



TECHNICAL SPECIFICATION OF DIGITAL EXCITATION CONTROLLERS FOR SYNCHRONOUS MACHINES

Document number	:	CEE/20023
Document Date	:	24-09-2026
Revision	:	07
Classification	:	Controlled Copy

	<i>Name:</i>	<i>Designation</i>	<i>Signature:</i>
Prepared & Checked by	P.K. Meher	Manager. (CEE)	
Approved by	Manoj Kumar	Sr. DGM (CEE)	

**CONTROL EQUIPMENT ENGINEERING DIVISION
BHARAT HEAVY ELECTRICALS LIMITED,
BHOPAL-462022 (INDIA)**



History of revisions

Issue	Description	Revision Date
00	Concept release, original version	11-11-2020
01	Specification updated	05-04-2021
02	Item-02 added.	25-06-2021
03	Inspection & warranty clause amended	18-12-2021
04	Item-2 deleted & minor correction	09-01-2026
05	Item-2, Item-3 and Item-4 added. Earlier specification of Item-2 and Item-3 (CEE21005, REV02)) is withdrawn.	11-07-2026
06	Item-05 & 06 added.	10-09-2026
07	Item-4 & item-5 items description interchanged.	20-09-2026



Table of Contents

1	INTRODUCTION	4
2	SCOPE OF SUPPLY	5
3	TECHNICAL REQUIREMENTS FOR ITEM-01 & 06	5
4	TECHNICAL REQUIREMENTS FOR ITEMS-02 & 03.....	6
5	TECHNICAL REQUIREMENTS FOR ITEM-04 & 05	6
6	CONTROLLER BASIC FEATURES (COMMON TO ALL).....	7
7	DETAIL SPECIFICATION OF CONTROLLER (COMMON TO ALL).....	8
8	GENERAL TERMS & CONDITIONS	12



1 INTRODUCTION

This specification covers the requirement of Digital Excitation controllers to be used in Excitation Control Panels for excitation control of synchronous machines both brushless and brush type.

The Excitation Controller shall be a proven, microprocessor-based digital Automatic Voltage Regulator (AVR) designed specifically for excitation control of synchronous generators employing either brushless or static (brush-type) excitation systems. The controller shall provide precise regulation of generator terminal voltage by continuously monitoring generator operating parameters, including terminal voltage, field current, field voltage, stator current, reactive power, power factor, frequency, and system operating conditions.

The controller shall support Automatic Voltage Regulation (AVR), Manual Field Current Regulation (FCR), automatic and bumpless transfer between operating modes, comprehensive protection and limiting functions, event and disturbance recording, self-diagnostics, and communication provision with user plant Distributed Control System (DCS) and SCADA.

The controller shall be specifically designed for critical power generation applications requiring high reliability, high availability, and fast dynamic response. The hardware shall be industrial-grade, modular, and designed for continuous operation under severe electrical and environmental conditions encountered in utility and industrial power plants.

The excitation controller shall have compliance to the latest applicable IEEE standards such as:

- IEEE 421.5 – Recommended Practice for Excitation System Models for Power System Stability Studies.
- IEC 60255-5 Impulse – Measuring relays and protection equipment.
- IEC 61000 series – Electromagnetic Compatibility (EMC), including Electrostatic Discharge (ESD), Electrical Fast Transients (EFT), Surge Immunity, Conducted and Radiated RF Immunity, Power Frequency Magnetic Field Immunity, Voltage Dips and Interruptions, and Emission Requirements.
- Applicable compliance for Environmental testing including temperature, humidity, vibration and shock.

The excitation controller shall be designed with a rugged hardware architecture incorporating industrial-grade components, high-speed processors, watchdog supervision, self-monitoring diagnostics, redundant power supplies (where specified), fail-safe operation, and automatic fault detection. The controller shall maintain reliable operation under electrical noise, switching transients, harmonic distortion, and severe electromagnetic disturbances without degradation of control performance.

The controller shall possess a proven service record of satisfactory operation in utility or industrial power plants for synchronous generators of comparable rating and application. Documentary evidence of successful installations operating continuously for not less than five (5) years shall be furnished upon request.

Only excitation controllers that are fully type-tested, field-proven, and compliant with the specified IEEE and IEC standards shall be considered technically acceptable.



2 SCOPE OF SUPPLY

Item No	BHEL Style Code	Item Description
01	BL9047583663	Digital Excitation Control System (with 24±20%V DC Aux. Supply) for Brushless Synchronous Machine with built-in Power Stage 20A with Redundancy
02	BP9048112397	Digital Excitation Control System (with 24±20%V DC Aux. Supply) suitable for Brush-type Synchronous Machine without Redundancy Suitable for Controlling for at-least Two Nos. Thyristor Bridges
03	BP9048114730	Digital Excitation Control System (with 110V AC/DC Aux. Supply) suitable for Brush-type Synchronous Machine without Redundancy Suitable for Controlling for at-least Two Nos. Thyristor Bridges
04	BP9048112400	Digital Excitation Control System (with 110V AC/DC Aux. Supply) suitable for Brush-type Synchronous Machine with Redundancy Suitable for Controlling for at-least Two Nos. Thyristor Bridges
05	BP9047589173	Digital Excitation Control System (with 24±20%V DC Aux. Supply) suitable for Brush-type Synchronous Machine with Redundancy Suitable for Controlling for at-least Two Nos. Thyristor Bridges
06	BP9047589181	Digital Excitation Control System (with 110V AC/DC Aux. Supply) for Brushless Synchronous Machine with built-in Power Stage 20A with Redundancy

3 TECHNICAL REQUIREMENTS FOR ITEM-01 & 06

The Excitation Controller ensures stable operation of the synchronous generator over its entire operating load range. It provides fast recovery of the generator terminal voltage following changes in load demand, thereby maintaining fast dynamic voltage regulation. The integrated protective functions ensure safe, reliable, and secure operation of the generator under both normal and abnormal operating conditions.

The controller automatically regulates the output voltage of the synchronous generator by supplying a controlled field current through an exciter system. The excitation control function remains active and effective throughout the complete operating range of the generator.

The controller incorporates a built-in 20A DC IGBT/MOSFET power stage, rated for continuous operation at ambient temperatures up to 55°C, for field current regulation. It provides a PID control output for controlling the integrated power stage for precise excitation control. The controller shall be equipped with digital inputs and digital outputs as specified in the technical specification and shall provide interfaces for Potential Transformers (PTs) and Current Transformers (CTs) for various auto control mode operation.

Limiting dimension: 250(W)*350(H)*250(D) tolerance ±5mm



Mounting: Suitable for flush mounting at door and panel mounting

4 TECHNICAL REQUIREMENTS FOR ITEMS-02 & 03

The Excitation Regulator shall be used in **Static Excitation System** for excitation control of a brush-type synchronous machine.

The regulator shall generate a PID control output for controlling an **external thyristor bridge**, which converts AC voltage into controlled DC voltage for generator field current regulation. It shall be equipped with digital inputs and digital outputs as specified in the technical specification and shall provide interfaces for Potential Transformers (PTs) and Current Transformers (CTs) to facilitate various auto control modes.

The Excitation Regulator shall ensure stable operation of the synchronous generator throughout its entire operating load range. It shall provide fast recovery of the generator terminal voltage following sudden load changes, thereby maintaining fast dynamic voltage regulation. The built-in protective features shall ensure safe, reliable, and secure operation of the generator under normal as well as abnormal operating conditions.

The equipment shall automatically regulate the output voltage of the synchronous generator by supplying a controlled excitation current to the generator field through the static excitation system. The excitation control system shall remain active and effective over the entire operating range of the generator, ensuring reliable voltage regulation under all loading conditions.

Excitation regulator suitable for external thyristor bridge consisting of PT, CT, AI/AO, DI/DO interface modules.

Field Voltage & field current sensing: Controller shall have either built-in functionality for measurement of field voltage & current or external transducer (Isolation module) shall be considered along with necessary interface cable. Field voltage shall be measured directly from thyristor bridge output & field current shall be measured through a shunt (xxxxA/100mV). Current measurement range shall be >20A & <5000A i.e. shunt rating range shall be 20A/100mV to 5000A/100mV)

Analog Output: Controller have **±10V PID output** for controlling external thyristor bridge for firing angle control from 0-180 degree.

Limiting dimension: 415(W)*170(H)*205(D) tolerance ±5mm

Mounting: Suitable for flush mounting at door

5 TECHNICAL REQUIREMENTS FOR ITEM-04 & 05

The Excitation Regulators shall be used in Static Excitation System in redundant operation for excitation control of a brush-type synchronous machine.

It shall have all features & functions of item-2 & the following additional features required:

- Auto tracking between two controllers in hot-standby (external tracking). If any special cable is required for communication between controller, to be supplied.
- Redundancy communication port
- Exciter diode monitoring
- Transient boost functionality



6 CONTROLLER BASIC FEATURES (COMMON TO ALL)

SN	Features	Compliance / deviation
1.	The control modes: • Auto Mode ➤ Automatic voltage regulation (AVR) ➤ Droop mode when operating in parallel or Grid connected ➤ Power factor (PF) regulation- Grid connected ➤ Reactive power (VAR) regulation) - Grid connected • Manual Mode ➤ Field current regulation -FCR ➤ Field Voltage Regulation -FVR	
2.	Limiting Features for both no-load and load conditions in all operating modes: • Over Excitation Limiter (OEL) • Stator Current Limiter (SCL) • V/f Limiter • Under Excitation Limiter (UEL)	
3.	Integrated Protection feature • Under/ Over Generator voltage (59/27) • Under/ Over Generator Frequency (81O/U) • Reverse power protection • Field Over-Voltage • Field Over Current • Loss of Field (LOS)	
4.	The programmable setting of PI controller for fine tuning and gain switching features for the following conditions: • No-load condition • Load condition	
5.	User programmable minimum two homing conditions for each operating control mode	
6.	Soft start and voltage build-up control with an adjustable ramp in both: • Auto control • Manual control	
7.	Generator voltage (rms) sensing • Three phase • Single phase	
8.	Three/two/single-phase generator current sensing for • Metering • Regulation	
9.	Auto tracking between operating modes and standby (non-working) control mode within the	



SN	Features	Compliance / deviation
	controller (internal tracking) to achieve bumpless transfer between control mode and units	
10.	Auto tracking between two controllers in hot standby (external tracking). If any special cable is required for communication between controller, to be supplied.	
11.	Minimum sixteen contacts sensing inputs for system interface as detailed in the proceeding section.	
12.	Minimum fourteen digital output for system control	
13.	Real-time metering (Integrated HMI/External)	
14.	Trending, Data logging and event recording	
15.	Generator paralleling with reactive droop compensation and reactive differential compensation	
16.	Real time clock	
17.	Generator paralleling with reactive droop compensation and reactive differential compensation	
18.	Time synchronisation with user server.	
19.	Communication port: • Communication port for windows base PC interface • Communication port for Modbus RTU & TCP/IP Protocol • Redundancy communication port	
20.	PC based configuration software compatible with Windows 11/10: 64 bit	

7 DETAIL SPECIFICATION OF CONTROLLER (COMMON TO ALL)

Sl. No.	Specifications	Compliance / Proposed Value
1.	Regulation Accuracy	
1.1	Regulation Accuracy (AVR mode)	
	Voltage regulation < $\pm 0.25\%$ over the entire load range	
	Response time: <1 cycle (20msec)	
1.2	Regulation Accuracy (FCR mode)	



Sl. No.	Specifications	Compliance / Proposed Value
	Field current regulation < $\pm 1.0\%$	
1.3	Regulation Accuracy (VAR mode)	
	VAR regulation < $\pm 2.0\%$	
1.4	Regulation Accuracy (PF mode)	
	PF regulation < ± 0.02 PF	
1.5	Internal tracking	
2.	Generator Voltage Sensing Three-phase line voltage, 110 volts/50 hertz nominal (85 to 127 volts) Burden = less than 1 VA per phase	
3.	Generator Current Sensing-1A & 5A	
4.	Bus Voltage Sensing: Single -phase line voltage, 110 volts/50 hertz nominal (85 to 127 volts).Burden = less than 1 VA	
5.	Contact Input Circuits	
	At least sixteen contact (programmable) input circuits to accommodate dry contacts (potential free) for the following functions	
	I. Start	
	II. Stop	
	III. Redundancy	
	IV. Unit/Parallel Operation (52L/M)	
	V. Auto (AVR) Mode	
	VI. FCR Mode	
	VII. VAR/PF Enable (52J/K)	
	VIII. Pre-position 1	
	IX. Pre-position 2	
	X. Raise	
	XI. Lower	



Sl. No.	Specifications	Compliance / Proposed Value
	XII. PID Setting Group Selection	
	XIII. Alarm Reset (ALRST)	
	XIV. PSS -optional	
	XV. SPARE	
	XVI. SPARE	
6.	Contact Outputs	
	Fourteen output contacts (programmable) rated as described with 300V surge suppressors installed across contacts to prevent arcing from inductive loads. Contacts are as follows	
	I. Build-up	
	II. Fail-To-Build-Up	
	III. Watchdog	
	IV. Start/Stop	
	V. Relay # 1	
	VI. Relay # 2	
	VII. Relay # 3	
	VIII. Relay # 4	
	IX. Relay # 5	
	X. Relay # 6	
	XI. Relay # 7	
	XII. Relay # 8	
	XIII. Spare relay	
	XIV. Spare relay	
7.	Parallel Compensation	
	Shall use either reactive droop or reactive differential (cross-current) compensation. Adjustable 30% of the rated generator voltage droop with optional 1 ampere or less or 5 amperes or less input. For parallel reactive differentiation compensation, burden may be greater than 1 VA if external resistors are added to the CT circuit.	
8.	Line Drop Compensation	



Sl. No.	Specifications	Compliance / Proposed Value
	Active when the droop setting is set as a negative value. Adjustable from -30% to +30% in 0.1% increments	
9.	Protections	
	I. Field Over voltage	
	II. Field Over current	
	III. Generator Under Voltage	
	IV. Generator Over Voltage	
	V. Loss of Field	
10.	Metering Accuracy	
	I. Line voltage <0.5% at 25 to 50°C (50Hz)	
	II. Bus voltage <0.5% at 25 to 50°C (50Hz)	
	III. Line current(s) <0.2% at 25 to 50°C (50Hz)	
	IV. Field voltage = $\pm 1.0\%$	
	V. Field current 0.5% at 25 to 50°C	
	VI. Phase angle = $\pm 1.0^\circ$	
	VII. Power factor ± 0.01 PF at 25 to 50°C	
	VIII. Active power (watts) $\pm 1.0\%$ at 25 to 50°C	
	IX. Reactive power (VARs) $\pm 1.0\%$ at 25 to 50°C	
	X. Generator frequency = ± 0.1 hertz.	
	XI. Bus frequency = ± 0.1 hertz.	
11.	SOE, data logging, disturbance recording & trending	
	Upto 1000nos Events, Up to 6 variables can be logged. The sampling rate is 1,200 data points per log, up to 1,199 pre-trigger, 4 ms to 10 s intervals, (4.8 s to 12,000 s total log duration)	
12.	RFI (Radio Frequency Interference)	
	EN 61000-6-2 EN 61000-6-4	



Sl. No.	Specifications	Compliance / Proposed Value
13.	Temperature	
	Operating Range 0 to +60°C	
14.	Shock & Vibration	
	IEC 60068-2-6 Test	
15.	Impulse	
	IEC 60255-5	
16.	Transient	
	IEC 61000-4-4,	
17.	Static Discharge	
	IEC 61000-4-2	

8 GENERAL TERMS & CONDITIONS

Sl. No.	Clause	Compliance / Proposed Value
1.	The warranty shall be 12 months from the date of acceptance of item at BHEL.	
2.	Controller Configuration software shall be English only.	
3.	Controller front facia will be printed in English only.	
4.	The manual will be enclosed alongwith tender. It should be complete in all respect operation, commissioning, terminal details etc.	
5.	Reference list of quoted controllers (Part no).	

Information required along with the offer

- Acceptance of all the clauses of our specification. Deviation if any should be clearly spelt out.
- Write up i.e. detailed specification, instruction manual & programming software details shall be provided in hard copy & soft copy.

**Notes**

- The offer shall be submitted in two bid, i.e. a technical bid and a price bid. Price bid of only those suppliers will be opened who shall comply to the above technical & physical specifications.
- 3 copies of test certificates and guarantee certificate are required along with the consignment.

Special Note: Bidder is requested to submit asked information only.