

SPECIFICATIONS OF 158kW Synchronous Generator Regenerative Loading System

1. Application: To drive, speed control and to conduct Regenerative loading of Synchronous Generator with Vector control/VVVF control. The schematic diagram is shown in Fig. 1. The supplied Drive Motor, Torque transducer, Synchronous Generator and Slip ring assembly with supporting structure will be mounted on a skid. The skid loading system should fit in 6500 mm (L) X 1700 mm (W) X 1500 mm (H).

2. Converter Topology: The loading setup system should have all IGBT based converters and sinusoidal filter compliance to related IES standard. The supplier should include shaft encoder (incremental type) for closed loop speed control.

3. Quantity: 1 Set - Converter System for supplying power to Driving motor and conduct Regenerative loading on Generator with loading system as per details given in Fig. 1.

4. Available Grid Supply:

- a. **No of Phases:** 3-Phase
- b. **Voltage:** 415V +/- 10%
- c. **Frequency:** 50Hz +/- 3%

5. Synchronous Generator Data (Unit Under Test and Over all dimensions shown in Fig. 2.)

NOTE: Synchronous Generator AC voltage is rectified to DC by a rotating rectifier mounted on the rotor.

- a. **Output DC Voltage Range:** 250V to 450V
- b. **Output Rated DC Voltage:** 350 V
- c. **Output Rated DC Current:** 450 A
- d. **Overload capacity:** 180kW (360V, 500A)
- e. **Ripple Frequency:** 450 Hz Rated
- f. **Rated Power:** 158 kW output
- g. **Rated speed:** 375 R.P.M
- h. **Loading speed range:** 250 R.P.M to 500 R.P.M
- i. **Efficiency:** 82%

6. Drive Motor

The Generator should be coupled through Gear box(if used) to the Drive motor with in-line Torque transducer as shown in Fig. 1. The Drive motor should be capable of driving the Generator from 250 rpm to 500 rpm with electrical power of 180 kW (considering **14% continuous over loading capacity** and 82% efficiency of Synchronous Generator) at Generator DC output. Drive motor should be compatible with normal motors (non-inverter duty) without de-rating.

Drive motor should be with cooling fan coupled to the shaft or forced air cooling blower mounted on drive motor stator frame only. Other type of cooling i.e. external water cooling is not acceptable.

7. Gear-box

Scheme with or without Gear-box meeting all the technical requirements is acceptable.

- a. Demand of Nominal power from Gear box : 220kW over 250 to 500 rpm
- b. Type : Foot mounted Parallel Axis horizontal shaft compact Helical type Gear Box
- c. No. of stages : Single stage
- d. Driven machine speed : As per the selected drive motor
- e. Gear/speed Ratio : As per the selected drive motor
- f. Minimum centre distance between input and output shaft : 250 mm
- g. Variation on design speed : +/- 2%

h.	Operation	:	Continuous
i.	Bearing life	:	>50000 hours
j.	Load nature	:	Steady load
k.	Gear box Input type	:	Male shaft with keyway
l.	Gear box Output type	:	Male shaft with keyway
m.	Efficiency of gear box	:	× 96%
n.	Cooling type	:	Forced Oil cooling
o.	Mounting of the cooling system:	:	On top of the gear box
p.	Oil cooler type	:	Air cooler

Note:

- Gear box should be compact in size
- Bearing and oil temperature sensing by RTD-100
- Gear accuracies as per IS: 3681-1995
- Gear corrections as per IS: 3756
- Gear load capacities as per IS: 4460-1995
- Gear lubricants as per IS: 15112-1/ IS: 1118-1992

8. Brush gear - Slip ring assembly with supporting structure

a. For DC power output

Three slip rings and suitable brushes rated for 600 V, 700 A should be mounted on shaft with supporting structure on skid as shown in Fig. 1.

Note: 1) Ring material - Phosphor Bronze with 90% Copper and 10% Tin

2) Insulation material - Fiber Glass

b. For Rotor Temperature measurement

Suitable wireless temperature data transmitting module should be provided on rotating shaft to transmit the measured temperature of Rotor winding and Diode heat sink with contact type temperature sensors as shown in Fig.1. Compatible receiver should be provided in control panel to decode and display on control panel LCD screen and Remote computer with real time.

9. Generator Shaft with supporting bearings and Pedestals for Generator

Shaft with supporting bearings and pedestals for Generator support should be provided as per Fig. 1. The shaft material should be of En24 type. The Generator rotor dimensions for shaft fitting are mentioned in Fig. 2. Shaft design should be as per the specification of Generator and it should integrate the DC slip ring assembly with suitable bearing, pedestal arrangement at DE side and NDE side with proper mechanical design. DC slip rings should be located at 200 mm away from the stator frame of Generator on NDE side. Temperature measuring and wireless transmitter system should be located at 200 mm away from the stator frame of Generator on DE side.

10. Environment condition

a. Site Ambient Temperature: 45 °C

b. Humidity: 90%

c. Location of the System: Indoor

11. Drive requirements:

a. Drive Motor converter:

This converter should supply power to the Drive motor as per the supplier system design for required operating conditions. Converter should take care of all protections on the drive motor side.

b. Regenerative converter:

This converter pumps power back from the DC Power available at the Generator output. The input voltage to this converter will be from 250 V to 450 V DC depending up on the speed of the Generator from 250 rpm to 500 rpm. The Generator DC output varies as the speed changes, but the converter has to regenerate power at above specified speed and voltage ranges with all protections on the regeneration side.

c. Emergency push button: Lockable Push-Button to be provided.

12. Drive Features:

a. Soft Start

b. Reset on Input grid supply off

13. Control and Monitoring with Local Control Unit and Remote computer

a. Door mounted multi-line 15" LCD colour Display with key pad

b. Digital Monitoring of loading system data in real time

c. Fault sequence display

d. Loading system has to be with an interactive and user-friendly door mounted with 15" LCD colour display. Operator should be able to access the following from display:

- Active Faults
- Fault History
- System Menu
- Monitoring various parameter
- Parameter Menu

e. The operator interface should be used for loading system programming, loading system monitoring and loading system trouble shooting. The operator interface must also be able to start and stop the loading system, reset loading system faults and manually adjust the Loading system's speed reference.

Control panel with inbuilt control system which incorporates the operator pendent switches, rotary knobs, LED lights showing the mains on, loading system healthy status, loading system run, forward direction of rotation and for other status indications, analog meters for local control of the whole loading system in case of remote failure, AC drive, Switch Fuse Unit (SFU) and other necessary electrical & electronics components for system desired operation.

f. The operator interface should be able to display all real time operating variables and all loading system programming parameters.

g. The operator interface should be capable of displaying a specific user selected parameter on power-up. This power-up parameter would typically be a parameter that is important to the operator such as Loading system speed or Loading.

h. The loading system control panel LCD screen should have built in monitoring of following parameters as minimum on its digital operator interface:

- AC GRID Voltage
- AC GRID Current
- AC GRID frequency
- AC GRID power factor
- AC GRID Power
- Drive motor Input Voltage
- Drive motor Input Frequency
- Drive motor Input Current
- Drive motor Input Power
- Drive motor speed
- Drive motor efficiency
- Synchronous Generator speed
- Synchronous Generator Input torque
- Synchronous Generator excitation voltage

- Synchronous Generator excitation current
 - Synchronous Generator Output DC Voltage
 - Synchronous Generator Output DC Current
 - Synchronous Generator Output Power
 - Synchronous Generator efficiency
 - Regenerated Output Voltage
 - Regenerated Output Current
 - Regenerated Output Power
 - Regenerative system efficiency
 - Total loading system efficiency
 - Synchronous Generator stator winding temperature with RTDs ó 2 No.s
 - Synchronous Generator Rotor winding temperature with RTD ó 1 No.
 - Synchronous Generator Rotor diode heat sink temperature with RTD ó 1 No.
- i. The above parameters should be also displayed on remote computer screen with respect to real time.
- j. The Loading system should store fault logs of minimum last 100 faults in memory.

14. Remote Computer for monitoring, controlling and data logging

Automation should be with RT controller with the help of Industrial grade PC with customized software to control remotely from 30 m distance and data log in. Windows based GUI to operate the test rig in Auto mode with provision to line up the sequences of the tests and in Manual mode.

15. Auxiliary Supplies required for Motor drive and Inverter drive System should be derived from input feeder.

16. Pre-charge: Pre-charging circuit has to be provided for pre-charging the DC link (if used) for each start-up operation

17. Indication to be provided on panel door

- a. Input power ON
- b. Drive motor Power ON
- c. Loading system Healthy
- d. Loading system Ready
- e. Loading system faulty
 - f. Regeneration ON/OFF
 - g. Regeneration faulty
 - h. Emergency stop activated

18. Drive Protections:

Motor Drive:

- Line input over-voltage and under-voltage
- Power module self-test during power-up initialization
- Power module over-voltage and under-voltage
- Drive motor Input over current protection
- Over-Speed protection
- Power module over-temperature
- Loss of Grid supply phase voltage
- Drive output short circuit protection.
- Cooling system failure

Inverter (Regenerative) Drive:

- SYNCHRONOUS GENERATOR Output Overload protection (Over loading > 20%)
- SYNCHRONOUS GENERATOR Output over-voltage protection

19. Control Features

- PLC/DSP based controller
- Remote operation and data-logging through PC
- Sensor/Sensor-less vector control for precise regulation of regenerative power.

- Space vector or sinusoidal PWM switching Technique has to be used
- Minimum 85% regenerative system efficiency at full load.
- 0.5% speed regulation

20. Control panel construction

a. Protection class: IP42 with Switch Fuse Unit (SFU) and other necessary protections for electrical & electronics components for systems best performance.

b. Panel: All the converters should be kept in single cubicle and as compact as possible.

c. Cooling: Air Cooled (Natural or Forced Air Cooled with suitable blowers).

d. Cable Entry: Input and output cable entry should be from bottom of the panel.

21. Torque transducer: Suitable Inline type with related supporting spindle housings and couplings.

22. Speed sensor: Speed measurement by incremental type encoder on Drive motor NDE side with $\pm 0.5\%$ accuracy.

23. Temperature sensor: Temperature sensing by contact type RTD100 temperature sensors with $\pm 0.5\%$ accuracy, temperature display with respect to time and with over temperature protection.

- Stator winding RTDs ó 2 No.s
- Stator Core temperature RTD ó 1 No.
- Rotor winding RTD ó 1 No.
- Rotor Diode rectifier Heat sink temperature ó 1 No.
- Bearing temperature RTDs ó 2 No.s

24. Couplings: The couplings employed in the test rig should be Torsionally rigid ó Flexible type like of Flexible disc type category & above. The Torque service factor should be greater than 1.4 times the rated torque.

25. Cables and Connectors: 415 V, 3 phase, 50 Hz supply will be arranged by BHEL. 20 meter cable from Input AC mains to drive panel input, 20 meter cable from Drive panel to Drive motor and 20 meter cable from Generator to Drive panel with required rating has to be provided by supplier. All other interconnecting wires and mechanical couplings are in the supplier scope.

26. Base frame: All above mechanical components mounted on common base frame ó fabricated ó suitably engineered for Static, Dynamic and Transient conditions with sufficient space for Synchronous Generator mounting as per Fig. 1.

27. Equipment and personnel safety: All rotating parts to have safety guards as per standard engineering practices along with necessary electrical protection and interlocks.

28. Warranty:

a. Supplier should give warrantee for a period of 1 year from the date of commissioning.

c. The Supplier should undertake AMC for the loading system supplied, after the expiry of the warranty period either directly or through a service representative.

29. Delivery Period: The supplier should supply the regenerative loading system within 16 weeks from the date of placing a purchase order.

30. Recommended Spares:

Supplier should recommend the list of spares required for its continuous operation (spares will be used after the warrantee period) and it will be purchased at a later date. The supplier should be able to supply the listed spares at least for a minimum period of 5 years after expiry of warrantee for reliable operation of the loading system.

31. Inspection, Training & Commissioning:

a. Final Inspection: BHEL representative will be present at manufacturer's works for witnessing of final testing as per above specifications.

b. Commissioning: Commissioning of the complete Loading System at BHEL R&D Hyderabad or at BHEL Bhopal or at BHEL Mumbai will be in the scope of supplier. The Final commissioning place will be intimated during Pre-despatch inspection. Final

Acceptance will be based on successful completion of the same. All the required equipments and material for installation and commissioning are in the supplier scope.

After testing, entire Regenerative loading system along with the synchronous Generator will be shifted to BHEL Corporate R&D, Hyderabad by BHEL. The loading system shall be made and commissioned finally at BHEL Corporate R&D by supplier for further testing of the Synchronous Generator.

c. Training: Training is required for two persons from BHEL for a minimum period of 3 days per person at manufacturer's works or place of commissioning.

32. Testing:

a. Test Protocol on complete regenerative loading system should be submitted by supplier for approval before inspection. These documents should explicitly list out all final tests done on all equipment comprising the Drive System.

b. Routine tests should be carried out on the Regenerative loading system as per relevant standards.

c. The loading test setup system should be fully loaded for demo test functionality at supplier's premises with demonstrating the sequence of test protocols as mentioned above during pre-despatch inspection.

33. Information required along with offer:

a. Loading system design methodology and Bill of material of all the components and parts

b. Dimensional Drawing of Drive Panel, Base frame, Regenerative Drive and other major components. Synchronous Generator Over all dimensions given in Fig. 2.

c. Tentative Scheme of Drive supply, Driving motor and Regenerative drive.

d. Weight of the total Drive supply, Driving motor and Regenerative drive.

e. Catalogues of the all components offered.

f. Completely filled and duly signed Technical compliance sheet

g. Civil works will be provided by BHEL at commissioning site.

34. Offer should consists of the following

a. Loading system Design, manufacture, testing and supply of 158 kW Regenerative loading system lump-sum cost with all applicable taxes meeting all the above specifications.

b. Installation and Commissioning lump-sum cost with all applicable taxes.

c. One year warranty lump-sum cost with all applicable taxes

d. Training lump-sum cost with all applicable taxes

e. AMC lump-sum cost after warranty with all applicable taxes

f. Payment terms for each of the above items 34)a. to 34)e. separately.

35. Maintenance manuals/Documentation to be given after Order Placement:

a. Erection, Commissioning and Maintenance manuals ó 3 copies

b. All drawings and schemes(In 30days from order placement)

c. Test and guarantee certificates.

d. Complete Bill of Material (item-wise) for the equipment supplied.

e. List of recommended spare list.

36. Tools: Any special tools required for commissioning and troubleshooting should be provided.

37. The supplier should have at least two 150kW@375rpm or 600kW@1500rpm or 1200kW@3000rpm (with $\pm 20\%$ variations in the power and speed) regenerative loading systems supplied experience in India or abroad and should furnish the details certified from such customers.

NOTE: BHEL Corporate R&D, Hyderabad reserves the right to relax/amend the above criterion based on fulfilment of other technical qualification.

38. Confirmations/Deviations (compliance) to Specifications :

Point-wise confirmation to this to be given along with the technical offer. Deviations if any should be indicated separately. If there are no deviations to the specifications, supplier should mention the same explicitly. A reply from vendor stating that "Equipment will generally meet the specifications" will not be accepted by BHEL Corp R&D. The following Technical compliance sheet is compulsory for validating any offer.

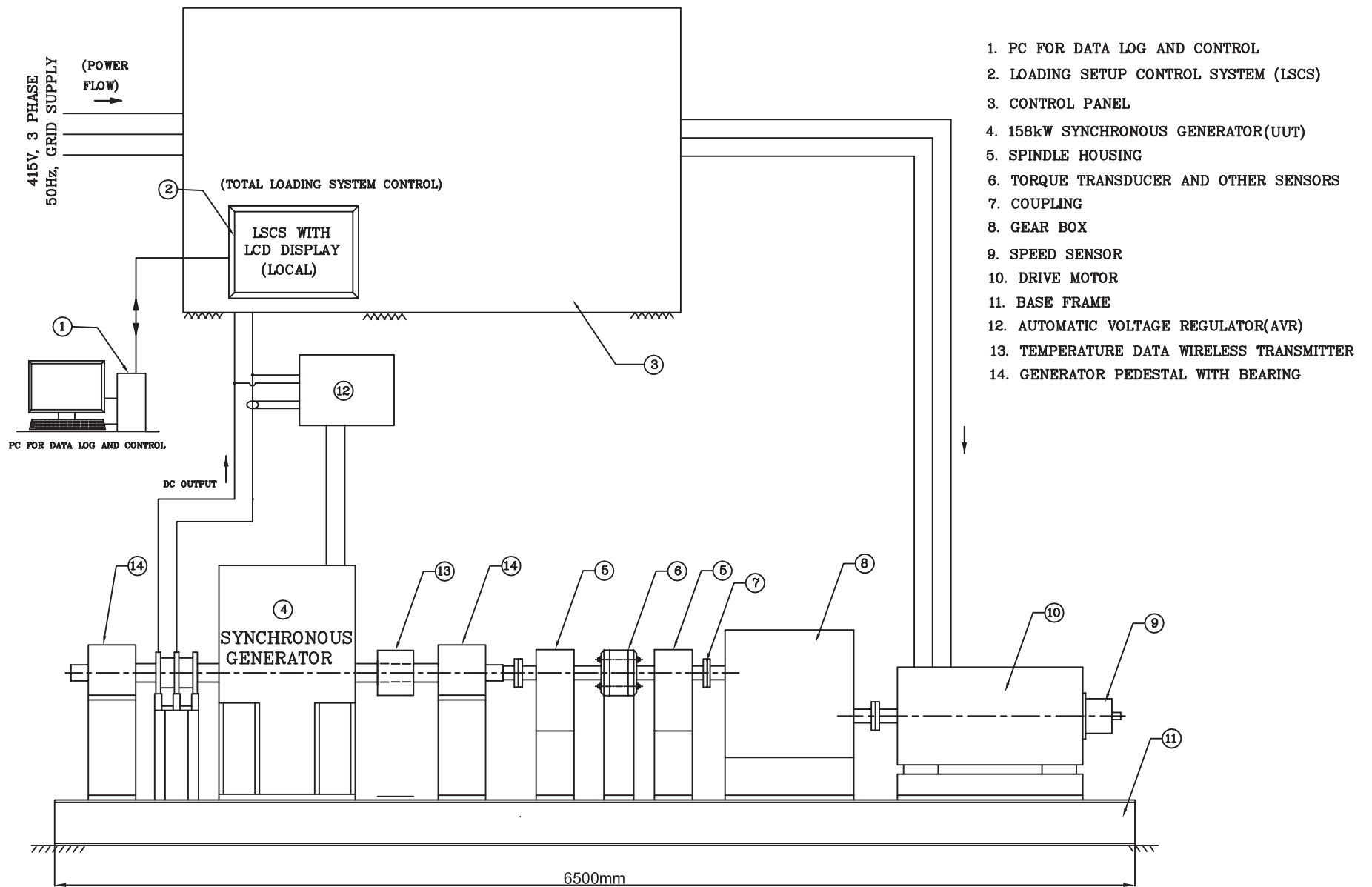


FIG.1: SCHEMATIC DIAGRAM OF 158kW SYNCHRONOUS GENERATOR LOADING SET-UP

NOTE: ITEM Nos 4 & 12 ARE NOT IN SUPPLIER'S SCOPE

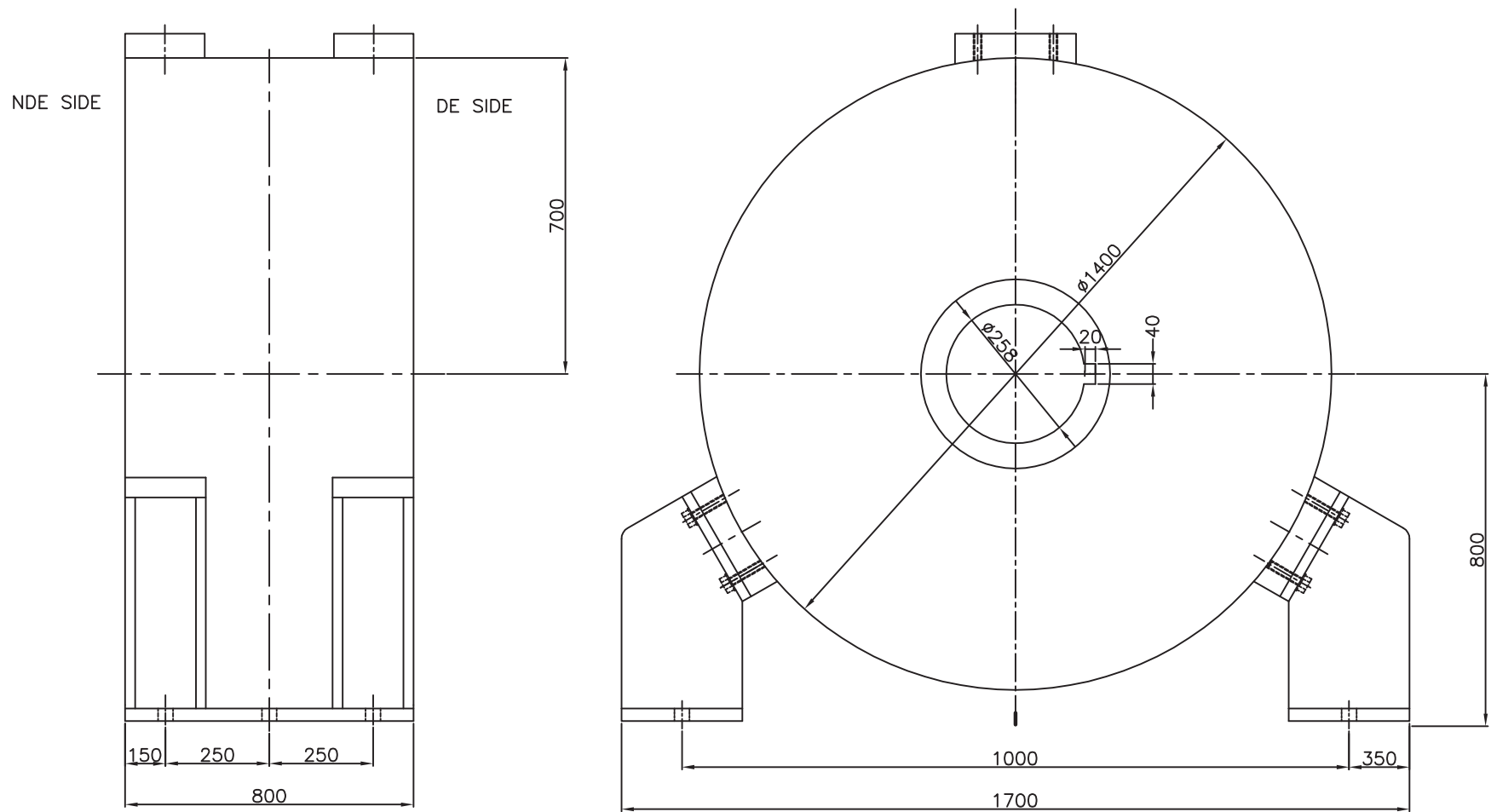


FIG.2: OVERALL DIMENSIONS OF 158kW SYNCHRONOUS GENERATOR

**TECHNICAL COMPLIANCE SHEET FOR 158 kW SYNCHRONOUS
GENERATOR REGENERATIVE LOADING SYSTEM**

S. No.	Specification	Compliance (Yes or No)	Remarks
1	Application		
2	Converter Topology		
3	Quantity		
4	Available Grid Supply		
5	Synchronous Generator Data		
6	Drive Motor		
7	Gear Box		
8	Brush gear - Slip ring assembly with supporting structure		
9	Generator Shaft with supporting bearings and Pedestals for Generator		
10	Environment condition		
11	Drive requirements		
12	Drive Features		
13	Control and Monitoring with Local Control Unit and Remote computer		
14	Remote Computer for monitoring, controlling and data logging		
15	Auxiliary Supplies		
16	Pre-charge		
17	Indication to be provided on panel door		
18	Drive Protections		
19	Control Features		
20	Control panel construction		
21	Torque transducer		
22	Speed sensor		
23	Temperature sensors		
24	Couplings		
25	Cables and Connectors		
26	Base frame		
27	Equipment and personnel safety		
28	Warranty		
29	Delivery Period		
30	Recommended Spares		
31	Inspection, Training & Commissioning		
32	Testing		
33	Information required along with offer		
34	Cost break up in the offer		
35	Maintenance manuals/Documentation to be given after Order Placement		
36	Tools		
37	Previous experience		
38	Confirmations/Deviations (compliance) to specification		

*Important: The supplier must send the above filled technical compliance sheet along with the offer.