GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION FOR SUPPLY OF AC - AC TRACTION SYSTEM FOR 4500HP WDG-4/WDP-4B DIESEL - ELECTRIC LOCOMOTIVES

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अनुसंधान अभिकल्प और मानक संगठन
लखनऊ–226 011.

RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW - 226011.
TECHNICAL SPECIFICATION FOR SUPPLY OF AC - AC TRACTION SYSTEM FOR 4500HP WDG-4/WDP-4B DIESEL - ELECTRIC LOCOMOTIVES

1.0 INTRODUCTION

1.1.1 Indian Railways had introduced 4000 HP Diesel-electric locomotives GT46MAC (heavy haul freight version renamed as WDG4) and GT46PAC (high speed passenger version renamed as WDP4B) equipped with 3-phase AC-AC transmission system employing propulsion based on GTO technology under TOT agreement with M/s General Motors, USA. Indigenous manufacture of both these types of locomotives is presently being done at DLW.

1.1.2 In the present system, overall loco operation is controlled by Locomotive Control Computer, which is tightly integrated with microprocessor based traction control and braking systems. 4000 HP locomotives employ EM – 2000 as the main Loco control computer, which controls:

   I) Traction Control Computers
   II) CCB of KNORR BREMSE
   III) Excitation of main Generator through SCR unit.
   IV) All the associated electrics housed in three electrical cabinets viz. ECC #1, ECC #2 & ECC #3.

1.1.3 EM-2000 and its peripherals along with proprietary embedded software of M/s EMD are being used presently on 4000 HP locomotives. These locomotives employ the Traction Control Computer, which controls the GTO/IGBT based Traction Inverter. Each Traction Inverter provides power for three Traction Motors. The Traction Inverter along with its Traction Control Computer is housed in a cabinet called Traction Control Cabinet (TCC). Two such TCCs are provided for each locomotive.

1.1.4 With the successful development of IGBT based traction control converter and testing of existing engine to deliver 4500 hp power, it has been decided to manufacture locomotives with 4500 GHP. This STR governs the requirements for supply of AC-AC Traction System consisting of loco control computer system (hardware & software), IGBT based traction inverters cum hotel load inverters system, ECC panels and allied equipment to be used on 4500 hp WDG4/WDP4B locomotives.

1.2 OBJECTIVES OF THE SPECIFICATION

It is proposed to develop an AC-AC Traction system and electrics for 4500 hp WDG4/WDP4B locomotives with following broad objectives:

1.2.1 To take care of increased horsepower requirements up to 4500 hp. The equipment supplied shall be deemed to have met the requirement of 4500 GHP by ascertaining the alternator output which shall not be less than:

(a) 2915 KW (minimum) in site conditions with both radiator fans at full speed and compressor loaded condition
(b) 2975 KW (minimum) in site conditions with both radiator fans at half speed and compressor unloaded

**Note:** Some of the auxiliaries are specific to the equipment to be offered and therefore the auxiliary load may vary to some extent from the present load. There may be some situations where the engine gross power shall go above 4500 hp; in such a situation a clamping protocol shall be provided by the locomotive microprocessor such that the power never exceeds 4525 hp for more than 3 minutes and clamping of excitation is done in such a situation. This shall be achieved through an excitation software and not LCP. Exact details of the clamping software proposed by the manufacturer can be decided mutually at design approval stage.

1.2.2 To take care of increased tractive effort requirements on different notches.

1.2.3 To develop a flexible, user configurable, traction inverter system preferably with six independent traction inverters common for both WDG4 and WDP4B locos. Complete details of user programmable parameters are listed at clause no. 7.1.4.

1.2.4 Hardware including Traction converters, loco control computer and ECC panels shall be common for both WDG4 and WDP4B locos and only the software configuration shall be different for the two applications. These equipments shall be fully interchangeable. The modified microprocessor based loco control system (hardware & software) shall completely integrate with the proposed IGBT based traction invertors, existing power pack, traction alternator, traction motors, auxiliaries and braking system.

1.2.5 To provide for Hotel Load capability, option to be offered if the tender calls for a quote for the hotel load equipment.

1.2.6 To accommodate distributed power control concept, option to be offered if the tender calls for a quote for the same.

1.2.7 To provide blended brake feature on both WDG4 and WDP4B locos. Tractive effort limiting feature to limit the tractive effort whenever required shall be provided in both the locomotives. This would be a user settable parameter.

1.2.8 It is proposed to provide a flexible and user configurable traction inverter system either with six independent traction inverters or with twin inverters, user configurable hotel load provision, and other features proposed in this spec. Loco Control Computer (LCC) controls shall require to be substantially modified. In the new system an exhaustive range of User Settable Parameters shall be provided in LCC as well as TCCs for flexibility and ease of future upgrades in the control system/Traction equipment. State-of-Art technologies like optical fiber communication, automatic engine start-stop/ Auxiliary power unit, provision for control of distributed power consist etc. shall be provided.

1.2.9 The LCC along with associated electrics shall completely integrate with existing power pack, traction alternator, traction motors, auxiliaries and braking system.
1.3 HOTEL LOAD FACILITY

1.3.1 At present, hotel load requirement of passenger carrying trains on IR is met through two diesel-alternator (DA) power cars, one at either end of the rake (Rajdhani and Shatabdi type trains) or through self generating equipment provided on each of the coaches (Normal Mail/Express trains).

1.3.2 In order to cater to the hotel load requirement of entire rake, alternative system with centralized hotel load power supply from the locomotive diesel engine itself is being envisaged by Indian Railways. This shall result in higher overall efficiency, passenger comfort and improvement in overall system reliability with reduced maintenance. For the purpose of Hotel load an additional inverter shall be provided if asked for in the tender. The additional inverter shall preferably be housed in the existing TCC cabinet, if housed separately, the envelop dimensions to be indicated with proposed lay out/mounting arrangement.

1.3.3 The output of the hotel load inverter on WDP4B locos shall be 750 V, 3-phase, 50 Hz, 500KVA supply to make it fully compatible with the existing hotel load supply arrangement of EOG power cars. In the proposed system, one of the power cars shall be removed, as the power shall be provided by the hotel load inverter from the locomotive itself.

1.4 CREDENTIALS OF THE TENDERER

1.4.1 This specification governs requirements for successful manufacture, testing and supply of IGBT based traction inverter system along with an integrated hotel load module and microprocessor based loco control computer system (hardware & software) with allied equipment to be used on 4500 hp WDG4/WDP4B locomotives.

1.4.2 Performance of 3-phase microprocessor controlled locomotives largely depends upon design of traction inverter and loco control system. Therefore, it may be noted that irrespective of whatever has been stated in this specification, complete integration (electrical, mechanical as well as software controls) of the offered traction inverter, loco control and hotel load systems with the other existing (OEM) equipment of the WDG4/WDP4B loco, such as alternator, motors, computer controlled brake system etc. shall be sole responsibility of the successful tenderer. Successful tenderer shall also be fully responsible for proper mounting, installation and commissioning of all the offered equipment as well as satisfactory performance of the locomotive in the field.

1.4.3 Since this specification calls for major design changes in the existing locomotive in hardware as well as software, tenderers are expected to sufficiently familiarize themselves with the functioning of existing EM2000 and other LCC makes controls and traction inverter controls with other allied equipments on WDG4/WDP4B locomotives along with hotel load system on existing Rajdhani / Shatabdi and other Mail/Express trains in order to get clear understanding of requirements for optimum design of the complete system.

1.4.4 Offers from only those tenderers who have sufficient experience in manufacture and integration of IGBT based traction control system for 4000/4500HP 3-phase AC-AC
diesel electric locomotives shall be accepted. The tenderer shall have prior experience of supplying IGBT based traction system for 4000HP and above Diesel Electric Locomotives.

1.4.5 Tenderers shall submit the evidence of successful track record of manufacture & integration of IGBT based traction invertors along with their offer. The tenderer shall also submit a detailed indigenization plan with the offer.

1.4.6 It may be noted that complete details regarding functioning of EM2000, TCC and their interaction / communication protocol are not available with RDSO/DLW and therefore only limited information, to the extent available with RDSO/DLW, can be shared with the successful tenderer. It may also be noted that such information, at any detailed level including communication protocol between EM2000 and TCC controls, is not a part of TOT agreement between M/s General Motors and Indian Railways and therefore is not available with RDSO/DLW.

1.4.7 Some proprietary information of the TOT (between M/s General Motors and Indian Railways) of WDP4B technology can not be passed on to / shared with the international competitors of M/s General Motors. Therefore, in order to design a technically optimum alternative to existing inverter and loco control systems fully compatible with each other, tenderers are required to have sufficient expertise and experience in the design of traction control systems.

1.4.8 Change in performance and functionality, if any with the proposed system, shall be brought out clearly in the offer. However, complete system shall be designed to improve the performance and functionality.

2.0 DESCRIPTION OF THE EXISTING SYSTEM

2.1 The existing locomotive control computer EM-2000 controls overall locomotive operation. Traction converters are controlled by traction control computer & braking system is controlled by CCB with interface from EM-2000. The traction control computers also provide failure detection and protection for inverters and also provide EM2000 with fault information to be displayed and archived in the memory for further analysis.

2.2 EM2000 is a 32-bit computer based on Motorola 68020 microprocessor running at 16 MHz with a math coprocessor and communication through RS-232 serial cable/port. The traction control computer receives data from EM2000 via RS-485 serial link. The bi-directional bus carries data such as how much power for traction the inverter shall develop as well as other information to control activation of devices like blowers and heaters. In addition to the data via RS-485 link, traction control computers continuously provide feed back information to monitor various parameters such as status of relays and temperature of various components, voltages and currents. Based on this feedback data and information received via RS-485 serial link, the programs stored in the traction control computers work, to drive the inverter as well as to protect it in the event of faulty operating conditions.

2.3 Diesel engine drives the traction alternator. Three phase output of the traction alternator type TA17-CA6 is rectified and fed to two inverters through DC link. Each
inverter supplies three phase controlled output to traction motors mounted on a bogie. Motors are four pole three-phase squirrel cage induction motors. Inverters are voltage source PWM type employing GTO/IGBT as basic switching device. Two traction control computers are used, one for each inverter, to directly control the firing of GTO/IGBT and thereby controlling the voltage and frequency output from inverters as per the traction requirement indicated by EM2000 locomotive control system. EM2000 controls overall locomotive operation. Traction converters are controlled by traction control computer and braking system by CCB with interface from EM2000. The traction control computers also provide failure detection and protection for inverters and also provide EM2000 with fault information to be displayed and archived in the memory for further analysis.

2.4 Layout diagrams showing L/H side internal and top views of the existing WDP4B/WDG4 locomotives are attached at annexure-A and annexure-B.

2.5 The characteristic curves for 4500HP loco application are attached at annexure nos. C & D (for WDP4B loco) and annexure nos. G & H (for WDG4 loco).

2.6 The locomotive is equipped with KNORR/NYAB CCB 1.5 (computer controlled braking) system. This is an electro-pneumatic microprocessor based system with 30A CDW type desktop controls.

2.7 End On Generation (EOG) and Self-Generating (SG) type hotel load supply systems are used on Indian Railways at present. On Rajdhani/Shatabdi trains, hotel load is met through EOG power cars wherein two power cars are provided one at either end of the rake. Each power car is a Diesel-Alternator set with associated power contactors and control / protection circuits. On other Mail/Express trains, the coaches are SG type and hotel load requirement of these coaches is met through axle-mounted alternator-rectifier-inverter system. In EOG system, hotel load power from power car to coaches is fed through two feeders running parallel along the rake (at 750 V, 3-phase, 50 Hz).

2.8 Inter Vehicular (IV) couplers are used to connect the feeders between adjacent coaches. Each coach has step down transformer which converts the 750 V feeder supply to 415 V output to be fed to the air conditioning equipment in the coach. Automatic interlocking and feeder selection system is used such that at a time only one power car can supply hotel load power to either feeder or both the feeders. Through proper interlocking between the power cars, simultaneous hotel load supply from both the power cars to a feeder is prevented. Inter vehicular couplers on Locomotive shall be in tenderer scope of supply. Tenderer shall provide adequate details on the type selected together with a data sheet. Proven, reputed make of inter vehicular coupler is to be offered. Interlocking and associated circuitry on the Locomotive shall also be in tenderer scope of supply.

2.9 The complete electrics of the locomotive is housed in three different cabinets named as ECC #1, ECC #2 & ECC #3. The ECC #1, ECC #2 & ECC #3 shall be as per relevant DLW/RDSO specification. The various switches, contactors, circuit breakers, indicators, transducers and sensors presently being used are categorized in the following three categories:
a. Items only from OEM.
b. Items from authorized Indian sources of OEM.
c. Items from indigenous sources.

3.0 GOVERNING SPECIFICATIONS

This specification is based on the following references:

1. IEC-61287: Electronic Power Converter mounted on board rolling stock.
2. IEC-60571: Specific rules concerning the electronic control part of converters.
3. IEC - 34.1: Auxiliary Electrical machines.
4. EN : 50121-3-2: Railway Applications – Electromagnetic Compatibility (CENELEC) (Part 3-2, Rolling Stock – Apparatus)
5. EN : 50121-2: Railway Applications – Electromagnetic Compatibility (CENELEC) (Part 2, Emission of the whole railway system to the outside world)

4.0 DEFINITIONS

4.0.2 ‘DLW’ means Diesel Locomotive Works, Varanasi-221 004.
4.0.3 ‘BG’ means 1676 mm gauge, referred to as Broad Gauge.
4.0.4 ‘IEC’ means International Electro-technical Commission.
4.0.5 ‘IS’ means Indian Standard.
4.0.6 ‘AAR’ means Association of American Rail-roads.
4.0.7 ‘UIC’ means Union International Des Chemins de fer (International Union of Railways)
4.0.8 ‘IRS’ means Indian Railway Standard.
4.0.9 ‘IR’ means Indian Railways.
4.0.10 Throughout this specification the words:

   .1 Horse Power (HP) shall be taken as metric horse Power, i.e. 75 kg metre/sec.
   .2 Tonnes (T) shall be taken as metric ton i.e. 1000 kg.

5.0 SCOPE OF SUPPLY

Following equipments are within the scope of supply of the tenderer. It is being attempted to have a common platform on the locomotive for fitment of various makes of equipments. In case any particular make requires fitment of equipment over and above the scope defined in this specification, the same shall be supplied by the tenderer (including cables, pipes, ducting etc) and the cost shall be borne by the tenderer and not DLW.
5.1 Electrical Control Cabinet ECC #1 consisting of Locomotive Control Computer (LCC) system (hardware and software) along with all control, protection and indication equipments like sensors, relays, breakers, indicators etc., along with other sub-systems required for proper functioning of the locomotive. The location of the DC link terminals at ECC#1 shall be as per the sketch placed at annexure ‘O’. Functional equivalents of all the existing components in this cabinet are within the scope of supply. The LCC may be located at an alternate location also, in this case, the tenderer shall have to supply any uncommon item arising out of this alternate location. All communication cables between LCC and TCC / ECC#1 are in the scope of supply of tenderer.

5.2 ECC#1, ECC#2, ECC#3 shall be as per relevant DLW/RDSO specification. DLW specification nos. are as follows-
(i) ECC #1 as per DLW specification no WDG4/EL/PS/17. Rev-03/ (Latest).
(ii) ECC #2 as per DLW specification no WDG4/EL/PS/20. Rev-02/ (Latest).
(iii) ECC # 3 as per DLW specification no WDG4/EL/PS/21. Rev-03/ (Latest).

Electrical Control Cabinets ECC #2 and ECC #3 consisting of all the additional protection and indication equipment, sensors, relays etc., along with other sub-systems required for proper functioning of the locomotive. ECC#1, ECC#2, ECC#3 shall be as per relevant DLW/RDSO specification. Functional equivalents of all the existing components in these two cabinets are within the scope of supply. The system shall be designed in such a way so as to eliminate the requirement of copper reactor that has been fitted in the ECC#2 of these locomotives till now. In case the tenderer is not meeting this requirement, then all related equipments including the extra cables required would be in the scope of supply of tenderer and not in the scope of DLW. Cost implications of such equipment shall be borne by the tenderer.

5.3 Two traction control cabinets TCC#1 and TCC#2 (or TCC#1 and TCC#2 housed together in one cabinet); each TCC shall house IGBT based inverters for traction motor control. The traction control computer(s) can be housed in this cabinet or can be separately located in ECC1. The inverter configuration can be either for single motor control or for bogie control. In this case, the tenderer shall have to supply any uncommon item arising out of this alternate location. In case of motor control, each motor shall be controlled by separate inverter and there shall be a total of 6 inverters. In case of bogie control 3 traction motors of a bogie shall be controlled by a single inverter and there shall be a total of 2 inverters. The location of the DC link terminals and traction motor terminals shall be as per the sketch placed at ‘Annexure-O’. Separate cables for each traction motor would be used from TCC to traction motors. All cooling requirements of the TCC shall be met by inbuilt blower within the envelope of TCC, any additional cooling requirement (including blower, motor and ducting) shall be in the scope of supply of tenderer and not in the scope of DLW. Cost implication for such equipments shall be borne by the tenderer.

5.4 Hotel load (Optional): For the purpose of Hotel load an additional inverter shall be provided, if asked for in the tender schedule. The additional inverter shall preferably be housed in the existing TCC cabinet. If housed separately, the envelope dimensions to be indicated with proposed lay out/ mounting arrangement. The proposed inverter for hotel
load shall be accommodated in the existing over all dimension of the locomotive. All inter-vehicular couplers and associated electrics shall be within the scope of supply.

5.5 Distributed power control (optional): To accommodate distributed power control concept, option to be offered if the tender calls for a quote for the same.

5.6 Cable Harnesses: All cable harnesses connecting traction motor temperature and speed sensor signals to TCC computer/LCC computer and cable harnesses between TCC and ECC#1 shall be as per DLW specification No. WDG4/EL/PS/25 rev - 02 mentioned at annexure-K.

5.7 Crow bar Resistor and Damper Resistor: Crow bar Resistor and Damper resistor or any other protection device required for proper functioning of IGBT TCC as per DLW specification No. WDG4/EL/PS/28 mentioned at annexure L.

5.8 Speed & Temperature Sensors shall be supplied alongwith TCC as a set i.e. 6 sensors for each TCC ordered. The sensors shall be compatible with the traction motors being used on the locomotive. The details of the traction motor are furnished in para 9.0 of the specification.

5.9 For ease of stocking, control of inventory and ease of withdrawal from store for production, a comprehensive packing list for items covered under scope of supply for AC-AC traction system shall be provided and it shall be in the format as shown in Annexure-N. Deviation to this packing list shall be submitted by the tenderer at the stage of offer. If feasible, DLW may consider granting the deviation.

5.10 Industrial type electronic notebook complete with communication data analysis software and configuration software for giving to the nominated shed. Notebook shall be industrial type (Panasonic tough book S9 or equivalent) so that it is sufficiently robust for handling on the locomotive and maintenance shed. The quantity of notebook shall be calculated as 0.05 per set of AC-AC system supplied.

5.11 Three years AMC of IGBT based TCC and LCC (beyond warranty period), as per terms and conditions placed at annexure M. The firm shall quote its offer for AMC as per tender SOR/Spec.

5.12 Documentation & Information required: covered under clause 10.

5.13 In the present design, the locomotive is having 3 Electrical Control cabinets i.e., ECC#1, 2 and 3. While ECC#1 is installed in the drivers cab, the ECC#2 is under slung from the locomotive under frame and ECC#3 is located near radiator compartment. It is preferable that the manufacturers shall eliminate the ECC#2 from their design while quoting against this specification and suggest alternative locations for the equipments currently contained in ECC#2.

The Tenderer shall supply above items to DLW and fitment of these equipments along with testing and commissioning of the complete locomotive shall be done at DLW under the supervision of successful tenderer. Tenderer shall arrange for special instruments,
tools etc. required for installation and commissioning of the locomotive which are not available at DLW.

6.0 ENVIRONMENTAL CONDITIONS

6.1 The complete microprocessor based loco controls and inverter systems shall be required to work continuously at full load under following atmospheric conditions:

| Maximum temperature (Atmospheric) | (i) 55 °C (under sun).
  | (ii) 47 °C (in shade)
  | (Temperature inside locomotive may reach 60 °C.) |
| Minimum temperature (Atmospheric) | -20 °C. |
| Humidity | 90 % (Up to 100% during rainy season as per IEC 60721-3-5. |
| Altitude | Max. 1200 meter above mean sea level |
| Reference site conditions | (i) Ambient temp. 47 °C
  | (ii) Temp. inside engine compartment 55 °C
  | (iii) Altitude 160 m. |
| Annual rainfall | Between 1750 mm to 6250 mm. The locomotive shall ve designed to permit it’s running at 5 Km/h in a flood water level of 10.2 cm above the rail level. |
| Dust | Extremely dusty and desert terrain in certain areas. The dust content in air may reach as high a value as 1.6 mg / m³. |
| Atmospheric conditions in coastal areas in humidity salt laden and corrosive atmosphere | All the equipment shall be designed to work in coastal areas in humidity salt laden and corrosive atmosphere. |
  | (a) Maximum PH value : 8.5
  | (b) Sulphate : 7 mg / liter.
  | (c) Max. concentration of chlorine : 6 mg / liter
  | (d) Maximum conductivity: 130 micro siemens / CM. |
6.2 Complete system shall be suitable for rugged service normally experienced for rolling stock where locomotives are expected to run up to a maximum speed of 130 km/h in varying climatic conditions existing throughout India. Complete loco control and inverter systems with their controls and gate drive electronics shall be protected from dusty environment by providing well sealed enclosures. Necessary precaution shall be taken against high degree of electromagnetic pollution anticipated in the locomotive. The cooling system shall be designed to take care of tilting and centrifugal forces which would normally be encountered in service.

6.3 The equipment and their mounting arrangements shall satisfactorily withstand the vibrations and shocks normally encountered in service as indicated below:

   a) Max. Vertical acceleration     - 1.5 g
   b) Max. Longitudinal acceleration   - 2.5 g
   c) Max. Transverse acceleration   - 1 g

   (*g* being acceleration due to gravity)

All the equipment and their mounting arrangement shall be designed to withstand vibrations and shocks as specified in IEC-61287 and IEC-60571 for the inverters and electronic equipment respectively.

7.0 MAIN FEATURES OF THE PROPOSED SYSTEM

The AC Traction system shall consist of Locomotive Control Computer, IGBT based Traction Inverters, various sensors for Current, Voltage, Temperature, Pressure, Speed and other allied equipment like relays, breakers, indicators, etc for WDG4/ WDP4B locomotives. For WDP4B locomotives, in addition to these, additional IGBT converter shall be required for hotel load requirement (optional).

7.1 LOCOMOTIVE CONTROL COMPUTER (LCC)

The offer shall include an LCC, which shall be totally compatible in respect of hardware and software for achieving the 4500 GHP requirements set out in this specification. The tenderers can either offer the current 4500 hp LCC in use on IR, viz., the EM 2000 family LCC or an LCC of his own design. In case the former is offered, the tenderer shall establish that they have entered into an agreement with M/s EMD/USA for sourcing and integration of the EM 2000 family LCC with the TCC offered by the tenderer. Alternatively, if the offer is for their own LCC, the said LCC shall be of such a design that it can be fitted in the ECC1 without any major mechanical modification.

7.1.1 LCC HARDWARE REQUIREMENTS

The Locomotive Control Computer (LCC) shall consist of following types of modules:

7.1.1.1 Digital Input Interface

All the locomotive digital signals of Switches, Relay Contact Feedbacks, Contactor Feedback contacts, etc shall be electrically isolated before being given to the Locomotive
Control Computer through a Digital Input Interface. All such Digital Inputs interfaces shall be provided with reverse polarity and surge protection to prevent damage to the LCC circuits against inadvertent wrong connection. LEDs indications shall be provided for On/Off Status of these inputs on the facia of the module, for ease of maintenance/troubleshooting. These LED indications shall be made visible without opening the cover of the LCC unit. If indication of ON/OFF status of individual digital inputs is not provided, the status of the channels shall be visible on the display screen without opening the LCC cover.

7.1.1.2 Digital Output Interface

All driving signals for the Relays, Contactors, Lamps, etc shall preferably be driven through a MOSFET based circuit of adequate rating. These outputs shall be electrically isolated from LCC circuits and shall be provided with protection against short circuit and reverse polarity. LEDs indications shall be provided for On/Off Status of these outputs on the facia of the module, for ease of maintenance/troubleshooting. These LED indications shall be made visible without opening the cover of the LCC unit. If indication of ON/OFF status of individual digital outputs is not provided, the status of the channels may be shown on the display screen without opening the LCC cover.

Note: Alternatively, combined DIO cards for digital input and digital output signals may also be provided as fitted in existing ECC circuits of M/s EMD, in place of separate digital input / output cards as described in para 7.1.1.1 and 7.1.1.2 above.

7.1.1.3 Analog Input Interface

All the Analog Signals that are received from the various Sensors e.g. Voltage, Current, Temperature, Pressure etc, shall be conditioned and electrically isolated with Isolation Amplifiers before being used by LCC.

7.1.1.4 Analog Output Interface

The LCC shall drive the Load Ammeter and Speedometer mounted on the Driver's control Desk. These outputs shall be electrically isolated from CPU and shall have short circuit protection.

7.1.1.5 Speed Sensor Interface

All RPM signals to LCC shall be electrically isolated and converted to signal levels required by the LCC. The inputs shall be surge protected.

7.1.1.6 Communication Interface

In view of the electrically noisy environment inside the locomotive, it is preferable that an optical fiber based communication system be provided between LCC and TCCs.
Preferably dual redundant optical fiber communication link with adequate redundancy shall be provided to improve the reliability of the system. Communication interface shall also communicate with the Computer of Knorr Air Brake System (CCB) and Display Unit.

7.1.1.7 Gate Drive Interface

The Companion Alternator output shall be controlled to give the desired Field current to Main Alternator Field Circuit. The Drive Interface shall interface the driving signal of CPU with the firing modules of SCRs.

7.1.1.8 Power Supply

These shall provide electrically isolated power supplies for functioning of the various circuits of the LCC. This shall be designed to accept wide variation in input voltage supply and shall continue to function even during the Engine Cranking when the power supply is expected to dip to a very low voltage for a short time. The Power Supply Input shall be protected against Reverse Polarity and Surge. The EMI/EMC filtering shall be provided at the inputs to prevent noise from power supply switching going back to source.

7.1.1.9 CPU

This is the heart of the system. It shall consist of a 32 bit micro controller running at minimum 25MHz, along with its programmed software, various peripheral and interface circuits e.g. Real Time Clock, Non Volatile Memory, etc. All other circuits that are meant for processing either input or output signals shall be controlled through commands from this card. The CPU shall continuously monitor all the inputs and control all the outputs of the system based on the software program. It is preferable that provision shall be made to configure the control system through Laptop for using the system with different types of traction equipments/locomotives, through user programmable parameters, loaded in Non Volatile Memory of CPU. The details shall be finalised in consultation with DLW/RDSO.

7.1.1.10 Non Volatile Memory

A memory module (removable type memory module is desirable) shall be provided for storing the Event Data. This data shall be logged during running of the locomotive. It is desirable that the removable memory module (if provided) shall be prevented from unauthorized access by a Lock and Key arrangement. The details of the data to be stored shall be finalised in consultation with DLW/RDSO.

7.1.1.11 Display Unit

This sub assembly shall consist of a high quality alphanumeric vacuum fluorescent display (VFD). Alternatively an LCD based display with graphics functionality may be used. Any fault, Alarm condition, etc shall be shown on the display with suggested action, if any, and sounding of alarm for the benefit of the Driver. The operation of display unit
shall be MENU driven and shall be made user friendly. Normally a group of parameters shall be shown on display. The details of the various Display Screens, Text Messages, etc shall be finalized in consultation with DLW/RDSO.

7.1.1.12 General requirements

- The system design shall be made modular in construction to the extent possible with provision of visual indications by means of LEDs for easy trouble shooting by maintenance staff.
- Various cards used in the design shall have polarized connections to prevent inadvertent insertion into wrong slot and possible damage resulting due to this.
- The system hardware design shall have provision to carry out self diagnostics at Driver’s Instruction and at Power ON.
- The Electronic components used shall be of Industrial Grade.
- It shall be preferable to have the entire control system hardware so optimized that, the component count is kept as low as possible, without sacrificing the overall system performance and reliability.
- Password protection shall be provided for configurable parameters.
- Voltage, Current, Temperature, Pressure, Speed, etc parameters shall be monitored through sensors of adequate rating. The sensors used in the system shall be provided, wherever necessary, with regulated power supplies.
- Sensors used in the system shall be based on the latest technology prevalent for the Rolling Stock application in the world.

7.1.2 LCC FUNCTIONAL REQUIREMENTS

The major functions of the proposed LCC shall be

- Engine starting; in both WDG4 and WDP4B locomotive, cab engine starting shall be provided and the control system wiring shall be done accordingly in the electrical control cabinet.
- Engine Control through Governor,
- Propulsion Control,
- Excitation control of Main Alternator,
- Traction Control
- Dynamic Braking Control,
- Wheel Slip Control,
- Control of Auxiliaries,
- On line Fault Diagnostics
- Display of operating status, faults in the traction equipment/electronics.
- Communication with Traction Control computers
- Communication with Knorr CCB Microprocessor
- Other user settable parameters as detailed elsewhere in the specification.

7.1.2.1 ENGINE CONTROL

The LCC shall receive driver’s operating requests through throttle handle and drive the solenoids in Woodward governor (not in tenderer scope of supply, to adjust the diesel engine RPM to specified level. LCC shall apply restrictions in case of any faults in
Traction machines. In case of WDP4B loco when Hotel load supply is configured, even when throttle handle is at Idle also, engine shall be run at sufficient speed to maintain Hotel load power supply.

7.1.2.2 AUXILIARY GENERATOR CONTROL

The Auxiliary Generator rectified output shall be maintained constant at 74VDC, irrespective of the variation in engine speed.

7.1.2.3 PROPULSION CONTROL

The LCC functions shall include loco operational control and protection of assemblies & circuits. Protective actions may include automatic action to isolate defective assembly, request to driver for manual corrective action, or shutting down or idling engine in emergency situations. Loco operational control includes sensing of master controller settings and implementation, including direction, motoring/braking, level settings, loading controls of engine etc.

7.1.2.4 TRACTION ALTERNATOR CONTROL

Traction Alternator field shall be driven by the Companion Alternator output through an SCR bridge or IGBT based excitation unit. The LCC shall provide gate drive signals for SCRs controlling the Traction Alternator field.

7.1.2.5 TRACTION CONTROL

The LCC shall compute engine power capability, kilowatts reference, DC Link voltage reference, locomotive torque reference, torque reference for individual traction motor (or traction motors on one bogie) and Traction Alternator field current reference, depending upon various operational limits of the equipment on the locomotive and operating requests of the driver through the throttle handle on the control console. At lower speeds of locomotive, the tractive effort limitation shall decide the operating point on the tractive effort versus speed curve. At higher speeds, the horse power limitation shall decide the operating point. Based on this, torque references shall be generated and sent to Traction Inverters.

7.1.2.6 DYNAMIC BRAKING CONTROL

When the throttle handle is in dynamic braking, the LCC shall measure the BKCP voltage through an appropriate voltage sensor, compute the braking effort level and send it to the Traction Computers. The LCC shall energize the BR relays to connect the Dynamic Braking Grid resistors across the DC Link. The power generated by the Traction Motors acting as generators shall be dissipated in DB Grids. The LCC shall protect DB Grids and their cooling blowers against over current, by measuring their currents. In case of WDP4B locos, the power generated by Traction Motors shall be fed to the Hotel Load
Power Supply through DC Link, to save fuel.

7.1.2.7 WHEEL SLIP CONTROL

To maximize the adhesion performance, creep control philosophy shall be used. Speed sensors mounted on the Traction Motors provide the speed signals. Wheel diameter calibration shall be done periodically, whenever loco is under coasting in a specified band of speed range and dynamic brake/pneumatic brake is not applied. Sand shall be applied automatically. Conservation of Sand shall be given due importance. During dynamic braking the controlled creep shall be used for wheel slide control.

7.1.2.8 AUXILIARIES CONTROL

The LCC shall measure the air pressure through an appropriate pressure transducer and control air compressor loading and unloading. The LCC shall measure Turbo speed and protect it from over speeding, by reducing the power. The LCC shall control other auxiliaries like starter motors, fuel pump motors, turbo lube pump motors, TCC blowers, radiators fan motors etc. LCC shall drive indicators such as Speedometer and Load meter on both control consoles. LCC shall transmit data to the Event Recorder for recording, through serial communication. The LCC shall control wheel flange lubricators. The LCC shall provide vigilance control.

7.1.2.9 FAULT DIAGNOSTICS

The LCC shall monitor the temperatures, pressures, currents, and voltages of various traction equipment and identify the faulty equipment. Whenever a fault is identified, the LCC shall take appropriate action to restrict the operation of the locomotive depending upon the fault, and to save the other equipment from consequential damage. The system shall preferably have a built-in feature to ensure that in case of failure of a component, locomotive operation, if feasible, is either not vitiated at all or downgraded only in such a manner that the locomotive is enabled to complete the trip safely. A set of data packs and an appropriate fault message shall be recorded in a nonvolatile memory. It shall be possible to download the faults through a Laptop PC by the maintenance shed staff. An application software shall be provided for use on Laptop PC. It shall be menu driven and easy to use by maintenance shed staff without any requirement for much computer literacy.

7.1.2.10 DISPLAY UNIT

A display unit shall be provided for drivers information display. The display shall be menu driven. It shall display operational status of loco, fault messages and data packs, running totals etc. It shall be possible to conduct self-tests on various equipment, by using a key pad to be provided on the display unit. It shall be possible to cut out Traction Motors, through keypad when required. It shall also be possible to conduct self load test on the engine and Traction Alternator through the keypad, wherein the Dynamic Braking Grid Resistors shall be used as load on Alternator.
7.1.2.11 MU OPERATION

The system shall be capable to multiple unit operation in consist of upto four locomotives.

7.1.2.12 COMMUNICATIONS

The LCC shall provide communication with the Traction Computers, Knorr CCB system and Display Unit.

7.1.3 INTEGRATION OF SUBASSEMBLIES

Fully assembled Electrical control cabinets ECC #1, ECC #2 and ECC #3 shall be supplied. The functional equivalents of all the existing components in these three cabinets like sub assemblies, sensors, relays, contactors, breakers, switches, panels, etc, shall be properly accommodated in these cabinets. The existing mechanical sizes and mounting dimensions of these cabinets shall be maintained. Depending upon the requirement, some of the sub assemblies/ components may be re-arranged or integrated with others. However it is essential that overall functionality shall be either improved or maintained same as the existing system. It shall not be degraded in any way due to such modifications in design.

For all external temperature/pressure/speed sensors mounted on the engine etc, compatibility of mounting dimensions shall be maintained.

7.1.4 USER SETTABLE PARAMETERS

For flexibility of operation and future upgrades in the traction equipment, it is desirable to provide user configurability for various control parameters like currents, voltages, horse powers, temperatures, pressures, tractive effort on both WDG4 & WDP4B locomotive and speed (AEB feature) of the traction equipment. It shall be possible to configure these parameters through a laptop PC. A menu driven easy to use application software shall be provided for loading on the Laptop PC for this purpose. Password protection shall be provided to safeguard against misuse.

Details of user settable parameters are listed as below:

(a) Selection /Setting through keyboard on the display unit

- Traction motors /bogie cut in and cut out as and when needed by loco pilot.
- Self load testing.
- Tractive effort limit (settable through keyboard on the display unit or hardware).
- Self test for the following:
  
  I. Air brake
  II. DC link shorting
  III. Excitation / SCR test
IV. Wheel slip light test
V. Auto test for contactor / Relay
VI. Cooling fan test
VII. Radar and meter test
VIII. TCC blower test
IX. Auto test for digital input and digital output

(b) Selectable / Settable through laptop with configurable software

- Loco no.
- Date and time
- Shed Name
- GHP at all notches; to be adjustable in the band of ± 5%. GHP at $6^{th}$ notch to be adjustable by only; +5% while that at $8^{th}$ notch to be adjustable by; –5%.
- Power ground leakage current limits.
- Temperature Limits for Radiator Fan on/off and slow and fast speed control; to be adjustable to upto; –10 °F.
- AEB enable/disable
- TM derating protocol.

It would be preferable to design the Loco Control Computer software to enable application on the following locomotives through menu selection:

- WDG4 Locomotive
- WDG4 locomotive with distributed power consist arrangement
- WDP4B loco
- WDP4B with hotel load

7.1.5 OPTIONAL FEATURES

Provision shall be made for the following optional features, which shall be made available at an extra cost, when the user requests. The tenderer shall quote for these optional features separately.

7.1.5.1 CONTROL OF DISTRIBUTED POWER CONSIST

Load and length of trains in conventional mode with locomotives at the head get limited by coupler capacity and adequate brake pipe pressure on the last vehicle. For operation of heavier and longer trains it becomes necessary that additional locomotives be placed either in the middle or at the end of the train formation. Effective communication between two locomotive consists placed away from each other in train formation is of paramount importance for safe operation. In this case all the control and operating signals from the lead loco shall be transmitted to the distributed trailing locomotives through radio transceiver, so that all of them are run in synchronization with a single driver control from the lead loco. Encryption shall be provided for commands sent from the lead loco and feedback messages from the trail locos for security purpose. The display shall indicate the status feedbacks received from the trailing units. At any time it shall be possible to view the status of all trailing locos from the leading loco by the driver. In the trailing locos
Train Lines shall be driven based on the commands received from the leading loco. Interface shall be provided for Air brake control in the trailing locos, from the commands from leading loco. It shall be possible to use any loco fitted with this system in leading or trailing position.

Control of distributed power consist shall be done in accordance with RDSO specification No. MP.0.0400.02 (Latest revision). Successful tenderer shall prepare the design of distributed power control based on the above specification and submit the design details for approval to RDSO /DLW

7.1.5.2 AUTO CREEP CONTROL

This facility shall be required for automatic loading and unloading of coal, iron ore, minerals etc. The locomotive shall be made to run at a constant low speed set by driver irrespective of the load, gradient, curvature of track etc. It shall be possible to set the desired speed in the range of 0.4 to 30 kmph by the driver. It shall be possible to change from Auto Creep mode to Normal mode and vice versa by the driver depending upon his requirement. Equipment shall be suitable for operation of the locomotives in multiple consist upto four locomotives under auto creep control. Suitable arrangement shall be provided for switching “ON” and “OFF” operation of the auto creep control, in all the locomotives in multiple consist, from the leading loco only. The overall functionality shall be similar to the pace setting equipment supplied by M/s VAPOR, which is in use by IR at present.

7.1.5.3 REMOTE MONITORING OF LOCOMOTIVE

It shall be possible to transmit the operational status of the locomotive to a centralized monitoring station by using satellite communication or commercial cellular networks like GSM/CDMA through service providers etc. A small antenna shall be provided on the locomotive and the information shall be transmitted through a commonly used internet protocol to the central monitoring station through the service providers. This information shall be hosted on an internet web server by the service providers (ISP).

It shall be possible to view this information through internet connection by concerned Railway officials and maintenance staff at various sheds. In case of any faults in the locomotive, the fault data message and data pack shall be transmitted to the central monitoring station. Automatic generation of alerts depending upon the level of fault shall be possible, for different levels of Railway Officers through SMS. All the available data on the LCC like operational data, fault data, running totals etc, shall be transmitted, when requested. It shall be possible to identify the location of the locomotive using GPS. Fuel level data shall also be transmitted. Based on the data, it shall be possible to generate work orders for loco sheds in advance, for maintenance of the locomotive. In case of any failure of loco online, an expert sitting in the centralised monitoring station shall be able to guide the driver by an interactive communication through text/voice mails.

The tenderer shall quote for the hardware and software to be provided on locomotive for this purpose in his offer. IR shall tie up with the service providers for satellite communication and/or commercial cellular networks like GSM/CDMA and Internet
service providers. The technical data required by these service providers shall be given by the successful tenderer at the required time. If this feature is opted by IR, the successful tenderer shall also provide his technical advice in setting up the centralised monitoring station.

**7.1.5.4 OPERATION AS HOTEL LOAD INVERTER**

- It is proposed to develop a user configurable traction inverter system with individual motor control or Bogie control.
- In case of WDG4 locos, these inverters shall drive six traction motors individually or in sets of three motors (bogie control).
- In case of WDP4B locos these inverters shall drive six traction motors individually or in sets of three motors (bogie control). An additional inverter shall be provided for catering to hotel load if asked for in the tender. The additional inverter shall preferably be housed in the existing TCC cabinet. If housed separately, the envelop dimensions to be indicated with proposed lay out/ mounting arrangement.

The output of the hotel load inverter shall be 750 V, 3-phase, 50 Hz, 500KVA supply to make it fully compatible with the existing hotel load supply arrangement of EOG power cars. In the proposed system, one of the power cars shall be dispensed with.

Hotel load power from the inverter on the loco to various coaches shall be fed through two feeders (one at left and other at right side of the coaches) running parallel to the rake at 750 V, 3-phase, 50 Hz supply. Feeders of the adjacent coaches are connected through standard IV (Inter Vehicular) plug/socket arrangement.

Automatic interlocking and feeder selection system shall be used such that at a time only one power car can supply hotel load power to either feeder or both the feeders. Thus, through a feeder, simultaneous hotel load supply from both the power cars is prevented.

Required changes in the speed settings from idle to full speed of engine to get the 500 KVA rated power for hotel load at all notches (even at idle) shall be informed to RDSO/DLW.

**7.1.5.4(a) The DC link voltage shall be used as input to the hotel load inverter. Major operating parameters of the hotel load module are listed as below :**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum input voltage</td>
<td>3200 VDC</td>
</tr>
<tr>
<td>Nominal input voltage</td>
<td>300 VDC to 2600 VDC</td>
</tr>
<tr>
<td>DC link voltage ripple</td>
<td>Less than 200 V</td>
</tr>
<tr>
<td>Output voltage</td>
<td>750 V ± 5%, 50 Hz, 3-phase, 3-wire sine wave</td>
</tr>
<tr>
<td>Maximum rated output power</td>
<td>500 KVA at 0.8 – 1.0 inductive P.F.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>More than 93% at full load</td>
</tr>
<tr>
<td>Total Current Harmonics</td>
<td>Maximum 5% up to 20th harmonics</td>
</tr>
</tbody>
</table>
7.1.5.4(b) Hotel load controls shall preferably be designed such that regenerated dynamic braking power is fed back to hotel load inverter. During dynamic brake, the system shall be able to use dynamic brake power to the extent possible for hotel load and any short fall shall be met from traction power. The system shall also be designed such that when hotel load is not required or partly required, full engine output is diverted for traction purpose.

7.1.5.4(c) Additional equipment such as feeder contactors, 4-pole switches, GP relays, interlocking circuit, hotel load ON/OFF switch, Junction boxes etc shall be required for proper functioning of the hotel load system and also to make it compatible with the existing arrangement on EOG trains. These shall be at least similar to or better than the existing equipment used in Indian Railways.

7.1.5.4(d) Feeder ON indications for each of the two feeders shall be provided in the driver’s cab.

7.1.5.4(e) Following minimum operating controls shall be provided in the driver’s desk:
   a) Hotel load supply ON/OFF
   b) Hotel load feeder selection

7.1.5.4(f) The feeder selector switch shall have four positions for selecting left feeder, right feeder, both feeders or OFF condition and shall be located at driver’s cab.

7.1.5.4(g) Following safety devices, in addition to safety devices for hotel load system, shall be provided:
   a) Adequate protection shall be provided against electrical overloads.
   b) Train parting condition / PCS operation resulting in power cut off & engine idling.

7.1.5.4(h) Interlocking circuit, compatible with the existing arrangement, shall also be provided in the hotel load supply circuit to enable hotel load supply from loco only when hotel load supply from power car (at the other end of the rake) is OFF and vice versa. In the existing EOG system, this is done by two wires (namely c1 & c2) running parallel with each feeder throughout the rake up to the other power car. A power car can supply through a feeder only when these wires get shorted at the other power car’s control circuit. This circuit also provides safety against train parting/accident by making the hotel load supply OFF.

7.1.5.4(i) One IV socket, one IV plug with dummy socket and two junction boxes shall be provided at each end of the locomotive for hotel load supply to coaches.

7.1.5.4(j) PROTECTIONS FOR HOTEL LOAD MODULE
7.1.5.4(k) INDICATIONS ON LED PANEL

a) Input ON 
b) Inverter ON 
c) Inverter fault 
d) Earth fault 
e) Over load 

7.1.5.4(l) INDICATIONS ON DISPLAY PANEL

a) Voltages of all three phases 
b) Currents in all three phases 
c) Line to line short circuit 
d) Earth fault 
e) Shoot through fault 
f) Heat sink over temperature 
g) Gate drive fault 
h) Over load 
i) Inverter failure 

7.1.5.4(m) Preferably display for fault diagnosis and trouble shooting for hotel load inverter shall be common to the fault diagnosis system of traction inverter module. Relevant parameters of the fault shall be stored such that they can be easily read later.
Fault diagnosis system shall preferably have diagnostic software to help in fault analysis and give tips for trouble shooting indicating area of fault, circuit etc.

7.1.5.4(n) All the hardware for hotel load interlocking including contactors (except selector switch) shall be housed at suitable locations.

7.1.6 End of Train Telemetry (EOTT) Equipment

This system envisages a standalone EOTT comprising a Communication Display Unit (CDU) (locomotive unit / front unit) and Sense and Brake Unit (SBU) (rear unit).

The EOTT system shall include the following:

- Front Unit (Locomotive Unit) interfaced with the loco controls (LCC) System with Antenna for communication with SBU.
- Sensor Brake Unit (SBU) including antenna for communication with Front Unit
- Battery charger with 220V main power supply.

Rear unit: The rear unit shall be capable of determining the brake pipe pressure on the rear vehicle and transmitting that information to the front unit for display to the locomotive driver.

Unique code: Each rear unit shall have a unique and permanent identification code that is transmitted along with the pressure message to the font train unit. A code allotted by IR shall be deemed to be a unique code for purposes of this Specification.

Front unit: The front unit (Locomotive Unit) shall be integrated with Microprocessor based Locomotive Control System, so as to share power supply, display unit etc. and receive pressure sensor information. All data entry requirements of the Front Unit shall be done through the Microprocessor display unit.

7.1.7 The optional systems, such as Distributed Power System, EOTT and Remote monitoring of locomotive, need to be compatible with various makes of AC/AC traction systems and interoperable with various makes of the optional systems, which is essential for rationalisation of design, procurement and operation of these systems.

In order to achieve this, the suppliers of the AC/AC system shall give an undertaking to share the interface architecture & protocol of their system to enable integration with the third party systems for the above mentioned features as and when the need arises.

7.2 TRACTION INVERTER

7.2.1 The traction inverter shall be IGBT based with following configuration:

7.2.2 In the existing WDP4B/WDG4 locomotives, one inverter per three motors configuration is used. Proposed inverter system may have six inverters and use one inverter individually for each motor. In this case, three inverters shall be housed in each TCC. It shall be possible to use the same TCC for either WDG4 or WDP4B loco through simple configuration change through software by the user. Alternatively, a configuration
of two traction inverters may also be offered. In this case each traction inverter shall drive 3 traction motors on one bogie as provided in existing GM locomotives.

Inverter cubicles shall be mechanically and electrically identical for both WDG4 and WDP4B locomotives. In other words, it shall be possible to use same inverter either on WDG4 or WDP4B locomotive without any structural changes on the existing locomotive.

Input supply for all the traction inverters and for hotel load inverter shall be the same DC link. In case of alternate configuration of IGBT converters for traction and hotel load the same shall be got approved from RDSO/DLW.

The hotel load configuration is detailed in para 7.1.5.4

7.2.3 The basic control philosophy for the induction motor shall be such as to achieve best suited results for traction application like minimum device losses, high dynamic response, stable constant speed operation, fast acting slip/slide control etc. Direct Torque Control, Vector Control, Slip Frequency Control etc. are some of the popular control strategies used for traction drives. Vector control system is used in the existing locomotives. The tenderer shall furnish the details of control strategy duly describing its merits.

7.2.4 The software of the inverter control system shall be fully compatible with the LCC software including closed loop propulsion control, slip slide control, exchange of temperature data, fault diagnosis etc. The inverter system shall have its own protection and control logic, which it shall also be able to communicate with the LCC in the event of a fatal failure to initiate a protective shutdown of the locomotive. Damage to IGBT devices of the inverter shall be prevented in case of a short circuit at the load end.

7.2.5 Existing WDP4B/WDG4 locomotives use two traction control cabinets (TCC) installed in parallel. The dimension of each cabinet is 1790 mm x 1061 mm x 1527 mm. The weight of each cabinet is 1420 Kgs. The proposed inverter system may consist of two cabinets (each housing three inverters in case of axle control) or single cabinet (housing both the inverters in case of bogie control). Overall envelope dimensions and total weight of the complete system including traction inverters and hotel load inverter shall generally conform to the existing overall envelope dimensions and total weight respectively. If transformers are required for hotel load application, they may be considered to be installed outside the TCCs depending upon availability of space. Details of available space shall be worked out mutually between DLW and successful tenderer. Redesign and engineering work required at DLW to adapt the carbody interface to accommodate proposed traction inverter cum hotel load inverter system and loco control system shall be minimized. Complete details of mechanical and electrical modifications along with part list and detailed drawing changes required to accommodate the proposed system shall be submitted to RDSO/DLW, before installation.

7.2.6 The TCC consisting of the inverters with their control systems, blower, transducers and protection circuits shall be supplied as a complete frame with doors and covers. However, traction control computer may also be provided as separate circuit module that can be integrated with proposed microprocessor based loco control system.

7.2.7 Motor cut out facility shall be provided to isolate defective traction motor(s) in case
of any fault. In case axle control philosophy is followed, each defective traction motor can be isolated individually. In the event of bogie control system and in case of inverter cut out, inverter control system shall be designed to automatically reduce locomotive power adequately so that remaining inverters and motors are not overloaded and the locomotive is able to reach up to destination with reduced power. Locomotive power shall be reduced in proportion to the number of traction motors cut out at that time.

7.2.8 The proposed traction inverter and loco control computer system shall be designed to use the traction motor speed sensors and temperature sensors to be supplied along with the system for the motors of WDP4B/WDG4 locomotives. Temperature sensors and speed sensors are connected to control cabling by a 5-pin VEAM connector mounted on the motor frame.

The traction motor speed and temperature sensors shall be compatible with TCC & LCC and shall also be mechanically compatible with the traction motors i.e. it shall be possible to fit these sensors in the existing traction motors without any alteration in the traction motor. The tenderers shall educate themselves regarding the type of traction motors and fitment provisions. Presently M/s Siemens make traction motors type 1TB2525 0TA02 (MAC version) and 1TB2525 0TB02 (PAC version) are used on these locomotives. Speed sensors of M/s Norris and M/s Krauss Maffei make whereas temperature sensors of M/s Norris make are being fitted on these locomotives.

7.2.9 In the existing locomotives, a system called IPS (Inverter Protection System) is used to protect the inverter from over voltage and over current conditions on supply as well as load side. Current and voltage values are continuously monitored and protection is achieved by short circuiting the source with a medium crowbar resistor and turning OFF the main alternator excitation by EM2000 control system in case current or voltage exceeds a pre-set value. Resistance and inductance values of this IPR (Inverter Protection Resistor) are 0.18 – 0.23 ohm and 20 – 50 mH respectively. An alternative proven and reliable protection system may be offered by the tenderers. Since IGBT based inverters do not have problem of device failing to turn-OFF, a soft crowbar resistor of suitable value may alternatively be used for each traction inverter to protect the inverter from over voltage. However, it is preferable to use the existing IPR mounted external to the inverter cabinet in the DBR hatch assembly.

7.2.10 The proposed traction inverter system shall be capable of withstanding dielectric test voltages as per following standards:

(a) Power circuit : As per IEC-61287.
(b) Control circuit : As per IEC-60571.

The inverter system shall be subjected to the above test voltages only once during prototype/routine testing.

7.2.11 The traction inverter system shall be designed for following protection class :

(a) For phase modules : IP20
(b) For electronic compartments : IP54
7.2.12 The main power semiconductor device used for switching shall be Insulated Gate Bipolar Transistor (IGBT). The PIV rating of device shall not be less than 4.5 kV. The IGBT module may contain external or internal protection circuits and gate drive circuits. The complete system shall be designed as simple as possible with reduced number of components without compromising reliability and efficiency. The devices offered shall be field proven. The detailed characteristics of the devices along with details of gate drive circuits and protection circuits used shall be furnished in the offer.

7.2.13 Suitable temperature sensors shall be provided so that temperature of phase modules / IGBT modules can be continuously monitored by the control system. In case of over temperature, traction motor torque shall be gradually reduced to keep phase modules / IGBT modules at safe operating conditions. Additionally, IGBT modules shall preferably be provided with a built-in self-protection function to avoid failure on over temperature, in case of failure of temperature sensor.

7.2.14 COOLING SYSTEM

In the existing locomotives, evaporation bath cooling is used for phase modules of the traction inverters. Air for the secondary cooling of phase modules of each inverter and cabinet cooling comes directly from the ambient supply by a forced air inverter-cooling blower located in the cabinet itself. Therefore two blowers are used, one in each inverter cabinet. These are dual speed 3-phase AC induction motor blowers with power supply taken from locomotive’s companion alternator at 24–120 Hz, 40–220 V for nominal engine speeds. The EM2000 control system of the locomotive exercises control of the blowers at the request of traction control computers via RS-485 serial link.

In the proposed system, secondary cooling shall be forced air cooling only. It is preferable that cooling requirement of complete TCC be met by blowers that are located inside the TCC itself. Power supply for these blowers may be taken from locomotive companion alternator.

7.2.15 In the existing locomotives, cooling and pressurization in some parts of the two inverter cabinets is achieved by inertially filtered air taken from the central air compartment followed by two paper filter assemblies, one located at each inverter cabinet. TCC electronic blower is located in the locomotive central air compartment and is driven by input supply from companion alternator. This air supply keeps dirt from contaminating areas containing DC link capacitor, Gate units and traction computers.

In the proposed system TCCs shall preferably be pressurized by fine filtered air in a similar way as in the existing locomotives. Sufficient air mass stream shall be available at TCC inlet clean air duct after air filter.

7.2.16 GENERAL POINTS OF GUIDANCE FOR TRACTION INVERTER DESIGN

(i) Inverter shall be of PWM type with high switching frequency to obtain near sinusoidal waveform and reduce current harmonics even in the lower speed region of traction motor.
(ii) The harmonics of the output waveform of inverter shall be controlled to minimize the traction motor torque pulsations, traction motor heating and also to provide constant and high adhesion between wheel and rail throughout the operating speed range of the locomotive.

(iii) The dv/dt on the inverter output shall be minimized to reduce motor winding stresses and prevent corona breakdown / insulation damage to the windings. It shall be designed considering motor cable length to reduce over voltage transients on motors.

(iv) The components and technology used shall ensure very high efficiency of the inverter system. Typical efficiency of about 98% is preferred. Manufacturer shall furnish the expected efficiency with respect to locomotive load/speed.

(v) In the design of IGBT based inverter and associated control equipment, reliability and maintainability shall be of paramount importance. Adequate margin shall be provided to take into account ambient conditions prevailing in India. Freedom from dust and protection from surges shall be ensured.

(vi) For semiconductor devices a safety margin of 25% on the ratings for current and voltage under worst operating conditions shall be provided and established through calculations.

(vii) Appropriate warning labels and safety provisions shall be made in the inverter system to prevent direct human contact to any electrical live part.

(viii) Inverter system shall be provided with following features to minimize possibility of trains being stalled on the section:

(a) In case of axle unit system, one axle can be cut-out in the event of major faults with the inverter. Similarly in case of bogie control, traction motors of a bogie may be cut out in the event of an inverter fault. In either case, it shall be ensured that journey is completed with defective equipment isolated.

(b) Suitable margin shall be provided in the equipment rating such that under emergency conditions with isolation of single traction unit such as inverter, traction motor(s), etc., there is no necessity to reduce trailing load on level track and the journey can be completed at reduced speeds, if adhesion conditions are satisfactory. The one-hour ratings of the equipment shall not be exceeded under such operations. For this purpose, short-time ratings of the major equipment shall be furnished by the manufacturer.

7.2.17 Inverter design shall be modular in construction to facilitate ease of replacement preferably with the use of interchangeable phase module assemblies. As far as possible, standard sub systems and modules shall be used. In case of any fault, removal and replacement of phase modules shall be easy. Complete inverter system shall be designed such that it requires minimum maintenance. Easy access for all sub-assemblies / components shall be provided for inspection and maintenance. Tenderer shall confirm support for obsolescence of all semiconductor devices for a minimum period of 15 years.
7.2.18 Inverter electronics shall be TCN compatible. All communication interfaces shall be TCN compatible as per IEC-61375-1. However, if it is not possible to design TCN compatible inverter control system having proper functional interface with locomotive control system, then the alternative communication interface offered shall be got approved. In this case, the tenderer shall submit details of the alternative protocol to RDSO/DLW for approval.

7.2.19 Features of data logging for monitoring fault conditions. Facility for interfacing PC / laptop for upload / download of data for fault diagnostics and further analysis shall be provided. A real time clock unit is to be provided along with the fault logs so that tripping time can be co-related with the operating conditions of the locomotive. The fault codes shall be in text format which shall be comprehensible for the operating and maintenance personnel. Faults shall be stored in permanent memory with a buffer battery. Minimum fault log size shall be 50 faults with ring buffer. It shall be possible to download the fault log using a lap top computer and interpret it through a separate common PC application such as MS EXCEL etc. Important parameters of the equipment at the time of occurrence of the fault shall be recoverable for fault analysis and shall include the following:

a) Identification of the fault and its brief description in text and coded form.
b) Identification of components and sub assemblies involved.
c) Time and date of fault occurrence.

The programme download shall preferably be through an online connected PC platform without the need to remove the memory chips. A FLASH EPROM based program memory is preferred.

Optionally, a facility for standalone testing may be offered, through which, it shall be possible to offline test the inverter by inserting a test EPROM or by downloading a test program in FLASH.

Features to take corrective action in case of certain critical recognizable faults. The inverter system shall have its own protection and control logic, which it shall also be able to communicate with the loco control system in the event of a fatal failure to initiate a protective shutdown of the locomotive.

The protective shutdown in case of defined fatal conditions shall be based on a predictable logic preferably implemented in the hardware of inverter electronics. Damage to IGBT devices of the inverter shall be prevented in case of a short circuit at the load end.

7.2.20 Proper shielding against electric and magnetic interference shall be provided. Cable length for gate drive timing signals transmitted from traction control system shall be kept minimum to minimize losses and prevent loss of data. Actual firing pulses shall be generated by gate drive units mounted in the phase modules. Proper electrical isolation for low voltage gate drive signals and high voltage gate drive power supplies shall be provided. Proper creepage distances between high and low voltage circuits as well as to the ground shall be maintained.
7.2.21 All cables used in the TCC & ECC shall be E-Beam cables. All control cables of size upto and including AWG size 3 (25.59 mm²) shall be governed by EDPS-179 and all power cables of size AWG1 (46.6 mm²) and larger shall be governed by EDPS-304.

7.3 AEB and Blended Brake Operation

7.3.1 Both WDG4 and WDP4B locos shall be provided with Auto Emergency Brake system (AEB). AEB by default initiates braking in the event of train/loco crossing the permissible set speed. AEB operation and reset procedure shall be as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Method of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable/Disable</td>
<td>Through toggle switch/key switch on ECC #1</td>
</tr>
<tr>
<td>AEB operating speed/reset speed</td>
<td>Operating and reset speed shall be user settable through software.</td>
</tr>
<tr>
<td>AEB reset speed/procedure</td>
<td>Automatic (through software), after achieving reset speed. A manual reset push button shall also be provided on ECC #1</td>
</tr>
<tr>
<td>Event after AEB activation</td>
<td>Air Brake &amp; dynamic brake by system. PCS “ON” indication and message on DID.</td>
</tr>
</tbody>
</table>

7.3.2 Both WDG4 and WDP4B locos shall be provided with blended brake feature. For train braking, dynamic brake effort shall be used to the extent possible to reduce wear and tear of wheels and rails. Existing CCB shall be retained and its compatibility with the complete system shall be the responsibility of the tenderer.

Blended brake operation process shall be as follows:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Method of operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable/Disable</td>
<td>Through toggle switch on ECC #1</td>
</tr>
<tr>
<td>Blended Brake indication</td>
<td>Indication lamp on ECC #1</td>
</tr>
</tbody>
</table>

* * In case a penalty brake application is imposed on the driver through the VCD, the same shall be reset as per extant procedure defined for VCD resetting.

7.4 EVENT RECORDER AND VIGILANCE CONTROL

7.4.1 EVENT RECORDER

This shall generally meet the requirement as per RDSO specification No. MP.0.3700-01, (Rev. 03), December 1999 with ordering specification for GT46MAC speed recorder interface, Nov’98. Successful tenderer shall prepare the design of event recorder based on the above specification and submit the design details for approval to RDSO /DLW. The system shall be able to record the following events in a separate (take out type) memory unit:

a. Train Brake pipe pressure \( \text{kg/cm}^2 \)

b. Loco Brake Cylinder pressure \( \text{kg/cm}^2 \)

c. Status of penalty application (through PCS)
d. Notch position (idle, 1st to 8th)
e. Status of power application (motoring/braking)
f. Direction of movement of loco (FOR/REV)
g. Locomotive speed (Kmph)
h. Status (ON/OFF & Dim/Bright) of headlight
i. Status (ON/OFF) of flasher light
j. TE limit switch ON/OFF

**Note:** (optional)

1. The system shall have provision for two additional digital and two analog signals processing and recording over and above the specified these ten parameters.
2. An alphanumeric data entry keyboard is to be provided in the display unit itself for entering Driver's code / token number / Driver's name in 16 digits, Train number/Name in 8 digits, Section name in 9 digits by the locomotive operator.

### 7.4.2 MULTI-SETTING VIGILANCE CONTROL

This shall generally meet the requirements as per RDSO specification No. MP.0.34.00.04 (Latest revision). Successful tenderer shall prepare the design of event recorder based on the above specification and submit the design details for approval to RDSO /DLW. Vigilance Control Device (VCD) is provided to enhance the safety of locomotive operation by ensuring alertness of the crew all the time. The system shall be of multi - resetting type i.e. acknowledgement of the system is not only by means of pressing push button but by the other normal driving activities (i.e. throttle handling, dynamic brake application, operation of horns, sanders or application of brakes), of the driver during the train operation. This reduces the strain on the driver, as he is not required to press the push button always when operating other controls of the locomotive.

a. VCD shall normally require the presence of the driver near the control stand from which the locomotive is being operated.
b. The electrically operated magnet valve of the device shall be designed to work on the normally de-energized principle.
c. The device shall be capable of being worked off batteries, and / or auxiliary generator provided on the locomotive.
d. The device shall ensure that the locomotive is brought to a halt if the driver were incapacitated at the controls.

### 7.4.2.1 ACKNOWLEDGEMENTS

Any of the following activities of the driver/crew occurring during vigilance cycle period T0 i.e. 60 seconds shall serve as an acknowledgement of the Vigilance Control Device and the timer shall be reset automatically to its initial position.

a. Vigilance cycle reset button pressed
b. Change of throttle handle position
c. Application of dynamic brakes
d. Operation of horns
e. Operations of sanders
f. Application of brakes

The Vigilance cycle reset button shall be located in the control stand in such a position that it is easily accessible to the driver without leaving his seat. In case of locomotive with two control stands/cabs, the reset button shall be provided on both control stands/cabs and connected in series.

### 7.4.2.2 SYSTEM OPERATION

The time sequence of system operation are summarized in the table below:

<table>
<thead>
<tr>
<th>Operating cycles</th>
<th>Time periods in seconds</th>
<th>Indications</th>
<th>Whether VCD can be reset or not by push button / acknowledgements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vigilance cycle (T0)</td>
<td>60</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>Warning cycle (T1) Level I</td>
<td>17 ± 2</td>
<td>Yellow flashing light</td>
<td>Yes</td>
</tr>
<tr>
<td>Warning cycle (T2) Level II</td>
<td>17 ± 2</td>
<td>Yellow flashing light and alarm sounds</td>
<td>Yes</td>
</tr>
<tr>
<td>Penalty brake (T3) Level I, Engine idling</td>
<td>34 ± 2</td>
<td>Yellow flashing light remains but alarm stops</td>
<td>No</td>
</tr>
<tr>
<td>Penalty brake (T4) Level II</td>
<td>Until reset</td>
<td>None</td>
<td>Yes, Only by reset button</td>
</tr>
</tbody>
</table>

i. Counter shall be provided which shall increase by one unit whenever penalty brake application takes place. This counter shall be visible to the driver through display unit so that reading can be noted whenever crew changes takes place.

ii. If the Vigilance control re-set button remains in press/release position for more than 60 sec, the vigilance cycle shall start again.

iii. The device shall ensure that the locomotive comes to halt in case driver is incapacitated at the control stands.

### 7.4.2.3 FAIL SAFE FEATURE DURING FAULT IN THE VIGILANCE CONTROL SYSTEM

The system shall be fail safe i.e. penalty brake shall initiate for any fault in the Vigilance control system and a fault indication given to the driver. The fault cycle period shall be set at 34 sec, during which the brake application cannot be cancelled. Only after the expiry of the fault cycle, and the throttle handle has been set to idle position, an attempt can be made by the driver to reset the fault condition, and resume normal vehicle operation using the Vigilance Control Reset push button. In case it is not possible to reset the fault condition, the Vigilance control system shall be isolated.
7.4.2.4 ISOLATION OF VIGILANCE CONTROL (optional)

The vigilance control shall be provided with an arrangement by the tenderer through which it can be isolated in case it becomes defective/malfunctions. This arrangement shall be accessible only on breaking of a seal or a glass cover.

7.4.2.5 VIGILANCE SUPPRESSION

a. There shall be a provision to suppress the operation of Vigilance control when continuous proof of driver’s vigilance is not required. Such suppression shall take place if Brake cylinder pressure is minimum 2.3 kg/sq cm.

b. Vigilance suppression shall not function during T1, T2 and T3 periods, as well as during Fault cycles.

c. Vigilance control system during MU Operation

The Vigilance control system shall be disabled on a slave locomotive in multiple operations. The vigilance shall also be automatically suppressed whenever both control stands are set to the OFF position.

7.5 ECC PANELS

Layout and mounting arrangement of ECC #1, ECC #2 and ECC #3 panels shall be such that it shall be possible to accommodate these in the existing envelopes and as far as possible mounting arrangement shall also be same as that of existing panels.

These shall be designed and manufactured generally conforming to DLW / RDSO specifications.

Following points shall be considered for proper design of ECC #1, ECC #2 and ECC #3 panels:

a) Ventilation engineering of the each cabinet shall be done based on the cooling requirement of major components of the cabinet.

b) Design of the cabinets shall be modular to facilitate quicker assembly.

c) The cabinets shall be pressurized to avoid ingress of dust and other contaminates inside the cabinets. A pressure of 2 to 3 inches of water gauze shall be maintained in the cabinets.

d) No electro pneumatic contactors shall be used.

e) Components and cables of common electrical circuits shall be grouped together to reduce EMC interference.

f) Cooling requirements of existing ECC #1, ECC #2 and ECC #3 cabinets are 200 CFM, 250 CFM and 75 CFM of fine filtered cooling air respectively.
g) The cabinets shall be designed to permit its welding with the underframe.

The functional equivalents of all the existing components in these three cabinets like sub assemblies, sensors, relays, contactors, breakers, switches, panels, etc, shall be properly accommodated in these cabinets. Depending upon the requirement, some of the sub assemblies/ components may be re-arranged or integrated with others. Such modifications shall be clearly brought out in the schematics and approval of DLW/RDSO shall be taken at design review stage.

It is essential that overall functionality shall be either improved or maintained same as the existing system. It shall not be degraded in any way due to such modifications in design.

8.0 PERFORMANCE REQUIREMENTS

8.1.0 TRACTION INVERTER

The proposed traction inverter system shall be designed to operate with following input/output voltage and current variations under specified site conditions:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal input supply voltage</td>
<td>300 VDC to 2600 VDC (with ripple less than 100 V).</td>
</tr>
<tr>
<td>Maximum continuous input current</td>
<td>1250 ADC per bogie</td>
</tr>
<tr>
<td>Maximum input voltage</td>
<td>3200 VDC</td>
</tr>
<tr>
<td>Output rms voltage (phase to phase), 3-phase AC variable (fundamental wave)</td>
<td>0 V to 2030 V</td>
</tr>
<tr>
<td>Maximum output rms phase current</td>
<td>900 Amps per bogie</td>
</tr>
<tr>
<td>Output frequency</td>
<td>0 Hz to 160 Hz</td>
</tr>
</tbody>
</table>

8.2 TRACTIVE EFFORT/ BRAKING EFFORT CHARACTERISTICS

8.2.1 Traction Motor torque vs. speed characteristics (for existing motor) and loco TE & BE characteristics of WDP4B and WDG4 locomotives are attached with this specification as listed below:

Traction motor characteristics:

(i) Traction motor torque vs. speed curve (driving operation) - Annexure-E
(ii) Traction motor torque vs. speed curve (braking operation) - Annexure-F

(a) WDP4B LOCOMOTIVES

(i) Loco Tractive Effort vs. speed curve (driving operation) - Annexure-C
(ii) Loco Braking Effort vs. speed curve (braking operation) - Annexure-D
(b) **WDG4 LOCOMOTIVES**

(iii) Loco Tractive Effort vs. speed curve (driving operation) - Annexure-G
(iv) Loco Braking Effort vs. speed curve (braking operation) - Annexure-H

8.2.2 Tenderer shall try to improve upon the current starting TE values and submit the proposed TE vs. speed characteristics along with the offer. These shall have to be worked out based on the cooling air available for traction motors and ventilation requirements of traction motor.

The control system shall have such a provision that, at any time, not-in-use hotel load power (residual from allocated 500 KVA) shall be used for traction.

Tenderer shall submit Tractive effort versus speed curves without hotel load and tractive effort versus speed curves with hotel load. The curves shall be drawn for all the notches.

8.2.3 The proposed inverters and LCC with existing or equivalent traction motors shall also be used for generating dynamic braking for the locomotive. Any change in the BE (Braking Effort) vs. speed characteristics of the locomotive, due to additional hotel load power, shall be fully explained and justified by the tenderer. Revised BE vs. speed curve shall be furnished with the offer. The existing DBR (Dynamic Braking Resistance) value may also undergo a change, which shall be specified. However, outside interface of the DBR (with other equipment on the locomotive) shall be maintained as existing. The DBR and blower assembly shall be provided by the DLW. The details of the existing DBR assembly shall be provided to the successful tenderer.

8.2.4 Typical data for existing WDP4B/WDG4 locomotives for 4500HP application is given as below:

- Maximum starting tractive effort : 400KN for WDP4B and 540KN for WDG4.

8.2.5 The traction inverter system shall use the existing traction motors and retain the existing gear and pinion ratio. The gear and pinion ratio for WDP4B locomotives is 77:17 and for WDG4 locomotives it is 90:17. The vehicle gauge is 1676 mm broad gauge and axle load permissible is 21.0 tonnes, +2% -4%. The curves given above shall be applicable for the new wheel diameter of 1092mm+0.5mm and shall be ensured.

8.2.6 In the existing system under normal operating conditions there is no reduction in tractive effort and not any continuous speed limitation exists. However, temperature sensors in the traction equipment are continuously monitored and inverter control system reduces the tractive effort suitably to protect the equipment from overheating during any abnormal condition such as loco operation over long gradients for prolonged periods etc. The de-rating protocol to be adopted to protect the major equipment such as traction motor, inverter etc., in case of such abnormal conditions, shall be furnished by the successful tenderer.

8.2.7 The supplier shall state the value of maximum starting tractive effort, continuous tractive effort and speed values that shall be developed under dry rail conditions and also under all weather conditions, which shall be demonstrated during testing.
8.3 ADHESION REQUIREMENTS

Microprocessor shall be provided with state of the art adhesion improvement system. The system shall be able to optimize the adhesion for all other weather conditions - dry rail, wet rail conditions- and all track conditions - mainline, branch line and station yards- and operating conditions (starting, running, braking).

Tenderers are required to indicate the expected level of adhesion improvement in various conditions. The proposed inverter and LCC shall achieve better or at least same adhesion performance compared to the existing WDG4 and WDP4B locomotives.

Starting adhesion on WDG4 loco in fair weather condition with sanding shall not be less than 41% and shall deliver maximum starting tractive effort of 540 KN. The starting adhesion on WDP4B loco, in fair weather condition with sanding, shall be adequate to obtain a minimum of 400 KN starting tractive effort.

8.4.1 The locomotive shall be working under 25 kV, 50 Hz, OHE system also. Electronic signals generated inside the traction inverters and loco control systems shall not be affected by this and locomotive shall work without any adverse performance.

8.4.2 The tracks over which the offered system shall work may be equipped with DC track circuits, 83-1/3 Hz track circuits as well as track circuits at higher frequencies. Harmonics generated by the inverter system shall not affect signaling gears like audio frequency track circuits and axle counters which work in the range 0-5 kHz with a limit of 400 mA. On the communication network, control circuits, teleprinter circuits, as well as VHF/UHF and microwave circuits are employed. The psophometric voltage induced on communication circuit running by the side of track shall not exceed 1 mV.

8.4.3 Compatibility with Signal & telecommunications installations

a). The design of the power electronics provided on the locomotive/ propulsion system shall be such as not to cause levels of interference exceeding the levels specified below at any point in the operating envelope of the locomotive:

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Interference current</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Psophometric current</td>
<td>10.0 A</td>
</tr>
<tr>
<td>2.0</td>
<td>DC component</td>
<td>4.7 A</td>
</tr>
<tr>
<td>3.0</td>
<td>Second Harmonic component (100 Hz)</td>
<td>8.5 A</td>
</tr>
<tr>
<td>4.0</td>
<td>1400 Hz to 5000 Hz</td>
<td>400 mA</td>
</tr>
<tr>
<td>5.0</td>
<td>More than 5000 Hz upto 50000 Hz</td>
<td>270 mA</td>
</tr>
</tbody>
</table>

b). Locomotive shall comply European Standards EN 50238 for Railway applications- Compatibility between rolling stock and train detection systems and EN 50121 for Railway applications-Electromagnetic compatibility, as applicable.
8.4.4 Acoustics noise level generated shall not exceed 80 dB at a distance of 1 meter.

8.5 OTHER REQUIREMENTS

8.5.1 It shall be possible to use the proposed locomotive control computer, and traction inverters along with the traction computers for WDG4 or WDP4B locomotives interchangeably through configuration of user settable parameters and some jumper settings, without any change in software or hardware.

8.5.2 Major existing equipment such as alternator, motors etc. shall be used without any change. Complete system shall be designed such that there are minimum changes required in the existing arrangement.

8.5.3 To ensure integration with existing equipment and good locomotive performance, extensive simulation / systems testing of proposed LCC with traction inverters and existing motors shall be performed by the manufacturer before prototype approval.

9.0 DETAILS OF TRACTION MOTOR

Main technical data of traction motor for both WDP4B/WDG4 locos for 4500HP loco application is given as below:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal starting torque</td>
<td>9500 Nm</td>
</tr>
<tr>
<td>Maximum continuous power according to IEC 60349-2 at motor shaft with DC link voltage = 2600V.</td>
<td>630 KW min at 1460 rpm</td>
</tr>
<tr>
<td>Maximum continuous power according to IEC 60349-2 at motor shaft at rated voltage.</td>
<td>485 KW min at 685 rpm (20% additional for bogie cut out)</td>
</tr>
<tr>
<td>Maximum current (RMS value of fundamental wave)</td>
<td>270A</td>
</tr>
<tr>
<td>Maximum permissible speed</td>
<td>3320 rpm min</td>
</tr>
<tr>
<td>Inverter Frequency Maximum</td>
<td>120 Hz</td>
</tr>
<tr>
<td>Circuit</td>
<td>Y</td>
</tr>
<tr>
<td>Supply conductor</td>
<td>70 sq.mm</td>
</tr>
<tr>
<td>Thermal class</td>
<td>Class 200N2</td>
</tr>
</tbody>
</table>
Electrical characteristics | Shall match the existing traction motor type Siemens make 1TB2525-0TB02 or 1TB2525-0TA02 such that there is complete compatibility with the existing locomotive and traction equipment, particularly the computers and there is no need for any change in the relevant OEM software. The system supplied shall be compatible with both the makes of speed sensors in the TM i.e. with 'Norris' make as well as 'Krauss Maffei' make.

Insulation | Class 220 IEC 60034-18 to be read along with special stipulations in this specification at clause 6.

Gear ratio | WDP4B: 77/17, WDG4: 90/17

10.0 DOCUMENTATION

10.1 All the information which would be required to evaluate the suitability of the offer vis-a-vis this specification shall be submitted along with the offer. Following documents shall invariably be submitted by each tenderer along with the offer for evaluation:

(a) Functional description of the complete system, including salient features and advantages of the offered system.
(b) Clause by clause compliance with the specification.
(c) Details of technical support and training offered.

(d) All characteristics curves, including the proposed notch-wise TE Vs Speed, notch-wise DC link V-I, efficiency numbers and ventilation characteristics of the equipment offered, parasitic load of the auxiliaries used in the system, BE Vs Speed, basic design data like ratings and temperature capability, envelope and mounting drawings etc. shall be submitted with the offer.

10.2 Following documents shall be submitted by the successful tenderer, in hard and soft copies, before commissioning of the equipment on loco.

(a) Technical documentation explaining the complete system including characteristic curves, inverter output curves and efficiency, diagnostics, and protection circuits etc.
(b) Locomotive control circuit schematics.
(c) Lay out and mounting drawings of all the equipment offered
(d) Drawings of each sub-system with interface details.
(e) Cooling system details.
(f) Details of enclosures provided.
(g) Details of lubricants.
(h) Procedure for user settable parameter alteration, fault data downloading and analysis etc.
(i) Maintenance and trouble shooting manual for all the equipment offered.
(j) Recommended list of spares for 3 years.
(k) List of special tools, jigs and fixtures needed for testing, commissioning, maintenance and repair.
(l) Modifications needed in the existing locomotives to adopt the offered system.

Irrespective of the details brought out here, all information and documentation which are essential for manufacture and maintenance of the locomotive with the equipment supplied shall be submitted on request of IR.

11.0 TESTING & INSPECTION

11.1 The details of tests and trials to be done on each electronic equipment/sub-assembly of the AC Traction System and on the complete system after installation on locomotive are indicated at annexure - I.

11.2 Type and routine tests on other equipment related with loco control and traction inverter system offered shall generally be conducted in accordance with IEC-60571, IEC-61287 and other relevant IEC standards separately. However, if the tenderer proposes a different test scheme, the same can be examined by DLW/RDSO on provision of alternative test procedures submitted by the tenderer.

11.3 The supplier shall submit detailed type and routine test programs to DLW/RDSO for its approval. RDSO/DLW may also decide to carry out some special tests on the equipment, which are not covered by relevant IEC specifications. Tests shall be carried out as per mutually agreed test program and the total cost shall be borne by the manufacturer.

11.4 The prototype unit shall be tested by RDSO/DLW representative(s) at the manufacturer’s premises where all the facilities shall be made available for carrying out the prototype test.

11.5 Validation test: A final validation test shall be conducted at DLW on the load box by IR, in which all the performance requirements, which can be determined in static condition, shall be established by the manufacturer, particularly the power requirement as per para 1.2.1. Any adjustment required on the Woodward Governor or fuel rack for achieving the performance requirements shall be arranged by IR, if necessary.

11.6 Instrumentation for type/routine and Validation tests tests

(a) All the instruments used for testing shall be duly calibrated. The calibration certificates are to be shown to RDSO/DLW representative(s) on demand.

(b) Value of the fundamental component and THD of traction inverter output shall be measured by power analyzer during the prototype test at various mutually decided preset points in traction and braking mode. True RMS value of output voltage is also to be measured for record.
11.7 **QAP:** The successful tenderer shall also be required to submit a detailed Quality Assurance Plan (QAP) along with the inspection plan for the equipment supplied for approval by IR before the same is adopted.

11.8 **Rating and performance trials:** These tests may be done on one prototype locomotive built with the equipment prototypes supplied by successful tenderers by IR at their own cost covering the following:

- Dynamometer car test to ascertain starting and rolling resistance of the locomotive and to prove “tractive effort-speed” characteristics and “dynamic braking effort/speed” characteristics.
- Adhesion test to prove adhesion capability.

The successful tenderer shall be permitted to associate with the tests as these tests are one of the means to determine clearance for series manufacture. If either the microprocessor data obtained after the prototype locomotive has been put in commercial service is considered adequate by RDSO or similar test/trial data is already available with RDSO, to establish the performance requirements of the locomotive, these tests may be waived.

11.9 **Field trials:** One prototype locomotive each shall be subjected to field trials on IR for at least three month. The manufacturer shall depute a team of engineers for commissioning, testing and field trials of the locomotive and its equipment in service. The manufacturer shall associate in the field trials jointly with IR. The manufacturer shall ensure availability of typical tools & spare parts in adequate quantity for field trials, to be done as part of commissioning.

11.10 All the modifications required due to defects noticed or design improvements found necessary as a result of the field test / trials shall be carried out by the tenderer in the least possible time. Total cost of such modifications/design changes shall be borne by the manufacturer.

11.11 **Type test:** shall be performed on one prototype unit of given design to verify that product meets the specified design requirements. However, routine tests shall be carried out on each equipment.

11.12 If mutually agreed between manufacturer and RDSO/DLW, witnessing of routine test may be waived for sets manufactured after the prototype. The routine test of equipment, for which witnessing has been waived, shall be accepted after successful scrutiny of test results submitted to RDSO.

11.13 Subject to agreement between RDSO/DLW and manufacturer, some or all the type tests shall be repeated on sample basis so as to confirm the quality of the product. This shall be part of revalidation of vendor approval. In addition, the manufacturer shall repeat all the type tests after 5 years without any additional cost. Type test may also be repeated in any of the following cases:

- Major modification of equipment, which is likely to affect its functionality or performance.
11.14 To obtain additional information regarding performance and functionality of any equipment or sub-system, investigation tests may be specially requested by RDSO/DLW.

12.0 WARRANTY

The complete system with controls shall be warranted for satisfactory and trouble free operation in conformity with the standard IRS conditions. All aspects of workmanship and design shall be covered by this warranty. The supplier shall immediately provide arrangement for rectification of failures reported under warranty.

Warranty period of any equipment of the system may be extended as per mutual agreement between RDSO/DLW and supplier if the equipment has undergone major design modifications during the warranty period.

13.0 FAILURES DURING WARRANTY PERIOD UNDER MAINTENANCE CONTRACT

13.1 In case of any failures, the details of failure and action taken to arrest re-occurrence of similar failure in future with failure analysis report etc. is to be submitted to RDSO/DLW.

13.2 In case of repeated failures, necessary changes in design on the units put in service or in production line are to be made by the manufacturer. Investigation tests, if considered necessary, are to be arranged/conducted by the manufacturer.

14.0 MARKING AND PACKING

14.1 Each equipment shall bear for identification DLW order number, batch/lot number, serial number, type, year of manufacture, manufacturer’s name as well as important nominal and short time ratings.

14.2 All equipment of the complete system shall be suitably packed in strong water proof boxes to prevent any damage during transit and handling.

15.0 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 complete system and any other factor, which may cause such dispute. The responsibility to settle any issue lies with the manufacturer.
Tractive Effort Vs Speed characteristics (AAR Condition)
4500 GHP WDP4B Diesel Electric Locomotive
One Traction Alternator type TA17
Six Traction Motor type ITB 2525 or equivalent
Gear ratio: 17:77, Wheel Dia.: 1054mm (Half Worn)
Starting Tractive Effort: 40775 Kg.
DYNAMIC BRAKING CHARACTERISTICS
OF 4500 HP BG DE WDP4B LOCOMOTIVE

Traction Alternator: TA17 at 950 rpm
Traction Motor: 1TB2525-0TA02 or equivalent (six)
Gear Ratio: 77:17, Wheel Dia: 1054 mm (HW)

Note: The maximum dynamic braking effort estimated in the chart is based on electrical parameters of the loco. Actual effort may vary slightly depending upon the adhesion.
ANNEXURE-G

Tractive Effort Vs Speed characteristics (AAR condition)

4500 GHP WDG4 Diesel Electric Locomotive

One Traction Alternator type TA17
Six Traction Motor type ITB 2525 or equivalent
Gear ratio: 17:90, Wheel Dia.: 1054mm (half Worn)
Starting Tractive Effort: 53000 Kg

![Graph showing tractive effort vs speed characteristics](image-url)
ANNEXURE - H

DYNAMIC BRAKING CHARACTERISTICS
OF 4500 HP BG DE WDG4 LOCOMOTIVE

Traction Alternator: TA17 at 950 rpm
Traction Motor: 1TB2525-0TA02 or equivalent (six)
Gear Ratio: 90:17, Wheel Dia: 1054 mm (HW)
ANNEXURE – I

TESTS AND TRIALS

1.0 Type and routine tests shall be conducted on the individual equipment of AC traction system separately. Complete inverter system shall also be tested after its installation on the locomotive.

1.1 In general, traction inverter shall be tested in accordance with IEC-61287, IEC-411.5 & the control electronics of inverter and LCC shall be tested as per IEC-60571. Individual equipment, system and sub-system as may be necessary, shall be type and routine tested in accordance with relevant IECs.

2.0 The list of tests to be carried out on the inverter system is as follows:

<table>
<thead>
<tr>
<th>S.N.</th>
<th>TEST</th>
<th>CLAUSE</th>
<th>TYPE</th>
<th>ROUTINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Visual inspection</td>
<td>IEC 61287 clause 2.4.6.1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2.</td>
<td>Tolerance &amp; Dimension</td>
<td>IEC 61287 clause 2.4.6.2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3.</td>
<td>Weight</td>
<td>IEC 61287 clause 2.4.6.3</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Cooling</td>
<td>IEC 61287 clause 2.4.6.5</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Protection and Measuring devices</td>
<td>IEC 61287 clause 2.4.6.6</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6.</td>
<td>Trigger Equipment</td>
<td>IEC 61287 clause 2.4.6.7</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7.</td>
<td>Light Load</td>
<td>IEC 61287 clause 2.4.6.9</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8.</td>
<td>Noise Measurement</td>
<td>IEC 61287 clause 2.4.6.11</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Temperature Rise</td>
<td>IEC 61287 clause 2.4.6.12</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Power Loss Determination</td>
<td>IEC 61287 clause 2.4.6.13</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Supply Over Voltage &amp; Transient</td>
<td>IEC 61287 clause 2.4.6.14</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Short circuit</td>
<td>IEC 61287 clause 2.4.6.15</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Sudden variation of Load</td>
<td>IEC 61287 clause 2.4.6.15</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Insulation Resistance</td>
<td>IEC 61287 clause 2.4.6.16</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>15.</td>
<td>Dielectric</td>
<td>IEC 61287 clause 2.4.6.17</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>16.</td>
<td>Partial Discharge</td>
<td>IEC 61287 clause 2.4.6.18</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Vibration and shock (sub modules)</td>
<td>IEC 61287 clause 2.4.6.21</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Interference</td>
<td>IEC 61287 clause 2.4.6.23</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>DC Link Discharge</td>
<td>IEC 411.5 clause 4.3.11</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>20.</td>
<td>Rated Current load</td>
<td>IEC 411.5 clause 4.2.7</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Output Voltage &amp; freq range</td>
<td>IEC 411.5 clause 4.3.3</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>Performance test by fault simulation</td>
<td>IEC 60571 clause 10.2.2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>23.</td>
<td>Voltage Surge</td>
<td>IEC 60571.1 clause</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
### Table 10.2.6.2

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Standard Clause(s)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic Discharge test</td>
<td>IEC 60571.1 clause 10.2.6.4</td>
<td>✓</td>
</tr>
<tr>
<td>Transient burst susceptibility test</td>
<td>IEC 60571.1 clause 10.2.7</td>
<td>✓</td>
</tr>
<tr>
<td>Radio interference test</td>
<td>IEC 60571.1 clause 10.2.8</td>
<td>✓</td>
</tr>
<tr>
<td>Salt mist test</td>
<td>IEC 60571.1 clause 10.2.10</td>
<td>✓</td>
</tr>
<tr>
<td>Damp heat</td>
<td>IEC 60571.1 clause 10.2.5</td>
<td>✓</td>
</tr>
<tr>
<td>Dry heat</td>
<td>IEC 60571.1 clause 10.2.4</td>
<td>✓</td>
</tr>
<tr>
<td>Burn – in test</td>
<td>Clause 2.1(d) of this annexure</td>
<td></td>
</tr>
</tbody>
</table>

#### 2.1

The tests mentioned in para 2.0 above vide Sl.No. 17. Vibration and shock, 18. Interference, 24. Electrostatic Discharge test, 25. Transient burst susceptibility test, 26. Radio interference test, 27. Salt mist test, 28. Damp heat, 29. Dry heat can be conducted on independent subsystems. Under the test under sl.no.18, Interference is to be conducted on loco and hence internal Interference test shall be conducted. The Electrostatic Discharge test shall be conducted on Display Unit.

Following points shall be noted regarding tests mentioned at para 2.0 above:

(a) **VISUAL INSPECTION**

All the important dimensions shall be measured as per approved drawing and shall be within permissible limits. System level bill of materials shall be submitted. The make and ratings of all equipment and subassemblies shall be checked with the details as per approved design. Any change in the make or rating of important equipment and subassemblies shall be intimated and this shall have approval of RDSO/DLW.

(b) **POWER LOSS DETERMINATION TEST**

This test shall be done at rated input DC link voltage. The efficiency of inverter shall be measured at full load and 0.8 power factor.

(c) **EARTH FAULT**

Simulate the earth fault by connecting a suitable resistor between cubicle frame and output phases. The inverter shall not trip and earth fault indication shall be in “OFF” state till the leakage current is less than the limit approved as part of design proposal submitted by the tenderer. Earth fault shall occur if the leakage current exceeds specified limit.

(d) **BURN IN TEST**

The cards used in the equipment shall be subjected to burn-in test as per the temperature cycle defined at annexure - J. 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 the manufacturer and results shall be submitted during routine testing.

(e) COOLING TEST

The air flow through various equipment / assemblies shall be measured to verify that cooling of various equipment / assemblies is as per design requirement.

(f) INSULATION RESISTANCE AND DIELECTRIC TEST

The insulation resistance with 1000 V megger shall not be less than 100 M ohms at 70% RH for all the power circuits. The dielectric test shall be carried out as para IEC-61287 after shorting various assemblies as may be necessary.

(g) TEMPERATURE RISE TEST

The inverter shall be loaded to full load for 6 hours with input voltage equal to 75% of rated input DC link voltage. The temperature rise shall be recorded by temperature sensors mounted at the specified reference points on the body of semiconductor devices / heat sinks, capacitors and any other components as agreed between DLW/RDSO and manufacturer. The maximum recorded temperature under worst conditions shall be corrected for 55ºC ambient and compared with maximum permissible temperature. (for semiconductor devices, junction temperature shall be considered). The temperature of the power devices shall have a margin of minimum 10ºC. The inverter shall also be tested for short time rating after continuous loading to ensure that temperature rise is within permissible limits. The maximum temperature rise of electronic devices on PCBs shall not exceed their (rated temperature - 10ºC). In case it is exceeding the limit, use of mil-grade components can be considered keeping RDSO informed.

h) DAMP HEAT TEST

Functional test of each equipment shall be carried out after the damp heat test.

i) DC LINK DISCHARGE

The dc link voltage shall come down below 50 V within 5 minutes.

j) SHORT TIME RATING

Short time rating of inverter, as declared by manufacturer, shall be verified by actual test.

2.2 OTHER TESTS

After installation and commissioning of loco with the new traction inverter and loco control system, it shall be subjected to certain tests conducted by Indian Railways with supplier’s representative mainly to satisfy the Railways regarding operational performance, capability and safety. The following tests may be conducted in this connection on one or more locomotives with new system:
2.2.1 RATING AND PERFORMANCE TESTS

Dynamometer car tests to ascertain following:

a) Starting and rolling resistance of the locomotive.
b) Tractive effort vs. speed characteristics of the locomotive.
c) Braking effort vs. speed characteristics of the locomotive.
d) Adhesive capability of the locomotive.

2.2.2 SIGNALLING AND INTERFERENCE TESTS

Tests to determine the levels of interference with the Signal and Telecommunication equipment and facilities to prove that these are within acceptable limits (see clause 7.4)
BURN-IN TEST

Temperature Cycle

Temperature in Degrees

+70°C
+25°C
0°C
-25°C

Time (Hrs)
0.1=10 Min
1.4 2.1 5.2 5.5 9.1 9.4 12.5 13.2 15
1.55 5.27 5.42 9.17 9.32 12.57 13.12 14.41

On
Off
ANNEXURE-K

INDIAN RAILWAYS
DIESEL LOCOMOTIVE WORKS
VARANASI
PURCHASE SPECIFICATION
FOR SUPPLY OF CABLE HARNESSSES REQUIRED FOR
IGBT BASED TCC EQUIPPED WDG4/WDP-4B
LOCOMOTIVES

SPEC. No.
WDG4/EL/PS/25

REVISION: 2.0

1. FOREWORD: With the successful development of IGBT based TCC and use of different Traction control computer by different sources, the requirement of cable assemblies connecting between ECC#1 and TCC have also become different for different types of IGBT TCC. This specification governs requirement for supply of different cable assemblies required for proper functioning of IGBT based TCC.

2. SCOPE OF SUPPLY: Requirement of cable harnesses for connecting ECC#1 to TCC blower 3 phase supply, ECC#1 to TCC 74V and also grounding sensor signal from TCC to LCC computer.

3. SPECIFICATION & TECHNICAL REQUIREMENTS:

<table>
<thead>
<tr>
<th>SN</th>
<th>Description</th>
<th>Drawing No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Power grounding sensor signal to TCC/ECC#1/Location decided by TCC manufacturer.</td>
<td>Siemens TCC Drg. No. 10634698 &amp; 10634699 /EMD TCC EMD Drg. No. 40142778/Any other cables Asm decided by TCC manufacturer.</td>
</tr>
<tr>
<td>2.</td>
<td>3 phase supply from ECC#1 to TCC blower</td>
<td>Siemens TCC Drg. No. 10634705 &amp; 10634706 /EMD, TCC EMD Drg. No. 40142778/Any other cables Asm decided by TCC manufacturer.</td>
</tr>
<tr>
<td>3.</td>
<td>74V supply from ECC#1 to TCC1</td>
<td>EMD TCC EMD Drg. No. 40133598 &amp; 40133600 /Any other cable Asm decided by TCC manufacturer.</td>
</tr>
<tr>
<td>4.</td>
<td>74V supply from ECC#1 to TCC2</td>
<td>EMD TCC EMD Drg. No. 40133599 &amp; 40133601 /Any other cable Asm decided by TCC manufacturer.</td>
</tr>
</tbody>
</table>

Appd. By By, CDE/TC

Checked by SSE/EL/D

Prepared by

REVISION DETAILS

<table>
<thead>
<tr>
<th>Revision No.</th>
<th>Date</th>
<th>Description</th>
<th>Checked By</th>
<th>Approved By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>13.07.2009</td>
<td>Specification revised due to commonality of Temperature Sensor &amp; Speed Sensor of Traction Motor to TCC.</td>
<td>Sd/-</td>
<td>Sd/-</td>
</tr>
<tr>
<td>2.0</td>
<td>12.05.2010</td>
<td>SN.1 to 6 common cable harnesses from Temperature Sensor &amp; Speed Sensor signal to TCC is deleted.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. **FOREWORD:** With the successful development of IGBT based TCC by different sources, the requirement of Crow Bar Resistor and Damper Resistor has also undergone changes. This specification covers supply of Crow Bar and Damper Resistor required for proper functioning of different make of IGBT based TCC.

2. **SCOPE OF SUPPLY:** Includes supply of any one of Crow Bar and Damper Resistor combinations to following specifications:

   - Resistor Crow Bar of 0.22 Ω to EMD Drg No. 40082110 and Resistor Crow Bar/Damper 0.22 Ω to EMD Drg. No. 40082111
   - OR
   - Resistor Crow Bar of 2.94 Ω to EMD Drg No. 40047781 and Resistor Crow Bar/Damper 2.94 Ω to EMD Drg. No. 40053020
   - OR
   - Any other protection device of IGBT TCC designed by TCC manufacturer. The proposed protection device shall be accommodated in existing envelope dimension of Resistor Crow Bar as per EMD Drg. No.40082110/40047781 and Resistor Crow Bar/Damper as per EMD Drg. No. 40082111/40053020. Over all dimensions shall be strictly followed.

3. **Condition for Tenderer:** these resistors shall be procured from DLW approved sources only.
SPECIAL CONDITION FOR ANNUAL MAINTENANCE CONTRACT OF IGBT BASED TRACTION CONTROL CONVERTERS AND LOCOMOTIVE CONTROL COMPUTER FOR WDG4 & WDP4B CLASS OF LOCOMOTIVES
1. GENERAL

This annual maintenance contract agreement is required to be entered between OEM of IGBT technology based TCC & LCC and Diesel locomotive Works for and on behalf of President of India for use and operation by the Zonal Railways at Headquarter/ Divisional level under the supervision of Zonal Railways. The above contract covers the comprehensive maintenance requirement of IGBT technology based TCC (Traction Control Converter) & LCC (Locomotive Control Computer) fitted on WDG4 and WDP4B class locomotives.

2. DEFINITIONS

Throughout this document, the terms:

a) **TCC (Traction Control Converter)**: means the IGBT technology based TCC.

b) **LCC (Locomotive control computer)**: means the locomotive control computer.

c) 'IR' means Government of India, Ministry of Railways, Railway Board, New Delhi or its nominees.


e) 'Tenderer' means the firm/company submitting the offer for annual maintenance of Traction Control Converters fitted on WDG4 and WDP4B locomotives.

f) 'Contractor' means the firm / company submitting the offer for annual maintenance of Traction Control Converters & Locomotive Control Computer fitted on WDG4 and WDP4B locomotives has been placed.

g) 'Sub-contractor' means any person, firm or company from whom the contractor may obtain any services for maintenance of IGBT based Traction Control Converters & Locomotive control computer.

h) **User Railway** - means the Zonal Railway or Divisional Railway which has placed the contract on firm in terms of this agreement.

i) **Designated Shed** - shall be the shed so designated by the user railway where the locomotives shall be brought for maintenance including the maintenance of IGBT based Traction Control Converters & Locomotive Control Computer.

j) 'Nominated Officer' means the person nominated by Zonal Railway for the purpose of execution of contract.

k) 'Loco Hours' is the total number of hours in service/breakdown for any locomotive.
3. SCOPE

3.1 Annual Maintenance for OEM TCC & LCC fitted on WDG4 and WDP4B locomotives.

3.2 The contract shall be comprehensive in nature wherein preventive as well as Breakdown Maintenance of TCC & LCC is to be attended including the supply of spares, tools, consumables, technical expertise and manpower.

3.3 The maintenance and support by the contractor shall consist of 4, “three monthly preventive checks of the Traction Control Converters & Locomotive Control Computers for trouble free services of the locomotives as prescribed by the OEM, including attention to the locomotives when they touch the shed at 25 days interval. It shall include all extra and out of course attentions including breakdown, if any required, to ensure trouble free operation of the locomotive.

3.4.1 The contractor shall ensure that downtime on account of all maintenance (Preventive and breakdown) of TCC & LCC does not exceed an amount equivalent to 5% of total loco hours for the locomotives covered in the contract. Downtime accountal shall be carried out every month and the contractor has to ensure not less than 95% availability on TCC & LCC account.

In addition, at no time, more than 5% locomotives shall be under breakdown repair on TCC & LCC account i.e. the number of locos under breakdown at 0.0 hrs daily shall not exceed 5% of the locomotive under contract.

3.4.2 Based upon the experience gained by the contractor in the first year of the contract, it shall be possible to improve upon the above referred levels of availability and downtime. The tenderer shall indicate the same in his quotation/tender.

3.5 The locomotives going out of the manufacturers' warranty for TCC & LCC shall only be included under the annual maintenance contract. The OEM has given warranty of TCC & LCC fitted in GT46MAC/PAC locomotive for trouble free service for 36 months from the date of commissioning or 500,000 kms of run of locomotive whichever is earlier. For those fitted in DLW built locomotives the warranty is for 24 months from the date of commissioning or 30 months from supply of TCC & LCC by the firm whichever is earlier.

4.0 PLACE OF WORK

WDG4 and WDP4B Microprocessor based locomotives are based / proposed to be based at Diesel Sheds under various Zonal Railways like, Hubli(SWR), Siligudhi(NFR), Gooty (S.C.R.), Erode (SR), Krishnarajapuram (SWR), Vatwa (WR), Etarsi (WCR), Jhansi (NCR), Lucknow (NR), BandaMunda (SER), Gonda (NER), Undaal (ER), Kalyan (CR), Patratu (ECR), Ludhiana (NR), New Katni Junction (WCR), Tughlakabad (NR), Guntkal (SCR), Bhagat ki kothi (NWR), Raipur (SECR), Kazipet (SCR), Vishakapattnam (ECR), Pune (CR), etc.. However, contract shall cover any other shed/place nominated during the currency of the contract. Also, the contractor may be required to attend to a locomotive TCC & LCC at a place not listed in the contract at no extra cost.

5.0 AUTHORITY FOR OPERATION OF CONTRACT

This contract is for trouble free operation of Traction Control Converters & Locomotive control computer by the user diesel sheds. Based upon this agreement, the contract shall
be signed by the user diesel shed at Zonal HQ and shall be executed under the overall supervision of Zonal Railway.

The User Railway shall nominate an officer who shall be responsible for making the contract (Liaison) with the firm at the defined address by telephone/telex/fax or in person immediately when the preventive maintenance breakdown is to be attended to as required.

The nominated Railway Officer shall also be responsible for supervision of the contractor's works for the verification of contractor's bill for payment.

6.0 RESPONSIBILITIES OF PARTIES

Following are the responsibilities of Railways and the Contractor.

6.1 RAILWAYS

6.1.1 The Railway authority shall permit the contractor to work on the Traction Control Converters & Locomotive Control Computer of the locomotives under preventive maintenance or break down.

6.1.2 User Railways shall nominate the Officer/Supervisor for supervision of the above activities.

6.1.3 The User Railway shall issue the necessary identity card (even if temporary) to the working staff/service engineer for their entry on the platform and other railway premises. However, this Identity Card shall not be taken as a travel authority.

6.1.4 The necessary space, electricity, and water connection shall be provided free of cost as required for at the nearest possible point of the site. In addition, a lockable room to store the tools and tackles shall be provided free of cost by the IR to the contractor. However, there shall be no separate exclusive security systems for the space/facility provided to the contractor.

6.1.5 The user Railway shall make the locomotives available for the maintenance.

6.1.6 Railway shall mention the details of the locomotives including the locomotive nos. covered under Annual Maintenance Contract for the reference of both the parties. In case the base maintenance designated shed of the locomotive is shifted to any other location, than those specified in the scope, the scope of AMC shall accordingly shifted to new site/base.

6.1.7 The nominated railway officer shall intimate the firm by Telephone/Telex/Fax or in-person mentioning the loco numbers and location of the locos along with the time of call. He shall maintain the register of such calls made for reference of both the parties.

6.1.8 In the event of failure of the Locomotive at a station other than the base maintenance (Designated) shed of the Locomotive, the concerned Railway official shall give intimation to the nearest regional office or the contractor who shall coordinate to get the break down call attended. This, however, does not absolve the nominated service engineer of the contractor at the base shed from making his own direct communication with the regional office and organizing attention.
6.2 CONTRACTOR

6.2.1 The contractor shall post a service engineer exclusively for the execution of this contract at the designated shed/sheds.

6.2.2 Service Engineer shall carry out preventive maintenance on locos at all days and times including Sundays and Gazetted holidays depending upon availability of locomotive in the shed.

6.2.3 Service engineer shall be available in the shed during working hours to attend breakdown calls/ preventive maintenance. Backup arrangement shall be made by the contractor in the absence of service engineer.

6.2.4 The service engineer shall report within 3 (three) hrs. at the designated shed if the breakdown call is given during the working days of the week after normal working hours.

6.2.5 The service engineer shall report within 12 (Twelve) hrs. on gazetted holidays (Govt. of India) and Sundays from the time of call of breakdown.

6.2.6 The contractor shall keep all the necessary tools, testing equipment / Spare Parts, Sub-Assemblies & Consumables in the ready stock in the firm's premises at the location of the designated shed of maintenance or their workshop or in the nearest office. IR shall, however, provide a lockable room to the contractor at the designated shed.

6.2.7 The contractor shall furnish the standard (OEM recommended) list of spares, consumable & tools to be stocked by the contractor at the designated shed with this tender for both types of Locomotives and different fleet size.

6.2.8 It shall be responsibility for contractor to ensure minimum recommended stock of all spares, consumables and tools are available with him & those used up during maintenance are replenished quickly to avoid delay in Locomotive repair time. The railway official has the authority to check spares, consumables & tools and insist of updation of stocks in case of discrepancies.

6.2.9 The service engineer nominated for the repair on the shed duty shall observe all safety and security rules prevailing at the place of work.

6.2.10 Some maintenance spares for TCC & LCC may be available at diesel Loco sheds. These can be utilized by the contractor. (The assessment is to be made by the contractor before quoting). However any such spares used by the contractor from the stock is the IR shall be replaced by new within 3 months of their uses at no extra cost.

6.2.11 The contractor shall maintain all such records/ log-books prescribed by the Railway & produce for inspection by the Railway whenever required.

7.0 PROGRESS REPORT
The regular observations and monthly progress report of the user railways shall be sent to DLW for future centralized reference.

8.0 VALIDITY OF CONTRACT
The above contract shall be valid for one/two /three years from the date of issue of the
contract or from the date of expiry of warranty of the Locomotive whichever later. All the repairs/three months schedule due within the date of expiry of contract shall, however be completed by firm & the contract shall be treated as valid till such completions of the work. Any extension of the contract shall be for a minimum period of one year of multiple thereof.

9.0 RATES

The rates to be quoted for comprehensive AMC covering both the break down & preventive maintenance (including spares and service) per Locomotive per year consisting of two Traction Control Converters & Locomotive control computer in figures and in words.

10.0 OWNERSHIP OF THE REJECTED & OLD COMPONENTS

The ownership of the rejected or defective replaced components/parts is of the Contractor against the replacement made by them on Traction Control Converters & Locomotive Control Computer to make it operative.

11.0 PENALTY: FOLLOWING PENALTIES SHALL BE IMPOSED:

11.1 PENALTY FOR DELAY IN ATTENDING THE BREAKDOWN CALLS

Problems reported would be advised to the contractor’s representative at the nominated place on contact phone no. (which contractor shall apprise at the time of award of contract). The contractor shall be required to attend such problems/failures within stipulated time starting from time of intimation failing which penalty as described hereunder shall apply.

Any delay by the firm in completing the above activities shall affect the running of the train services and may cause loss of revenue to the user Railway. Therefore, the user Railway shall recover from the contractor as agreed damages and not by way of penalty a token sum of Rs.5,000/- in each case of delay stipulated in Clause 6.2.4 & 6.2.5

11.2 PENALTY FOR DOWNTIME (ref. clause 3.4.1 & 3.4.2):

For this purpose, downtime shall be calculated as percentage of total loco hours under contract for the month. In case the contractor fails to maintain the contracted availability requirements, a penalty shall be levied as under

<table>
<thead>
<tr>
<th>Down Time</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% or less</td>
<td>Nil</td>
</tr>
<tr>
<td>5% - 7%</td>
<td>2% of the total monthly proportionate bill</td>
</tr>
<tr>
<td>7% - 10%</td>
<td>5% of the total monthly proportionate bill</td>
</tr>
<tr>
<td>More than 10%</td>
<td>20% of the total monthly proportionate bill</td>
</tr>
</tbody>
</table>
11.3 PENALTY FOR LOCOMOTIVE UNDER REPAIR (ref. clause 3.4.1 & 3.4.2):

For this purpose the maximum of the figure of locomotives under repair everyday at 0.00 hrs on Traction Control Converters & Locomotive Control Computer account over a period of a month shall be worked out. This maximum figure shall not exceed 5% of the total no. of locomotives under maintenance contract during the particular month or else penalty shall be levied as under:

<table>
<thead>
<tr>
<th>Max number of Locos Down</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>5% or less</td>
<td>Nil</td>
</tr>
<tr>
<td>5% - 10%</td>
<td>2% of the total monthly proportionate bill</td>
</tr>
<tr>
<td>More than 10%</td>
<td>10% of the total monthly proportionate bill</td>
</tr>
</tbody>
</table>

12.0 PAYMENT

12.1 For the purpose of contract, a locomotive shall be considered as covered under the AMC from the month, first attention is given to it, after its warranty cover is over.

12.2 The total yearly payment shall be made in four equal installments and such installments of the payment shall be made in advance against the Bank guarantee submitted by the firm of the equal amount valid for 12 months. The firm shall be allowed the advance payment in the beginning of the each quarter for the number of maintenance schedules which are planned to be carried out in that quarter duly certified by the nominated officer.

12.3 A bill shall be submitted by the contractor quarterly and it shall be certified by the nominated officer for completion of maintenance and after calculation of penalties as stipulated in para 11.0. On account of penalty or non performance of a planned scheduled maintenance, such dues, if any, shall be deducted from the next quarterly payment as above.

12.4 The bills submitted by the firm for payment shall accompany:

12.4.1 The certificate of maintenance of the locomotives issued by nominated Officer.

12.4.2 The above bill shall bear the individual locomotive number of the locomotives maintained by the firm for each quarter covered under this AMC.

12.4.3 Current and valid ITCC.

12.5 The firm shall submit the Bank Guarantee (BG) for the amount equal to the payment to be made for each three month installments in the prescribed format at annexure-D. This Bank Guarantee shall be submitted in favour of FA & CAO of the User zonal Railway and shall remain valid for min 15 months from the date of issue of Bank Guarantee. This Bank Guarantee is submitted in lieu of the advance payment to be made by the Railways to the firm. The Bank Guarantee shall be released after issue of No Dues Certificate from the Nominated Officer.

The B.G of the amount as advised by the user Railway(s) shall be submitted by the firm from any nationalized bank in f/o of the paying authority. The Railway reserves the right for making adjustments/recoveries outstanding against the firm under this contract by the way of encashment of this B.G.
13.0 THE RECORDS TO BE MAINTAINED BY NOMINATED OFFICER.

13.1 The user Railway & the contractor shall jointly sign the list of locos to be covered under this contract. Any modification shall also be jointly signed, as proposed by the user Railway.

13.2 The user railways shall maintain records of maintenance contract stating the locomotive numbers to be maintained under this AMC along with the date of inclusion of the locomotive under AMC.

13.3 The nominated officer shall keep the register/record for the previous bills paid for each locomotive to avoid duplicity of payments at any time.

14.0 PAYING AUTHORITY

The payment against this contract shall be made by the Controlling Accounts Officer of the user Diesel Shed. Any taxes including Income tax required to be deducted at source shall be deducted and a certificate to that effect shall be issued to the contractor as prescribed under the rules;

15.0 CONTRACT PERFORMANCE GUARANTEE

The firm shall submit 5% as security deposit for 39 months. This performance guarantee/security deposit shall be in the form of bank guarantee valid for a period of 39 months. The above S.D. is to be submitted to the User Railway. The user railway may forfeit the S.D. in case of the failure of firm in execution of the contract.

16.0 GUARANTEE FOR AMC

Guarantee period shall be 12 months from the date of completion of preventive maintenance or breakdown work for the work attended by the contractor.

17.0 FORCE MAJEUER CLAUSE

Force majeure shall comprise the occurrence beyond the control of the railways and the firm as the "case may be but not limited to the events such as explosion, flood, fire, major power failure, accident, breaches, act of God, act of public enemy, wars, riots, sabotage or any law of state or Ordinance or the order or regulation of Govt. or local public authority. In such situation, either party shall promptly notify the other party in writing for such act with proof that it is beyond their control to carry out obligation of this contract and agree for mutually acceptable course of action.

The liquidated damages shall however not be applicable during this period.

18.0 ARBITRATION

In the event of any question, dispute or differences arising under the condition of this contract which cannot be resolved by mutual discussions, such dispute can be referred to the sole arbitrator nominated by the General Manager of user railways. The sole arbitrator appointed by the General Manager in this case shall be Gazetted Railway officer. However the person shall not be one of those who have dealt with the matter related to or who in the course of their duties as railway servant have expressed view on all or any of the matter under dispute or differences.
The award of the sole arbitrator shall be final and binding on both the parties to this contract. Subject as after said, the arbitration act, 1996 & the rule of their under and any statutory modifications there of for the time being in force shall be deemed to apply to the arbitration proceeding under this clause.

19.0 LAWS GOVERNING THE CONTRACT.

The contract shall be governed by the Laws of India for the time being enforced irrespective of the place of performance or payment under the contract.

20.0 JURISDICTION OF THE COURTS

The courts of the place where the contract has been entered into by the user railway and the firm shall alone have the jurisdiction to decide any dispute arising out of or in respect of the contract.

21.0 FAILURE

If the contractor fails in the performance of the contract (except in case of force majeure & having been allowed a reasonable time to complete the obligation), the user Railway may without prejudice to his other rights, cancel the contract or a portion thereof and if he so desires, to enter into another contract for fulfillment of the obligation for the remaining period, at the risk and cost of the contractor.

22.0 SUBLETTING AND ASSIGNMENT

The contractor shall not, save with the previous consent in writing of the user Railway, sublet, transfer or assign the contract or any part thereof or interest therein or benefit or advantage thereof in any manner whatsoever.

In the event of the contractor's subletting or assigning this contract or any part thereof without any such permission, this shall be deemed as the breach of contract and the user railways shall be entitled to cancel the contract.

23.0 OTHER CONDITIONS

The manufacturer of Traction Control Converters & Locomotive Control Computer are considered fully equipped with required man-power and technical know how along with the latest technological upgradation and developments in the field.

(Documents in proof are to be enclosed by the tenderer)

24.0 CONTRACT ISSUING AUTHORITY

24.1 This contract is issued on M/s Firm & shall remain valid for a period of one/two/three years from the date of issue of the contract unless otherwise extended or terminated.

24.2 For the conditions not covered in this document, General Conditions of contract shall apply.

This concludes the contract and is issued for and on behalf of the president of India.
Annexure-N

**Packing List**

Items of AC-AC traction system as per RDSO specification to be supplied with its different constituents packed in boxes as listed below and the boxes shall be clearly marked with alphanumeric markings listed below. These markings shall be in letter size of minimum 15 cms and provided on at least three sides of the boxes.

![Part-A](image)

<table>
<thead>
<tr>
<th>S N</th>
<th>Description</th>
<th>Part No.</th>
<th>Packing Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ECC#3</td>
<td>18000897</td>
<td>In one box marked A1</td>
</tr>
<tr>
<td>2.</td>
<td>TCC</td>
<td>18000940</td>
<td>In one box marked A2</td>
</tr>
<tr>
<td>3.</td>
<td>Resistor Crow Bar</td>
<td></td>
<td>In one box marked A3</td>
</tr>
<tr>
<td>4.</td>
<td>Resistor crow bar damping</td>
<td></td>
<td>In one box marked A4</td>
</tr>
</tbody>
</table>

![Part-B](image)

<table>
<thead>
<tr>
<th>S N</th>
<th>Description</th>
<th>Part No.</th>
<th>Packing Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ECC#2</td>
<td>1800022</td>
<td>In one box marked B1</td>
</tr>
<tr>
<td>2.</td>
<td>Temperature &amp; speed sensor for TM-1 to TM-6</td>
<td></td>
<td>In one box marked B2</td>
</tr>
</tbody>
</table>

![Part-C](image)

<table>
<thead>
<tr>
<th>S N</th>
<th>Description</th>
<th>Part No.</th>
<th>Packing Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ECC#1</td>
<td>18000885</td>
<td>In one box marked C1</td>
</tr>
</tbody>
</table>

![Part-D](image)

<table>
<thead>
<tr>
<th>S N</th>
<th>Description</th>
<th>Part No.</th>
<th>Packing Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cable harness for power grounding sensor signal to TCC</td>
<td>(18010234 &amp; 18010246) or 40142778</td>
<td>In one box marked D1 containing all these cable harnesses</td>
</tr>
<tr>
<td>2.</td>
<td>Cable harness for 3 phase power supply from ECC#1 to TCC blower</td>
<td>(18010258 &amp; 18010260) or 40142778</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Cable harness 74 V supply from ECC#1 to TCC#1</td>
<td>40133598 &amp; 40133600 (Only for M/s EMD)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Cable harness 74 V supply from ECC#1 to TCC#2</td>
<td>40133599 &amp; 40133601 (Only for M/s EMD)</td>
<td></td>
</tr>
</tbody>
</table>

![Part-E](image)

<table>
<thead>
<tr>
<th>S N</th>
<th>Description</th>
<th>Part No.</th>
<th>Packing Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>LCC with modules</td>
<td></td>
<td>IN one box containing all the module cards marked E1</td>
</tr>
<tr>
<td>2.</td>
<td>Electronic note books as per respective clause of RDSO specification</td>
<td></td>
<td>In one box marked E2</td>
</tr>
</tbody>
</table>

![Part-F](image)

<table>
<thead>
<tr>
<th>S N</th>
<th>Description</th>
<th>Part No.</th>
<th>Packing Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Uncommon items if any, related to respective AC-AC traction system</td>
<td></td>
<td>In one box marked F</td>
</tr>
</tbody>
</table>
ANNEXURE- O