The mechanism with necessary formulae and graph for linking adhesion characteristics with the percentage rail wheel creep in dry, wet and contaminated rail wheel conditions at different operating speed shall be submitted at Design Stage. The Supplier shall state the value of maximum starting tractive effort that shall be developed under dry rail conditions and also under all weather conditions, which shall be demonstrated during testing. The achievable running adhesion characteristics shall be made available. The formulae for linking adhesion characteristics with the operating speed shall be indicated. During wet rail condition TE should normally not fall below 80% TE of dry rail. Indication lamp is available in cab (LSP) and it should be activated by the propulsion system indication for the tractive effort control to crew to wheel slip detection.

2.7 Duty Cycle

2.7.1 The Locomotive shall be available for operational service in accordance with Availability requirements of Clause 1.7.

2.7.2 Each Locomotive shall be capable of travelling 200,000 km in service annually without any detrimental effect on the performance of the Locomotive.

2.7.3 At times the Locomotive working in adverse terrain shall be required to negotiate longer periods at lower speeds. The typical duty cycle encountered in operation is outlined below and the Locomotive shall be capable of operating under these conditions.

Speed (in km/h)	0-10	10-30	30-60	60-80	80-100	100-120	120-140
% of total running time of Locomotive	5%	5%	5%	10%	15%	50%	10%

Chapter -3

Technical Requirements of Upgraded Equipment

3.1 General

3.1.1 The mechanical design of WAP-7 locomotive shall generally remain the same as that of the existing 6000 hp WAP-7 locomotive. No change is envisaged at this stage in the existing locomotive equipment except items mentioned in clause 3.1.2.

3.1.2 Following major equipment are envisaged to be upgraded:

a) Main Transformer
b) Integrated converter comprising traction converter and Hotel Load Converter (auxiliary converter may also be integrated in the common DC link - optional).
c) OCU and Radiator
d) Pump

3.1.3 The upgradation kit for propulsion set consists of transformer, Integrated converter with traction converter, auxiliary converter, hotel load converter, VCU, DDU, OCU, Radiator and pumps to be designed by contractor.

3.1.4 All the components supplied by the firm shall confirm to relevant RDSO/CLW specification of respective components unless otherwise specified in this specification. Any deviation is to be clearly pointed out by the firm at the time of design approval.

3.1.5 Minimal changes in equipment layout in the machine room/mounting arrangement may be accepted based on design requirement. Firm shall propose all such changes during the design approval stage itself.

3.1.6 The upgraded components supplied by the manufacturer are to be designed such that the important and vital performance parameters of the locomotive as mentioned in this specification are adhered to Contractor shall confirm the same in the design document.

3.1.7 The footprints of the integrated converter can be modified as per the requirement of the design within the available space. The Contractor is expected to study the same in detail and shall be responsible for necessary modifications in the machine room layout. The detailed design and corresponding modifications in the machine room shall be submitted to CLW during design approval stage. The existing layout of the machine room and equipment shall be provided to Contractor by CLW for development and modification, if required. In case of modification of existing layout, the supplier shall ensure that the Center of Gravity (CG) of the locomotive does not get altered. The same needs to be approved during design approval stage.

3.1.8 The design and arrangement of the Integrated Converter to be supplied against this specification shall be such that the performance requirements of the Locomotive are achieved

under the climatic and environmental conditions prevalent in India as specified in Clause 1.4 of these Specifications and Standards. Adequate margin, in accordance with Good Industry Practice, shall be built in the design of the these equipment to take care of conditions of high ambient temperatures, dust, humidity, shock and vibration as specified in these Specifications and Standards. These equipment and their mounting arrangement shall be designed to withstand satisfactorily the vibrations and shocks encountered in service and as specified in IEC 61373 except where specifically defined in these Specifications and Standards.

3.1.9 Necessary precautions in accordance with Good Industry Practice shall be taken to ensure that any electromagnetic interference generated in the machine room does not adversely affect the performance of loco and signaling equipment.

3.1.10 Modular constructions shall be adopted with easy access for inspection and maintenance shall be given special consideration in the design and layout of the Integrated Converter.

3.1.11 The technical parameters of the cooling arrangement for existing WAP7 locomotive are provided in the clause 3.2.9 & 3.2.10. As the HLC part is going to be water cooled as integrated with Traction Converter, there might be requirement to increase the cooling capacity of oil cooling unit and radiator. The firm shall calculate the additional cooling requirements, if any, against this specification according to their design concept. If the modified cooling requirements warrant change in the existing cooling arrangement, the same shall be clearly indicated by the Contractor in their offer. The detailed calculations and the effected equipment of the cooling concept shall be brought out by the Contractor during design approval stage.

3.1.12 There are two concepts; first one is Integrated Converter having Traction and Hotel load converter in the same cubicle with common DC link to be used with isolation transformers. Alternately, one integrated converter having Traction, auxiliary converter and hotel load converter in the same cubicle with common DC link can be used with isolation transformers. In such case the isolation transformer windings shall be provided in the main transformer. The Contractor shall clearly indicate about the use of any of these concepts in their offer.

3.1.13 The 'tractive effort-speed' and 'draw bar pull-speed' curves shall be drawn after making suitable correction for derating under ambient conditions as specified in Clause 1.4 of these Specifications and Standards and with half worn wheels.

3.1.14 Necessary precautions in accordance with Good Industry Practice shall be taken to ensure that any electromagnetic interference generated in the machine room does not adversely affect the performance of equipments.

3.1.15 The maximum starting tractive effort shall be achieved gradually, without producing jerks in the train being hauled when its application is initiated at zero speed, and it shall be maintained constant throughout the acceleration up to the rated power curve of the Locomotive is achieved.

3.1.16 It shall be possible to use the locomotive in multiple unit operations of up to two Locomotives in one group. The control of both the Locomotives shall be achieved from either of the Locomotives being used under the multiple unit operations**.** Provision shall be made to enable the driver in the driving cab to monitor the parameters of the other Locomotive as well as to identify the fault in both the Locomotives.

3.1.17 It shall be possible to use the locomotive as banking locomotives. In case of rolling stock equipped with air brakes the brake pipe of rolling stock will not be charged by the banking locomotive. It will be possible for the banking locomotive driver to apply train brakes from banking locomotive in case of emergency.

3.1.18 Provision shall be made in the control circuitry of the Locomotive, to limit the starting tractive effort to predefined values when required during operation. The two predefined values shall be 200 kN and 300 kN for control the TE.

3.1.19 The Locomotive shall be provided with a speed control system, which shall enable the driver to pre-set the speed at which the Locomotive is desired to run the train irrespective of the track profile. The speed control shall work within the limits of maximum electrical performance as specified in Clause 2.1 of these Specifications and Standards. The selection of speed shall be possible by press of a switch. However, the system shall be inherently fail safe and shall immediately come out of the pre-set speed mode to normal mode on actuation of master/ brake controller or as required from safety considerations.

3.1.20 Redundancy shall be built in with the design of the sub-systems and systems in order to ensure reliability and availability. In the vital units of the power control circuit, where any defect/failure of a component would cause complete failure of Locomotive's electrical system, suitable redundancy shall be provided preferably with automatic substitution features to avoid Locomotive failure due to such defects. The power supplies to the control circuit shall be hot redundant.

3.1.21 The power drawn by the pantograph of the Locomotive from OHE shall be close to unity power factor subject to the interference levels as specified in Clause 1.5.2 of these Specifications and Standards. The power factor will be maintained at the requisite value by the microcomputer.

3.1.22 Pantograph bouncing shall not adversely affect the propulsion equipment.

3.1.23 There shall be provision of energy metering of the Locomotive for the monitoring and energy saving feature with recording of energy saved.

3.1.24 Weight distribution:

The general layout of the equipment in the locomotive shall ensure equitable weight distribution. The tolerance in working order will be limited to:

a. Axle load : +2% of the nominal axle load (Clause 2.3.1)

b. Total weight of loco : 1% (Clause 2.3.3)
c. Difference in weight on the wheels of the same axle not to exceed 4% of particular axle load.
d. Method for wheel/axle load adjustment to meet the above requirements shall be indicated.

3.1.25 Integrated Converter shall not affect the center of gravity of the locomotive. The contractor shall submit the detail calculations for center of gravity during the design approval stage.

3.1.26 Cooling Concept of the existing WAP7 locomotives

a. In the existing WAP7 locomotive, the cooling air for the transformer and traction converter cooling radiators is drawn from the roof area through grid filters and is discharged below the underframe. The same arrangement shall be retained.
b. For Traction Motor cooling air is drawn through inertial filter grids in the upper section of the sides of the locomotive. This filtered air is used to cool the traction motors.
c. Similarly, the machine room pressurizing air is drawn through inertial filter grids in the upper section of the sides of the locomotive. This filtered air is used to pressurize the machinery compartment and is also used to cool the electronic equipment.
d. The design takes care of the dusty and moist conditions prevailing in India.
e. The main transformer shall be oil cooled. Integrated Converter shall be cooled by suitable means of coolant, i.e., mixture of water and ethylene glycol with corrosion inhibitors in ratio of 70:30. Contractor shall submit the details in this regard.

3.2 Main transformer:

3.2.1 The Main transformer footprint and envelope to be same as per existing transformer type LOT 7775. The Main transformer needs to be designed duly meeting the additional winding power requirements with latest technical knowhow and practices being adopted worldwide for traction applications. The manufacturer should consider the all the aspects specified in the specification while designing the transformer and he should take necessary approval during design stage.

3.2.2 Fixed ratio main transformer shall be provided with single/multi-traction windings suiting the requirements of integrated system and with or without auxiliary winding(s) for the auxiliary system.

3.2.3 The kVA rating of the transformer shall be specified at a line voltage of 17.5kV and shall be designed to deliver a total current corresponding to the continuous rated traction motor currents at full voltage and continuous full load current of Hotel Load and Auxiliary loads in the voltage range of 17.5V to 30 kV. The transformer winding shall also be designed to deliver the rated power at the maximum continuous line voltage of 30 kV.

3.2.4 The transformer shall be designed with adequate overload capacity, in accordance with Good Industry Practice, to permit full utilization of the traction motor capacity during starting as well as running.

3.2.5 The transformer shall be designed to conform to IEC: 60310 and the temperature rise limits on the windings and the oil shall correspond to IEC: 60310 limit minus 20 degree Celsius under all conditions of operation.

3.2.6 The transformer shall be oil immersed and forced oil cooled by means of an oil-circulating pump and a radiator.

3.2.7 The functional requirement for transformer tank such as mechanical structure, overall dimension, mounting pads and clearance with rail level shall be same as for existing LOT 7775 Transformers.

3.2.8 Transformer Tank:

Transformer tank being used presently is made of Aluminium alloy with following technical parameters:

Material of Transformer Tank	Aluminium alloy
Cover of Transformer Tank	Bolt-on, oil proof
Shock Resistance	As per IEC 60068-2-77
Color	RAL-7009
Finish	Silky

Manufacturer may also opt to design the transformer making use of Steel Tank in place of aluminium tank being used presently. The supplier shall take care of the losses with the steel tank and ensure the performance levels specified therein. Technical proposal for the same shall be submitted with the tender and approval should be taken during design stage prior to manufacturing the same.

3.2.9 Cooling System:

The existing cooling system for transformer consists of Transformer Oil Pump, Oil Cooling Radiator and Oil Cooling Unit. The capacity of Transformer Oil Pump, Oil Cooling Radiator and Oil Cooling Unit to be upgraded to dissipate heat generated due to increase in power of integrated Traction winding. Maximum temperature of the winding and oil shall confirm to IEC 60310 minus 20°C.

a. The details of existing cooling system for transformer with presently used oil cooling radiator/heat exchanger as per CLW specification no. CLW/ES/3/0102 are as given below:

PARAMETER	UNIT	CONVERTER	TRANSFORMER
Heat to be dissipated	kW	116	120
Air Inlet Temperature	°C	47	62.8
Air Outlet Temperature	°C	62.6	76.2

Oil Inlet Temp.	°C	68.2	84.5
0il Outlet Temp.	°C	64	80
Oil flow	LPM	960	1000
Pressure drop oil side	Bar	0.6 to 0.66	0.6 to 0.76
Coolant type		Water+ Glycol	Shell Diala DX
Cooling air mass flow	Kg/sec	8.8	8.8

b. In the present design of Oil Cooling Radiator (Heat Exchanger), top 50% (separable component) is used for Traction Converter Cooling Circuit and bottom 50% is for Transformer Cooling Circuit. Thus, capacity of Heat Exchanger is equally divided between Traction Converter Cooling Circuit and Transformer Cooling Circuit.

c. The Contractor shall study the rating of existing radiator for its efficacy to meet the cooling requirements envisaged against this specification. In case, there is a need to redesign the radiator, the following aspects shall be considered

- The radiator shall be in two separate parts for Integrated converter and transformer.
- The integarted converter shall be water cooled and the transformer shall be oil cooled
- The radiator shall be air blast cooled by means of a motor driven blower set.
- The radiator shall be so designed that cleaning interval is in synchronization with the scheduled maintenance, but shall not be less than six months in any case.

d. The transformer tank, radiators and associate equipment shall be coated with pollution/oil resistant and dust repellent epoxy paint.

Note: Further the supplier may design the cooling system with radiator to meet the requirement of cooling as per their design.

3.2.10 Oil Cooling Unit:

At present, two no. of oil cooling units are being used to provide necessary cooling to the heat exchanger. At this stage, it is envisaged that the existing cooling system should be sufficient for the upgraded traction transformer. However, the supplier shall carry out the detailed calculations and confirm the same at the time of submission of offers. Any deviation shall be clearly pointed out by the firm. However, details may be finalized during the design approval stage.

Type	Forced Oil Cooling with Two Circuit
Oil Flow Rate (Nominal)	2x1000 Lt./Min
Pressure Drop, Transformer Tank (Max)	1000 mbar at 1000 Lt./Min
Pump Type	Plumettaz TA08-2174/15
Oil Temperature, Tank Drainage (Max)	80 °C at Pyert max = 240 kW
Oil Temperature, Tank Drainage (Max)	84°C
Oil Temperature Rise (Max)	4 Kat 1000 Lt./Min

a. The supplier may propose a better and more efficient cooling system also. However, the design, manufacturing and supply of such system shall be in the scope of supply of the firm.

b. The foot prints of the system needs to be maintained so that no changes are required in the car body.

3.2.11 Transformer Oil Pump Technical Detail:

Existing transformer Oil Pump confirms to CLW specification CLW/ES/3/0106.

Motor Type	Single Stage Mixed Flow Centrifugal Type
Oil Flow Rate (Nominal)	1000 Lt./Min
Nominal Pressure	1.83 bar
Maximum Oil Inlet Temperature	85°C
RPM	2920
Power Mechanical	4.7kW
Efficiency	48%
Sound Level (Maximum)	65 dBA

Note: Further the supplier may design the cooling system with pump to meet the requirement of cooling as per their design.

3.2.12 Coolant: The technical detail coolant used for the existing LOT 6500 transformer is given below:

Coolant	Mineral
Make	Shell Diala DX
Iden. No.	NDT 402 614
Oil Weight	1850 kg

An improved cooling media may be proposed by the firm. Transformer designed with improved cooling media having existing design for oil pump, heat exchanger and oil cooling unit shall be preferable.

3.2.13 The pressure sensor with differential amplifier is being used as per CLW specification no. CLW/EL/3/0035 for monitoring of transformer oil pressure. Similarly, the temperature sensors are used as per CLW specification no. CLW/EL/3/0033. The Contractors may study the same and in case of any better alternate solution, the same may be proposed during detailed design stage. However, for further details, the Contractors may refer to CLW specification No. CLW/ES/3//0456 Alt. H or latest.

3.2.14 The transformer tank, radiators and associate equipment shall be coated with pollution/oil resistant and dust repellent epoxy paint.

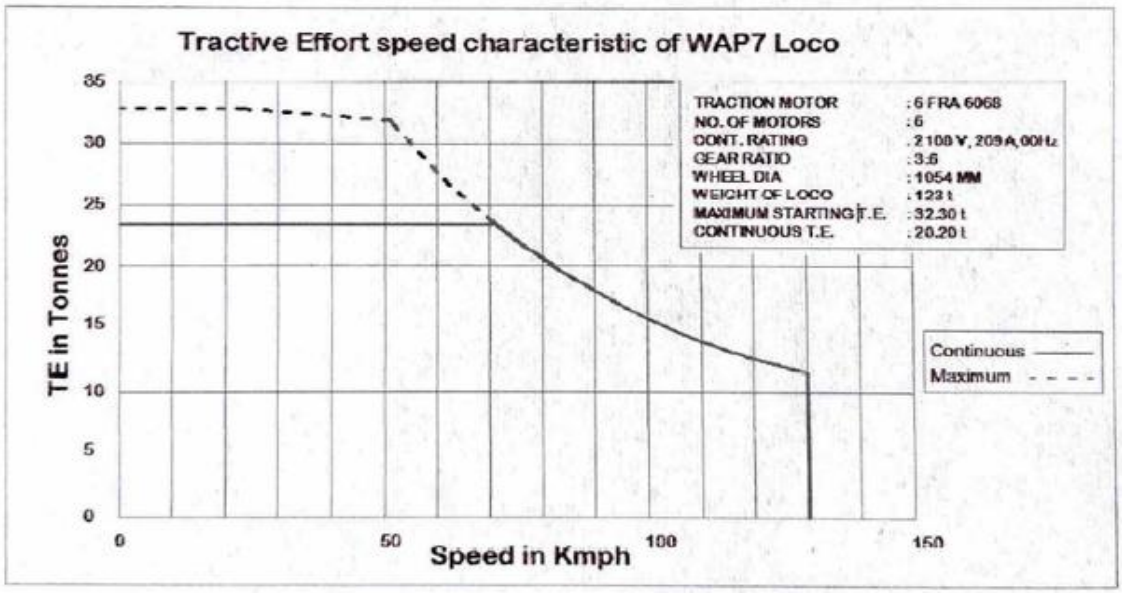
3.2.15 In order to reduce the harmonics the switching frequency of the line side converter of Integrated converter shall be suitably decided by contactor to ensure optimal performance of transformer & converter. The thermal simulation studies of the transformer tank for different switching frequencies of the power converter shall be submitted during the detailed design stage.

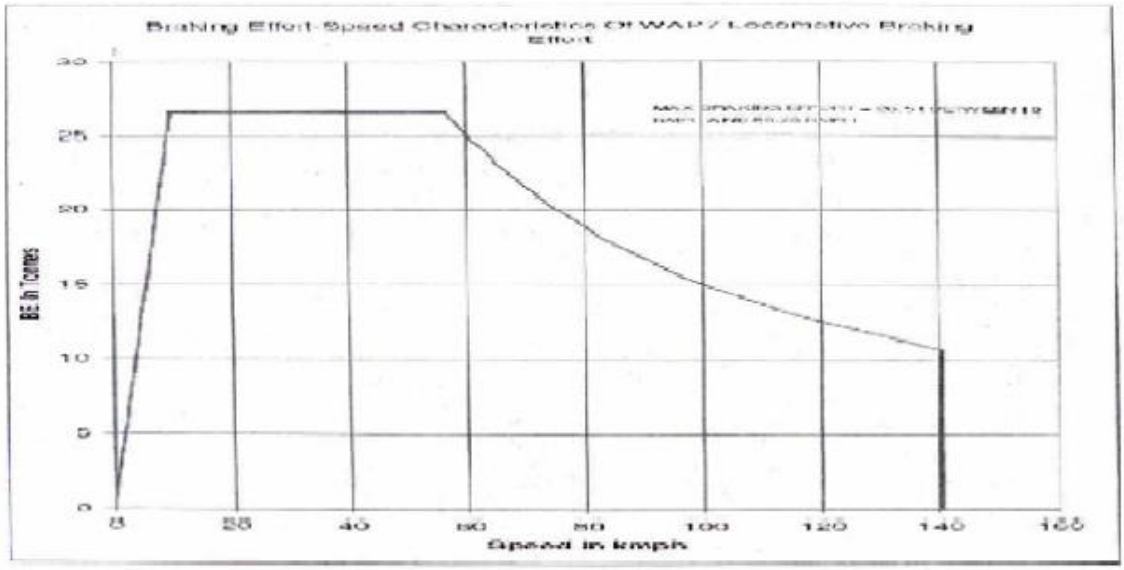
3.3 Integrated Converter

Integrated Converter having Traction and Hotel load converter in the same cubicle with common DC link to be used with isolation transformers

3.3.1 Integrated converter

3.3.1.1 The present characteristics of WAP-7 locomotives with IGBT based propulsion are as given below:





With adoption of IGBT based Integarted converter, using the same traction motors and gears and pinions, the tractive effort / braking Effort curve of WAP-7 locomotives shall match the existing curves.

The drive control electronics shall have an installed protection against sustained overloads of the converter and connected drive system so as to prevent damage.

In case of any fault in Hotel Load Converter part, the functioning of Traction Converter part and Auxiliary Converter part shouldn't be affected except the fault condition of IGBT short circuit In Hotel Load Converter.

3.3.1.2 Speed sensor and accessories

(i) Power supply for the speed sensor shall be from the electronics card of the converter. Presently 2 (two) shielded cables, each having single twisted pair are used in the loco machine room for speed sensor. Same arrangement of cable shall be retained.
(ii) Active speed Sensor with 120 tooth wheel ring shall be provided.
(iii) Speed sensor shall confirm to latest CLW specification which shall be made available at CLW**.**

Following shall be within the scope of supply of the Supplier:

- Active speed sensor with existing mechanical interface. The drawing of the speed sensor is provided in Annexure-8.
- Tooth wheel with existing mechanical interface. The drawing of the tooth wheel is provided in Annexure-9.
- The sensor plate shall also be within the scope of the supply. The drawings of the plate shall be supplied by CLW.
- Suitable male and female parts of the speed sensor connectors at the sensor plate shall also be within the scope of supply of the Supplier.
- The sensor connector at the converter end shall also be within the scope of supply of the firm.
- The drawing for location of speed sensor connectors used presently in GTO converter is given in Annexure-10. It is proposed that the location of speed sensor connectors at converter shall be kept as per the drawing to have same length of cable for speed sensors.

Desired control scheme

Control system of the integrated converter shall be suitably designed to get considerably better performance and overall service reliability. Following special features shall be provided in the Integrated converter to maximise the performance and reliability and minimise possibilities of the locomotive being stalled in the section:

(i) independent drive converter per axle;

(ii) suitable redundancy in the vital PCBs, particularly connected with safety and power supplies, so that in the event of their failure the likelihood of the Locomotive becoming inoperative or its performance being degraded is avoided and

(iii) only dry type capacitors (having self healing property) shall be used for DC link / harmonic filter / resonant circuits.

(iv) During Neutral section negotiation, one or more number of traction motors depending upon requirement shall go into Regenerative mode. But locomotive running with speed less than 30kmph, this feature may not work.

3.3.1.3 The existing fault screen of the driver (fault messages displayed on driver display) and DDS recording shall remain same with the adoption of IGBT traction converter part of Integrated part except for following new messages needed due to individual axle control:

- Motor 1 – Bogie 1 isolated – reduced traction/braking
- Motor 2 – Bogie 1 isolated – reduced traction/braking
- Motor 3– Bogie 1 isolated – reduced traction/braking
- Line converter 1 – Bogie 1 isolated – reduced traction/braking
- Line converter 2 – Bogie 1 isolated – reduced traction/braking
- Motor 1 – Bogie 2 isolated – reduced traction/braking
- Motor 2 – Bogie 2 isolated – reduced traction/braking
- Motor 3– Bogie 2 isolated – reduced traction/braking
- Line converter 1 – Bogie 2 isolated – reduced traction/braking
- Line converter 2 – Bogie 2 isolated – reduced traction/braking
- Messages regarding hotel load converter (to be submitted as part of design details)

The generation and adoption of these new messages and other DDS messages as a result of new control of the converter shall be responsibility of the Supplier.

3.3.1.4 In the event of breakdown of any component or basic unit of the integrated converter, it shall be possible to continue to haul the train with the least reduction possible in its services, operating within restricted but permissible conditions. The basic principles and procedures to be followed in the event of a breakdown shall be:

(i) Breakdown of drive side converter of traction part(except for short circuit of IGBT) or electrical failure of traction motor:

The power of the locomotive shall be reduced only by 1/6th, only isolating the broken down equipment and HLC and auxiliary converter (if integrated) shall be able to cater to full load power;

(ii) Failure of drive controller unit or power supply of drive controller unit of drive side converter of traction part:

The power of the locomotive shall be reduced only by 1/6th, only isolating the failed equipment and HLC and auxiliary converter (if integrated) shall be able to cater to full load power only in case of failure of drive controller unit; and hot redundancy shall be available in case of failure of drive controller power supply unit.

(iii) Failure of gate unit or gate unit power supply of drive converter of traction part:

The power of the Locomotive shall be reduced only by 1/6th, only isolating the failed equipment and HLC and auxiliary converter (if integrated) shall be able to cater to full load power only in case of failure of gate unit; and hot redundancy shall be available in case of failure of gate power supply unit.

(iv) Failure of one speed sensor:

The operation of the locomotive shall not be degraded and all traction motors shall remain operational.

(v) Breakdown of line side converter (except short circuit of IGBTs):

The power of the Locomotive shall be reduced only by 1/4th, only isolating the failed equipment; and HLC may be inoperative and auxiliary converter (if integrated) shall not adversely affect the performance of locomotive operation

(vi) Failure of line controller unit or power supply of line controller unit or gate unit or gate unit power supply of line side converter:

The power of the Locomotive shall be reduced only by 1/4th, only isolating the failed equipment and HLC may be inoperative and auxiliary converter (if integrated) shall not adversely affect the performance of locomotive operation only in case of failure of line controller unit; and hot redundancy shall be available in case of failure of line controller power supply unit.

3.3.1.5 Output of Traction Converter part of Integrated Converter

The motor converter output current ripple shall be such as to keep the torque pulsations and traction motor heating to a minimum. It is the Supplier's responsibility to make sure that output quality of the traction converter part of integrated converter is entirely suitable for the existing traction motors.

3.3.2 Hotel Load *Converter*

3.3.2.1 Hotel load converter shall be part of the Integrated converter suitable for supply power to hotel load of coaches.

3.3.2.2 Rated output shall be as under:-

- Voltage phase to phase - 750 V+ 5%-2%, 3 phase sine wave AC, 3 Wire
- Voltage between phase to earth feeder – less than 0.8 kV (Peak)
- Frequency - 50 Hz ±2%.
- Capacity - 2X750 kVA (Two units of 750 kVA per locomotive) at power factor 0.8.
  Note: Rated capacity of each converter shall be 750 kVA for OHE voltage range of 17.5kV to 30kV. It shall not be possible to regulate the duty cycle of the loads.

- Input power factor: Shall be close to unity at full load with normal input parameters.
- Total harmonic distortion (THD) of output voltage: Less than 10%.
- Output Voltage unbalance: Less than 3%.
- Expected current unbalance in load current: Up to 15% of rated output current.
- Direct on load starting of converter: Minimum 1500 A (steady state current) of induction motor load for 3 seconds**.**

3.3.2.3 It shall not be possible to regulate the duty cycle of the loads for the hotel load converter part.

3.3.2.4 It shall have to be established with calculations during design stage by the Tenderer about the suitability of the designed transformer winding shall be rated to supply rated power in OHE voltage range of 22.5kV to 30kV to Traction converter part and voltage range of 17.5kV to 30

kV to Auxiliary converter part and Hotel load converter part. Below 22.5kV OHE voltage power degradation will be applicable for Traction Converter part only. The details to be submitted along with the offer.

3.3.2.5 Pantograph bouncing duration up to 45 ms (limit of zero pressure contact) shall not affect hotel load converter with or without loads. Hotel load Converter part shall be able to supply the rated power without any supply interruption during the pantograph bouncing.

3.3.2.6 There shall be OHE power interruptions at neutral sections varying from 12 seconds to 20 seconds. However, it must be taken into consideration that power interruptions shall be of longer durations than specified above. During Neutral section negotiation, one or more number of traction motors depending upon requirement shall go into Regenerative mode. There shall not be any supply interruption/power degradation of Hotel Load converter part. But locomotive running with speed less than 30kmph, this feature may not work.

3.3.2.7 The converter at AC input and output must use IGBTs. The control shall be microprocessor / micro-controller based with diagnostic facilities**.**

3.3.2.8 Approximate Power Requirement with Different Coach Combinations with HOG System is given in Annexure -10

3.3.2.9 Independent control of hotel load converter to be provided so that output of hotel load converter shall be 750V + 5%,-2% 3Ø sine wave. Any electric disturbance on the of drive side of the Integrated converter shall not affect the operation of hotel load converter and vice versa, except the IGBT short circuit condition.

3.3.2.10 The operation of the hotel load converter shall be done by the loco pilot (driver) by pressing spring loaded BLHO switch. The signal from the BLHO shall be integrated with VCU and necessary processing for reliable operation of the hotel load converter shall be done in VCU. The details of the integration of control of the hotel load converter with VCU shall be decided during the design evaluation stage and necessary software/hardware adaptations shall be done by the Supplier.

3.3.2.11 Hotel Load Converter part of the integrated converter shall comply RDSO MS 468 for compatibility with Power Car.

3.3.2.12 Suitable output contactor for the hotel load converter shall be provided at the output of the hotel load converter. The details of the contactor shall be decided during the design evaluation stage.

3.3.2.13 Suitable filter circuit shall be provided at the output of the hotel load converter.

3.3.2.14 Necessary adaptation in the VCU software to be done by the supplier.

3.3.2.15 Indications:

The following indications shall be provided on the hotel load converter:

- Main contactor stuck ON/OFF;
- Input over current
- Input earth fault;
- Input available;
- Output available;
- Converter healthy;
- Converter faulty; and
- Output earth fault**.**

3.3.2.16 Fault Indication, Diagnostics and Trouble Shooting

For fault generation, fault recording, pop-up or indication of fault in Driver display unit for any fault of Hotel load converter part, the same mechanism is to be followed as followed by Traction converter part. The faults shall be downloadable on a laptop computer through a standard port /interface. Further all the fault data of Hotel load converter part shall be stored in DDS and can be fetched any time.

The following messages shall be recorded in the memory of hotel load converter for the purpose of fault diagnostic:

SN	Fault	Remarks
1.	Input Fuse Failure	In case the input fuse is blown due to high current drawn
2.	Input Voltage High	Input voltage exceeding upper limit
3.	Input Voltage Low	Input voltage drops below limit
4.	DC Link / Input Current High	Excess current following in the DC Bus or input High current conditions persisting
5.	DC Link Voltage High	DC Link voltage exceeds upper limit
6.	DC Link Low Voltage	DC Link voltage drops below lower limit
7.	Output Current High	In case of output high current conditions persisting
8.	Output Voltage High	Output voltage exceeding upper limit
9.	Output Voltage Low	Output voltage drops below lower limit
10.	Input Earth Fault	In event of earth fault at input of the converter
11.	Output Earth Fault	In event of earth fault at output of the converter
12.	Single Phase Fault	Unbalance / single phasing at the output
13.	Fault in cooling system	Failure of blower/pump/radiator for cooling
14.	Inverter Fault	In event of fault in Inverter section
15.	Chopper Fault	Chopper section faulty (if design includes chopper)
16.	Over Temperature	Any temperature sensing device operated in the Rectifier and Inverter sections
17.	Power Supply Fault	In event of failure of any of the electronic/ control power supply
18.	Chopper Current High	Chopper section current exceeds upper limit (if design includes chopper)
19.	No synchronization/ Communication Error	Communication fault in software
20.	XXXXXXXX	Any other faults to be specified in Design Document

3.3.2.17 Arrangement for recording of energy consumption by Hotel Load Converter part: Supplier shall provide necessary arrangement in Integrated converter to keep record of energy consumed over a period of time through hotel load converter part and the energy consumed and accumulated energy should be stored in non-volatile memory of Hotel load converter part. The user should be able to generate report on energy consumption on the basis of day wise, weekly, monthly for a period of minimum three months.

3.3.2.18 Suitable indication for the healthiness of the hotel load converter shall be provided in the driver display unit.

3.4 Protection

The devices used in the integrated converters/inverters shall be protected against high rate of rise of voltage & current, line transient surge, switching surges etc.

The converter shall be protected against following:

- Open circuit in traction winding
- Ground fault/ Earth fault in AC input circuit
- Ground fault in 3-phase output. Limits for earth fault detection should be not more than 50mA for traction converter part and 3A with opration time of 0.5 seconds for hotel load converter(settable by software and to be fine tuned during field trials).
- Converter phase fault
- Line to line short circuit due to dead short at load terminal,
- Thermal over loading
- Fuse failure in for hotel load converter if fuses are used.
- High / low voltage in DC link
- Failures of power supply to control electronics
- DC link short circuit
- Input over voltage / under voltage
- Input over current
- Single phasing in load for hotel load inverter
- Output overvoltage / under voltage for hotel load inverter
- Output overcurrent for hotel load inverter

The details of such protection along with their concept/working principle shall be submitted by the supplier for review during design stage.

The equipment shall be protected against internal transient, spikes and surges as per limit laid down as per IEC 60571(1998-02).

3.5 Vehicle Control Unit:

3.5.1 The general provisions of this para 3.5.1 shall be applicable to the Electronics used for integrated and Auxiliary Converters also. The electronics used shall conform to IEC-60571. However, due to higher ambient temperature in India, it shall be suitable for working for short time (at least 15 minutes) at high temperatures as expected to be encountered in locomotive standing under sun (refer to clause 1.4 of this specification). Therefore, there shall be no requirement of pre-cooling of the electronics on locomotive standing in summer sun for long duration. The electronic control equipments shall be protected against unavoidable EMI in the machine compartment.

3.5.2 Control and communication shall be based on open control architecture and compliant to IEC-61375 “Train Communication Network" protocol or any other superior, internationally published protocol. The programmable devices shall be programmed using language compliant to IEC-61131, if PLCs (Programmable Logic Control) are used.

3.5.3 It is desirable that the majority of control and monitoring function is implemented by software so as to reduce hardware and cables.

3.5.4 The control system shall integrate the task of fault diagnostics and display in addition to control task. It shall be capable of real time monitoring the status of all the vital equipment continuously and occurrence of faults It shall also take appropriate protective action and shut down the equipment wherever necessary. Features of self-check, calibration and plausibility checks shall be incorporated in the design.

3.5.5 The vehicle control unit (VCU) has to interface with the existing brake system of locomotive as well as new brake system to be introduced in future. Presently E-70 brake system of M/s D&M / Faively Transport and CCB System of M/s Knorr- Bremseare used on of locomotives. The interface hardware and software shall be designed accordingly. The automatic Flasher operation (in case of train parting) and the Vigilance Control functionality, which are available at present through the brake system, shall be implemented. In addition, provision shall be kept to interface with the brake system through multiplexed pair of wire on RS-485 protocol.

3.5.6 The VCU shall have a diagnostics computer, with non-volatile memory, to store all the relevant diagnostic data. On occurrence of each fault related to propulsion system in the scope of this specification, besides the fault information on equipment parameters, background data with time stamp shall also be captured and stored with a view to enable proper fault analysis. There shall be facility to capture post trigger and pre-trigger background information. The diagnostic computer shall specify diagnostic of If firm does not require to use the existing transformer link as per CLW specification No. CLW/ES/3/0138, then they will have to supply the suitable flexible links fault up to card level. The diagnostic system shall be able to identify and log all faults on the locomotive caused by incorrect operation by the driver and such data shall be stored in the diagnostic computer for a period of not less than 100 days. Application software shall be provided to facilitate the fault diagnosis and the analysis of equipment wise failures. The steps required for investigation to be done by maintenance staff shall be displayed in simple language along with background information. Such software shall be compatible for working on commercially available operating systems.

3.5.7 The vehicle control unit (VCU) shall also provide on-line, context sensitive trouble shooting assistance to the driver in case of any fault, through the driver's display.

3.5.8 It shall be possible to access all the processors within a vehicle using a standard laptop connected to one of the ports provided on the VCU rack. Such access is needed for uploading of firmware/application program, visualization of process parameters and also force or record the same and downloading the diagnostic data. Required interfaces shall be built in the VCU so that standard laptops shall be directly plugged to the VCU without any special interface. Supply of a suitable software tool and laptops is included in the scope. Using this tool, it shall be possible to reset the diagnostic memory for further recording. This tool shall also provide detailed off line analysis facility. Preferably Ethernet/ USB 2.0/ USB3.0/RS232 interface shall be used.

3.5.9 Supply of a suitable visualization software tool, which would run in a laptop connected to the vehicle control Unit, for visualizing the process variables, is within the scope of supply. Using this tool, it is expected to visualize any process variable on the screen, record and temporarily force its value. Recording shall be both in numerical and graphical form.

3.5.10 It shall be possible for the Railways to execute parametric changes in the software in respect of user's interface viz: modifying some of the permissible parameters like currents, horse powers, temperatures, pressures, speeds etc., for adjusting the characteristic within permissible range, changing preset values, limits, characteristics etc. and behavior of the locomotive in general, and add/alter the protection features, if so required in future in order to improve the operation of locomotive. It shall be possible to configure these parameters through laptop. A menu driven easy to use application software shall be provided for loading on the laptop for this purpose. Password protection shall be provided to safeguard against misuse.

3.5.11 The electronics shall be designed to be sealed from the remaining part of the machine room so as to ensure that there is no dust ingress whatsoever in to the electronics. For its cooling, internal ventilation arrangement along with heat exchanger for removal of heat shall be provided. The cooling arrangement of the electronics of the integrated converter, auxiliary converter and the VCU shall be designed so that the temperature adjacent to the electronic cards remains below 45 °C (degrees Celsius) while the locomotive is operating. Alternatively, the cooling arrangement of the electronics of the integrated converter, auxiliary converter and the VCU shall be designed so that at least 20 deg Celsius margin is maintained between temperature adjacent to the electronic cards and the maximum temperature allowed adjacent to the electronic cards.

3.5.12 The electronic cards shall be mechanically coded to ensure that insertion of card in wrong slot is not possible. Two additional expansion slots shall be kept to integrate additional system in future or firm should have sufficient spare channels (DIO&AIO) for future requirement. The firms can also supply wall mounting or din rail mounting type arrangement for PCB.

3.5.13 Capacitors shall be liberally rated, keeping in view the high ambient in India, vibrations of electric rolling stock and electrical surges expected during operation. Indian Railways have experienced high failure rates of electrolytic mounted on PCBs of electronic cards due to high operating temperature/voltage/current vis-à-vis designed operating temperature/voltage/current. This aspect shall be especially kept in view during design. Dry type of capacitors shall preferably be used. Expected life of the cards, and electronics in general shall be at least 18 years under working conditions.

3.5.14 Maintenance of electronic systems:

a) On-board diagnostic shall be used on the locomotive to discriminate between fault on the rest of the locomotive and fault on the electronic equipment.

b) Shall the electronic equipment found faulty, the on board diagnostic shall enable fault finding to be carried out at module level.

3.5.15 It has been IR's experience that the temperature inside the machine room near electronic cubicle of passenger locomotives rises to more than 65 deg Celsius during summer season when ambient temperature is as high as 50 deg Celsius. The Supplier shall do trials of temperature measurement 12 mm away from card by suitable equipment, such as thermocouple, in working condition of loco to demonstrate the temperature rise.

3.5.16 IR shall facilitate doing trials, if desired by Supplier, on existing passenger locomotives for temperature rise inside machine room near electronic cubicle and dust ingress in machine room to appreciate Indian conditions so as to consider appropriate design of electronics and suitable filters and blowers.

3.5.17 In the existing system, the electronic racks are mounted within a sealed casing located at low voltage cubicles (SB1 & SB2). The air from the machine room blower indirectly cools the casing. In this offer also, the racks are to be mounted at the same locations to avoid change in the locomotive cable harness. The suppliers may choose to adopt the same mechanical system as existing today, which means the racks are mounted within the casing and the casing is cooled indirectly. In such a case, supply of rack integrated with casing and heat exchanger shall be part of the supply. The offered rack shall be having its own cooling and ventilation arrangement. The physical location of present VCU1 and VCU2 shall be retained. The offered VCU racks are to be mounted within the mechanical space envelope existing. Presently the rack which comes in a casing is indirectly cooled by a heat exchanger mounted on this casing through which the machine room air passes. The rack is a 6U card cage. While the location has to be retained within the constraints of existing space envelope and mounting arrangement, the requirement of the cooling shall be met either by utilizing the existing arrangement or by providing a suitable alternative within existing space envelop and airflow. Supply of rack casing and the cooling arrangement is part of the scope of supply.

The essence is as follows:

- New racks are to be accommodated in casing on which SB1/2 cubicles shall be mounted like used presently.
- The Supplier may or may not utilize the present indirect cooling arrangement using MR air depending on the design. In case the heat exchanger is not required opening has to be suitably blanked at this point by the Supplier
- The Supplier has to make his own arrangement for internal circulation of air to avoid hot spots. Presently a fan tray is mounted below the rack.
- Casing shall be within the scope of supply.
- External heat exchanger is also part of the supply in case the design so needs it.

The interconnections of VCU1/A/CU2 with control rack of Integrated Converter and Auxiliary Converter is given in Annexure-14.

3.5.18 IR prefers to retain the existing cable looms with connectors (for I/Os and battery power) without any change, so that the same shall be plugged on to the new system under

consideration. The tenderers are expected to study the present arrangement and expected to comment specifically about the retention of present arrangement without any change.

3.5.19 Special Comment on Control Cabling from Driver's Desk:

In existing scheme, the driver's desk is physically wired to the VCU1 and VCU2 cubicles. The tenderers may propose alternative schemes involving intelligent I/Os which shall reside in the driver's desk for capturing and actuating various drivers' interfaces communicate with VCU over CAN/MVB and the existing cabling then can be saved upon.

3.5.20 Maximum mechanical Dimension (envelope) of VCU housing Case

Length - 760 mm
Width - 502 mm
Height - 560 mm

3.6 Driver Display Unit:

At present, one driver display unit is fitted at the Loco Pilot (LP) side in each cab. The existing DDU of 3- Phase electric locomotive is to be retained, with adequate changes in software. But, if there is any change in the hardware of the existing DDU, then supplier should maintain the same dimensions as of existing DDU. The following should be kept in mind while designing the DDU:

a. In the DDU, all the parameters/data (Condition data, event data, process data, message data) of locomotive shall be displayed.

b. Colour graphics display units for driver shall be provided in each cab on driver's desk displaying important information relevant to the driver, including operational aspects, fault status and messages. The display shall be menu driven.

c. The interface with the driver shall be very simple considering average level of proficiency of drivers in handling electronic devices.

d. The display shall be designed to provide full guidance and assistance to the driver about the action to be taken in case of a fault. The interface shall be user friendly and there shall not be any need for a separate trouble shooting directory for the driver's use.

e. Selection of display medium shall take into account high ambient temperature and light, due to direct sunlight on the driver's desk. Backlight arrangement shall be provided for all time visibility. The display system shall be protected against dust and moisture with an IP rating of 65.

f. Display language shall be English and Hindi (bilingual). However, the detailed contents on Hindi & English shall be discussed during design stage.

g. The equipment shall have a LCD display of 10.4”(diagonal), duly protected against inadvertent handlings errors. Protection of LCD by use of transparent sheet is recommended. Larger size LCD display may also be used but the same shall be accommodated in the available space.

h. The equipment shall provide a Pentium class processor or equivalent together with provision for variable access from locomotive’s vehicle bus.

i. The equipment shall have provision to communicate with a PC through a suitable interface like COM/USB/Ethernet, which shall be protected against ingress of dust/moisture. Such interfaces shall be easily accessible still retaining the aesthetic look of the display terminal.

j. The equipment shall have provision for authentication by the driver and entering driver details by way of special key with pre-programmed memory module or by swiping a driver's personality card. The functions shall become active only after such authentication.

k. Selection of various functions and screens shall be possible through function keys and menu navigation with touch screen feature. The function keys shall have tactile feedback and must be arranged on right side vertically and at bottom horizontally (if needed). The keys to avail the functions of the present 4x40 character LCD display shall be grouped separately at a convenient location.

l. The equipment shall house its own power supply module, which will work from the locomotive battery. The nominal battery voltage is 110V DC, which is subjected to variation from 77V to 137.7V.

m. The display terminal shall have provision to access MVB variables by direct access through a signal converter connected to a separate MVB multiplier card. The MVB multiplier card shall house the connector receptacle for the type of interface used and shall be arranged by the Firm. The circuit schematic of MVB multiplier card to be submitted to CLW for approval.

n. The 110V DC power connector to the equipment shall be provided through a 3 pin miniature circular connector of MIL-C-26482 (Series-I) standard with bayonet locking. The receptacle on the equipment side shall have pin contacts and on the cable side, socket contacts. The contacts shall be of crimp type, gold plated. The supplier shall provide power supply cable (2m length), duly provided with connector at one end and crimped to cable lug on the other side. The power supply connector shall be provided at the rear of the equipment.

o. The mechanical housing shall be compact and robust. The display will be mounted on the driver desk. Hence, the equipment shall be made for panel mounting. Through holes of M4 size shall be provided on left and right flanges (2 each) for panel mounting purpose. Welded threaded nuts on the driver desk will be used to secure the display unit. Sharp edges on top facia shall be avoided.

p. The C-panel plate shall be required to be modified. The supplier has to supply the modified C-panel plate and arrange the mounting of the equipment on the modified C-

panel including wiring after unmounting from the old c-panel. Panel shall be of with black anodized aluminium material. However, the supplier shall not be required to arrange the mounting of the equipment on the modified C-panel including wiring after unmounting from the old c-panel for CLW supplies.

q. Suitable connection between the Vehicle control Unit (VCU) and New Drivers Display unit will be done through cable / wires/optic fiber cable. The cable /wires/ optic fiber cable used will be suitable for the traction application and shall be responsibility of the firm.

r. The equipment shall have its own cooling arrangement. Natural cooling is preferred.

s. The equipment shall be packaged to conform to IP65 ingress protection class in accordance with IEC-60529.

t. For further details, the Contractors may refer to CLW specification No. CLW/C-D&D/ES/3/0487 Alt. C or latest.

3.7 Event Recorder:

The present WAP-7 locomotive does not have any event recorder. The upgraded version of loco shall have event recorder. The event recorder shall monitor and record various events so that data is available for analysis to assist in determining the cause of accident, incident or operating irregularities. The equipment shall be designed in such a way so as to provide an intelligence-based recording of the following 43 parameter with sampling time of 1 sec. for 72 hours.

The following parameters shall be recorded:

1. Loco speed (KMPH);
2. OHE Volt (KV);
3. OHE Current (Amps);
4. Energy Consumed(Kwh);
5. Battery Volt (Volts);
6. BP Pressure (Kg/cm2);
7. TE/BE Demand% (%)
8. TE/BE BG1 (KN)
9. TE/BE BG2 (KN)
10. CAB1FwSand (-)
11. CAB2 FwSand (-)
12. CAB1 Key in D(-)
13. CAB2 Key in D(-)
14. Compressor ON/OFF status(-)
15. CAB1 DirFor (-)
16. CAB1 DirRev(-)
17. CAB1 MaxTELimit(-)
18. CAB2 MaxTELimit(-)
19. CAB1 EmgStop(-)
20. CAB2 EmgStop(-)

21.CAB1 FtSwlocBrk(-)
22.CAB2 FtSwLocBrk(-)
23.CAB2 DirFor (-)
24.CAB2 DirRev (-)
25.Panto 1 PrSw (-)
26.Panto 2 PrSw (-)
27.VCB Status(-)
28.Motoring(-)
29.Regenerative Brake(-)
30.Emergency Brake Applied(-)
31.Isolating Emg Exhaust(-)
32.Start/Run Interlock(-)
33.Traction Interlock(-)
34.Node number
35.Vig Warning(-)
36.VigEmgBrk(-)
37.Air Flow PrSw(-)
38.BC1 PrSw(-)
39.BC2 PrSw(-)
40.MR Low PrSw(-)
41.BrkEleHlth(-)
42.Loco number
43.LSP Status (-)

The above parameters may be selected either through DDU or loco diagnostic tool.

The event recorder shall be designed to:

- Permit rapid extraction and analysis of data for the purpose of monitoring driver or Locomotive system;
- Assist retrieval of data after an incident or accident; and
- Mitigate the effects on recorded data of foreseeable impact or derailment.

The event recorder shall be designed and constructed to ensure the integrity of the recorded data and the ability to extract data following an incident.

3.8 Auxiliary systems:

3.8.1 The existing load distribution of the Auxiliary machines is given for reference in the Annexure -8. In the existing system of WAP7 locomotive, the load distribution is among three Auxiliary Converters of 130 kVA each. In case of failure of any Auxiliary Converter, the load distribution changes in such a way that the whole load can be catered through remaining two healthy converters. Therefore, for auxiliary system, there is 100% redundancy in case of failure of any auxiliary converter.

3.8.2 In case the supplier tends to adopt integrated converter approach, the auxiliary converters should be of adequate capacity and identical in all respects including the battery-charging arrangement. Design and rating of auxiliary converter and load distribution shall be such that in case one auxiliary/integrated converter fails, the

remaining converter shall take the entire auxiliary load including the battery charger and the locomotive remains healthy. The changeover arrangement shall be automatic.

3.8.3 **Battery charger redundancy:** There shall be feature of hot-standby for battery charger. There shall be separate battery charger module for each Auxiliary Converter box/Auxiliary Converter. Further during failure of any battery charger, the other battery charger should take the loading of the Auxiliary Converter.

3.8.4 The responsibility to modify the cable index related to auxiliary/integrated converter shall lie on the firm and same should be provided to IR at the time of approval of design document.

3.8.5 It is to mention here that the rating of the auxiliary machines like pump, radiator, oil cooling unit may require upgradation for this project. The details may however, be worked out in the detailed design stage and submitted to IR along with the proposal.

3.8.6 The auxiliary system shall consist of auxiliary converters, auxiliary machines, blower-motors, compressor motors, oil / water pumps, cab air-conditioner, battery charger, DC loads and associated protection system. The AC auxiliary system shall be galvanically isolated from the traction power system and the DC battery system. Auxiliary system design shall ensure that there is no surge / spike in the output voltage between phase to phase and with respect to earth. The common mode output voltage (vector sum of three phases) with respect to earth shall be as low as possible, preferably zero.

3.8.7 The auxiliary converters shall be IGBT based and forced water cooled or air cooled. The control shall be microprocessor / micro-controller based with diagnostic features. Protection from overload/short circuit, single phasing and any other protection considered necessary for reliable functioning shall be provided. The output of auxiliary converter shall be sinusoidal. Total harmonic distortion at the output voltage shall be less than 10 % and supply regulated to +/- 5% of the nominal voltage under all operating conditions.

3.8.8 Auxiliary converters of adequate capacity identical in all respects and a battery-charging unit shall be provided. Design and rating of auxiliary converter and load distribution shall be such that in case one auxiliary converter fails, the remaining shall take the entire auxiliary load and the Locomotive remains healthy. The changeover arrangement shall be automatic.

3.8.9 Rating of the auxiliary converters shall be decided after considering the connected loads, requirement of redundancy and keeping a margin of 10 kVA per converter for possible increase of load in future.

3.8.10 In order to reduce energy consumption as well as to increase equipment life, multiple level ventilation control shall be adopted, which shall vary the output of all the blowers according to the cooling needs. Auxiliary converter output and control system shall be designed accordingly.

3.8.11 The standard low tension supply voltage in India is 415 V, 3-phase, 50 Hz AC. The auxiliary machine supply voltage will be 415 V + 10%, 3- phase, 50 Hz +3%.

3.9 Remote Monitoring System

The Locomotive shall be provided with remote diagnostic and tracking equipment. Provision of Remote Monitoring System (RMS) either in standalone form or inbuilt with propulsion system. The propulsion system shall be provided with remote diagnostic and

tracking equipment. The equipment shall be based on GPS/GSM-R or latest technologies. This equipment shall perform the function of tracking of the locomotive and also communicate with the locomotive diagnostic system, and pass on this information to the central server. The central server shall be provided by the contractor at mutually agreed locations with back up servers. It shall be possible to remotely send and obtain the information stored in the diagnostic memory of the computer system, depending on availability of the communication channel, for control and diagnosis, with the aim of facilitating and speeding up the maintenance process of the locomotives. It should also be possible to send the data on IR/ CRIS server. Collective data shall have provision for seamless integration with Maintenance Management Information System (MMIS) in future.

3.10 Electronics, Control and Communication:

3.10.1 The general provisions of this paragraph shall be applicable to the Electronics used for Integrated and Auxiliary Converters also. The electronics used shall conform to IEC-60571. However, due to higher ambient temperature in India, it shall be suitable for working for short time (at least 15 minutes) at high temperatures as expected to be encountered in locomotive standing under sun (refer to clause 1.4 of this specification). Therefore there shall be no requirement of pre-cooling of the electronics on locomotive standing in summer sun for long duration. The electronic control equipments shall be protected against unavoidable EMI in the machine compartment.

3.10.2 Control and communication shall be based on open control architecture and compliant to IEC-61375 “Train Communication Network” protocol or any other superior, internationally published protocol. The programmable devices shall be programmed using language compliant to IEC-61131, if PLCs (Programmable Logic Control) are used.

3.10.3 It is desirable that the majority of control and monitoring function is implemented by software so as to reduce hardware and cables.

3.10.4 The vehicle control unit (VCU) shall also provide on-line, context sensitive bilingual (Hindi & English) trouble shooting assistance to the driver in case of any fault, through the driver’s display.

3.10.5 Preferably Ethernet/ USB 2.0/ USB3.0/RS232 interface shall be used.

3.10.6 Supply of a suitable visualization software tool, which would running a laptop connected to the vehicle control Unit, for visualizing the process variables, is within the scope of supply. Using this tool, it is expected to visualize any process variable on the screen, record and temporarily force its value. Recording shall be both in numerical and graphical form.

3.10.7 The cooling arrangement of the electronics of the integrated converter, auxiliary converter and the VCU shall be designed so that the temperature adjacent to the electronic cards remains below 45 °C (degrees Celsius) while the locomotive is operating. Alternatively, the cooling arrangement of the electronics of the power converter, auxiliary converter and the VCU shall be designed so that at least 20 deg Celsius margin is maintained between temperature adjacent to the electronic cards and the maximum temperature allowed adjacent to the electronic cards.

3.10.8 It has been IR's experience that the temperature inside the machine room near electronic cubicle of three phase locos rises to more than 65 deg Celsius during summer season when ambient temperature is as high as 50 deg Celsius. The Supplier shall do trials temperature measurement 12mm away from card by suitable equipment, such as thermocouple, in working condition of loco to demonstrate the temperature rise.

Chapter -4

General Conditions, Inspection, Test & Trials and Other Requirements

4.1 General Conditions

4.1.1 General design features of locomotive

(i) The equipment shall incorporate features to yield high availability for traffic use, low maintenance requirements, easy maintainability, high reliability in operation and high efficiency.

(ii) The Contractor will provide the items required for proper functioning of the locomotive in accordance with current international practices.

(iii) The specification has been prepared for the general guidance of the Contractor to prepare the key design for the proposed locomotives. Any deviation from specification, intended to improve the performance, utility and efficiency of the locomotive as a whole or part thereof may be proposed for consideration. All such proposals will, however, be accompanied with complete technical details and justification for proposed deviation.

4.1.2 Approval of design: - The design of the additional equipment of locomotive shall be developed based on the requirements given in this specification and sound engineering practices. The design shall be developed in SI units.

4.1.3 The entire design of equipment being supplied by contactor to achieve the functionalities mentioned in the specification shall be carried out by the Supplier and submitted to IR along with required technical data and calculations for necessary approval. The supplier shall be responsible for achieving the desired performance parameters of the locomotive for the equipment supplied. The manufacturing shall commence after the approval of design by IR.

4.1.4 The Supplier shall submit all necessary data, designs, calculations, drawings and specifications referred in their drawings or design documents in English language as required by IR for examination and shall provide explanation and clarification of the documents for which approval is sought. For the purpose, the supplier shall depute his technical experts to IR for design discussions and finalization. After the final design is approved, the supplier shall furnish complete set of specifications and standards as mentioned in the approved drawings & documents and shall also submit the list of equivalent Indian Standards, wherever applicable. Supplier shall submit complete design details, block diagrams, functional description of all sub-systems, schematic drawings, loading calculations, circuits, component rating, wiring diagrams, ventilation design, device rating & data sheets of converter, inverter and other power, control and the major equipment, loading of electronic equipment /components calculated under the ambient conditions as specified, etc. The aspects covered above are not exhaustive and the Supplier shall commit to supply / furnish complete technical details with respect to their system and equipment design and to the satisfaction of IR for design approval.

4.1.5 Supplier shall enclose details of their system design, weight particulars and its disposition covering all items, basic software specification, electronics, communication protocols, display systems, and any other aspect / equipment which is within the scope of supply of the supplier. The Supplier shall also submit in their design the simulated values of the maximum interference currents in the power supply.

4.1.6 The Supplier shall submit the complete material / technical specification and sources of the components during design approval. The specification shall specifically be indicated on relevant drawings / documents.

4.1.7 The Supplier shall furnish details of its Quality Assurance and Quality Control at the design approval stage. The quality checks to be made at various stages of manufacture, final assembly and commissioning with tolerance would be indicated. The system would also cover the quality assurance for bought out items.

4.1.8 Approval of design means the approval of general design features. Notwithstanding approval from IR the Supplier shall be wholly and completely responsible for the satisfactory performance of the equipment.

4.1.9 The Supplier shall be responsible for carrying out improvements and modifications at his own expense on all the equipment supplied, provided such modifications/improvements are decided to be necessary for meeting the requirements of reliability, performance, safety etc. jointly between Supplier and Purchaser.

4.1.10 For the purpose of technical decisions on improvements/modifications etc. on equipment, the final authority from the Purchaser's side shall be IR.

4.1.11 The design will be made based on the requirements given in this specification and sound, proven and reliable engineering practices. The entire key design will be submitted with technical data and calculations for approval.

4.1.12 The Contractor will submit a program indicating the expected dates on which drawings will be submitted for approval to plan resources for this approval.

4.1.13 The Contractor's engineer will deliver the drawings and will provide explanation and clarification of the drawings for which approval is sought.

4.1.14 The design will be developed in SI units only.

4.1.15 Approval of design means the approval of general design features. For this purpose, detailed drawings will be submitted for approval before commencing manufacture. Notwithstanding approval the Contractor will be wholly and completely responsible for the satisfactory performance of the locomotive offered.

4.1.16 Deviations proposed by the Contractor in the interest of reliability and better performance will be examined in close consultation and association with the manufacturer so as to arrive at the final locomotive design.

4.1.17 All necessary data, designs, calculations and drawings required for examination of the manufacturer's proposals will be furnished by the Contractor. The design data calculations and drawings required for approval of the design.

4.1.18 The Contractor will, in addition to furnishing information required, also liaise with Indian Railways for any exposure of Indian Railways to current state of the art technology abroad so as to assess the relative merits/demerits of different designs offered and to arrive at mutually final designs. Information on experience on the equipment offered on different user railway systems will also be required by the Indian Railways for an appropriate assessment. The manufacturer/Contractor will give appropriate assistance in this regard also.

4.2 Inspection, test and trials:

4.2.1 The locomotive will be tested generally in accordance with IEC 61133 (ED. 2.0): Rolling stock Testing of rolling stock on completion of construction and before entry into service. The inspection of the locomotive will be carried out by a representative of Indian Railways.

4.2.2 The individual equipment, systems and subsystems, as may be necessary, shall be type and routine tested in accordance with relevant IEC, BS and RDSO publications as per details given in clause 1.2 according to the test program to be drawn up by the Contractor in consultation with IR. If equipment of the same make and type not undergone changes affecting performance has already been type tested according to clause 1.2, under reference site conditions given in clause 1.4 and equivalent operating conditions, reports will be submitted to IR. In such case type tests may be exempted. However, all major equipment shall be type tested. Some type test may be conducted after delivery of first locomotive.

All equipment shall be routine tested according to the relevant IEC publications.

Required type tests of electrical and mechanical equipments shall be carried out by the Contractor at his own responsibility and costs and in the presence of and to the satisfaction of the Inspecting officials of RDSO and CLW. The type test shall be carried out at the manufacturing premises of the Contractor where all the facility required for type test shall made available by the Contractor.

4.3 Equipment/Systems/Subsystems testing:

4.3.1 The equipment, systems and subsystems will be type/routine tested accordingly to this Specification and Standards. Wherever the relevant standard test procedures for type and routine tests prescribed in accordance with this specification and standards do not adequately cover the requirements.

4.4 Service Trials: The locomotive shall also be evaluated during operation under actual load conditions. These shall be termed as "Service Trials". Apart from checking on repeatability of the operational performance under different conditions of track, OHE, signaling systems, etc. as well as under different conditions of wear and tear on the locomotive itself, these tests will also be used to throw light on the maintainability, accessibility, reliability and such other aspects which have been mentioned in this specification.

4.5 Characteristics of wheel slip & adhesion: Wheel slip and adhesion will receive proper attention during the tests and trials under different track conditions.

4.6 Prototype trials: During the prototype tests/trials, which may last about 6 months or 50,000 km whichever is later if any problems are thrown up or feedback information is obtained, which warrants a re-check of the design/manufacture/quality of the equipments and components (supplied by contactor), action will be taken as may be necessary by the Contractor to carry out the required investigations and to incorporate the improvements considered most appropriate to reach compliance with the specification without any extra costs to the Purchaser. Such improvements will be carried out in all locomotives and will be evaluated for their validity for a further period of time as may be agreed mutually in each case.

Modifications mutually agreed to comply with the specification will be incorporated by the Contractor at his own cost in the locomotives in a manner approved by the purchaser. Drawings incorporating the modifications found necessary as a result of test and trial will be submitted. Final documentation will be provided incorporating experience gained in final manufacturing phase and the first period of trials within 6 months after completion of these trials. Terms and conditions in this regard will be incorporated in the contract documents.

4.7 Training of IR personnel: The supplier shall arrange for the training of CLW, RDSO and the maintenance & operating personnel of IR of 5 man months at supplier's premises, where each man month shall be of 25 working man days. The cost of training shall be included in the offer. The details of the training shall be worked out during contract finalization stage/design approval stage.

4.8 Documentation: The Contractor will furnish as made drawings and tracings, manual of instructions for operation and maintenance of the locomotive and equipments, troubleshooting

instructions and such other technical information as may be required for the maintenance and operation of the locomotives in India. A preliminary version will be supplied during the commissioning of first locomotive with equipment at CLW. Final documentation will be provided incorporating experience gained in final manufacturing phase and the first period of trials within 6 months after completion of these trials. Terms and conditions in this regard will be incorporated in the contract documents.

4.9 Technical support: The Contractor will ensure the availability of technical support in the service trials and during the period of guaranty and AMC. The terms and conditions regarding these aspects will also be incorporated in the contract.

4.10 Special extras: The Contractor will supply special tools, jigs, fixtures and testing kits. Should further spares, tools, testing instruments, other special jigs and fixtures as well as special training kits for simulation of locomotive operation, trouble shooting by driver and maintenance staff be required by IR, the Contractor will provide a quotation for the supply of these items.

Chapter -5

Contractor's and Railway's Responsibilities

5.1 Contractor's detailed scope of work:

5.1.1 The Contractor shall design, manufacture and supply the equipment and shall ensure that the locomotive meets the functional requirements as mentioned in the specification.

5.1.2 Contractor shall perform necessary simulation and analysis including FEM analysis and load analysis, running dynamics etc. in simulation mode on modified equipments to be supplied against the specification. Test results should be within acceptable limits in light of enhanced rating of equipments on existing locomotive. The test results with observations, if any, shall be submitted with the design document.

5.1.3 Integration & testing/validation of additional equipments with the locomotive shall be under Contractor's scope of work. Contractor shall also associate themselves during the field trial of first locomotive.

5.1.4 Contractor should submit all the design details covering modified items, their mounting & integration details, wiring diagram etc. in hard and soft copy to IR.

5.1.5 Performance Curves: The preliminary notch-wise "Tractive Effort Vs Speed" & 'Braking Effort Vs Speed' at standard as well as site conditions shall be submitted along with the design. In addition, the manufacturer shall submit "Draw Bar Pull Vs Speed" and "DC link voltage/current Vs Speed" characteristic curves at standard as well as site conditions.

5.1.6 Efficiency: The Contractors shall indicate efficiency for the different additional/modified components/equipments/systems supplied by them against the specification.

5.2 Railway's Scope of Work:

5.2.1 The basic dimension of locomotive shall remain the same and the supplier should design the equipment layout accordingly within the existing framework. However, the fixing arrangement and relocation of existing equipment (if required) shall be submitted during design approval stage and approval for the same shall be obtained.

5.2.2 The mounting and necessary cable layout for different equipment which are under the scope of supply against the present specification shall be carried out by the purchaser as per the design details given by the supplier. However, the supplier shall ensure close liaison for the commissioning of the equipment supplied against this specification.

5.2.3 All skilled as well as unskilled artisan staff shall be provided by the purchaser.

5.3 Manufacturing facility to be provided by Railways:

After getting the requisite information from the supplier regarding the equipment/sub-assemblies to be modified, CLW shall start equipment mounting including cabling in supervision of the supplier. However, CLW shall arrange the following (as per advice of supplier) for successful commissioning of the new equipment on the locomotive:

a. Updated jigs and fixtures as per advice of supplier.
b. Assembly and testing tools.

5.4 In general, the differentiation of scope of work of supplier & Purchaser shall be done on following lines as given below:-

Item No	Item description	Responsibility of design or specification	Responsibility of manufacturing or procurement	Note
1	**Carbody and cabs**			
1.1	Underframe	CLW	CLW	Unchanged
1.2	Carbody side walls and servicing doors, roofs	CLW	CLW	Unchanged
1.3	All cab components ind. Cab windows, doors HVAC, lighting and seats, floor cover, wipers	CLW	CLW	Unchanged
1.4	Driver display Unit	Supplier	Supplier	If required, to be modified
2	**Bogie, suspension and Undergear Arrangement**			
2.1	Bogie complete	CLW	CLW	Unchanged
2.2	Suspension system	CLW	CLW	Unchanged
2.3	Transmission system including Traction bar/link	CLW	CLW	Unchanged
2.4	Bull gear, pinion, gear case	CLW	CLW	Unchanged
2.5	Wheel, axle, axle box bearing	CLW	CLW	Unchanged
3	Traction chain			
3.1	High voltage & roof equipment (Roof)	CLW	CLW	Unchanged
3.2	Transformer	Supplier	Supplier	New
3.3	Integrated convertor traction	Supplier	Supplier	New
3.4	Cooling units for transformer and integrated converter	Supplier	Supplier	New
3.5	Traction Motors and mounting arrangement	CLW	CLW	Unchanged

4	Pneumatic equipment			
4.1	Compressed air supply system	CLW	CLW	Unchanged
4.2	Complete brake system including piping and brake rigging	CLW	CLW	Unchanged
5	Auxiliary machines, control equipment and filters			
5.1	MR blowers with filters & scavenge blowers	CLW	CLW	Unchanged
5.2	TM blowers	CLW	CLW	Unchanged
5.3	Air filter grids, dynamic filters, ducts	CLW	CLW	Unchanged
5.4	Aux/Control cabinet and components	CLW	CLW	Unchanged
5.5	LV cabinet and components	CLW	CLW	Unchanged
5.6	Battery	CLW	CLW	Unchanged
5.7	Filter Cubicle	CLW	CLW	Unchanged
5.8	All TCMS components, MU control interface	Supplier	Supplier	If changed
6	Miscellaneous			
6.1	Tools, fire fighting arrangement, cab equipment etc	CLW	CLW	Unchanged
7	Schematics and cabling			
7.1	Set up electric schematics with part list	CLW	CLW	Unchanged
7.2	Cable harnessing and connectors	CLW	CLW	Unchanged

Annexure-1

Details of existing Series Resonant Inductor Unit:

	LOT 6500
Type	2 S0D 240
Inductance	2x0.551 mH (+15%) Linear to Ipeak = 1391 A
Thermal Current (1)	2x984 A_{eff}
Resonant frequency	**100Hz**
Voltage Stress between clamps (Max.)	**282 VAC**
Voltage Stress against Earth (Max.)	**3471 V**
Dissipation power (Inom)	125kW+15%

Details of Auxiliary Converter Choke Unit:

	LOT 6500
Type	
Inductance per BUR Choke	
0 A	30 mH
120 A	30 mH
155 A	30 mH
190 A	30 mH
Tolerance	-0 %, + free
Frequency	100 Hz
Rated Current	155 A
Maximum Current	190 A
Ripple	38.6%
Maximum Ripple	50.2 %
Voltage Stress against Earth (Rated)	1153 V
Voltage Stress against Earth (Max.)	2000 V
Dissipation power at Inom	12kW+15%

Annexure-2

DETAILS OF EXISTING TRACTION TRANSFORMER

SN	Parameter	Value
1	Type	LOT 7775
2	Original Design	Secheron SA
3	Windings	
	Traction	4
	Auxiliary	1
	Filter	1
	Hotel load	***2***
4	Frequency (f nom)	50 Hz
5	Primary Voltage	
	Maximum	30.0 kV
	Nominal	25.0 kV
	Minimum	17.5 kV
6	Voltage Ratings (at 25.0 kV Catenary)	
	Traction	1269V
	Auxiliary	1000V
	Filter	1154V
	Hotel Load	960 V
7	Current Ratings	
	HT	311 A
	Traction	4 x 1142 A
	Auxiliary	333 A
	Filter	347 A
	Hotel Load	2x648 A
8	Thermal Ratings	
	Primary	7775 kVA
	Traction	4 x 1449 kVA
	Filter	400 kVA
	Auxiliary	333 kVA
	Hotel Load	2x622.5 kVA
9	Winding Data	
	Traction	37.0 mΩ, 2.1 mH + 15%
	Auxiliary	60.0 mΩ, 0.43 mH
	Filter	19.0 mΩ, 0.29 mH
	Hotel Load	11.0 mΩ, 0.65 mH

Annexure-3

CHARACTERISTICS OF EXISTING TRACTION MOTOR

SN	Characteristics	Unit	6FRA 6068
1	Continuous Rating		
1.1	Shaft output	kW	850
1.2	Nominal voltage	V	2180
1.3	Current	A	270
1.4	Speed	Rpm	1283
1.5	Tirque	Nm	6330
1.6	Frequency	Hz	65
1.7	Power Factor	-	0.88
2	One Hour Rating		
2.1	Shaft output	kW	850
2.2	Nominal voltage	V	2089
2.3	Current	A	290
2.4	Speed	Rpm	1135
2.5	Torque	Nm	7140
2.6	Frequency	Hz	57.5
2.7	Power Factor	-	0.86
3	Short Time Overload Rating		
3.1	Shaft output	kW	850
3.2	Nominal voltage	V	1660
3.3	Current	A	370
3.4	Speed	Rpm	892
3.5	Torque	Nm	9100
3.6	Frequency	Hz	45.7
3.7	Power Factor	-	0.86
4	Max. speed	rpm	2584
5	Temperature sensor	2 Pt. 100 resistance elements installed in stator tooth	
6	Speed sensor	Active Hall effect speed sensor with tooth wheel ring giving 120 pulses per rotor revolution.	

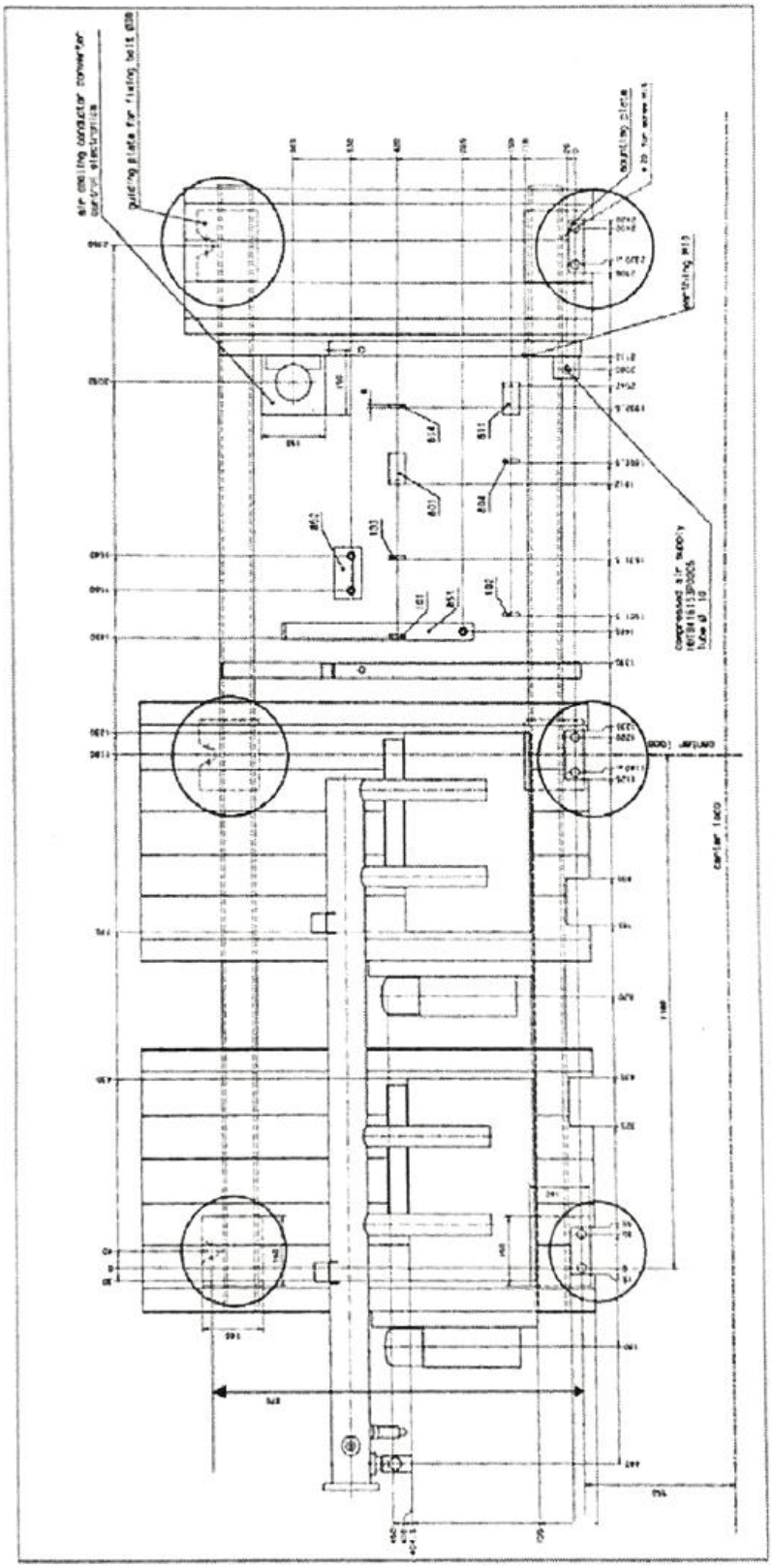
Annexure-4

CHARACTERISTICS OF VCB

SN	Parameter	Value
1	Type	Single bottle
2	Original Design	Secheron, Alstom
3	Number of Poles	Single
4	Control System	Electro-pneumatic
5	Rated operational voltage (Ue)	27.5 kV
6	Nominal voltage (Un)	25 kV
7	Dielectric test voltage	75 kV
8	Rated impulse withstand voltage (Uimp)	175 kV
9	Conventional free air thermal current (Ith)	1000A
10	Rated frequency	50/60 Hz
11	Rated breaking capacity	16 kA
12	Opening time	30 to 60 ms
13	Auxiliary voltage	110 V DC
14	Number of auxiliary contacts	4 + 4
15	Air Supply Pressure	4.5 – 10 bar
16	Approximate weight	140 Kg (Approximately)

Annexure-5

BOTTOM FIXING HOLES AND FOOT-PRINT OF GTO BASED TRACTION CONVERTER



Annexure-6

Existing load distribution of Auxiliary Converters:

BUR-1		
	Oil cooler blower-1	25 kW
	Qil cooler blower-2	25 kW
	Total	50 kW

BUR-2		
	Traction motor blower- 1	25 kW
	Traction motor blower -2	25 kW
	Qil pump transformer — 1	4.7 kW
	Oil pump transformer -2	4.7 kW
	Oil pump converter — 1	11 kW
	Oil pump converter — 2	11 kW
	Total	81.4 kW

BUR-3		
	Scavenge blower -1	3 kW
	Scavenge blower — 2	3 kW
	Compressor — 1	15 kW
	Compressor — 2	15 kW
	Battery charger	12 kVA
	Total	48 kW

When BUR-1 Isolated:

BUR-2		
	Traction motor blower- 1	25 kW
	Traction motor blower -2	25 kW
	Oil cooler blower-1	25 kW
	Qil cooler blower-2	25 kW
	Scavenge blower -1	3 kW
	Scavenge blower — 2	3 kW
	Total	106 kW

BUR-3		
	Qil pump transformer — 1	4.7 kW
	Oil pump transformer -2	4.7 kW
	Oil pump converter — 1	11 kW
	Oil pump converter — 2	11 kW
	Compressor — 1	15 kW
	Compressor — 2	15 kW
	Battery charger	12 kVA

	Total	73.4 kW

When BUR-2 Isolated

BUR-1		
	Traction motor blower- 1	25 kW
	Traction motor blower -2	25 kW
	Oil cooler blower-1	25 kW
	Qil cooler blower-2	25 kW
	Scavenge blower -1	3 kW
	Scavenge blower — 2	3 kW
	Total	106 kW

BUR-3		
	Qil pump transformer — 1	4.7 kW
	Oil pump transformer -2	4.7 kW
	Oil pump converter — 1	11 kW
	Oil pump converter — 2	11 kW
	Compressor — 1	15 kW
	Compressor — 2	15 kW
	Battery charger	12 kVA
	Total	73.4 kW

When BUR-3 Isolated

BUR-1		
	Traction motor blower- 1	25 kW
	Traction motor blower -2	25 kW
	Oil cooler blower-1	25 kW
	Qil cooler blower-2	25 kW
	Scavenge blower -1	3 kW
	Scavenge blower — 2	3 kW
	Total	106 kW

BUR-2		
	Qil pump transformer — 1	4.7 kW
	Oil pump transformer -2	4.7 kW
	Oil pump converter — 1	11 kW
	Oil pump converter — 2	11 kW
	Compressor — 1	15 kW
	Compressor — 2	15 kW
	Battery charger	12 kVA
	Total	73.4 kW

Annexure-7

Power Requirement with Different Coach Combinations with HOG System

Type	Coach Combination	**Existing Connected Load in kW***	**Power Requirement at 0.8 Diversity Factor (in kW)**
24 Coach Rajdhani	AC-20, POWERCAR-2, PANTRY-2	932	745.6
19 Coach Rajdhani	AC-15, POWERCAR-2, PANTRY-2	742	593.6
12 Coach Shatabdi	AC-9, POWERCAR-2, PANTRY-2	440	352

* Considered power factor for inductive load is 0.7.

The types of load in detail for each and every type of coaches are given below:

	Connected load calculation for LHB type coaches 1-AC			
SN	**Component**	**Power (Watt)**	**Qty.**	**Total Connected Load (Watts)**
1	**Anti-skid device**	48	1	48
2	**Fan**			
2.1	Exhaust fan	132	2	264
3	**Pantry equipment**			
3.1	Hot case	1200	1	1200
3.2	Bottle Cooler /refrigeration	800	1	800
4	**Switch BD cabinet**	500	1	500
5	**Coach lighting**			
5.1	Lightings 40 Watts	40	9	360
5.2	Lighings 20 Watts			
5.3	Single Comt.+ vastibule +Door Way	20	17	340
5.4	Reading Light	10	24	240
5.5	Toilet Occupied Light	16	4	64
5.6	Lav. Light	16	4	64
6	**AC System**			
6.1	AC unit	13600	2	27200
6.2	Control Panel	140	1	140
7	**Sanitary System**			
7.1	WC Control System (24V)	40	4	160
7.2	Water Pump	220	1	220
7.3	Magnetic Valves	8	6	48
7.4	Electric Shaver Socket	20	4	80
8	**PA System**			
8.1	Loud Speaker Equipments	60	1	60

9	**Electric Car Equipments**			
9.1	Battery Charger	6160	1	6160
Total Load				37948
				37.95 kW

	Connected Load Calculation Forlhbtype Coaches 2-AC			
SN	**Component**	**Power (Watt)**	**Qty.**	**Total Connected Load (Watts)**
1	**Anti-Skid device**	48	1	48
2	**Fan**			
2.1	Exhaust Fan	132	2	264
3	**Pantry Equipment**			
3.1	Hot Case	1200	1	1200
3.2	Bottle Cooler /Refrigeration	800	1	800
4	**Switch BD Cabinet**	500	1	500
5	**Coach Lighting**			
5.1	Lightings 40 Watts	40	9	360
5.2	Lighings 20 Watts			
5.3	Single Comt.+ vastibule +Door way	20	15	300
5.4	Reading Light	10	52	520
5.5	Toilet Occupied Light	16	4	64
5.6	Lav. Light	16	4	64
6	**AC System**			
6.1	AC Unit	13600	2	27200
6.2	Control Panel	140	1	140
7	**Sanitary System**			
7.1	WC Control System (24V)	40	4	160
7.2	Water Pump	220	1	220
7.3	Magnetic Valves	8	6	48
7.4	Electric Shaver Socket	20	4	80
8	**PA System**			
8.1	Loud Speaker Equipments	60	1	60
9	**Electric Car Equipments**			
9.1	Battery Charger	6160	1	6160
Total Load				38188
				38.2 kW

	Connected Load Calculation For LHB Type Coaches 3-AC			
SN	**Component**	**Power (Watt)**	**Qty.**	**Total Connected Load (Watts)**
1	**Anti-Skid Device**	48	1	48
2	**Fan**			
2.1	Exhaust Fan	132	2	264

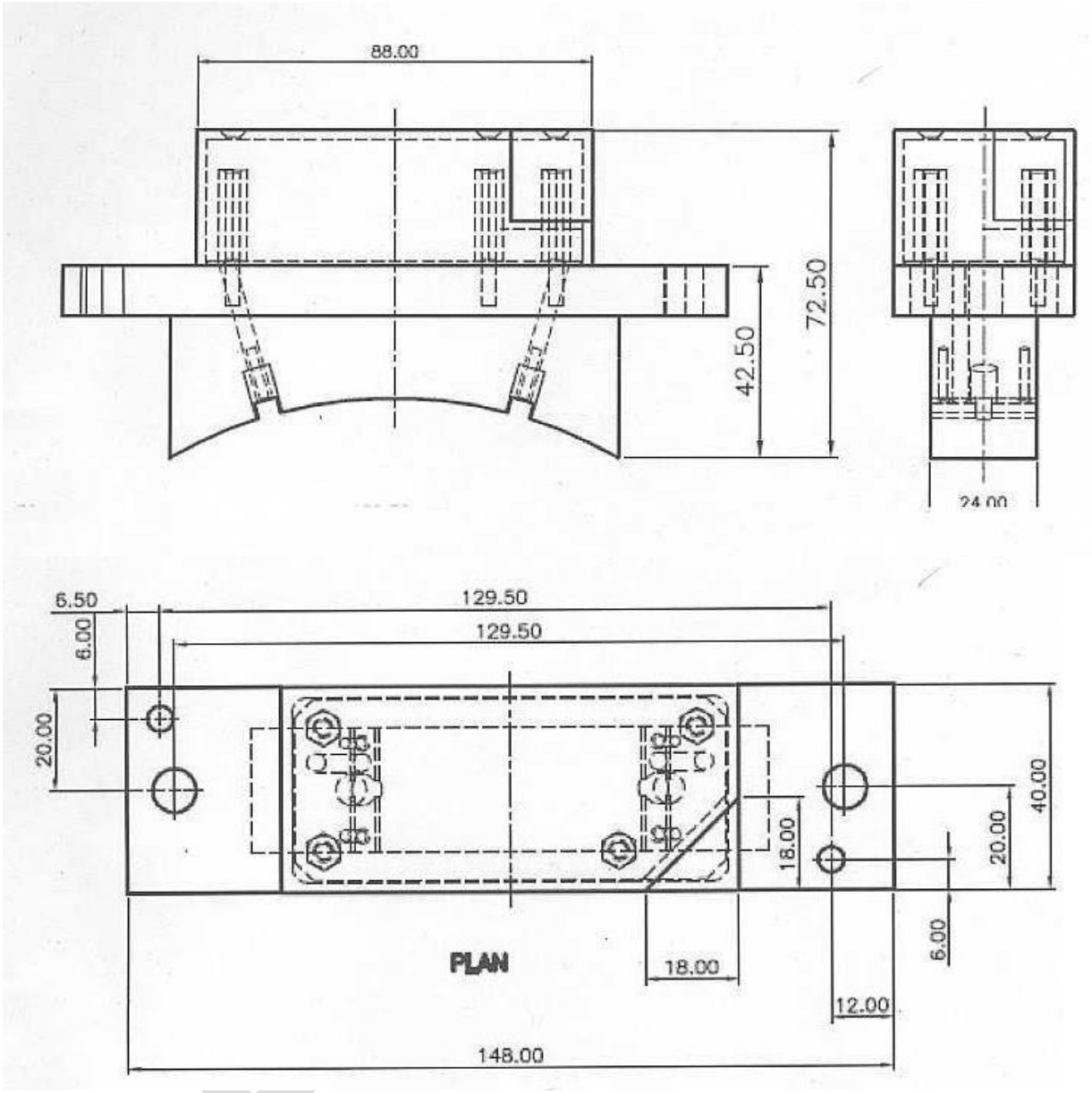
3	**Pantry Equipment**			
3.1	Hot Case	1200	1	1200
3.2	Bottle Cooler /Refrigeration	800	1	800
4	**SWITCH BD CABINET**	500	1	500
5	**Coach Lighting**			
5.1	Lightings 40 Watts	40	9	360
5.2	Lighings 20 Watts			
5.3	Single Comt.+ Vastibule +Door way	20	10	200
5.4	Reading Light	10	24	240
5.5	Toilet Occupied Light	16	4	64
5.6	Lav. Light	16	4	64
6	**AC System**			
6.1	AC Unit	13600	2	27200
6.2	Control Panel	140	1	140
7	**Sanitary System**			
7.1	WC Control System (24V)	40	4	160
7.2	Water Pump	220	1	220
7.3	Magnetic Valves	8	6	48
7.4	Electric Shaver Socket	20	4	80
8	**PA System**			
8.1	Loud Speaker Equipments	60	1	60
9	**Electric Car Equipments**			
9.1	Battery Charger	6160	1	6160
Total Load				37568
				37.57 kW

Connected Load Calculation for LHB Type Pantry Car (Hot Buffet)							
SN	**Component**	Power (Watt)	Qty.	3-PH AC/415V (Watt)	1-PH AC/240V (Watt)	1-PH AC/110V (Watt)	DC/110V (Watt)
1	**Anti-Skid Device**	48	1	0	0	0	48
2	**Fan**						
2.1	Exhaust Fan	132	2	264	0		0
3	**Pantry Equipment**						
3.1	Hot Case, for 140 Meal	1500	1	0	1500	0	0
3.2	Bottle Cooler 90 Ltrs	200	1	0	200	0	0
3.3	Refrigerator 310 Ltrs	300	1		300		
3.4	Deep Freezer, 230 Ltrs	400	1		400		
3.5	Oven Toster Grill	1200	2		2400		

3.6	Water Boiler-1,2&3	3000	3		9000		
3.7	Electric Burner-1	2000	2		4000		
3.8	Electric Burner-2 &3	2000	2		4000		
3.9	Electric Burner-4	5100			5100		
3.10	Electrical Chimney-1, 2 & 3	300	3		900		
3.11	Insect Killer	20	2		40		
3.12	Waterfilter	200	1		200		
SUB TOTAL OF PANTRY					28040		
4	**Switch Board Cabinet**	500	1	0	0	0	500
5	**Coach Lighting**						
5.1	Lightings 40 Watts	40	9	0	0	360	360
5.2	Lighings 20 Watts				0		
5.3	Single Comt.+ Vastibule +	20	15	0	0		300
5.4	Door Way				0		
5.5	Lav Light	16	2	0	0	32	0
5.6	Toilet Occupied Light	16	2	0	0	0	32
6	**AC System**						
6.1	Ac Unit	13600	2	27200	0	0	0
6.2	Control Panel	140	1	0	0	0	140
7	**Sanitary System**						
7.1	Wc Control System (24v)	40	2	0	0	0	80
7.2	Water Pump	220	1	220	0	0	0
7.3	Magnetic Valves	8	6	0	0	0	0
7.4	Electric Shaver Socket	20	2	0	0	0	40
8	**PA System**						
8.1	Loud Speaker Equipments	60	1	0	0	0	60
9	**Electric Car Equipments**						
9.1	Battery Charger	6160	1	6160	0	0	0
Sub Total				33844	28044	392	1608
Total Load				62276			
				62.276kW			

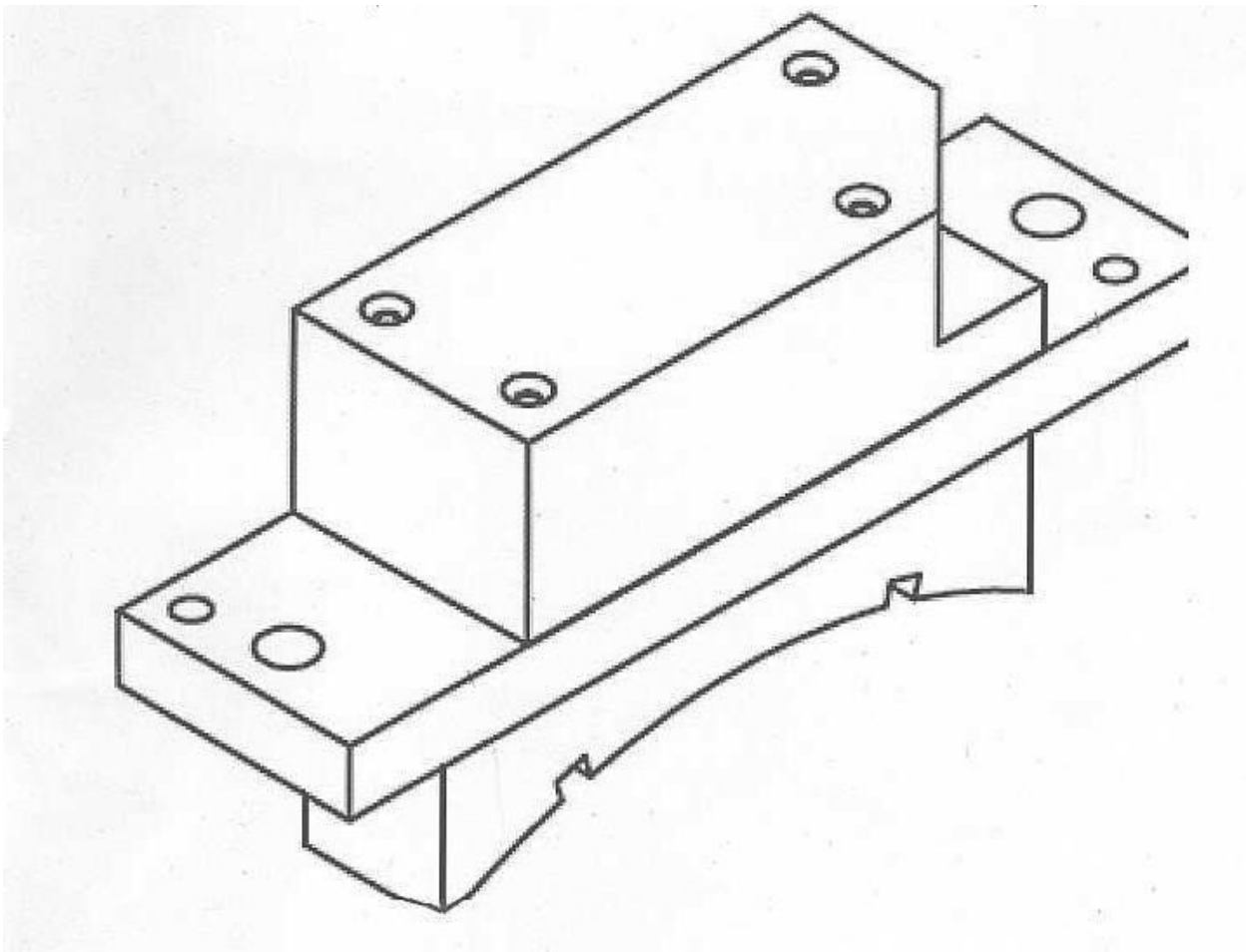
Annexure-8/1

Drawing of the Active speed sensor



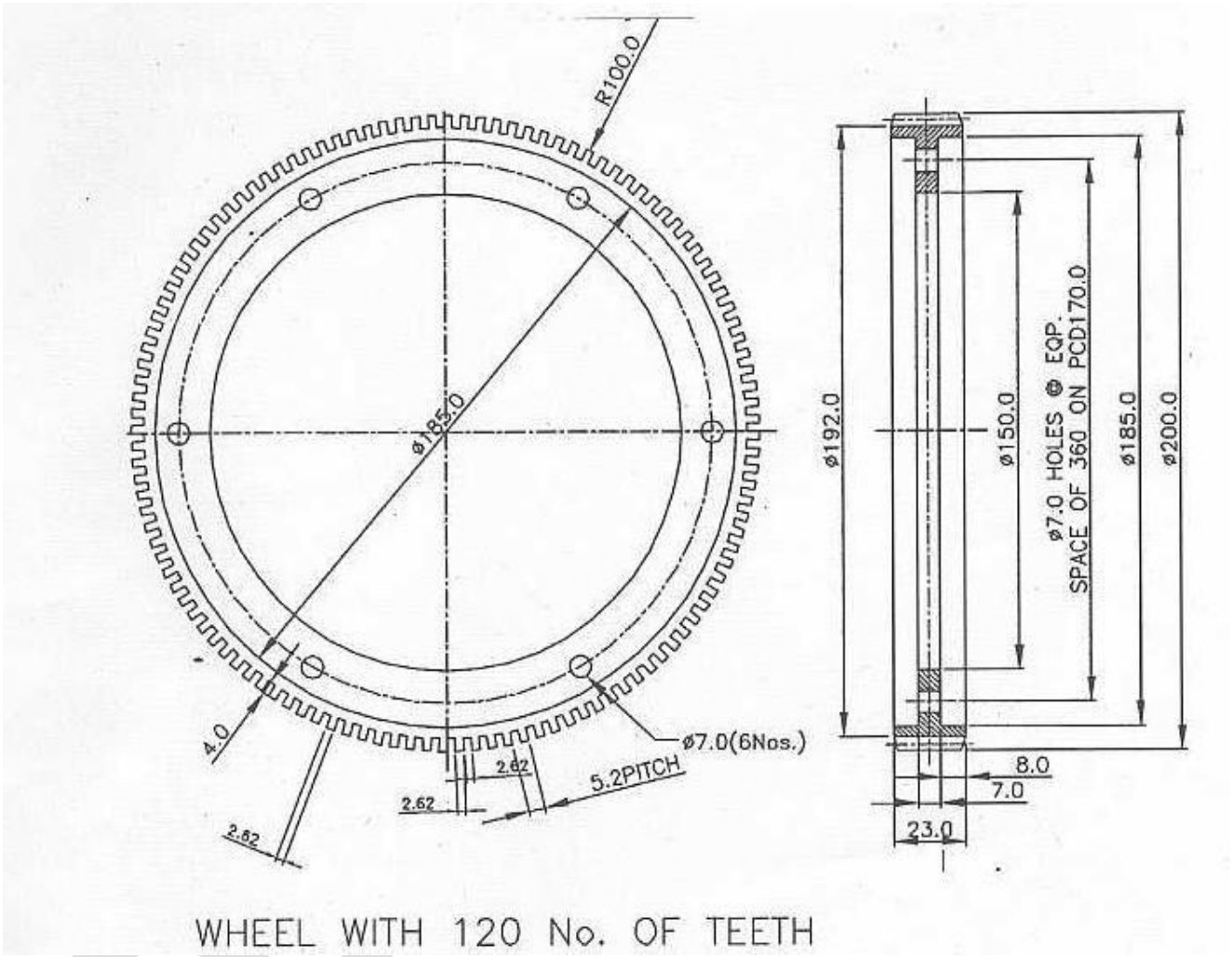
Annexure-8/2

Isometric view of Speed Sensor



Annexure-9

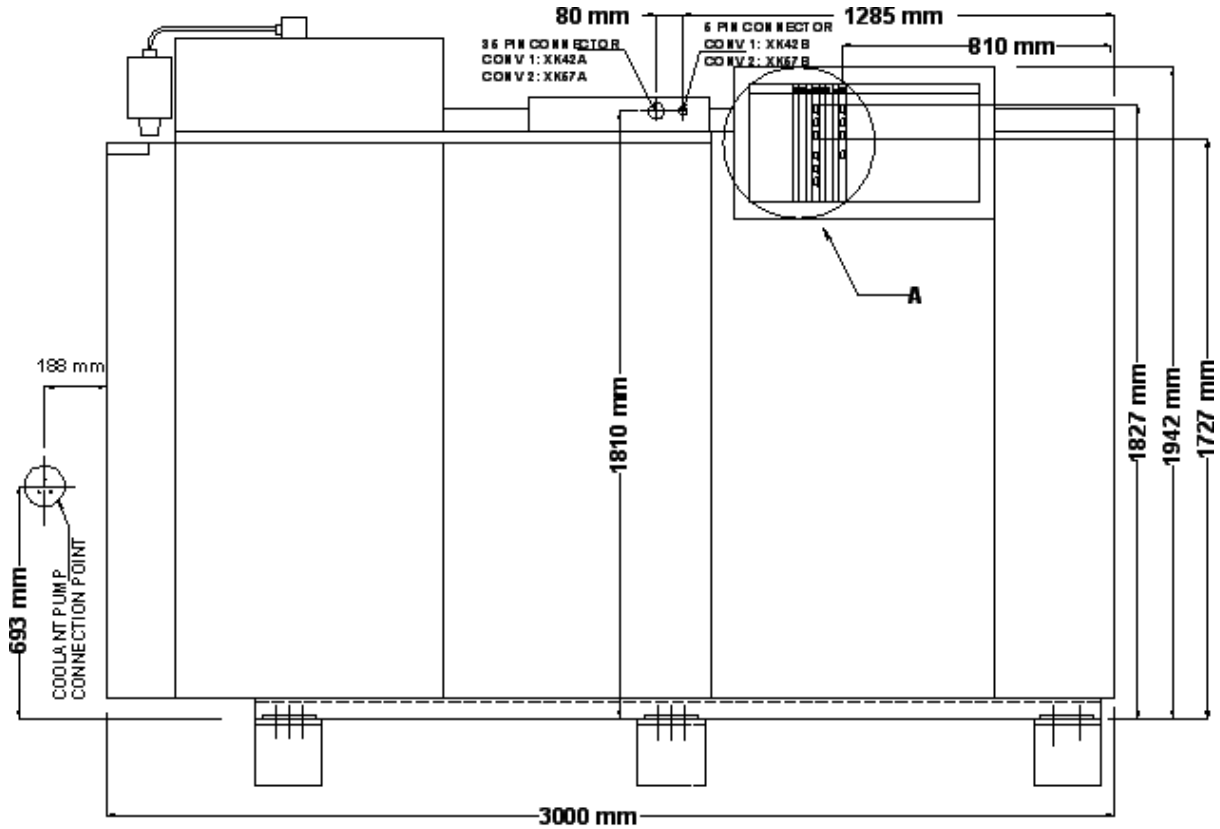
Drawing of the tooth wheel ring

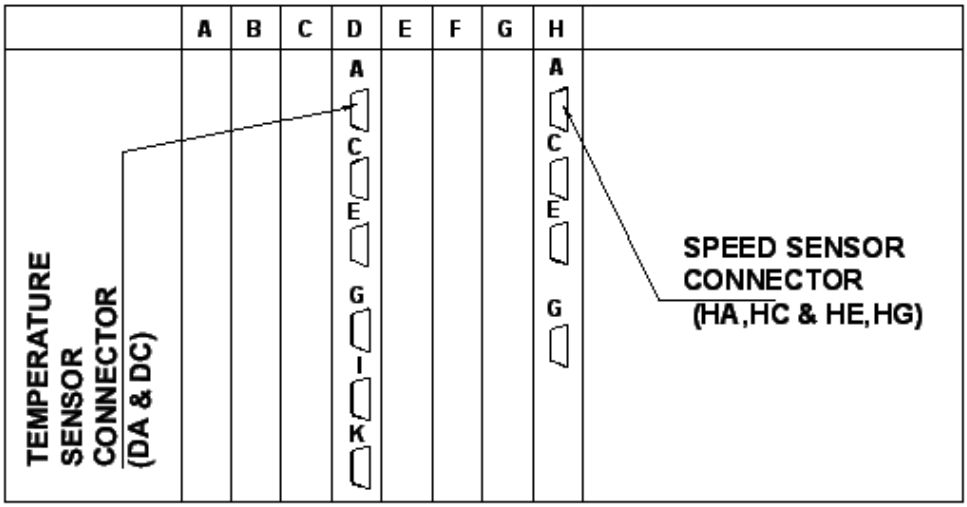


SPECIFICATION FOR UPGRADATION KIT FOR IGBT BASED INTEGRATED CONVERTER WITH TRACTION CONVERTER AND 2X750KVA HOTEL LOAD CONVERTER FOR WAP-7 LOCOMOTIVE	PREP.BY. SSE/D&D	CHECKED .BY SEE/D&D	CENTRE FOR DESIGN & DEVELOPMENT CHITTARANJAN LOCOMOTIVE WORKS NO: CLW/ES/03/0556, Rev. '0'						
	ISSUED BY DY. CEE/D&D-I		ALT						

Annexure – 10

Drawing showing location of various connectors for control cable & pump used in GTO convertor

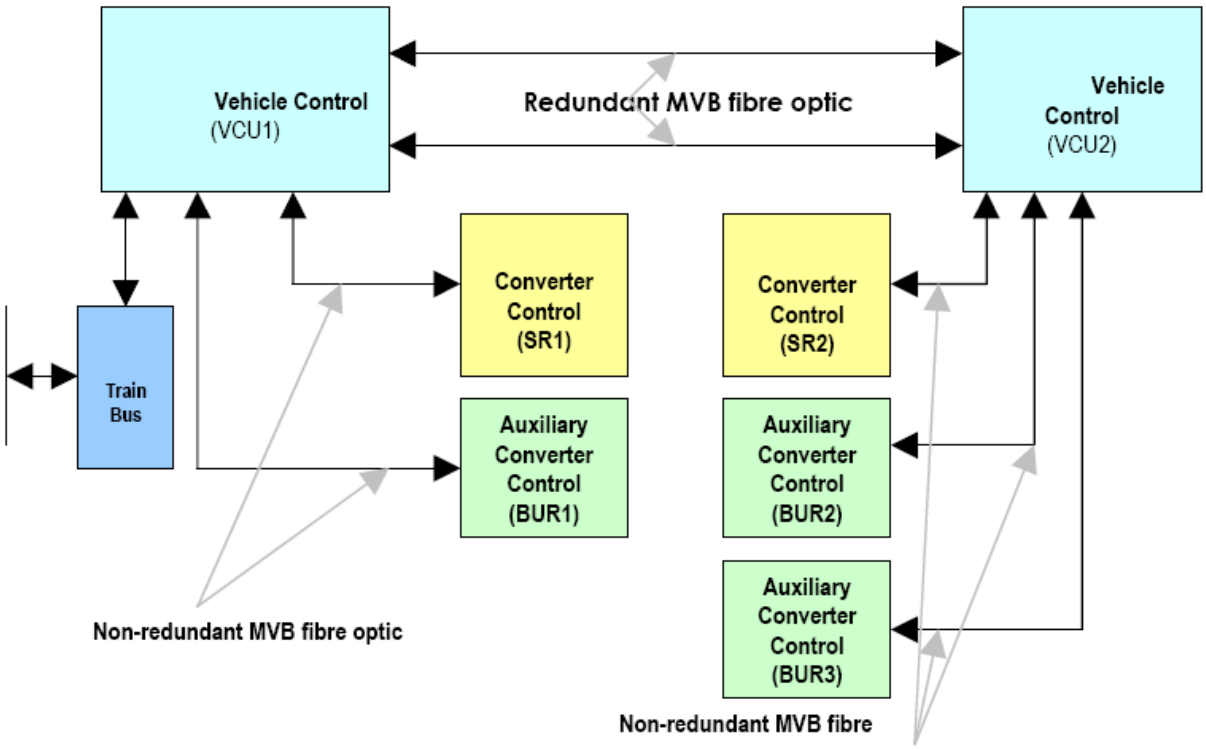




DETAILS OF A

Annexure-11

Interconnection of VCU with Traction and Auxiliary Converter



Indicative Schematic