INDIAN RAILWAYS
CHITTARANJAN LOCOMOTIVE WORKS
CHITTARANJAN

SPECIFICATION FOR IGBT BASED COMPOSITE CONVERTER WITH TRACTION CONVERTER AND HOTEL LOAD *CONVERTER* FOR THREE PHASE CO-CO WAP-7 LOCOMOTIVES

SPECIFICATION NO - CLW/ES/3/IGBT/0518 ALT-C

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ALTERATION RECORD SHEET

Amendment in clause no.	Date of amendment	Page No	Alteration	Changes
2.1.10	11-01-2012	10	A	Clause 2.1.10 is appeared twice. The clause 2.1.10 to 2.1.17 are corrected and renumbered.
2.9.3	11-01-2012	17	A	Clause 2.9.3 is renumbered by 2.9.2.
Chapter 4 and Sl. No. 4	11-01-2012	19	A	The line “200 tooth wheel ring” is replaced by “120 tooth wheel ring”.
Chapter 4 and Sl. No. 10	11-01-2012	19	A	Quantity in man hours is replaced by 75 man days.
Chapter 4 and Sl. No. 11	11-01-2012	19	A	Quantity in man hours is replaced by 25 man days.
5.4	11-01-2012	10	A	Clause 5.4 is appeared twice. The clause is corrected.
1.2,1.3,1.6	Aug.-2015	04-05	B	Clauses have been modified
2.1.2	Aug.-2015	09	B	Clause has been modified
2.1.7	Aug.-2015	10	B	Clause has been modified
2.1.18	Aug.-2015	10	B	Clause has been deleted
2.2.3,2.2.5	Aug.-2015	12	B	Clauses have been modified
2.2.6,2.2.7	Aug.-2015	13	B	Clauses have been modified
2.3.2,2.3.3,2.3.8 and 2.3.10	Aug.-2015	14	B	Clauses have been modified
2.3.12, 2.3.13	Aug.-2015	15	B	Clauses have been modified
2.3.16,2.3.17, 2.3.18, 2.3.19	Aug.-2015	15-16	B	Clauses have been added
2.7, 2.8	Aug.-2015	17-18	B	Clauses have been modified
2.9.1	Aug.-2015	18	B	Clause has been modified
2.10,2.11	Aug.-2015	19	B	Clauses have been added
2.12, 2.13	Aug.-2015	19-20	B	Clauses have been added
2.14,2.15	Aug.-2015	20-21	B	Clauses have been added
Chapter 4	Aug.-2015	23-24	B	Chapter has been modified
5.4 and 5.7	Aug.-2015	25-26	B	Clauses have been modified
Appendix-2	Aug.-2015	30	B	Appendix has been modified
Appendix-3	Aug.-2015	31	B	Appendix has been modified
Appendix-6	Aug.-2015	34-38	B	Appendix has been modified
Appendix-9	Aug.-2015	42	B	Appendix has been added
	March-2025		C	Bo-Bo is changed to Co-Co and WAP5 is changed to WAP-7 in all places of the specification
1.1,1.4,1.7,2.2.4(iii),	March-2025		C	Appendix has been modified
1.2	March-2025		C	Motor rating is changed
1.6	March-2025		C	Motor type is changed
2.1.2	March-2025		C	Hotel Load Converter rating is changed from 500 kVA to 600kVA. Voltage range is changed.

2.2	March-2025		C	Characteristics curve of WAP5 is changed to WAP-7 locomotives
2.2.5	March-2025		C	Two new more messages added and 'Optional' option deleted
2.2.8	March-2025		C	Clause (v) and (vi) added
2.3.3	March-2025		C	Capacity is changed to 600kVA.Tolerance level of output voltage modified. A 'Note' is added. Voltage range for 600kVA is changed. Direct on load starting current modified. Construction: Modular is added
2.3.6	March-2025		C	Appendix has been modified during panto bouncing period
2.4	March-2025		C	New protection features added
2.12	March-2025		C	Length of power cables are changed
2.13	March-2025		C	Length of control cables are changed
5.1	March-2025		C	Test conditions are modified
5.7	March-2025		C	Test condition for Hotel Load Converter is added under rated load test
Appendix-1	March-2025		C	Salient data of locomotive is changed
Appendix-3	March-2025		C	Characteristics of Traction Motors is changed

'Table of Contents'

CHAPTER 1- GENERAL

1.0 This specification deals with the design, development, supply, installation, commissioning & field validation of Composite Converter having IGBT based traction converter and hotel load converter for WAP-7 class of Co-Co locomotive plying on Indian Railways.

1.1 Indian Railways is currently manufacturing WAP-7 locomotive with Standalone HOG Converter of 2X500kVA. In addition, IR also plans to implement the composite converter in order to use the HOG of 2X600kVA in WAP-7 locomotives. This specification defines requirements of IGBT based composite converter having both traction converter and hotel load converter including all necessary adaptations.

1.2 IGBT based composite converter to be used in Co-Co locomotive shall have two line converters, a DC link and three drive side converter to feed independently three ~~two~~ traction motors of 850 kW capacity in Co-Co WAP-7 types locomotives and a separate hotel load converter fed from the hotel load winding of traction transformer. The proposed composite converter shall be designed and accommodated within the space available on the WAP-7 locomotive. The composite converter having both traction converter and hotel load converter shall be in same cubicle. The composite converter, output contactors and filters shall preferably fit in the existing foot print of the IGBT converter. However additional space of approximate 300 mm lengths available between the converter and machine room blower can be utilised for this purpose keeping maintainability of the converter and machine room blower in view.

1.3 The hotel load converter shall have output of 750 V, 3-Phase 50 Hz supply which is required for feeding the coach load of the train through Inter Vehicular Coupler (IVC). Hotel load inverter output shall further be stepped down to 415 V, 3-phase AC by existing transformers provided in every coach. This electrical power shall be used to operate the lights, fans, air conditioning, water raising apparatus, etc of the coaches and the pantry car equipments.

1.4 The IGBT version shall also be compatible to MICAS-S2 based Vehicle Control Electronics (VCU) and suitable for retro fitment on existing 3 phase WAP-7 locomotives working in field.

1.5 IR may also intends to go for open control system for vehicle control and would like to integrate, in future, the traction converter and hotel load converter with the vehicle control electronics on a bus system conforming to published open standard. The Supplier shall keep this aspect in view while designing the composite converter.

1.6 The existing three phase traction motors 6FRA 6068 shall be retained and transformer LOT 7775 KVA as per CLW specification No. CLW/ES/3/0660 with latest alteration with two separate hotel load windings each capacity of 622.5 kVA, 960 V shall be used for input supply of hotel load converters. Two series resonant chokes available in the transformer also shall be used. The leading characteristics of WAP-7 locomotive, transformer LOT 7775 KVA and traction motor 6FRA 6068 are appended at Appendix 1, 2 and 3 respectively. The existing choke inside the transformer may be utilised, if use of the choke is necessary.

1.7 The Tenderer is expected to study in detail the existing interface of the IGBT Converter with the remaining equipment on the locomotive (e.g., traction motor, it's speed and temperature sensors, transformer with it's series resonant choke, harmonic filter, cooling arrangement, Vehicle Control Unit etc.). The Tenderer is also expected to study in detail the existing machine room layout, ducting, cable routing etc. on the locomotive. Site visit for this purpose shall be arranged on prior intimation to CLW. It shall be deemed that the firm knows all the relevant aspects at the time of submitting offer.

1.8 ABBREVIATIONS AND DEFINITIONS

IR - Indian Railways
RDSO - Research Designs & Standards Organisation
CLW - Chittaranjan Locomotive Works
Tenderer - Firm/companies participating in the tender
Supplier - The successful tenderer for supply of the equipment
VCU - Vehicle Control Unit
GTO - Gate Turn Off Thyristor
IGBT - Insulated Gate Bipolar Transistor
BOM - Bill of Material
VCB - Vacuum circuit Breaker
TM - Traction Motor
CON - Converter
Aux - Auxiliaries
FLG - Fahrzeulelt gert (German) – Engl. VCU – Vehicle Control Unit
SLG - Engine Control Unit
DCU - Drive Control Unit
TE/BE - Tractive effort/Braking effort
S&T - Signal and Telecommunication
IVC - Inter Vehicular Couplers
AFTC - Audio Frequency Track Circuiting
OEM - Original Equipment Manufacturer
MCB - Miniature Circuit Breaker
HB - Auxiliary circuit cubicle
TCN - Train Communication Network
BLHO - Switch for hotel load converter
Tenderer - Firm/companies participating in the tender
Supplier -The person, firm or company with whom the order for supply of the work has been placed.
Sub Supplier - Any person, firm or company from whom the supplier may obtain any materials or fittings to be used for the works
Purchaser - The President of the Republic of India as represented by the Railways organisation entering into the contract
Inspecting Officer- The person, firm or department nominated to inspect the converters or the representative of the inspecting officer so nominated.
ToT documents- Transfer of technology documents for GTO based traction converter.

1.9 STANDARDS

This Specification is based on the following normative references. In addition to the following, relevant ToT documents shall also be referred wherever required.

Standards	Title
IEC 60077-1	Railway applications – Rolling Stock General Rules
IEC 61287-1	Railway applications – Power converters installed on rolling stock
IEC 60571	Specific rules concerning the electronic control part of converters.
IEC 61373	Railway applications – Rolling stock equipment – shock and vibration test
IEC 60310	Traction transformers and inductors on board rolling stock
EN 50121-3-2 (CENELEC)	Railway applications – Electromagnetic compatibility Part 3-2: Rolling stock - Apparatus
EN 50121-2 (CENELEC)	Railway applications – Electromagnetic compatibility Part 2 : Emission of the whole railway system to the outside world.
IEC –61375-1	Electric Railway Equipment-Train Bus Part –1 : Train communication network.
EN 50153	Railway applications – Rolling stock – Protective actions against electrical hazards.
EN 60529	Protection classes of cases (IP-Code)

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

1.10 **DOCUMENTATION**

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

- Schematic Circuit;
- functional description;
- system design concept;
- communication protocol and software structure description along with compatibility with the locomotive control system;
- cooling design;
- mechanical interface diagram and compliance to existing mechanics;
- clause by clause compliance of this specification;
- credentials with details of supply made of similar items;
- data sheets for devices and other equipment proposed alongwith detailed description of supply proposed;
- Thermal calculation of power devices;
- salient features and advantages of the offered system;
- details of technical support and training offered, the training shall cover on assembly, testing, commissioning, operation, maintenance and repair to IR personnel and training shall also cover in software parameter settings, fault diagnostic and analysis;

- ❖ recommended list of spares for 3-year maintenance after warranty alongwith full drawing/design and details of OEM;
- ❖ list of special tools, jigs and fixtures needed for assembly, testing, commissioning, maintenance and repair alongwith full technical specifications and probable suppliers;
- ❖ logistics proposed for warranty support within India;
- ❖ declaration for long-term support by the tenderer; and
- ❖ IRIS/ISO 9001 certification.

1.11 The Supplier shall submit the design details, including but not limited to the following, to RDSO and CLW before commencing manufacturing. Only on getting the approval from RDSO in writing should the production begin.

- ❖ Technical documentation explaining the complete scheme, characteristics, diagnostics, protection and control etc.;
- ❖ detailed drawings of each system/sub-system with interface details;
- ❖ design calculations for selection of devices, cooling systems and various subsystems, establishing the adequacy of the components selected;
- ❖ complete BOM / technical specification of components with source of supply;
- ❖ cooling system design description, data and cooling fluid data;
- ❖ mechanical drawings, mounting arrangement, weight, details of mounting accessories;
- ❖ procedure for parameter alteration, software downloading, diagnostic uploading, analysis etc.;
- ❖ schedule maintenance activities with periodicity;
- ❖ maintenance, trouble shooting and repair manual in soft form & hard copy;
- ❖ guaranteed values of efficiency of devices/subassemblies and assemblies;
- ❖ calculation to withstand short circuit current under fault conditions;
- ❖ details of short time rating of the converter;
- ❖ expected efficiency with respect to vehicle load/speed alongwith calculations;
- ❖ calculation and simulation results of system behaviour, including interference to the S&T circuits;
- ❖ all calculations evaluated on the basis of software simulations shall be supported by sample calculations; and
- ❖ shall details of tools and plants with design/drawings and supplies.
- ❖ Interfacing and control scheme of hotel load converter with power car.

Approval of design means approval of general design features. Notwithstanding the approval, the Supplier shall wholly and completely be responsible for the performance of the complete equipment.

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

1.12 **INFRINGEMENT OF PATENT RIGHTS:**

Indian Railway shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, components used in design, development and manufacturing of inverter and any other factor, which may be cause of such dispute. The responsibility to settle any issue lies with the manufacturer.

1.13 **SUPPLIER'S RESPONSIBILITY:**

The supplier's responsibility shall be extended to the following:

The supplier shall supply detailed instructions for proper installation of the equipment on the locomotive. For this purpose the supplier shall also depute his representative during installation and commissioning of the composite converter in the locomotive.

The supplier shall arrange to carry out detailed test and performance proving jointly with CLW.

The supplier shall supply special tools, testing jigs, and instruments, which may be required for troubleshooting and maintenance of the converter.

The supplier shall also submit on demand repair charges for the cards. A separate contract shall be executed by the Railways with the supplier for the repairs.

The supplier shall supply suitable software for off-line analysis of diagnostic data downloaded from the composite converter.

The design shall be developed as per requirement given in this Specification.

CHAPTER 2- TECHNICAL SPECIFICATION

2.1 GENERAL

2.1.1 The overhead voltage is 25kV AC 50Hz, single phase. The supply voltage is fed to the traction transformer through a Vacuum Circuit Breaker (VCB). The transformer output is to be connected to the composite converter. The overhead traction supply is subjected to variations as under:

Nominal Voltage	- 25 kV AC
Maximum Voltage	- 27.5 kV AC
Minimum Voltage	- 19 kV AC
Occasional Maximum	- 31 kV AC
Occasional Minimum	-16.5kV AC
Supply Frequency	- 50Hz± 8%

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

2.1.2 The traction converter shall deliver constant power of 2105 kW* between 22.5 kV and 30 kV of OHE voltage. The design calculation shall establish the same. The variation of power above 30 kV and below 22.5 kV shall be submitted for traction converter. The hotel load converter shall deliver constant power of 600 kVA between 21 kV and 30 kV of OHE voltage. The design calculation shall establish the same. However, design calculations shall be based on OHE voltage of 22.5 kV.

*Note: The capacity of traction converter shall be such that, by using two such composite converters in one WAP-7 locomotive, power requirement at wheel of WAP-7 locomotive, as indicated in Appendix 1, is achieved.

2.1.3 The system and equipments shall be of proven latest technology specially adopted for application to meet the performance requirements under environmental conditions specified in this Chapter 3. Adequate margin shall be built in the design, particularly to take care of condition of high ambient temperatures, dusty condition, high humidity prevailing in India.

2.1.4 The composite converter shall be designed and operated to achieve near unity power factor within the line voltage range from 19 kV to 30 kV at all speeds of operation of the locomotive and minimum harmonic interference current. The maximum interference current permitted is specified in Para 2.6 of this Specification

2.1.5 In design and construction, reliability and maintainability shall be of paramount consideration. Tenderer shall submit reliability calculations indicating MTBF for different devices, cards and sub-assemblies. Adequate margin shall be provided to take into account ambient conditions prevailing in India. The components shall be sourced from reputed firms.

2.1.6 High efficiency of equipment shall be important consideration, next only to high reliability. The components and technology used shall ensure very high efficiency of the converter. Tenderer shall furnish the expected efficiency with respect to vehicle load/speed with necessary calculations.

2.1.7 Modular constructions shall be adopted wherever considered possible. Easy access for inspection/maintenance and minimum maintenance requirement shall be given special consideration in design and layout. Composite Converter shall be designed in such a way that main Transformer bushings are visible after opening of Composite Converter front door to check any oil leakage from bushing.

2.1.8 Converter control electronics and IGBT modules enclosures shall comply IP 54. The panel sheet used for fabrication of enclosure shall be of steel as per IRSM 41-97 of minimum thickness 2.0 mm with corrosion resistance coating. To have a light weight door, the aluminium alloy material may be used and number of fixing bolts to be restricted to maximum quantity to say 10 nos. per door.

2.1.9 Semi conductor devices rating shall be selected so as to provide margin of 25% vis-à-vis design/calculated current and voltage values under worst operating conditions after taking into account voltage jumps and current surges on account of inductance and capacitance in the circuit.

2.1.10 The design calculations of worst case temperature rise of equipment shall be made. A safety margin of at least 10°C shall be kept with respect to maximum permissible junction temperature of power devices declared by the manufacturer.

2.1.11 The converter/inverter system shall be capable of withstanding the maximum short circuit current under fault conditions and these shall be established through calculations. The converter/inverter system shall also be designed to withstand extreme disturbances like short-circuit/open circuit etc. at all points of input/output interfaces with locomotive, without any failure.

2.1.12 All equipment shall be adequately earthed, insulated, screened or enclosed. They shall be provided with essential interlocks and keys as may be adequate to ensure the protection of the equipment and safety of those concerned with its operation and maintenance.

2.1.13 The electronic card shall be mechanically coded to ensure that insertion of card in wrong slot is not possible.

2.1.14 All the proposed equipments shall not violate the given space envelopes of the equipment to be replaced.

2.1.15 Existing principle of the machine room ventilation shall be kept unchanged. The Supplier can propose enhancements on the system if indicated for better reliability of the whole system.

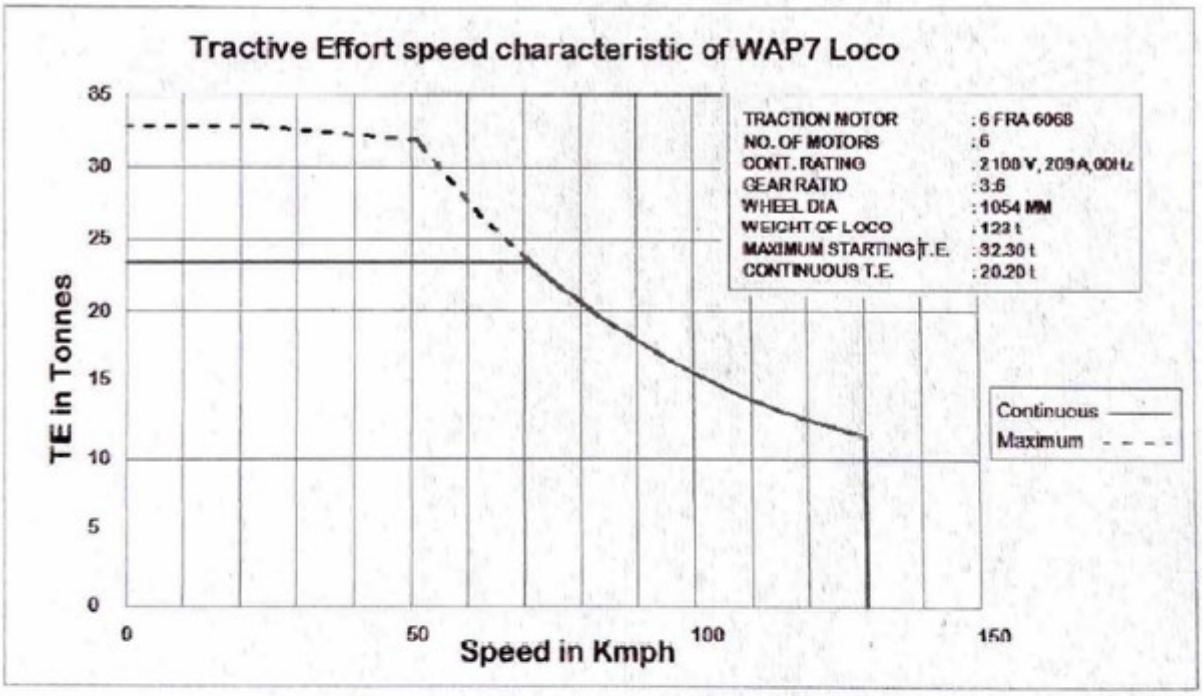
2.1.16 The electronics of the traction converter and hotel load converter shall be suitably placed to avoid the effect of heat radiation of sun coming from roof top of the locomotive.

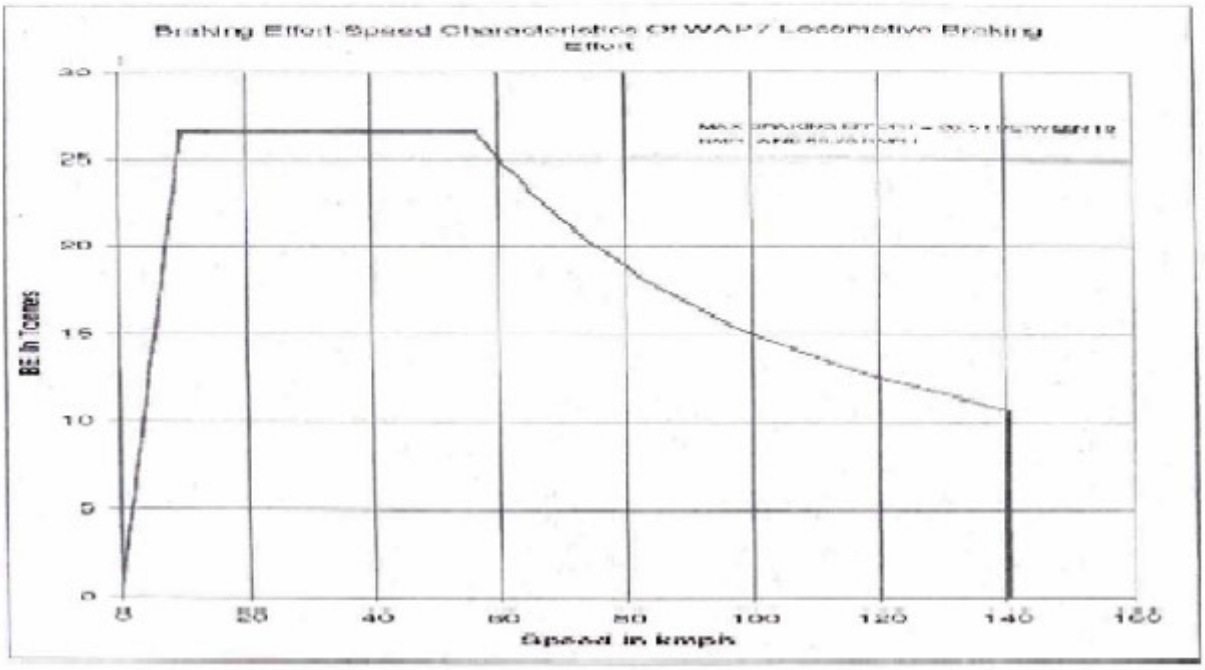
2.1.17 Existing motor and gear shall be retained. The Supplier shall provide IR with all necessary manufacturing drawings for necessary adaptations.

2.1.18 Harmonic winding provided in the transformer may be removed by IR. Hence system shall be designed considering this aspect.

2.2 TRACTION CONVERTER

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





SPECIFICATION FOR IGBT BASED COMPOSITE CONVERTER WITH TRACTION CONVERTER AND HOTEL LOAD CONVERTER FOR 3-PHASE CO-CO WAP-7 LOCOMOTIVES	PREP.BY. SSE/D&D	CHECKED .BY SEE/D&D	CENTRE FOR DESIGN & DEVELOPMENT CHITTARANJAN LOCOMOTIVE WORKS NO: CLW/ES/3/IGBT/0518						
	ISSUED BY DY. CEE/D&D-I		ALT	A	**B**	C			

With adoption of IGBT based traction 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.

2.2.2 Adhesion requirements.

The design of the adhesion control shall be optimised for maximum utilisation of adhesion factor and should be such that it is capable of generating the required starting tractive effort on WAP-7 locomotives under dry rail conditions. 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 adhesion control system shall be capable of giving high adhesion through a wheel slip control system of proven performance. The objective should be to maximise the delivered draw bar pull through control system in conjunction with sanding. The achievable running adhesion characteristics shall be made available. The formulae for linking adhesion characteristics with the operating speed shall be indicated.

The transformer output voltage for traction load winding shall vary in accordance with the overhead supply. The details of the VCB and transformer used are given in Appendix-4 and Appendix-2 respectively. The converter shall be designed to withstand the voltage variations mentioned above.

2.2.3 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 appendix-7.
- Tooth wheel with existing mechanical interface. The drawing of the tooth wheel is provided in appendix-8.
- 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 Appendix-9. 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.

  Firm has to take prior approval for the speed sensor & connectors from RDSO.

2.2.4 Desired control scheme

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

(i) independent drive converter per axle;

(iii) 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 ~~minimised~~; and

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

2.2.5 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 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.

2.2.6 Existing input power connection from transformer terminal to converter terminal shall have to be used. Supplier shall use same transformer links and flexible links as per latest CLW specification no CLW/ES/3/0138.

2.2.7 Existing MCB of 16A in HB panel shall be used for power supply of pump/fan etc, in the Traction Converter.
No MCBs shall be used inside the Traction Converter. Standard cable length as in GTO loco shall be adopted for cooling pump connection. Drawing for location of pump connection point at converter end is given in Appendix-9.

Loom no.	Cable length(m)
230	13.5
341	14.5

2.2.8 In the event of breakdown of any component or basic unit of the traction 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 (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;

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

The power of the locomotive shall be reduced only by 1/6th, only isolating the failed equipment;

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

The power of the Locomotive shall be reduced only by 1/6th, only isolating the failed equipment; and

(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

(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.

2.2.9 Traction Converter Output

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 is entirely suitable for the existing traction motors. It is desired that the motor converter shall generate the 3-phase output with higher pulsating frequencies and improved pulse pattern.

2.3 HOTEL LOAD *CONVERTER*

2.3.1 Hotel load converter shall be integrated part of the proposed composite converter suitable for supply power to hotel load of coaches.

2.3.2 The hotel load converter shall be fed from the separate hotel load winding of the main transformer LOT 7775 kVA with hotel load capacity of 2x622.5 kVA,1-phase at 960 voltage at 25 kV OHE voltage nominal, which shall vary from 16.5kV to 31kV, Frequency-50Hz ±8%.

2.3.3 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 - 2X600 KVA (Two units of 600 KVA per locomotive) at power factor 0.8.
  Note: Rated capacity of each converter shall be 600kVA for OHE voltage range of 21kV to 30kV. However, at OHE voltages below 21kV, the power degradation(kVA) shall be linear in proportion to the voltage reduction such that it

shall not be less than 500kVA at 17.5kV. it shall not be possible to regulate the duty cycle of the loads.

- Efficiency at full load: Not less than 93% at rated input voltage of 960 V.

Note:

- Rated capacity of each converter shall be 600 kVA for OHE voltage range of 21kV to 30kV.
- Input power factor: Shall be close to unity at full load with normal input parameters.
- THD of input current at full load: Less than 5% (up to 20th harmonic).
- 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 900 A (steady state current) of induction motor load for 3 seconds.
- Construction: Modular

2.3.4 It shall not be possible to regulate the duty cycle of the loads.

2.3.5 It shall have to be established with calculations in the offer by the Tenderer that traction converter part of Composite converter will cater the rated power in the OHE voltage range of 22.5 kV to 30 kV.

2.3.6 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 shall be able to supply the rated power without any supply interruption during the pantograph bouncing.

2.3.7 There shall be 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.

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

2.3.9 Approximate total hotel load to be attached with the converter is given in Appendix-6.

2.3.10 Independent control of hotel load converter to be provided so that output of hotel load converter shall be 750V ± 5%, 3Ø sine wave. Any electric disturbance on the of traction converter shall not affect the operation of hotel load converter and vice versa.

2.3.11 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.

2.3.12 If any information is required to be shared with the power car for better operation of the hotel load converter the complete arrangement like supply of cables, connectors, jumper

cables, or any other item required for the same shall be within the scope of supply of the Supplier. The details of such signals shall be decided during the design evaluation stage.

2.3.13 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.

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

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

2.3.16 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.

2.3.17 Fault Indication, Diagnostics and Trouble Shooting.

The faults shall be downloadable on a laptop computer through a standard port /interface. Large capacity of storage of faults along with the background data shall be provided, so that data pertaining to minimum latest 200 faults are kept stored.

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.	Rectifier Fault	In event of fault in Rectifier section
15.	Inverter Fault	In event of fault in Inverter section
16.	Chopper Fault	Chopper section faulty (if design includes

		chopper)
17.	Over Temperature	Any temperature sensing device operated in the Rectifier and Inverter sections
18.	Power Supply Fault	In event of failure of any of the electronic/ control power supply
19.	Chopper Current High	Chopper section current exceeds upper limit (if design includes chopper)
20.	No synchronization/ Communication Error	Communication fault in software
21	XXXXXXXX	Any other faults to be specified in Design Document

2.3.18 Arrangement for recording of energy consumption by Hotel Load Converter. Supplier shall provide necessary arrangement in composite converter to keep record of energy consumed over a period of time through hotel load converter. 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.

2.3.19 Suitable indication for the healthiness of the hotel load converter shall be provided in the driver desk/panel.

2.4 PROTECTION

The devices used in the composite 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
- Open circuit in hotel load winding and no input voltage available
- 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 and 0.5A to 1.5A 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).

2.5 FAULT INDICATION, DIAGNOSTICS AND TROUBLESHOOTING

A suitable fault diagnostics and trouble-shooting arrangement as per functional requirement of 3-phase locomotive shall be provided. Large capacity of storage of faults along with the background data should be provided.

2.6 INTERFERENCE

The harmonic currents injected in the overhead supply system (as also the track return current) can introduce voltage harmonics on power supply and can interfere with signal and telecom circuits. The following interference current in the input current shall not be exceeded at any point in the operating envelope of the locomotive:

	Interference Current	**Limit**
1.0	Psophometric current	10.0 A
2.0	DC component	4.7 A
3.0	Second Harmonic component (100 Hz)	8.5 A
4.0	1400 Hz up to 5000 Hz	400 mA
5.1	>5000 Hz up to 32000 Hz	270 mA
5.2	39500 Hz up to 43500 Hz	270 mA

The Supplier shall undertake FFT (Fast Fourier Transformation) analysis of the total current from 1000Hz to 5000Hz and 5kHz to 50kHz 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. This test shall be included within the tests listed within Chapter 5 and the results shall be provided in type test report.

EN 50238 includes interference current limits for track circuits and axle counters. Where these overall interference current limits are more onerous than those stated above these limits shall be applied.

The Supplier shall submit the simulated values of these interference currents during design evaluation stage.

The existing transformer, which is to be used, is provided with a filter winding as given in the schematic diagram. The resistance and inductance values of the windings have been given in the Appendix – 2. The filter resistor and filter capacitor ratings are 2800 V, 0.45 ohm/20 KW & 0.40 ohm/20KW and 0.133 mF, 2500V, 160A (bank capacity) respectively. During single bogie operation, filter adaptation contactor (8.2) is opened thereby introducing an additional resistor. During normal operation, contactor 8.2 remains closed. The existing harmonic filter shall have to be considered while designing the system for interference limits. It is expected that with higher switching frequency of IGBT, this shall be sufficient to meet the stipulated harmonics requirements.

2.7 MECHANICAL DIMENSIONS AND WEIGHT

Dimensions of the composite converter shall be 3000 X 1100 X 2087 mm (lxdxh). The preferred dimensions of the composite converter shall not exceed the existing foot print and necessary adaptation for installation shall be provided by the Supplier. However additional space of approximate 300 mm lengths available between the converter and machine room blower can be utilized for this purpose keeping maintainability of the converter and machine room blower in view. CLW intends to make use of DC contactors

inside the converter for isolation of individual Traction Motor in future. This aspect may be taken into consideration, while designing the converter. Detailed dimensional drawings of the existing traction converter shall be made available to the Tenderer at CLW.

The existing weight of GTO traction converter is 3330 Kgs. The weight of the composite converter shall be such that overall weight of WAP-7 locomotive remains within permissible limit as indicated in Appendix 1, after provisions of two such composite converters in one WAP-7 locomotive.

No intermediate frame shall be allowed for mounting of composite Converter as a separate part of converter.

2.8 COOLING

The Present GTO traction converter uses forced oil cooling. There is a common aluminium alloy heat exchanger module for both GTO based traction converter and transformer but with different circuits. One cooling circuit is used for traction converter oil and other for transformer oil. The blower is common. There are two such cooling units, one for each bogie.

The proposed composite converter shall be water cooled (mixture of water and an ethylene glycol containing corrosion inhibitors) and the ratio of ethylene glycol and water in coolant shall be 30:70 i.e. ethylene glycol 30% & water 70%. The form and appearance of coolant shall be liquid green. The scope of supply of required quantity of coolant lies with the supplier.

Visibility of coolant level shall be provided in conservator of the converter and there shall be sufficient gap between maximum & minimum level. There shall also be a drain cock on the converter side to prevent spillage of coolant.

The supplier can use the existing radiator. For this purpose, the supplier can use the existing heat exchanger for cooling the traction converter and hotel load converter coolant. It shall have to be established from the calculations that the existing heat exchanger is suitable for cooling the composite converter's coolant. Detailed design calculation of cooling system and its efficiency shall be furnished by the Tenderer. Minimum coolant flow rate, which shall give the desired cooling, shall be mentioned. This aspect shall be discussed during the design evaluations stage. The detailed drawings of the existing system can be obtained from CLW by the Tenderer.

2.9 INTERFACES WITH CONTROL EQUIPMENTS

2.9.1 The composite converter may also require to work with the old VCU, which is based on MICAS S2 control & communication (C&C) system. The supplier shall give a suitable interface to the existing VCU. All the control and communication functionalities of the existing traction converter shall be met by the proposed IGBT based traction converter. Modified software suitable for the converter shall be within the scope of supply.

The composite converter shall also be ready for use with latest TCN compliant VCU which is as per latest CLW specification. Specification can be made available to the Tenderer at CLW.

2.9.2 For MICAS VCU, complete vehicle level software source code and programming tools used are with IR. The proposed changes in VCU shall not dilute IR's control over the vehicle level software and tools in terms of their ability to carry out changes on their own, or shall not impact the existing preparedness in terms of rendering acquired skills and tools un-usable. Thus changes if any, made shall be done in association with CLW and

validated by RDSO following present practice of IR. However, the primary responsibility of the software changes and integration for Co-Co type WAP-7 locomotives shall lie with the Supplier.

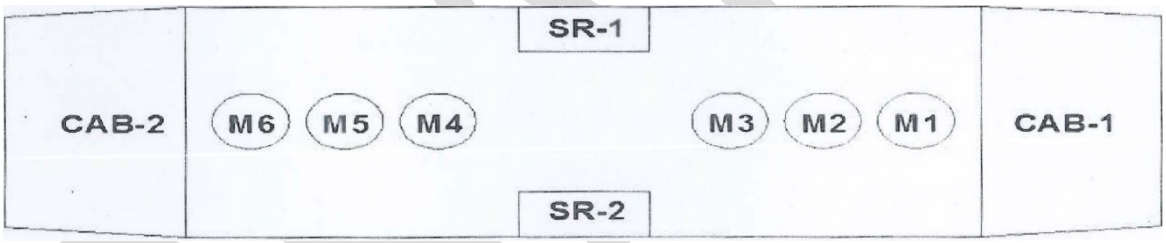
The MICAS-S2 C&C is administered over MPB card based diagnostic system. Changes in VCU shall not necessitate a separate tool for VCU. The converter may have a tool of its own for its diagnostic and troubleshooting. Existing versions of tools used are as under:

#	Tool	Version	#	Tool	Version
1	MIC Project	3.8	4	MIC Info	7.1.3
2	MIC View	4.6.1	5	MIC Bus	3.5
3	MIC Download	4.5.4			

2.10 ***Training:*** The Supplier shall organize training of 50 mandays per 10 loco sets of order quantity or part thereof at CLW and at their factory premises for Railways (CLW and Zonal Railways). Supplier shall arrange for training modules, trainer as well as all logistics for the trainees. The cost of training shall be included in the offer. The detail of training shall be worked out during contract finalization stage/design approval stage.

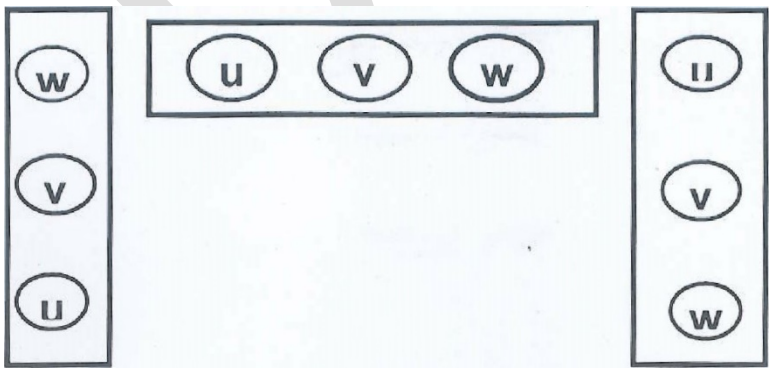
2.11 Orientation of Traction Motors:

Standard orientation of Traction Motors to be adopted as in existing GTO based Traction Converter. The same configuration shall be used by CLW for the connection of Traction Motors. The orientation of Traction Motors shall be as follows:



2.12 Sequence of Motor Terminals:

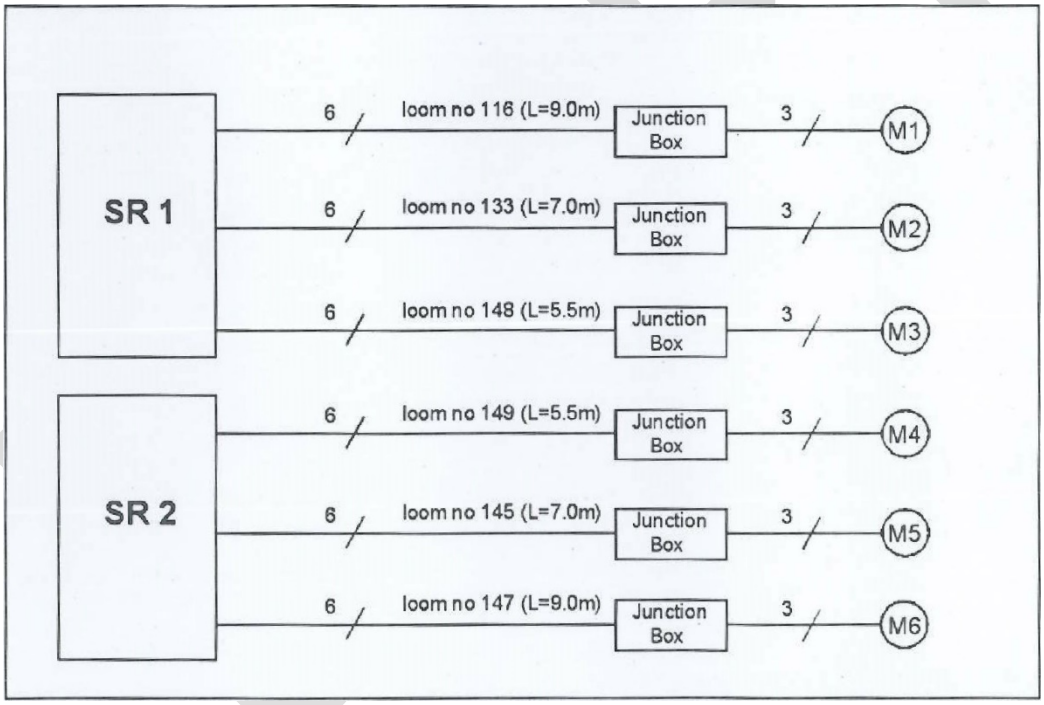
The standard sequence of motor terminals at the traction converter end shall be adopted. The suppliers shall adopt motor terminal layout as given below.



Suppliers shall adopt same lengths of power cable for traction motor connection as in case of GTO traction converter. The details of cable lengths of different looms are as given for reference as below:

Loom no	Motor No.	Length of power cable (m) (in GTO converter)
116	Motor(M1)	9.0
133	Motor(M2)	7.0
148	Motor(M3)	5.5
145	Motor(M3)	9.0
147	Motor(M4)	7.0
149	Motor(M3)	5.5

The drawing for connection of power cables from converter terminals to junction box of traction motor is as given for reference as below:



2.13 Length of Control Cable:

Supplier shall adopt the standard lengths of the following control cable connection as in case of GTO converter. Drawings showing location of various connectors in GTO converter are given for reference as Appendix-9.

Loom No.	Cable length(m)
323(SB1 to SR1)	7.5
324(SB1 to SR1)	7.5
328(SB1 to SR2)	16.0

344(SB2 to SR2)	8.0
341(connection between SR1 & SR2)	21.0

2.14 Software Requirement:

a) Any change in MICAS-S2 software for adaptation with IGBT Composite Converter shall be required to be pre-approved by CLW/RDSO. The changed software along with the source code and comprehensive details of changes shall be submitted to CLW. The responsibility of execution of changes will be of the supplier.

b) Indian Railway is installing systems like Graphical DDU, Radio Remote Control and Remote Diagnostic System on locomotives. Supplier shall provide full co-operation for adoptability of these systems with their Composite Converter. The co-operation may include minor design changes in Composite Converter, hardware modifications and software changes.

c) Supplier shall ensure complete interoperability of Composite Converter with GTO Auxiliary Converter, Auxiliary Converter of other makes and VCUs. CLW/RDSO may specify some requirement to ensure interoperability from time to time and such requirement shall be complied by supplier.

d) The initialization time for IGBT based converter shall be kept less than 30 sec. Further, the total time for achieving node 504 should be less than 50 sec.

2.15 Safety:

Following shall be provided in each converter cubicle for human safety.

a) Indication of presence of high voltage (Voltage Indicator).

b) Safety inter lock on front panel with lock and key to be integrated with existing key multiplier system used in GTO traction converter (3-phase loco).

CHAPTER 3- CLIMATIC & ENVIRONMENTAL CONDITION

3.1 Temperature

Maximum atmospheric temperature : 50 deg. C

Maximum touch temperature of metallic surface inside stabled Locomotive under sun during summer : 75 deg. C

Maximum touch temperature of metallic surface inside stabled Locomotive under shade : 55 deg. C

Maximum temperature near electronic cards inside stabled Locomotive standing under direct sunlight during summer : 70 deg. C

Maximum temperature near electronic cards in working condition of Locomotive during summer : 65 deg. C

Minimum atmospheric temperature : 10 deg. C

The equipment shall be able to start up at the maximum specified temperature inside the locomotive without any pre-cooling requirement.

3.2 Humidity: Up to 100% during rainy season.

3.3 Altitude: Up to 1776 m above mean sea level.

3.4 Rainfall: Very heavy in certain areas. The propulsion equipment shall be designed suitably.

3.5 Atmosphere during hot weather: Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 1.6 mg/m^3. In many iron ore and coalmine areas, the dust concentration is very high affecting the filter and air ventilation system.

3.6. Coastal area: The equipment shall be designed to work in coastal area in humidity and salt laden and corrosive atmosphere. The maximum values of the condition shall be as follows:

a) Maximum pH value : 8.5.
b) Sulphate : 7 mg per litre.
c) Max. concentration of chlorine : 6 mg per litre.
d) Maximum conductivity : 130 micro siemens /CM

3.7 Vibration: The equipment shall be designed to withstand the vibrations and shock encountered in service satisfactorily as specified in IEC 61287 and 60571 publication for the converter and electronic equipments.

3.8 Electromagnetic Pollution – High degree of electromagnetic pollution is anticipated in locomotive machine room, where the equipment shall be mounted. Necessary precaution should be taken in this regard.

3.9 Solar radiation: The locomotive shall be exposed to solar radiation and the design of the composite converter shall take this into consideration. A minimum value of 1kW/m2 shall be applied during summers.

CHAPTER 4 – SCOPE OF SUPPLY

The following shall be scope of supplies.

SL No.	Item Description	Quantity per locoset
1	IGBT based Composite Converter with traction converter and hotel load converter with its control system and along with the base platform and top fixing of all cubicles for mounting.	2 nos. (1 Loco set)
2	Hardware and software Interface with vehicle control Unit.	1 loco set
3	Portable data logging and processing unit (Laptop, latest configuration available at the time of delivery) pre-loaded with Windows XP or latest operating system for downloading the software, viewing and changing the parameters, trouble shooting, in Traction Converter control system and hotel load converter along with user licence	01 no. Per 10 locosets of converter or part thereof.
4	New active speed Sensor with 120 tooth wheel ring, Cable & connectors, speed probe housing, etc. (Ref. Clause 2.2.3 of chapter-2)	1 loco set (6 Nos)
5	Coolant used for the composite converter (Ref. Clause 2.8 of chapter-2)	Lump sum
6	Software update for the vehicle control	Lump sum
7	Testing, commissioning and performance proving of the above equipment	Full ordered quantity
8	Installation Drawings, Maintenance, operation and repair manual (hard copy and soft copy both)	3 sets for full ordered Quantity.
9	Training on assembly, testing, commissioning, operation, maintenance, repair and software parameter settings, fault diagnostic and analysis to IR personnel (Ref. Clause 2.10 of chapter-2).	50 mandays per 10 loco sets of order quantity or part thereof.
10	Special tools and jigs for maintenance.	01 set per 5 loco sets of converter or part thereof.
11	Item specific to hotel load converter like Inter Vehicular (HOG) Couplers (IVC), as per RDSO specification no. RDSO/PE/SPEC/AC/0177(Rev.0)-2013 or latest alteration. Prior approval shall be obtained from RDSO/CLW.	04 numbers.
12	Pump for filing of coolant in the Converter.	1 no. per 10 loco sets of converter or part thereof.
13	Lifting jigs for Composite Converter	1 no. per 10 loco sets of converter or part thereof.
14	UIC Coupler for interfacing the coach/power car and hotel load converter. UIC coupler shall be provided in the locomotive. Suitable jumper cable shall also be provided. Supplier shall be responsible for ensuring connection at both hotel load converter end as well as coupler end. Required material like special lug if any or connector etc. shall be provided by supplier.	04 nos.

Installation & commissioning of the Composite Converter shall be the responsibility of the firm. The special tools, machines, instruments and other facilities, which are required for installation and commissioning of system and are not available in CLW, shall be supported by the supplier.

CHAPTER 5 –TESTS & TRIALS

TYPE TEST

5.1 Prototype tests shall be performed on one unit (manufactured as per design) to verify that product to meet the requirements specified and agreed upon between the Purchaser and the Supplier. Series manufacture shall commence only after successful completion of prototype tests. Subject to agreement between user and manufacturer, CLW at its direction may carry some or all the type tests once in five years on sample basis so as to confirm the quality of the product.

Type test shall be repeated in following cases.

- First time supply to IR.
- Modification of equipment, which is likely to affect its function.
- Failure or variations established during type or routine test.
- At the time of indigenisation, if the firm has supplied the product with foreign collaboration originally.
- Resumption of production after an interruption of more than two years.

5.2 The Supplier shall formulate and submit a type test protocol / plan at design approval stage for approval before undertaking manufacture. It shall, however, be open for RDSO/CLW to waive some of tests in case of equipment and sub-assemblies, where the manufacturer can establish to the satisfaction of RDSO/CLW that such tests have already been carried out earlier on the same equipment and where equipment has been proved in prolonged service.

5.3 The converter shall be tested in accordance with IEC 61287-1 (including all optional tests) and the control electronics shall be tested as per IEC 60571 [including the following optional test–performance test (Cl. 10.2.2), dry heat test (Cl. 10.2.4 to be done at 80 °C), damp heat cyclic test (Cl. 10.2.5), salt mist test (Cl. 10.2.10)].

5.4 The list of tests to be carried out is as (Test as per IEC 61287-1) follows:

Sl. No	Clause no.	Description	Remarks
1.	4.5.3.2	Verification of Dimensions and Tolerances	
2.	4.5.3.3	Weighing	
3.	4.5.3.5	Cooling system performance tests	
4.	4.5.3.5.3	Check of effectiveness of air filers	X[a]
5.	4.5.3.6	Tests of mechanical and electrical protection and measuring equipment	
6.	4.5.3.8	Test of the degree of protection	X[a]
7.	4.5.3.9	Commutation Test	
8.	4.5.3.10	Acoustic Noise Measurement	
9.	4.5.3.11	Temperature Rise Test	
10.	4.5.3.12	Power loss determination	
11.	4.5.3.13	Supply over voltage and transient energy	
12.	4.5.3.14	Sudden variation of load	X[a]
13.	4.5.3.17	Partial Discharge Test	X[a]
14.	4.5.3.18	Safety Requirements	
15.	4.5.3.19	Vibration and Shock	

16.	4.5.3.20	Electromagnetic compatibility	
17.	4.5.3.21	Step change of line voltage test	
18.	4.5.3.22	Short-time supply interruption test	
19.	4.5.3.23	Current-sharing Test	Xᵃ
20.	7.4.1	Output characteristics test	
21.	7.4.2	Starting and restarting test	
22.	7.4.4	Voltage and frequency ranges verification	
23.	7.4.6	Overload capability test	

Xᵃ = The execution of the test is subject to agreement between the Supplier and the Purchaser.

The prototype units shall be inspected and tested jointly by the Engineers of CLW and RDSO at the factory premises or at mutually decided venue where all the facilities shall be made available for carrying out the prototype test. The equipments shall be kept in field trials for 50,000 Kms. The RDSO and CLW engineers shall associate and witness the tests in the locomotive also till they are successfully completed. Any defects noticed / design improvement found necessary as a result of the test / trial shall be carried out by the Supplier in the least possible time. Serial production shall only start after successful trial run on loco and clearance to this effect given by RDSO.

ROUTINE TEST

5.5 Routine tests shall be carried out to verify that properties of the product corresponding to those measured during type tests. Routine test shall be carried out by the Supplier on each equipment.

5.6 The converter shall be routine tested in accordance with IEC 61287-1 (including all optional tests) and the control electronics shall be tested as per IEC 60571.

5.7 The list of tests to be carried out is as (Test as per IEC 61287-1) follows:

Sl. No	**Clause no.**	Description	**Remarks**
1.	4.5.3.1	Visual Inspection	
2.	4.5.3.4	Marking Inspection	
3.	4.5.3.5.4	Leakage Test	
4.	4.5.3.6	Tests of mechanical and electrical protection and measuring equipment	
4.	4.5.3.7	Light Load Test	
5.	4.5.3.15	Insulation Resistance Test	Xᵃ
6.	4.5.3.16	Dielectric Test	
7.	7.4.5	Rated load test	Rated load test of Hotel Load Converter shall be carried out at 0.8 power factor

Xᵃ = The execution of the test is subject to agreement between the Supplier and the Purchaser.

The above mentioned tests are also applicable for Proto type test.

Other points to be followed:

5.8 The suppliers shall submit complete test programme and internal test report for type test to CLW and RDSO and for routine test to CLW before the test for its approval. The Supplier shall carry out the test as per mutually agreed test programme at his own cost.

5.9 Investigation tests are intended to obtain additional information regarding the performance of the product. They shall be specially requested either by the Purchaser or the Supplier.

5.10 Authorised representative of CLW and RDSO may conduct surprise check on manufacturing process and quality control along with any of the test to ensure quality of product and its conformance to specification.

5.11 INSTRUMENTATION:

(a) All the instruments used for testing shall be duly calibrated. The calibration certificates shall be shown to Inspecting Officer on demand.

(b) Value of the fundamental component and total Harmonic Distortion (THD) of inverter output shall be measured by power analyser during the prototype test at various mutually decided preset points in traction and braking modes. True value of output voltage shall also be measured for record.

(c) Input power factor and the efficiency shall be measured using power analyzer at rated load.

5.12 Clarifications with respect to certain tests are given below:

(a) Visual inspection –The objective of visual inspection is to check that the equipment is free from defects and the equipment is as per approved drawing. Bill of materials shall be submitted. The make, rating of equipments, subassemblies shall be checked with the details as per approved design proposal submitted in design proposal. If a change is needed in make or rating of important equipments, sub-assemblies, it shall be intimated and shall have approval of RDSO. All the important dimensions shall be measured and shall be in permissible tolerance.

(b) Power loss determination test – This test shall be done at voltage corresponding to 22 .5 kV in OHE. The efficiency shall be measured at full and 80 % of load.

(c) Earth fault – Simulate the earth fault by connecting a suitable resistor between cubicle frame and output phases. The traction converter and hotel load converter shall not trip and earth fault indication shall be in “OFF” state till the leakage current is less than limit approved as part of design proposal submitted by the Supplier.

(d) Burn in test -- The electronic cards used on the equipment shall be subjected to burn-in 80 hours as per the temperature cycle in Appendix – 5. The cards shall be kept energized during the test. Functional test of each card shall be carried out after the burn in test. (Pl. Refer Clause 10.2.13 of IEC 60571). This shall be part of internal test by manufacturer, whose results shall be submitted during routine test.

(e) Cooling test – The purpose of this test is to verify that the cooling of various components / assemblies. The parameters for measurement to check efficacy of

cooling system shall be decided based on scheme proposed as part of design proposal.

(f) Insulation resistance and dielectric test – The insulation resistance with 1000 V megger shall not be less than 100 M ohms for all the circuits. The dielectric test shall be carried out after shorting semiconductor device, pulse transformer earthed, earthed special cards if necessary before applying Dielectric voltage. The level of dielectric voltage shall be as per IEC 61287.

(g) Temperature rise test –The traction and hotel load inverters shall be loaded to full load for 6 hours with input OHE voltage of 19 kV and with 50% blockade of the inlet filters, if used, inside a heat chamber whhere ambient temperature shall be maintained at 60 degree C. The temperature rise shall be recorded by temperature detectors mounted at the specified reference points on the body of semiconductors, capacitors, and other components as agreed between purchaser and manufacture. The maximum recorded temperature under worst condition shall be compared with maximum permissible temperature (for power devices at junction). The thermal margin available shall be compared with the safety margin declared by the manufacturer. The temperature of the power devices shall have a margin of minimum 10 degree C.

h) Damp heat test – Function test of each card shall be carried out after the damp heat test.

i) Vibration and Shock test: The panel / modules subjected to vibration and shock test shall not be allowed to be used for series supplies against the contract as Vibration and shock test is destructive test. The panel / modules shall be kept with the manufacturer. No item of these panel/modules would be allowed to be used for supplying spares to any Railways.

5.13 Signaling and Interference tests:

Tests to determine the levels of interference with the traction power supply and signal and telecommunication equipments and facilities to prove that these are within acceptable limits (Reference to chapter-2, clause 2.6), shall be done after provision of composite converters in the locomotive.

CHAPTER -6 (APPENDIXES)

APPENDIX – 1

SALIENT DATA OF LOCOMOTIVES

SN	Characteristics	Unit	WAP-7
1	Guaranteed performance at 22.5 kV and half-worn wheels		
1.1	Max. service speed	Kmph	140
1.2	Cont. rated TE up to speed	kmph	70
1.3	Starting tractive effort	kN	322
1.4	Cont. rated Tractive Effort	KN	228 (0-71 kmph)
1.5	Cont. rated power at wheel rim	KW	4500 (71-140 kmph)
1.6	Max. regenerative braking effort	KN	182 (10-89 kmph)
2	Axle Arrangement	-	Co-Co
3	Gear Ratio		3.6
4	Traction Motor type	-	6FRA 6068
5	No. of Traction Motors	-	6
6	Weight	Tonnes	123 +/- 1%

APPENDIX – 2

IMPORTANT DATA OF TRACTION TRANSFORMER
(NOT IN THE SCOPE OF SUPPLY)

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

APPENDIX-3

CHARACTERISTICS OF TRACTION MOTORS

SN	Characteristics	Unit	6FRA 6068
1	Continuous Rating		
1	Shaft output	kW	850
2	Nominal voltage	V	2180
3	Current	A	270
4	Speed	rpm	1283
5	Torque	Nm	6330
6	Frequency	Hz	65
7	Power Factor	-	0.88
2	One Hour Rating		
1	Shaft output	kW	850
2	Nominal voltage	V	2089
3	Current	A	290
4	Speed	rpm	1135
5	Torque	Nm	7140
6	Frequency	Hz	57.5
7	Power Factor	-	0.86
3	Short Time Overload Rating		
1	Shaft output	kW	850
2	Nominal voltage	V	1660
3	Current	A	370
4	Speed	rpm	892
5	Torque	Nm	9100
6	Frequency	Hz	45.7
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.	

APPENDIX-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)

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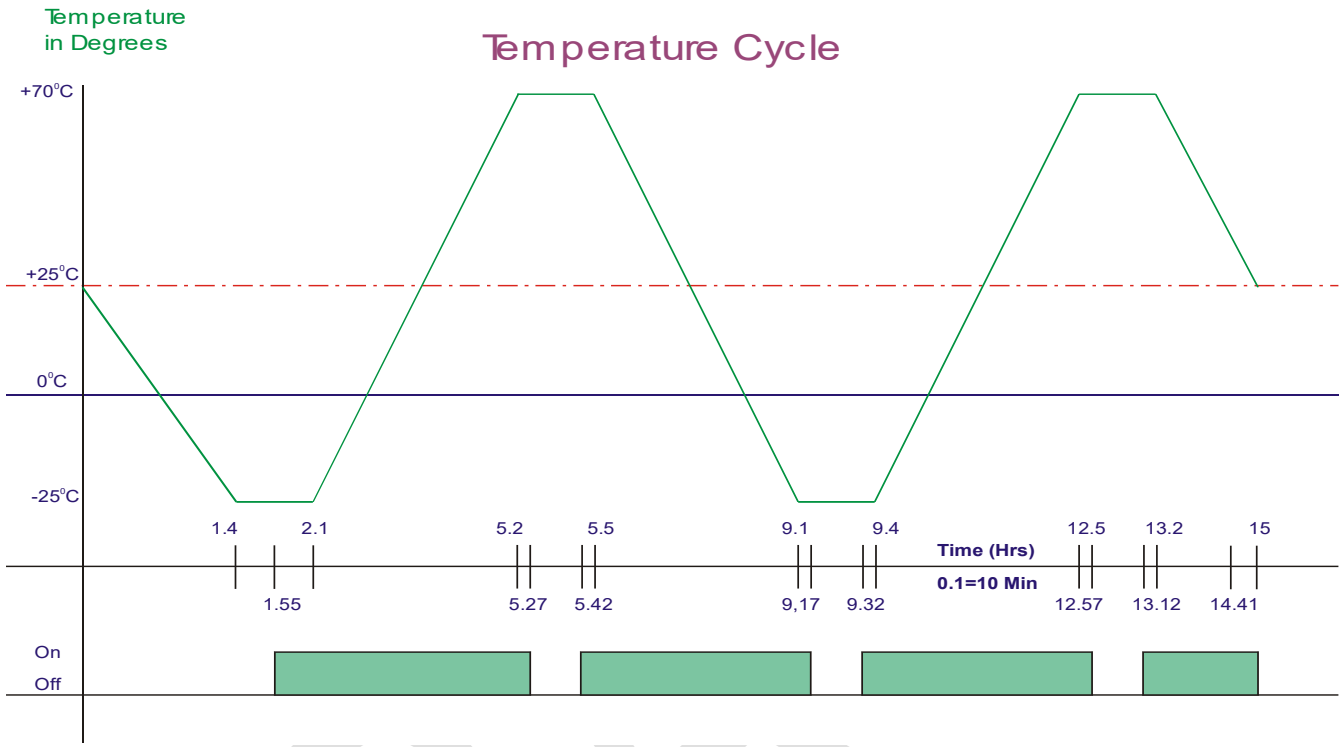
APPENDIX – 5

BURN-IN TEST



Burn-In test shall be elevated to 85 Deg Cel for 10 Minutes.

APPENDIX-6

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, POWER CAR-2, PANTRY-2	932	745.6
19 COACH RAJDHANI	AC-15, POWER CAR-2, PANTRY-2	742	593.6
12 COACH SHATABDI	AC-09, POWER CAR-2, PANTRY-1	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			
S.NO.	**COMPONENT**	**POWER**	**QTY**	**TOTAL CONNECTED LOAD**
		IN (WATTS)		**IN (WATTS)**
1	ANTI-SKIDDEVICE	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/	800	1	800
3.3	REFRIGERATION			
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 +DOORWAY	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 (24 V)	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	LOUDSPEAKER EQUIPMENTS	60	1	60
9	**ELECTRIC CAR EQUIPMENTS**			
9.1	BATTERY CHARGER	6160	1	6160
				37948
	TOTAL LOAD			**37.95 KW**

CONNECTED LOAD CALCULATION FOR LHB TYPE COACHES 2-AC

S.NO.	COMPONENT	POWER (WATTS)	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 +DOORWAY	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(24 V)	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	LOUDSPEAKER EQUIPMENTS	60	1	60
9	**ELECTRIC CAR EQUIPMENTS**			
9.1	BATTERY CHARGER	6160	1	6160
		TOTAL		38188
		TOTAL (KW)		**38.2 KW**

CONNECTED LOAD CALCULATION FOR LHB TYPE COACHES 3-AC

S.NO.	COMPONENT	POWER IN WATTS	QTY	TOTAL CONNECTED LOAD IN (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/	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 +DOORWAY	20	10	200
5.4	TOILET OCCUPIED LIGHT	16	4	64
5.5	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(24 V)	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	LOUDSPEAKER EQUIPMENTS	60	1	60
9	ELECTRIC CAR EQUIPMENTS			
9.1	BATTERY CHARGER	6160	1	6160
TOTAL IN WATTS				37568
TOTAL (KW)				**37.57**

CONNECTED LOAD CALCULATION FOR LHB TYPE PANTRY CAR (HOT BUFFET)

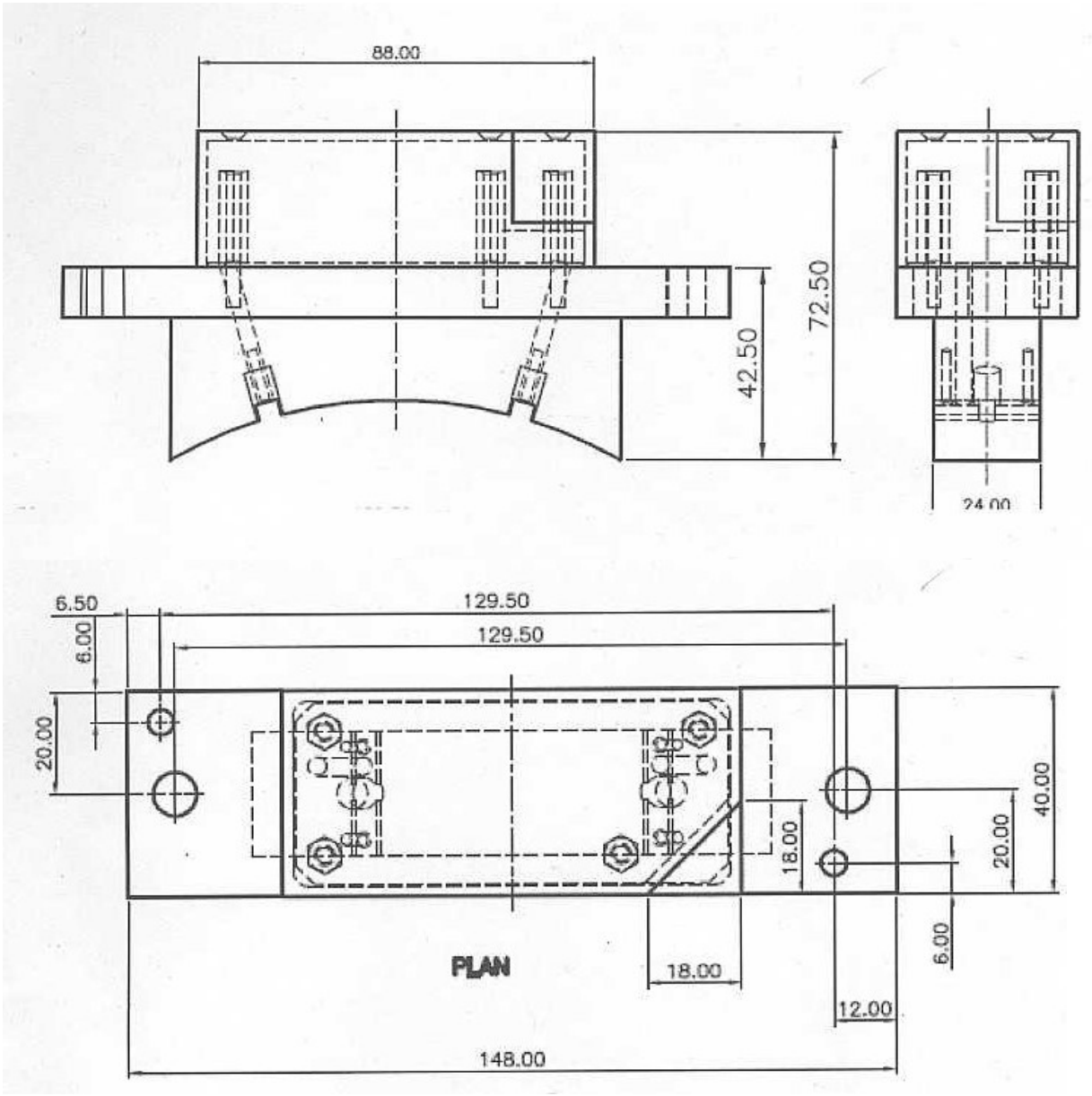
S.NO.	COMPONENT	POWER IN (WATTS)	QTY	3-PH AC/415 V	1-PH AC/240V	1-PH AC/110V	DC/110V
				WATTS	WATTS	WATTS	WATTS
1	ANTI-SKIDDEVICE	48	1	0	0	0	48
2	**FAN**						
2.1	EXHAUST FAN	132	2	264	0		0
3	**PANTRY EQUIPMENT**						
3.1	HOT CASE,FOR 140MEAL	1500	1	0	1500	0	0
3.2	BOTTLE COOLER 90 LTRS	200	1	0	200	0	0
3.3	REFRIGERATOR, 310LTRS	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	1		5100		
3.10	ELECTRICAL CHIMNEY-1,2 & 3	300	3		900		
3.11	INSECT KILLER	20	2		40		
3.12	WATER FILTER	200	1		200		
	SUB TOTAL OF PANTRY EQUIPMENTS				**28040**		
4	**SWITCH BOARD CABINET**	500	1	0	0	0	500
5	**COACH LIGHTING**				0		
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	DOORWAY				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(24 V)	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	48
7.4	ELECTRIC SHAVER SOCKET	20	2	0	0	0	40
8	**PA SYSTEM**						
8.1	LOUDSPEAKER EQUIPMENTS	60	1	0	0	0	60
9	**ELECTRIC CAR EQUIPMENTS**				0		
9.1	BATTERY CHARGER	6160	1	6160	0	0	0
		SUB TOTAL		**33844**	**28040**	**392**	1608
TOTAL Watts					**62276**		
TOTAL (KW)					**62.276**		

- Connected load will increase depending on addition of passenger amenities like pantry in each coach, laptop charger at each berth, PIS, CDTS, etc.

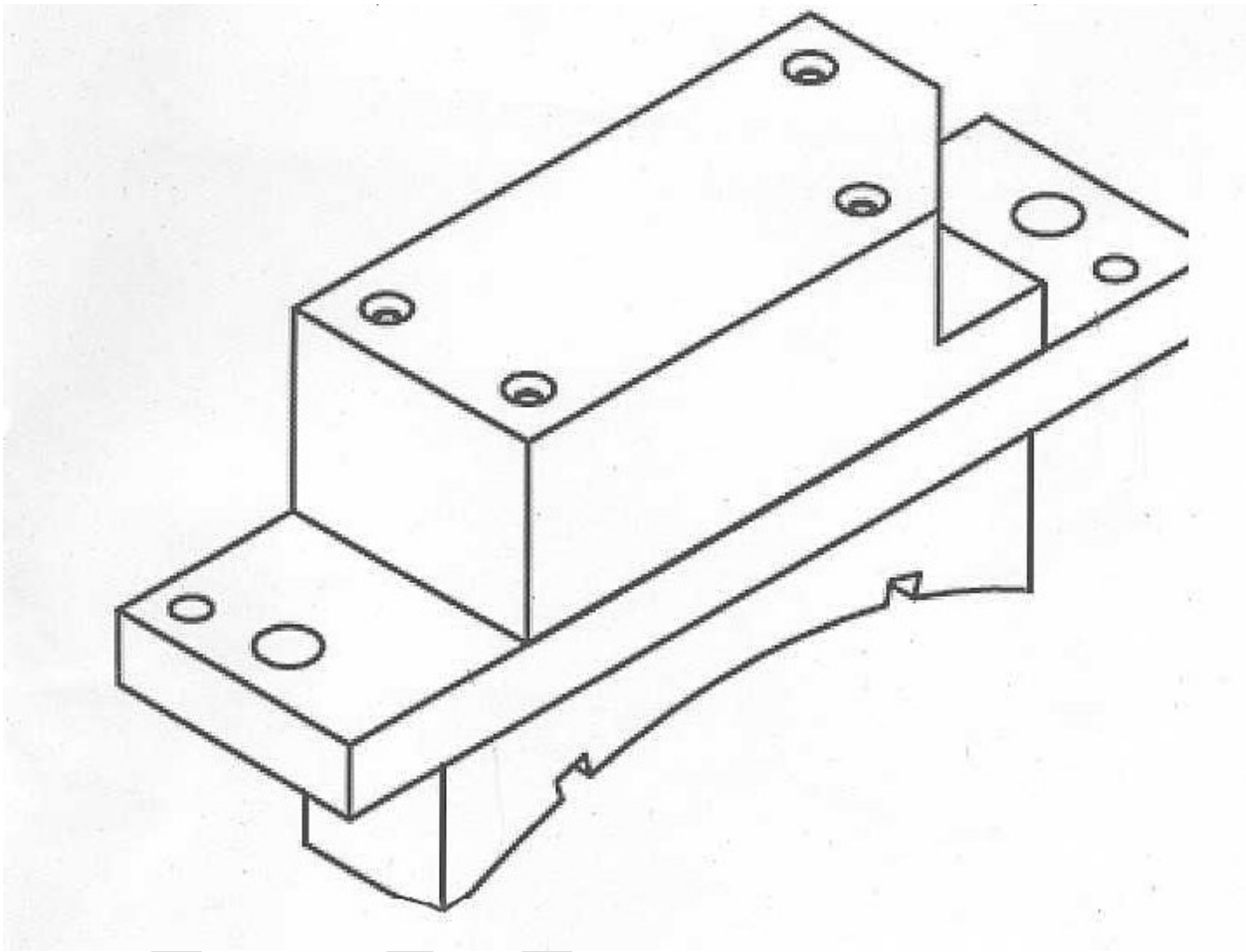
APPENDIX – 7/1

Drawing of the Active speed sensor



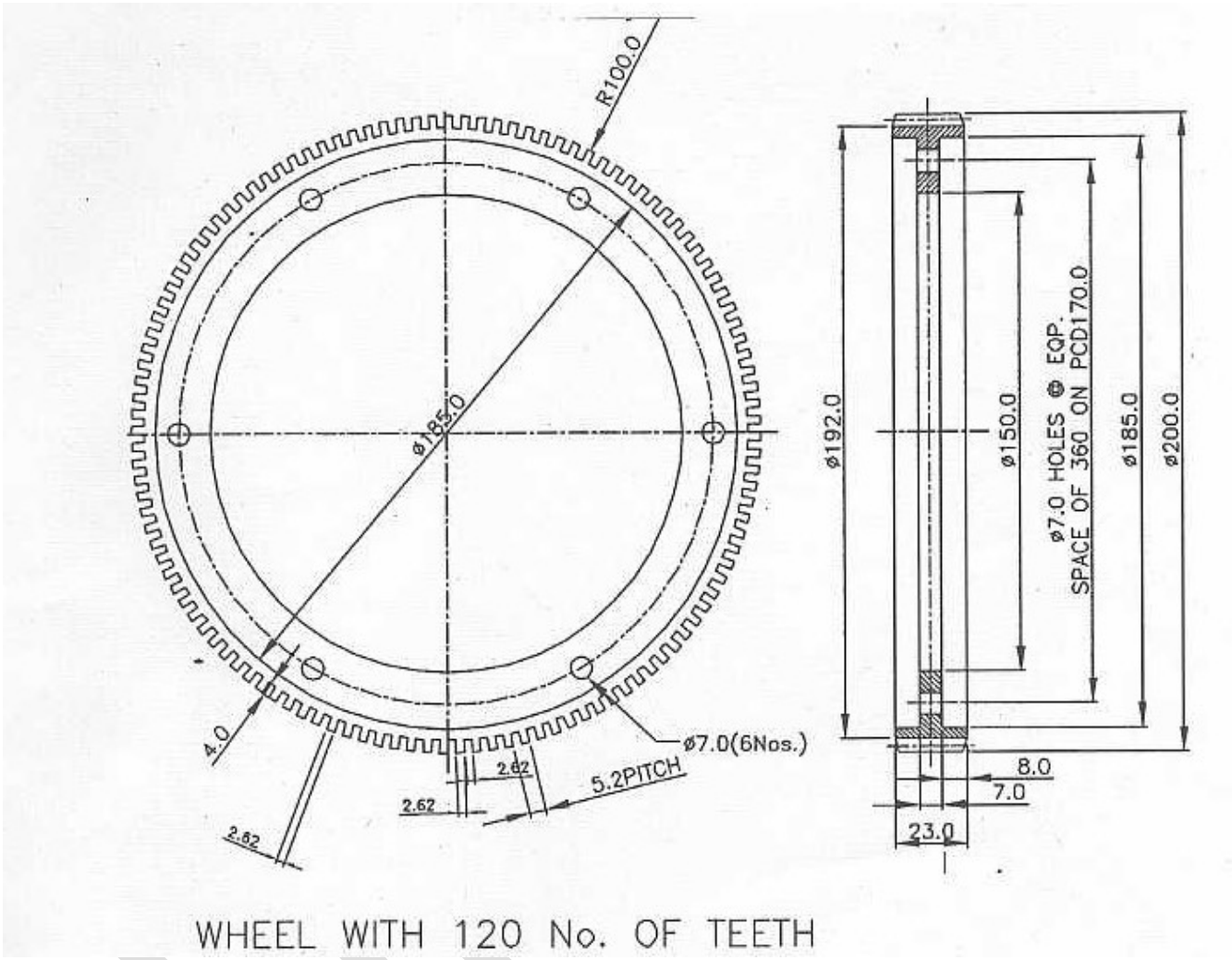
APPENDIX – 7/2

Isometric View of Speed Sensor



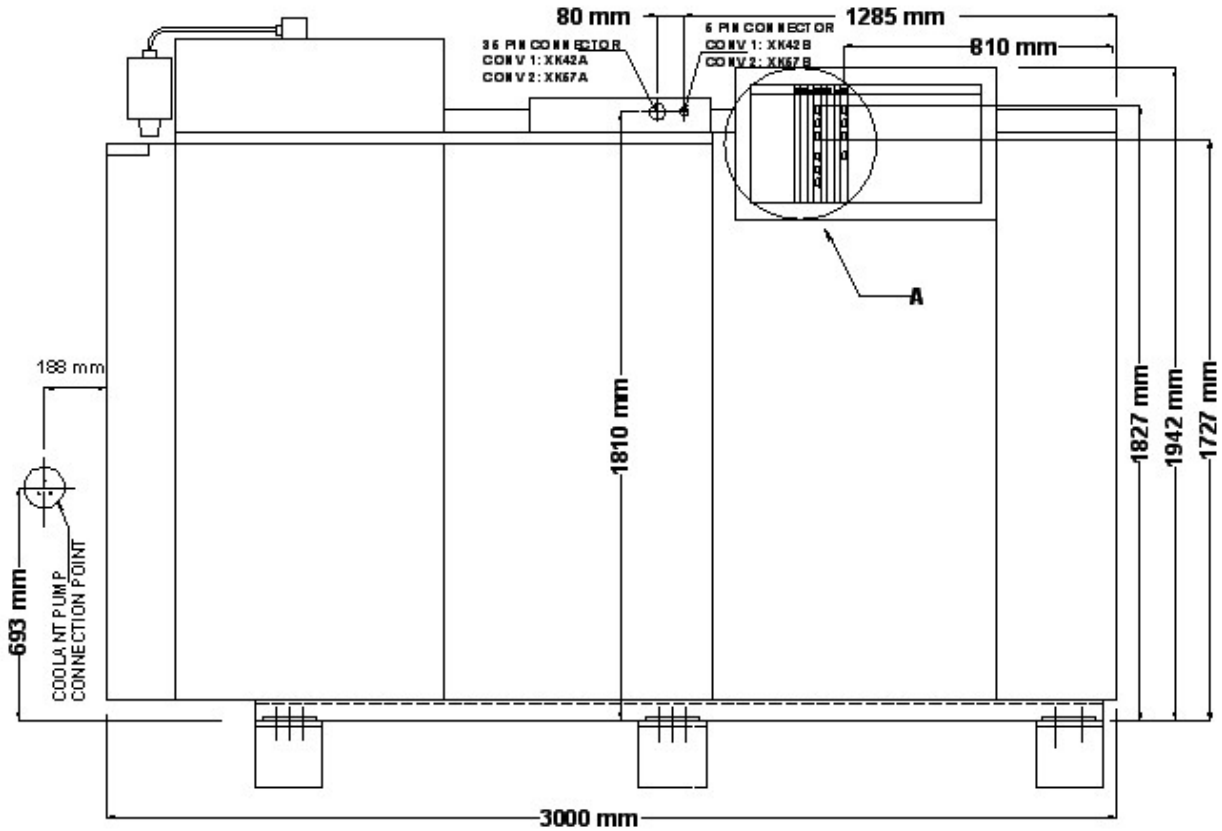
APPENDIX – 8

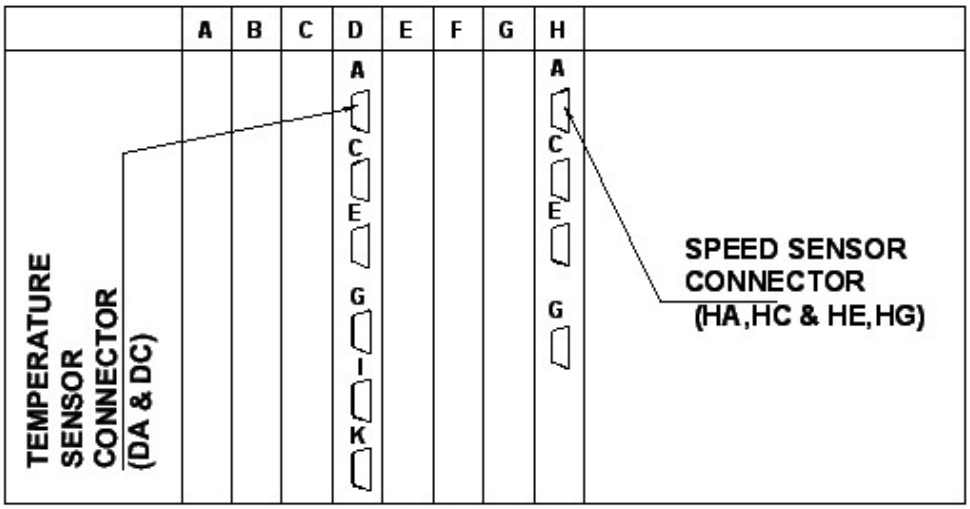
Drawing of the tooth wheel ring



APPENDIX – 9

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





DETAILS OF A