

SPEC. NO. TCE.M4- 203-71	TATA CONSULTING ENGINEERS LIMITED	SECTION: D
	VARIABLE SPEED DC/AC DRIVES	SHEET 1 OF 21

1.0

SCOPE

1.1

This specification covers the technical requirements for the design, manufacture, testing and supply of semiconductor (Thyristor/Transistor, IGBT) controlled variable speed DC/AC drives in industry.

1.2

The motors and Converter Transformer when forming part of Bidder's scope shall meet the requirements given in following standard specifications:

(a)

Squirrel Cage Induction Motor (General Purpose)

:

TCE-M4-203-01

(b)

Squirrel Cage Induction Motor (Special Purpose)

:

TCE-M4-203-02

(c)

DC Motor

:

TCE-M4-203-11

(d)

Converter Transformer

:

TCE-M4-200-21

(e)

Induction motors for hazardous area (General purpose)

:

TCE-M4-203-51

2.0

CODES AND STANDARDS

2.1

The design, material, construction, manufacture, inspection, testing and performance of AC/DC Drives shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

2.2

Unless otherwise specified, the equipment / system shall conform to the latest applicable standards as mentioned in enclosed Data Sheet-A3.

3.0

DESIGN BASIS FOR POWER SEMICONDUCTORS

3.1

Power semiconductors of reputed make either in stud mounting form or disc/flat pack type can be offered based on the duty requirements specified in Data Sheet A1 and to meet the technical and functional requirements.

3.2

The peak reverse voltage rating of each power semiconductor shall be as follows:

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3.2.1 Power Semiconductors Protected by RC Snubber

The following factors of safety shall be observed:

(a) For converters operating in rectifying mode only : 2.0 times peak of the No load source voltage.

(b) For converters operating both in rectifying and inverting modes : 2.5 times peak of the no load source voltage

3.2.2 Power Semiconductors Protected by Avalanche Diodes

The BIDDER shall choose and recommend the factor of safety which however, shall not be less than 1.5.

3.3 The current rating of the power semiconductor shall be estimated for the specified duty class in Data Sheet A. In sizing the power semiconductor both the forward voltage drop and the forward resistance shall be considered.

3.3.1 A derating of approximately 20% shall be made to take into account series operation of devices.

3.4 The class of overload shall be one of the following:

Duty Class	Rated current values for converter (in percent of rated direct current)
I	100 %/ Continuous
II	100 % Continuous 150 % overload for 1 minute once in period of 24 hours
III	100% continuous 150 % overload for 2 minute once in period of 24 hours 200 % overload for 10 seconds once in period of 24 hours

However, for mill duty drive the overload percentage shall be as per following:

115% /150% Continuous based on type of mill.

200% for 6 seconds in every 60 seconds

250% for 3 seconds in every 60 seconds

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<p>The above overload percentage criteria may vary based on process requirement.</p> <p>3.5 For the cases where the power semiconductor chosen is of inadequate current or voltage capacity the BIDDER shall conform to the following guidelines:</p> <p>3.5.1 <u>Inadequate Current Capacity</u></p> <p>(a) If the power semiconductor is of stud mounting type, then current sharing reactors shall be provided to prevent current missharing between the power semiconductors connected in parallel.</p> <p>(b) If the power semiconductors in parallel are of capsule type, then, one of the following options may be exercised:</p> <p>(i) Power semiconductors with adequate derating and the layout configured so that current missharing between various power semiconductors in parallel is minimised.</p> <p>(ii) Selection of power semiconductors so that their forward voltages are within a tolerance band of 100 mV to 250 mV.</p> <p>3.5.2 <u>Inadequate Voltage Capacity</u></p> <p>In this case the power semiconductors shall be connected in series with adequate protection to prevent irregular voltage grading across each power semiconductor during turn-on.</p> <p>3.6 The converter shall be provided with adequate surge suppression circuitry at the AC input, DC output and across the devices to limit the main voltage surges, transformer switching surges, reverse recovery transients to less than twice the peak value of line working voltage.</p> <p>4.0 <u>QUADRANTS OF OPERATION</u></p> <p>The drive should be according to the no. of Quadrants specified in Data Sheet A. The Quadrant Operation of the Drive will be according to the following criteria.</p> <p>(a) One Quadrant Operation -> (I): One Quadrant of operation means only Motoring is required & the drive should operate in the 1st Quad. The motor is rotating clockwise as the torque in the same direction as the speed. The drive is accelerating.</p> <p>(b) Two Quadrant Operation -> (II):- Two Quadrant Operation means the drive should be able to control the motoring & Braking of the motor.</p>		

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<p>The motor still rotating clockwise but the torque in opposite direction so the drive is decelerating. It can be of two types.</p> <p>(i) Voltage Positive & Current can change Polarity i.e. operating in first & second quad.</p> <p>(ii) Current Positive & Voltage can change Polarity i.e. operating in first & fourth quad.</p> <p>(c) Third & Four Quad Operation -> (IV) :- The drive should be able to operate in third & four Quadrant i.e. the motor requires forward motoring, forward braking, Reverse motoring & Reverse braking depending upon the torque direction.</p> <p>5.0 <u>CONTROL FOR DC MOTORS</u></p> <p>5.1 <u>ARMATURE VOLTAGE CONTROL CONVERTER</u></p> <p>5.1.1 This converter shall consist of, unless otherwise stated in Data Sheet-A, a three phase full wave bridge circuit.</p> <p>5.1.2 Each arm of the bridge can have a number of power semiconductors both in series and/or in parallel. The design basis for such cases shall be in conformity with Clause 3.0 of this specification.</p> <p>5.1.3 If the drive operates in the first quadrant only, a free wheeling diode may be provided for the purpose of allowing decay of energy during the condition of braking of the drive. This diode may be housed within the same cubicle as the bridge converter.</p> <p>5.1.4 Redundancy shall be provided as follows:</p> <p>(a) For power semiconductors in parallel one additional parallel three phase full wave bridge arm shall be provided as redundant element.</p> <p>(b) For power semiconductors in series, at least 2% of the total thyristors in series for each parallel arm shall be provided.</p> <p>The factors of safety to be observed in such designs shall be in conformity to Clause 3.0 of this specification.</p> <p>5.2 <u>FIELD EXCITATION CONTROL CONVERTER</u></p> <p>5.2.1 Unless otherwise stated in Data Sheet A, this converter shall be powered from a single phase line-to-line source tapped at the three-phase incomer to the armature voltage control converter with adequate isolation.</p> <div data-bbox="1398 2013 1487 2087"> ISSUE R2 </div>		

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5.2.2 Unless otherwise stated in Data Sheet-A, this converter shall be a bridge of diodes of adequate capacity.

5.3 TRANSDUCERS

5.3.1 Armature Circuit

- (a) For drives where accuracy of speed control is better than 0.5%, the actual speed of the drive shall be measured by a tacho-generator of suitable rating, and type (Digital pulse tacho or analog tacho).
- (b) For drives where accuracy of speed control required can exceed 2% or more, measuring the current by a current transformer on the AC side of the converter can be accepted.
- (c) For drives whose accuracy of speed should not exceed 2% it is necessary that a suitable DC shunt of 75 mV and adequate current capacity shall be provided.

5.3.2 Field Circuit

For Drives where there is a possibility of field circuit failing, then in such cases transducers should be provided.

6.0 TECHNICAL REQUIREMENTS OF AC DRIVES FOR SQUIRREL CAGE INDUCTION MOTORS

The voltage source DC link frequency converters shall be provided for applications where speed of AC motors is required to be adjusted steplessly from approximately zero to maximum speed.

The unit shall be pulse width modulation (PWM) type with either open loop frequency control to keep the ratio of voltage and frequency (v/f) constant throughout speed range to maintain constant motor torque or vector control for closed loop speed control with or without pulse encoder feedback where high speed accuracies and good dynamic performance of the motor desired.

The unit shall comprise incoming load-break isolator, line semiconductor fuses, moulded case circuit breaker (MCCB), main contactor as required, reactor, three phase rectifier as the line converter and three phase inverter as load converter interconnected through DC link reactor and capacitor unit.

The PWM inverter shall have fully digital microprocessor based regulation and control system with suitable interfaces for communication with plant automation system. The microprocessor based control shall carry out all the functions required from the unit including triggering, protections, self diagnostics and operator interface. Display of faults, alarms as well as

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<p>diagnostic messages will be available in plain text on the operator panel mounted in the drive cubicle. All metering feature viz voltage, current, frequency for incoming and outgoing side shall be included in the panel.</p> <p>Wherever system called for electrical braking viz dynamic braking resistor unit shall be provided.</p> <p>By-pass arrangement of VVFD shall be considered as per requirement.</p> <p>AC Drives should be considered with built in DC choke for longer life of dc link capacitors, minimize voltage drop at motor terminal & harmonic reduction at the drive input.</p> <p>Regenerative AC drives shall be provided as per process application requirement.</p> <p>Shielded power & control cables from drives to motor terminals shall be provided by the purchaser until and unless special cables are recommended by the drive manufacturer. Also, drive manufacturer shall indicate the maximum distance limitations from drives to motors to avoid output choke.</p> <p>12 pulse or 6 pulse rectifier & inverter units shall be considered as required based on process requirement.</p> <p>Duty of AC drives (heavy duty or light duty) shall be provided based on process requirement as per applicable IEC standards.</p> <p>Hardware & software tools of drive window for drive parameterization & programming shall be provided..</p> <p>Drives shall be selected based on rating & application of motors, duty class, current, torque values, GD² value, speed range etc and ambient temp derating factor & altitude derating factor.</p> <p>7.0 <u>FREQUENCY CONVERTERS FOR SQUIRREL CAGE INDUCTION MOTORS</u></p> <p>7.1 <u>CONFIGURATION</u></p> <p>Frequency converters shall have one of the two configurations given below:</p> <p>(a) Current source inverter.</p> <p>(b) Voltage source inverter.</p> <p>7.2 <u>DC LINK</u></p> <p>7.2.1 <u>Current Source Inverter</u></p> <div data-bbox="1396 2011 1495 2098"> ISSUE R2 </div>		

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<p>(a) The smoothing reactor shall be sized to avoid conditions of discontinuous current operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5 Hz.</p> <p>(b) The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.</p> <p>(c) The smoothing reactor shall be made from electrolytic grade copper/aluminium and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with relevant IEC standards..</p> <p>7.2.2 <u>Voltage Source Inverter</u></p> <p>(a) The smoothing reactor shall conform to requirements specified in Clause 6.2.1</p> <p>(b) The DC capacitor shall be shunt connected at the input to the inverter. It shall be sized so that the reactive power requirements of the motor during its total range of operation are met. Further, the following aspects shall be observed:</p> <p>(i) As per standards, the nominal value of capacitance referred to the temperature of 25^oC shall be within tolerance range of 10%. At the design ambient temperature, the value of capacitance and the tolerance range shall be such as to meet the normal operation/performance requirements of the frequency converter.</p> <p>(ii) As per standards, the dissipation factor of each unit of the capacitor shall be less than 1% at 25^oC. However, the design ambient shall be such as to meet the normal operational/performance requirements of the frequency converter.</p> <p>(iii) The impregnant used for the capacitor shall be non-inflammable, non PCB dielectric liquid.</p> <p>(iv) The voltage rating of each capacitor shall be selected based on considerations of life expectancy, overvoltage during regeneration of energy, design ambient temperature, ripple voltage etc.</p> <p>7.3 <u>INVERTER</u></p> <p>7.3.1 The inverter system suitable for three phase output shall consist of the following subsystems:</p>		
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<div data-bbox="331 331 1358 907"> <p>(a) The basic inverter circuit consisting of the switching device IGBT connected so as to supply three phase power.</p> <p>(b) The logic network to enable rapid transition of the main inverter switching devices from on-state to off-state.</p> <p>(c) Suitable feedback system to allow balance of reactive power flow during load power factor fluctuation as well as regeneration.</p> <p>(d) The filter system of the inverter output to suppress 5th, 7th, 11th, 13th harmonics at the output of the inverter to less than 5% of the fundamental amplitude for voltage THD. However, individual frequency voltage distortion shall not exceed 3% as per IEEE standard.</p> <p>(e) The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.</p> </div> <div data-bbox="236 938 1358 1008"> <p>7.3.2 The output frequency of inverter shall be controlled to within the limits specified in Data Sheet-A.</p> </div> <div data-bbox="236 1039 703 1075"> <p>7.4 <u>INVERTER FOR AC DRIVE</u></p> </div> <div data-bbox="236 1106 646 1142"> <p>7.4.1 <u>Current Source Inverter</u></p> </div> <div data-bbox="331 1173 1358 1715"> <p>(a) <u>Constant Torque Operation</u></p> <p>The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant and the duty cycle requirements indicated in Data Sheet A are met. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.</p> <p>(b) <u>Constant Horsepower Operation</u></p> <p>In this type of operation, the motor's internal voltage shall be maintained within $\pm 1\%$ while the frequency of the inverter is varied to meet the duty cycle requirements indicated in Data Sheet A. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.</p> </div> <div data-bbox="236 1814 644 1850"> <p>7.4.2 <u>Voltage source Inverter</u></p> </div> <div data-bbox="331 1881 791 1917"> <p>(a) <u>Constant Torque Operation</u></p> </div>		
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<p>The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated/design value so that the duty cycle requirements indicated in Data Sheet A are met. The DC voltage input shall be maintained within $\pm 1\%$ of the required value. Should this fall for any reason, necessary action for tripping the frequency converter, and initiation of annunciation/alarm and fault diagnostic shall be provided.</p> <p>(b) <u>Constant Horsepower Operation</u></p> <p>In this type of operation, the voltage at the terminals of the motor shall be maintained within $\pm 1\%$ of the rated value while the frequency of the inverter is varied to meet the duty cycle requirements indicated in Data Sheet A. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.</p> <p>7.5 <u>OUTPUT OVERCURRENT LIMIT</u></p> <p>Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated and an alarm contact initiated for annunciation.</p> <p>AC drives should meet the relevant IEC standard for EMC & operate reliably at their full rated capacity.</p> <p>Additional output filters as required shall be provided based on cable distance between drive panels to motor terminal. Manufacturer shall also recommend the type of cables from VVFD to motor.</p> <p>8.0 <u>CONTROL REQUIREMENTS</u></p> <p>8.1 Short time voltage dips upto 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.</p> <p>8.2 The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.</p> <p>8.3 The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.</p> <p>8.4 The required provision of RTD and BTD inputs for motor winding and bearing temperature shall be furnished by bidder.</p> <div data-bbox="1398 2013 1487 2087"> ISSUE R2 </div>		

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8.5 The required provision of interface module for pulse encoder shall be furnished by bidder.

8.6 Local/Remote selection provision should be available in offered drive panel.

9.0 DRIVES WITH WOBBULATION CONTROL

Drives used in application like synthetic fibre projects should have the main feature of Wobulation control as specified in the data sheet.

The Wobulation control should consist of a generation of a modulated frequency, in converters feeding traversing drives. The drive should produce a triangular voltage of variable frequency and amplitude, which is superimposed on the frequency set-points voltage in the analog frequency generator.

10.0 PROTECTION

10.1 PROTECTION OF POWER SEMICONDUCTOR

(a) Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I^2t does not exceed the I^2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

(b) All fuses shall have a trip indicator to operate a suitable microswitch with at least 1 NO + 1 NC potential free contacts for annunciation and/or tripping.

(c) A fast tripping feeder circuit breaker shall be used in case fuses for short circuit protection of thyristors are not used.

10.2 PROTECTION OF CONVERTER SYSTEM FOR DC DRIVE

10.2.1 Armature Circuit

The basic protections to be provided are as follows:

(a) Earth fault relay

(b) Thermal overload relay

Other optional protections that are required shall be considered in scope of supply as listed in Data Sheet A.

10.2.2 Field Circuit

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The basic protections to be provided are as follows:

- (a) Minimum excitation limit relay
- (b) Thermal overload relay
- (c) Earth Fault Relay

Other optional protections that are required shall be considered in scope of supply as listed in Data Sheet A.

10.3 PROTECTIVE SYSTEMS FOR AC INVERTER DRIVE

- (a) Fuses for all power semiconductors and/or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents.
- (b) Under voltage and over voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.
- (c) Protection for all control cards, power supply stabilisers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.
- (d) Polarising relay to prevent reversal of polarity on the input side of the inverter.
- (e) Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.
- (f) Besides the above, the following protective systems shall be supplied if called for in Data Sheet A.
 - (i) Current limit fuses at the output of the inverter.
 - (ii) Commutation circuit under voltage
 - (iii) Inverter over frequency
 - (iv) Programmable overcurrent
 - (v) Phase sequence/loss of phase protection
 - (vi) Earth fault protection
 - (vii) DC link overvoltage protection
 - (viii) Specific motor protection

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- (ix) Incoming line surge protection
- (x) Ventilation Loss
- (xi) Over temperature
- (xii) Phase loss protection

10.4 All controls, indication, Metering, Annunciation on the Drive Panel, will be as specified in Data Sheet-A.

Common Technical feature of AC Auxiliary Drive:

- (i) Control Method: DTC (direct torque control) Control, PWM technique with harmonic compensation.
- (ii) Rated Output frequency: 5-300 Hz.
- (iii) Inverter : The inverter of each drive shall be IGBT based.
- (iv) Over Torque Capacity: As per requirement.
- (v) Braking Torque: As per project requirement.
- (vi) Provision of Control I/Os: Digital Inputs
 Analogue Inputs
 Digital Output (Relay)
 Analogue Output
 RTD/BTD inputs as required.
 (All PLC Compatible)
- (vii) Line choke: To be provided
- (viii) Output choke/Reactor: To be provided, If required.
- (ix) Acc / Dec Time: 0-3600 sec. (programmable independently).
- (x) Response time of torque loop: Less than 5 msec
- (xi) Provision of remote or on-board programming console / operating control.
- (xii) Protections: Drive overload protection, phase loss, instantaneous over current, power loss ride through, ground fault, fin overheat, o/p short circuit protection, stall prevention, I/P & O/P open circuit protection, torque limit etc.

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(xiii) Provision for EMC Filters:

To be provided.
Harmonics to be limited to as defined by relevant IEEE standard.

10.5

SELECTION OF INVERTERS AND LINE SUPPLY UNITS:
The sizing of the inverters shall be considered as continuous load of 125% of the installed motor load including margin under stall condition.

10.6

AC INVERTERS
Main circuit to DC converter – along with Semi conductor fuses.
It shall include following protection:

- Overload protection
- Stall Protection
- Instantaneous over current protection
- Over speed protection
- Loss of speed feedback

Operating and Indicating Equipment

- Each inverter is to be provided with prevention of unexpected start up
- Each inverter shall be provided with drive monitoring display units.
Such as status for ready, run and fault on the front door
- Each line shall have drive control panel where setting of parameter and reading can be done

10.6.1

Interlocking:
Fool proof interlocking should be provided in complete system:

(a) Potential free contacts of drive fault, ready to start, normal stop, emergency stop, Zero speed should be terminated for using in other equipment and PLC inputs.

(b) Wires from start, normal stop, and emergency stop circuits should be terminated so that potential free contact and PLC outputs can be connected in the same.

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10.6.2 PLC Interfacing:

All drives should be suitable to accept the following from PLC as a minimum requirement:

- (a) Start-command
- (b) Normal stop
- (c) Emergency stop
- (d) Master speed reference
- (e) Additional speed reference
- (f) Current limit reference
- (g) Jog speed reference.

All drives should be able to send following to PLC as a minimum requirement:

- (a) Normal stop
- (b) Emergency stop
- (c) Fault and event
- (d) Zero speed
- (e) Actual speed
- (f) Motor mounted field device feedback from drive to PLC.

11.0 **COOLING OF POWER CONVERTERS**

11.1 Power semiconductors shall be mounted on heatsink which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available.

11.2 Cooling of power semiconductors can either be natural air cooled or forced air cooled. The BIDDER shall recommend the type of cooling. However, for power converters which exceed capacities of 2 kA continuous load, alternative cooling methods as oil or water cooling shall be considered. The power semiconductors shall preferably be double side cooled.

11.3 Auxiliary power supply for the forced cooling system shall be drawn from the alternatives specified in Section-B. All equipment required for safe and correct operation as drive motor, blower/pump, cooling water/oil header, water/oil distribution piping, deionizer system, flow monitors etc. as applicable shall be considered in the BIDDER's scope of supply.

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<p>The drive should have enough free space for the components to ensure sufficient cooling. Minimum clearance should be maintained for each components inside the drive panels.</p> <p>The air inlets and outlets must be equipped with fine wire mesh/ gratings to ensure the following:</p> <ul style="list-style-type: none"> • Guide the air flow • Protect against contact • Prevent water splashes from entering the cabinet and prevent entry of insects <p>The thick filter mats are used to prevent water splashes from entering the cabinet so that higher IP as required can be achieved. Hot air exhaust fans may also be required to achieve the higher IP.</p> <p>12.0 <u>SWITCHING DEVICES</u></p> <p>12.1 Switching devices as circuit breakers, isolators, contactors; switch-fuse units/MCCB etc. shall be considered in the scope of supply as specified in Section-C of this specification and Data Sheet A-3.</p> <p>12.2 The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper/aluminium strips. These connections shall be adequately braced and insulated.</p> <p>13.0 <u>CONSTRUCTIONAL FEATURES</u></p> <p>The controller should have modular construction to facilitate maintenance.</p> <p>13.1 <u>BUSBARS</u></p> <p>13.1.1 Power connections shall be of the bolted type and mating surfaces shall be tinned.</p> <p>13.1.2 The bus bars running to various converters shall be suitably designed to ensure equal sharing between the parallel strings and prevent mechanical stress on the fuse.</p> <p>13.1.3 All bus bars shall be adequately insulated for full circuit voltage by insulating tapes and similar insulating material.</p> <p>13.1.4 In case aluminium bus bars are specified, care shall be taken to ensure that bimetallic connections are provided wherever necessary.</p> <p>13.1.5 All cubicles shall have copper earth buses of adequate size running the entire cubicle height along the sides.</p> <div data-bbox="1398 2013 1487 2087"> ISSUE R2 </div>		

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<p>13.2 <u>CUBICLE</u></p> <p>13.2.1 Cubicles housing the power semiconductors and drive level control system shall conform to IP 42 degree of protection to enclosures.</p> <p>13.2.2 Panels shall be free standing, floor mounting type, dust and vermin proof and shall comprise rigid welded structural frames enclosed completely with cold rolled sheet steel of thickness no less than 2.5 mm for front and rear portions and 2.0 mm for sides, top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.</p> <p>13.2.3 All doors, removable covers and panels shall be gasketed all round with neoprene gaskets. Ventilating louvers shall have screens and filters. The screens shall be made of either brass or GI wire mesh.</p> <p>13.2.4 Design, material selection and workmanship shall be such as to result in a neat appearance inside and outside with no welds, rivets or bolt heads apparent from outside, with all exterior surfaces true and smooth.</p> <p>13.3 <u>PAINTING</u></p> <p>13.3.1 All sheet steel work shall be phosphated in accordance with the following procedure and in accordance with relevant IS standard .</p> <p>13.3.2 Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.</p> <p>13.3.3 Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.</p> <p>13.3.4 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.</p> <p>13.3.5 The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.</p> <p>13.3.6 After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.</p> <p>13.3.7 The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns.</p> <p>13.3.8 Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.</p> <p>13.3.9 A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.</p> <div data-bbox="1398 2013 1487 2087"> ISSUE R2 </div>		

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<p>13.4 <u>BINS AND PRINTED CIRCUIT CARDS</u></p> <p>13.4.1 Individual bins shall be mounted on a swingable frame so that the connections at the rear are also accessible.</p> <p>13.4.2 Self retaining thumb head screws shall be needed for holding the bins in position.</p> <p>13.4.3 Adequate number of card/bin extenders for testing of PCBs shall be provided, each with flexible cables at least two metres long. These extenders shall be of a universal type suitable for use with any card / bin as the case may be.</p> <p>13.4.4 All adjustments which are to be made while changing a card shall be outside in a separate module preferably plugged into the regulator bin.</p> <p>13.4.5 Locking of individual cards in a bin shall preferably be through self retaining thumb-head screws.</p> <p>13.4.6 Control modules shall be in the form of plug in packages, plugged into a module bin. Each plug in unit shall consist of a strong frame on which a printed circuit board would be permanently screwed. The plug connections shall only be of the pin type.</p> <p>13.4.7 The printed circuit board (P.C.B.) shall be made of glass fibre filled with epoxy laminates. The plug in unit shall be screwed to the basic socket in the module bin with long through bolts and knurled heads.</p> <p>13.4.8 The front plates of the plug in unit shall have the switches, the potentiometers, miniature monitoring meters, test points etc. Each plug in unit shall have its own identification legend.</p> <p>13.4.9 All plug in units shall be polarised to prevent incorrect insertions into the module bin.</p> <p>13.4.10 The gap between two plug in units inside a bin shall be sufficient to permit adequate ventilation.</p> <p>13.4.11 The copper side of the printed circuit board shall be lacquered to prevent oxidation.</p> <p>13.4.12 Each side of the printed circuit board shall have a shield cover to prevent inter circuit and external interference.</p> <p>13.4.13 The P.C.B. shall be mounted on P.C.B. guides fixed on standard racks and the shield properly grounded.</p> <p>13.4.14 Control circuit test points shall be easily accessible for monitoring and maintenance.</p> <div data-bbox="1398 2013 1487 2087"> ISSUE R2 </div>		

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13.5 ANNUNCIATION

13.5.1 The annunciator shall work on DC power supply as specified in Data Sheet-A.

13.5.2 Each annunciator window shall have two lamps connected in parallel which operate at not more than 75% of their rated voltage.

13.5.3 Window shall be arranged in a logical group.

13.5.4 The annunciator shall have a module construction with glass epoxy plug in cards.

13.5.5 Alarm bell/siren shall be continuously rated and shall have a series resistance.

13.5.6 The annunciator shall have the following facilities.

- (a) First in sequence, memory reset.
- (b) Fleeting faults shall be memorised.
- (c) Test Feature.

13.5.7 There shall be a three tier system of protection and annunciation:

- (a) Alarm both audible and visual.
- (b) Warning with delayed shut down –time delay through a timer of range 0-60 sec.
- (c) Disturbance associated with failures of systems elsewhere.

13.6 METERS

13.6.1 Individual meters shall be provided for speed reference, speed feed back, current reference, current feedback, pulse output, and regulated power supply voltages.

13.6.2 All meters shall be identical and fed through individual buffer I.C. amplifiers.

13.6.3 All meters shall be the circular scale type having a full scale deflection of 270°.

13.6.4 All meters shall conform to at least accuracy class 1.0

13.6.5 All meters with their individual buffer amplifier cards shall be housed in separate bin. It is recommended that the buffer amplifiers all be housed on a

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<p>single/two card/s and this card/s be itself/themselves housed in the regulator bin.</p> <p>Sensitive signal leads in that case will not have to traverse from one bin to another, only noise insensitive buffer amplifier output leads will need to go to the meter bin.</p> <p>13.6.6 Selector switches if used with any meters shall have pistol grip handles.</p> <p>13.7 <u>WIRING</u></p> <p>13.7.1 Stranded, flexible copper cable of 2.5 sq.mm shall be used for C.T. circuits and 1.5 sq.mm for other control circuits. However for PCB terminals 0.75 sq.mm may be accepted.</p> <p>13.7.2 Ultra flexible cables shall be used for all connections from a fixed part to a movable member. In addition, a hanging loop of sufficient length shall be provided to avoid any cable stressing.</p> <p>13.7.3 All terminal boards for outgoing connections shall be at a height of at least 250 mm from the cubicle floor, and preferably tilted at an angle of 45° to the horizontal for ease of connections. Similarly, connection of the incoming power cables to the bus bars shall be done at a height of at least 250 mm from the cubicle floor.</p> <p>13.7.4 Item designation and location marking shall be in line with IEC recommendations.</p> <p>13.7.5 Device labeling shall be on its fixed mounting and not on the device itself such that labeling remains even when the device is replaced. Metallic labels/paper labels or sticker shall be accepted.</p> <p>14.0 <u>TESTING</u></p> <p>All routine tests shall be carried out on various devices / assemblies in line with codes & standards indicated in data sheet-A4. Type Tests shall be carried out wherever indicated in Data sheet-A1 to A3 and / or in Section 'C'</p> <p>14.1 <u>TESTS ON POWER SEMICONDUCTORS</u></p> <p>All power semiconductors selected shall be subject to quality assurance tests to check on the characteristics submitted by the successful BIDDER on samples. The BIDDER and/or his sub-vendor shall allow PURCHASER'S authorised representative to witness the tests. Details of the test are to be agreed between the PURCHASER and the BIDDER. The broad outlines of the tests to be conducted are as follows:</p> <p>(a) Off state voltage and reverse voltage</p>		
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- (b) Critical rate of rise of off state voltage
- (c) On state voltage
- (d) Thermal resistance
- (e) Surge on-state current
- (f) Triggering data
- (g) Recovery charge and recovery time
- (h) Critical rate of rise of on-state current
- (i) Switching losses
- (j) Environmental Tests

14.2 TESTS ON CONVERTERS

Converter with its enclosure and cooling system shall be connected to a dummy load. A variable voltage source on the source side shall be adjusted so that the specified current rating of the converter at no-delay of the firing angle (in case thyristors) shall be passed. At the end of stipulated period of test a timer shall cut-off the source. The load side and source side current shall be measured/recorded during the testing phase. The temperature of the case and the heat sink and wound components like chokes shall be suitably recorded. The temperature decay measurement/recording shall continue for the off-duty cycle at agreed intervals. During the course of test the cooling system shall be operative.

The following tests shall be conducted: as per relevant (IEC standard

- (a) Checking of the setting of the protection devices and their functioning.
- (b) Checking of the auxiliary devices and their functioning.
- (c) Speed regulation of the drive shall be observed at different output voltage and frequency settings (for AC drives).
- (d) Determination of the power losses at specified loads (By Calculation). (Type Test)
- (e) Load test or rated current test for large converters (above 1 MW).
- (f) Insulation test
- (g) Temperature rise (Type Test).

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(h)

Light load & Functional Test.

(i)

Observation of various wave forms i.e. current and voltage.

14.3

OTHER COMPOSITE TEST AT NO LOAD

(a)

Environmental tests on printed circuit boards, pulse transformers etc.

(b)

Other tests as may be agreed on various converter subsystems.

14.4

ACCEPTANCE TEST

These shall be conducted at the works of the VENDOR'S and/or his sub-vendor to ascertain that performance stipulated in this specification has been honoured (e.g. overcurrent capability, measurement of ripple voltage & current, P.F. measurement, Audible noise, etc). Dummy loads as required for the purpose of simulating the operation conditions at the VENDOR's works shall be considered in scope of this specification. However, should this not be possible, testing at site with the actual load shall be conducted to prove the performance of the power converters.

14.5

All the meter, instruments, devices used for the testing purpose shall be properly calibrated by standard authorised agencies which shall be traceable to National Standards. For each such instrument proper validity of calibration shall be documented by Vendor.

15.0

HARMONICS LIMITATIONS

When specified in Data Sheet A, the harmonics generated on source (Input) side (Both AC/DC drive) and output side (For AC drive only) shall be restricted to the following limits: (relevant IEEE for source side and IEC- for load side)

(a)	Voltage Harmonics	Source side Maximum 5%	Load side Maximum 5% (THD)
(b)	Current Harmonics	Source side	
	5 th	Maximum 30%	
	7 th	Maximum 20%	
	11 th	Maximum 10%	

Bidder shall indicate clearly the method of achieving above requirement.

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SPECIFICATION NO. TCE.M4-203-71	TATA CONSULTING ENGINEERS LIMITED	SECTION: DATA SHEET B
	DATA SHEET B	SHEET 1 OF 3
ENQUIRY NO. TCE.		BIDDER:

SL. NO.	ITEM	UNIT	
1.0	Converter Designation		
2.0	Overload capacity & duration	% , Mins	
2.1	Minimum duration required for two successive overloads as specified above	Min/Hrs	
2.2	Switching frequency (specify if derating required for any switching frequency)	kHz	
3.0	Transient change in the nominal output voltage for 100% charge in motor load		--- % with recovery to steady state within ----- sec.
4.0	Size of largest motor which can be started direct on line	kW	
4.1	Maximum length of power supply cable without output filter	m	
5.0	Max distortion factor of input current at I/P of drive		
6.0	<u>CONTROL SYSTEM</u>		
6.1	Nature of system		Digital
6.2	Detailed technical information enclosed		Yes/No
6.3	Auxiliary Voltage Supply		
6.3.1	Analog Inputs No. of Inputs Input Range		
6.3.2	Digital Inputs No. of Inputs		
6.3.3	Analog Output No. of Output Range		
6.3.4	Digital Outputs		
	<u>RTD/BTD compatible Inputs</u>		

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6.3.5	Serial Communication for panel (specify port and protocol)		
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NOTES TO BIDDER 1. ITEMS WHICH DEVIATE FROM THE SPECIFICATION SHALL BE MARKED WITH ASTERISK (*) AND DETAILS SHALL BE GIVEN IN SCHEDULE OF DEVIATIONS. 2. THIS DATA SHEET SHALL BE FILLED UP COMPLETELY AND A COPY SHALL BE ENCLOSED WITH EACH COPY OF THE BID.	SIGNATURE OF BIDDER AND DATE	ISSUE R2
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SPECIFICATION NO. TCE.M4-203-71	TATA CONSULTING ENGINEERS LIMITED	SECTION: DATA SHEET B
	DATA SHEET B	SHEET 2 OF 3
ENQUIRY NO. TCE.		BIDDER:

SL. NO.	ITEM	UNIT	
6.3.6	Serial Communication for external control (specify port and protocol)		
7.0	<u>MONITORING AIDS</u>		
7.1	Power Semi-conductors		
7.1.1	Are temperature sensing elements provided?		Yes/No
7.1.2	Technical write up enclosed		Yes/No
7.2	Cooling system		
7.2.1	Nature of cooling of converters		Natural/Forced
8.0	Tentative Dimensions & weight		
9.0	Type of Mounting		
10.0	GA drawing of Drive Panel enclosed		Yes/No
11.0	Pulse Number		6/12
12.0	<u>DC drives</u> No. of parallel six pulse bridge arms		
12.1	Current rating per bridge arm		
12.2	Total current rating of converter		
13.0	No. of power semi-conductors in series per bridge arm		
14.0	Whether Converter connected to source directly		Yes/No
14.1	If no rating of the converter transformer	KVA	
15.0	If Armature Control used the field is connected		
15.1	Directly to the sources		Yes/No
15.2	Through converter transformer of the armature voltage control		Yes/No
15.3	Through separate converter transformer of rating	KVA	
16.0	Rated Output Voltage	V	
17.1	Accuracy of output voltage to maintain constant V/f		
18.0	Output Frequency	HZ	

NOTES TO BIDDER 1. ITEMS WHICH DEVIATE FROM THE SPECIFICATION SHALL BE MARKED WITH ASTERISK (*) AND DETAILS SHALL BE GIVEN IN SCHEDULE OF DEVIATIONS. 2. THIS DATA SHEET SHALL BE FILLED UP COMPLETELY AND A COPY SHALL BE ENCLOSED WITH EACH COPY OF THE BID.	SIGNATURE OF BIDDER AND DATE	ISSUE R2
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	DATA SHEET B	SHEET 3 OF 3
ENQUIRY NO. TCE.		BIDDER:

SL. NO.	ITEM	UNIT	
19.0	Setting range	HZ	
20.0	Accuracy	%	
21.0	Output rating kVA at power factor specified in data sheet A		
22.0	Output transformer rating & details, if provided	KVA, V, %Z	
23.0	Maximum Distortion factor of output Voltage		

NOTES TO BIDDER 1. ITEMS WHICH DEVIATE FROM THE SPECIFICATION SHALL BE MARKED WITH ASTERISK (*) AND DETAILS SHALL BE GIVEN IN SCHEDULE OF DEVIATIONS. 2. THIS DATA SHEET SHALL BE FILLED UP COMPLETELY AND A COPY SHALL BE ENCLOSED WITH EACH COPY OF THE BID.	SIGNATURE OF BIDDER AND DATE	ISSUE R2
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	DATA SHEET C	SHEET 1 OF 1

DATA SHEET – C

DATA TO BE SUBMITTED BY VENDOR

- 1.0 Following data shall be submitted within the period specified in Section C, after placing the order, for the PURCHASER'S approval.
- 1.1 General arrangement drawings showing outline dimensions, cable entry openings, fixing/foundation details, weights and door openings.
- 1.2 Front & cross section views showing arrangement details of equipment and terminals and with a Bill of Material for all equipment.
- 1.3 Schematic diagram indicating terminal number for external connections & block diagram of control system.
- 1.4 MANUFACTURER'S technical literature on various equipments supplied.
- 2.0 Wiring diagram of complete inverter. This shall be based on approved schematic drawing. The correctness of this drawing shall be the responsibility of the VENDOR.
- 3.0 Test certificates for the cabinet and all individual equipments and performance load tests shall be submitted atleast 2 weeks before dispatch of equipment. Copy of type test certificates shall also be submitted.
- 4.0 Operation and maintenance manuals shall be furnished with the equipment.
- 5.0 Detailed drawing of converter showing layout of power semiconductors, fuses, heat sinks, cooling system etc.
- 6.0 Details of testing procedures for power semiconductors and power converters as per Standards/Code of Practice for approval.
- 7.0 Shipping details of the equipment.

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ENQUIRY NO. TCE.7547A-H-OST-300	DATA SHEET A3	SHEET 1 OF 2

SL. NO.	ITEM	UNIT	
1.0	Type of Drive		Digital type IGBT based Inverter controlled AC drives.
1.1	Rating of the drive		*
1.2	Type of duty (cl. 3.5)		*
1.3	Quadrants of operation		I/II/IV*
2.0	Quantity		*
3.0	Power supply		415 V, 3ph, ,50Hz
4.0	Variation voltage		± 10 %
5.0	Variation in Frequency		50 Hz ± 5
6.0	Combined voltage and frequency variation		± 10%
7.0	Environmental Conditions		Refer Project Information
8.0	Location		Indoor
	a) Whether in air conditioned room		Yes/No
	b) If No:		
	Average ambient temperature ° C		Refer Project Information
	Design ambient temperature ° C		45°C
	Relative humidity %		Refer Project Information
	Vibration		*
9.0	Type of cooling for drive panel		Natural cooling /forced cooling with fan or water cooled
	If water cooled, is DM water required	Yes/No	
	If yes, quantity of DM water		----- litres/minute
10.0	Cable		
	a) Size and type		*
	b) Entry		Top/Bottom*

Note:

* Bidder to fill the details.

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CHD. BY	KVK					7547A	
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ENQUIRY NO. TCE.7547A-H-OST-300	DATA SHEET A3	SHEET 2 OF 2

SL. NO.	ITEM	UNIT	
1.0	Specification for metal clad base materials for printed circuits for use in electronic and telecommunication equipment		IS:5921
2.0	Specification of Transformers and Inductors (Power, Audio, Pulse and Switching) for Electronic Equipment		IS:6297
3.0	Semiconductor rectifier equipment safety code		IS: 6619
4.0	Specification for printed wiring Board		IS:7405
5.0	Recommended practice for emergency and standby power systems for industrial and commercial applic.		IEC : IEEE :446
6.0	Semiconductor devices		IS: 3700 IEC:146
7.0	Essential rating & characteristics		
8.0	Basic climate for mechanical durability tests for electronic components		IS:9000
9.0	Specification for metal-clad base materials for printed circuits for use in electronic and communication equipment		IS:5921
10.0	Specification for transformers and inductors (Power audio pulse and switching) for electronic equipment		IS:6297
11.0	Specification for printed wiring board		IS: 7405
12.0	Degree of protection provided by enclosures for low voltage switch-gears and control gears		IS:2147
13.0	Environmental requirements of semiconductor devices and integrated circuits		IS:6553
14.0	Ambient temp. of electronic equipment		IS:9676
15.0	Environmental tests for electronic equipment		IS:9000
16.0	Terminal for electronic equipment		IS:4007

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ENQUIRY NO. TCE.7547A-H-OST-300	DATA SHEET A3	SHEET 3 OF 2

SL. NO.	ITEM	UNIT	
17.0	Equipment accessories, component parts, raw materials and test shall in general conform to		IS: IEC:
18.0	Factory built assemblies of low Voltage		IS: 4237 IEC:439
19.0	Semiconductor rectifier assemblies And thyristor converters		BS:4417 IEC:148
20.0	Busbars and Busbar connections		IS:5082 BS:159 IEC:
21.0	Code of practice for earthing		IS:3043 BS:CP:1013 IEC:
22.0	Control cabinet		IS:4237 BS: IEC:
23.0	Current transformers		IS:2705 BS:3938 IEC:60044
24.0	Potential transformers		IS:3156 BS:3941 IEC:60044
25.0	Power transformers		IS:2026 BS:171 IEC:60076
26.0	Indicating meters		IS:1248 BS:89 IEC:51
27.0	Wiring rectifiers		IS:2274 BS: IEC:
28.0	Pulse transformer		IS:6297 BS: IEC:
29.0	Semiconductor Converters		IEC:146
30.0	Basic climate and Mechanical Durability Tests for Electronic Components		IS:589
31.0	Environmental tests for electronic and electrical equipment		IS:9000 Parts 1 to 18
32.0	Low-voltage switchgear & control gear – General Rules		IS:13947
33.0	Recommended practices and Requirements for harmonic control In electrical power systems.		IEEE 519
34.0	EMC requirements		IEC 61800-3
35.0	Painting code of practice for Phosphating iron & steel.		IS:6005
36.0	Functional safety of AC drives		IEC 61800-2

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