GE Energy

EX2100 Excitation Control

User's Guide

GEH-6632G

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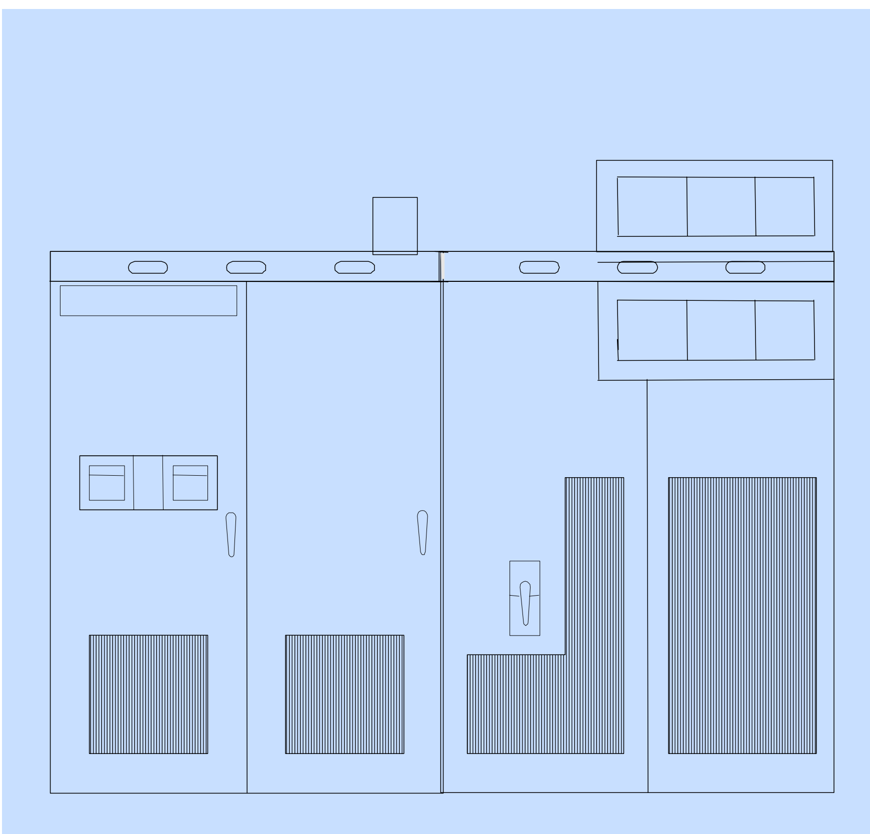

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Organization	○	○	○	○	______
Technical Accuracy	○	○	○	○	______
Clarity	○	○	○	○	______
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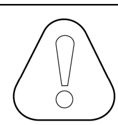
Safety Symbol Legend

Warning

Indicates a procedure, condition, or statement that, if not strictly observed, could result in personal injury or death.

Caution

Indicates a procedure, condition, or statement that, if not strictly observed, could result in damage to or destruction of equipment.



Attention

Indicates a procedure, condition, or statement that should be strictly followed in order to optimize these applications.

Note Indicates an essential or important procedure, condition, or statement.

Warning

This equipment contains a potential hazard of electric shock or burn. Only personnel who are adequately trained and thoroughly familiar with the equipment and the instructions should install, operate, or maintain this equipment.

Isolation of test equipment from the equipment under test presents potential electrical hazards. If the test equipment cannot be grounded to the equipment under test, the test equipment's case must be shielded to prevent contact by personnel.

To minimize hazard of electrical shock or burn, approved grounding practices and procedures must be strictly followed.

Warning

To prevent personal injury or equipment damage caused by equipment malfunction, only adequately trained personnel should modify any programmable machine.

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Chapter 1 Equipment Overview

Introduction

The EX2100 (EX2100 or exciter) produces the field excitation current to control generator ac terminal voltage and/or the reactive volt-amperes. It is a thyristor excitation system designed for generators on both new and retrofit steam, gas, and hydro turbines.

This chapter introduces the exciter and defines the document contents. Its purpose is to present a general product overview as follows.

System Overview

The exciter is a flexible modular system that can be assembled to provide a range of available output currents and several levels of system redundancy. These options include power from a potential, compound, or auxiliary source. Single or multiple bridges, warm backup bridges, and simplex or redundant controls are available. An overview of the turbine generator excitation system is shown in the figure *Overview of Generator and Exciter System*.

Power for the exciter is drawn from a power potential transformer connected to the generator terminals, or from an excitation transformer connected to an auxiliary bus. Generator line current and stator output voltage are the primary feedbacks to the exciter, and dc voltage and current is the controlled output to the exciter field.

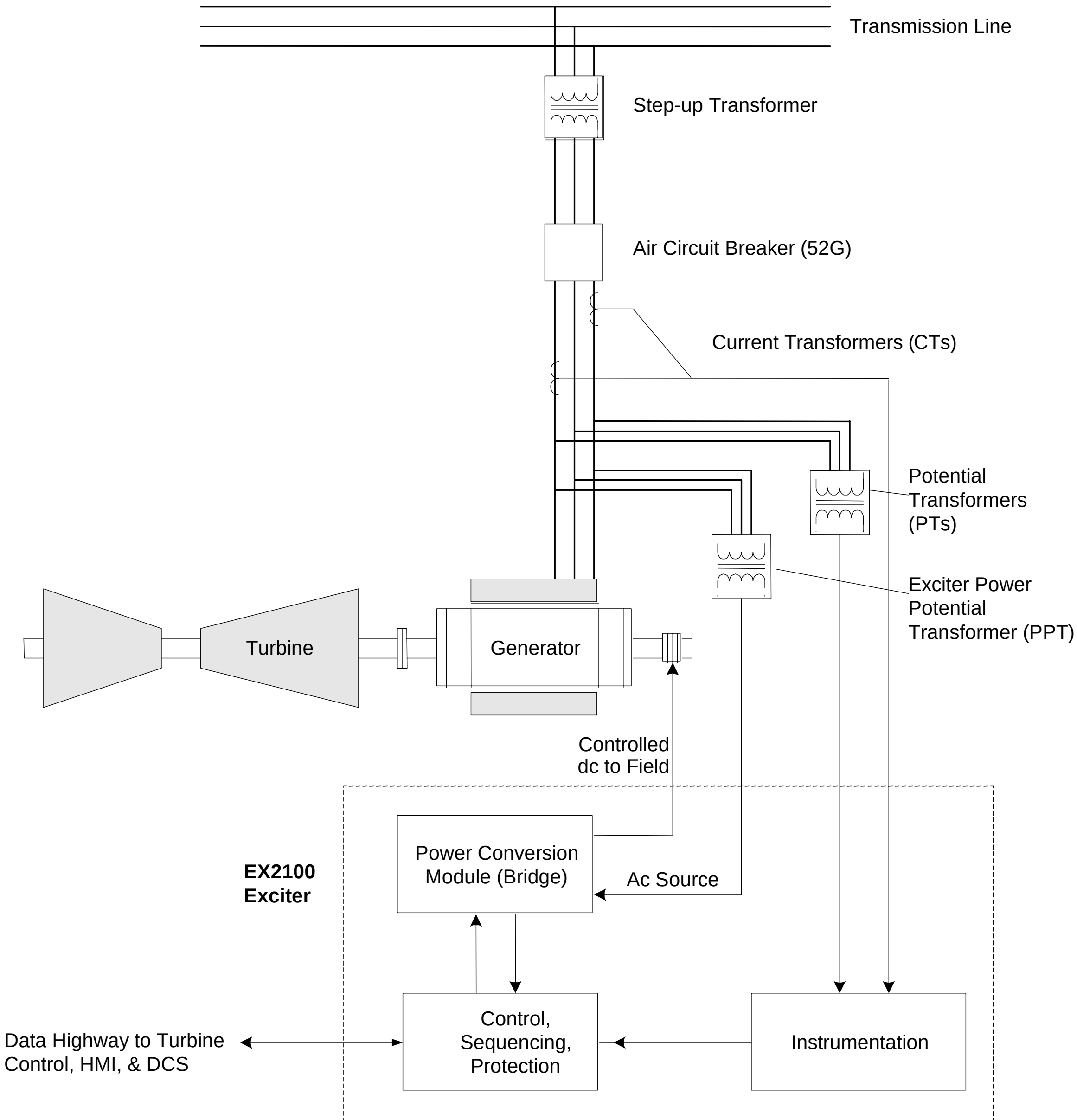
The EX2100 supports both static excitaion systems and rotating exciters such as brushless and Alterrex*

The architecture supports Ethernet LAN (Unit Data Highway) communication with other GE equipment including the GE Control System Toolbox (toolbox) for configuration, the turbine control, the LS2100 Static Starter, and the HMI (operator interface).

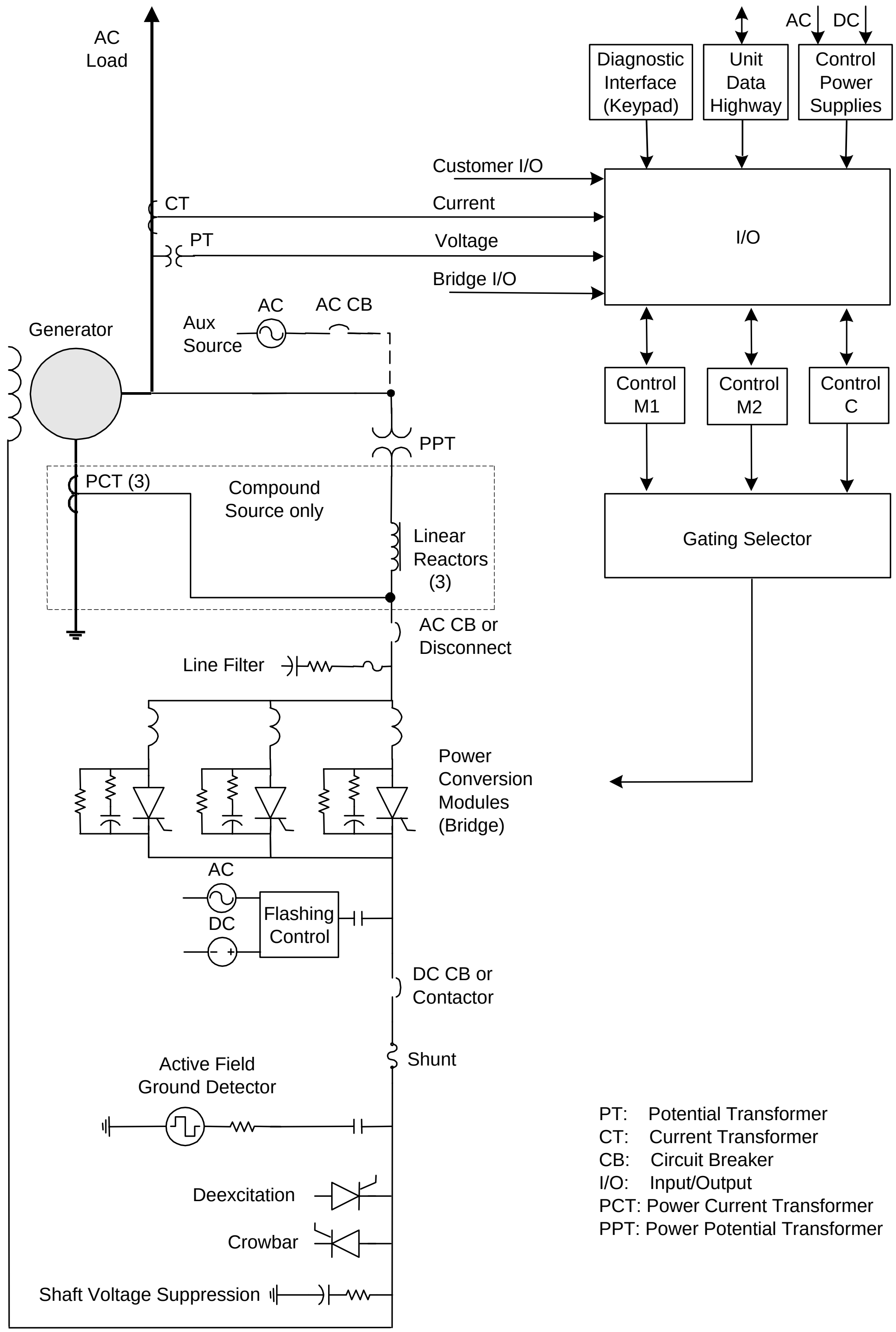
The *Exciter One Line Diagram* is a simplified one line diagram of the exciter showing the power source, generator current and voltage measurements, control module, power conversion module (PCM), and protection circuits. In the potential source system, the secondary of the PPT is connected to the input of a 3-phase full-wave inverting thyristor bridge. The inverting bridge provides both positive and negative forcing voltage for optimum performance. Negative forcing provides fast response for load rejection and de excitation.

Excitation control results from phase controlling the output of the SCR bridge circuit. The SCR firing signals are generated by digital regulators in the controller. In the redundant control option (See *Exciter One Line Diagram*), either M1 or M2 can be the active master control, while C monitors both to determine which should be active and which should be standby controller. Dual independent firing circuits and automatic tracking are used to ensure a smooth transfer to the standby controller.

Note Either simplex or redundant control is available.



Overview of Generator and Exciter System



Exciter One Line Diagram

Hardware Overview

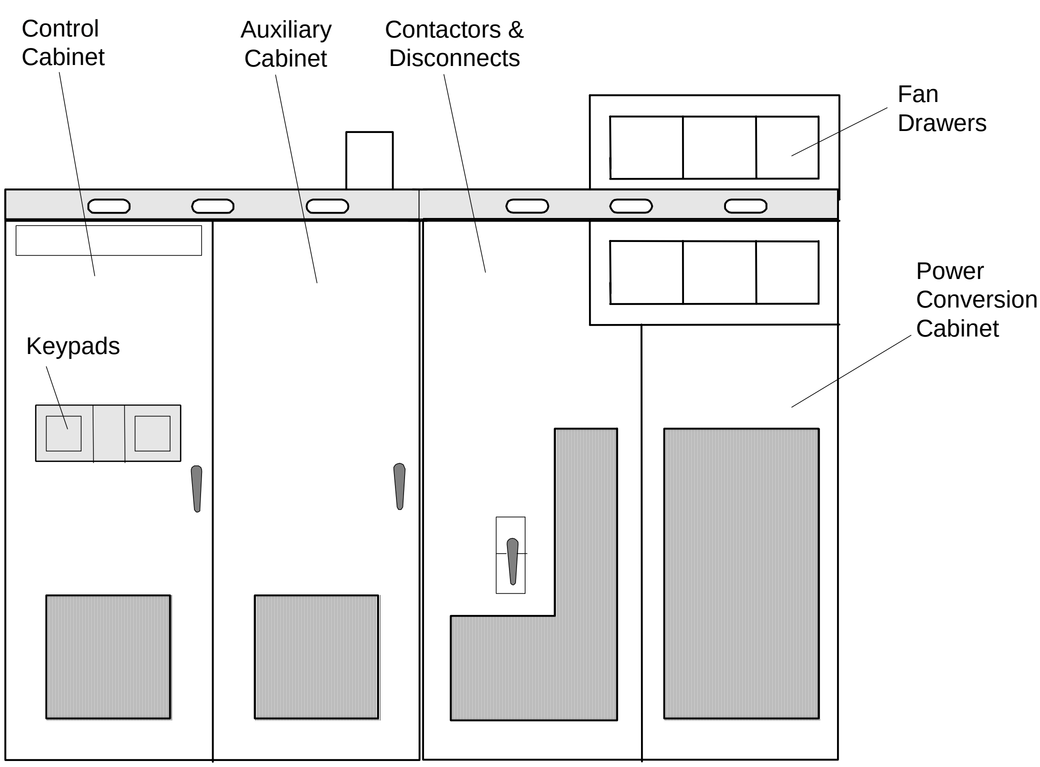
The EX2100 hardware is contained in cabinets as follows:

- Control cabinet for the control, communication, and I/O modules
- Auxiliary cabinet for field flashing and protection circuits such as de-excitation and shaft voltage suppression
- Power conversion cabinet for the power SCR cells, cooling fans, dc contactors, and ac disconnect

The exciter's power converter consists of bridge rectifiers, resistor/capacitor filter configurations, and control circuitry. An outside view of the cabinets for a typical 77 mm or 53 mm warm backup lineup is shown in the figure *Exciter Cabinets (77 mm and 53 mm WBU Typical)*. The components and bridge size vary for different excitation systems and for the power output required.

Bridge sizes are referenced to the size of the SCR device used. 100 mm, 77mm, 53 mm, and 42 mm (equivalent) sizes are available. Bridge configurations of simplex or single bridge, warm backup or redundant bridge, multiple parallel bridges (up to 4 total), and N+1 or N+2 online maintainable versions are available. The 42 mm thyristor bridge is available in both inverting and non-inverting topologies. The larger bridge sizes are always supplied as inverting bridges.

The EX2100 is also available without a power converter, as a Digital Front End Control only, for bridge retrofit applications. The 42 mm power modules are available as separate modules to facilitate upgrades into existing power converter cabinets, such as Frame 5 generator control installations.



Software Overview

Microprocessor-based controllers (ACLx and DSPX) run the exciter control code. The software consists of modules (blocks) combined to create the required system functionality. Block definitions and configuration parameters are stored in flash memory, while variables are stored in random-access memory (RAM).

The exciter application software emulates traditional analog controls. It uses an open architecture system, with a library of existing software blocks configured from the toolbox. The blocks individually perform specific functions, such as logic gates, proportional integral (P.I.) regulators, function generators, and signal level detectors. The control selects one of two modes, either generator voltage regulation (Auto Regulation), or direct control (voltage or current, depending upon the application). Generator protection functions are integrated into the control, including over and under-excitation limiting, power system stabilization, and V/Hz limiting.

The blocks can be interrogated while the exciter is running by using the toolbox. The dynamically changing I/O values of each block can be observed in operation, which is valuable during startup or troubleshooting.

Technical Characteristics

Summary characteristics for the EX2100 are as follows; for further details refer to *Appendix B.*

Caution

Unit Specific ratings are provided on equipment nameplate and supersede all information herein.

EX2100 SCR	Approximate Exciter Current Capability	PCM Type	Number of PCMs	Number of Shippings Splits	Approximate Weight (pounds)	Approximate Dimensions (l x w x h)(inches)
42 mm	165 A dc	Simplex or WBU, Conv.	1	1	1875 lbs (simplex)3200 lbs (wbu)	71 x 31.5 x 104.5 (simplex)
42 mm	500 A dc 200 A dc (PMG)	Simplex or WBU, Forced	1	1	1875 lbs (simplex)3200 lbs (wbu)	118.5 x 31.5 x 104.5 (WBU)
53 mm	1000 A dc	Simplex or WBU	1 or 2	1	4000 lbs (simplex) 5600 lbs (wbu)	112 x 31.5 x 104.5 (simplex, no aux)
77 mm	2000 A dc	Simplex or WBU	1 or 2	1	4000 lbs (simplex) 5600 lbs (wbu)	142 x 31.5 x 104.5(wbu)
100 mm	2800 A dc	Simplex or WBU	1 or 2	2	17400 lbs(2 PCM)	198.5 x 48.5 x 106(2 PCM)
100 mm	6000 A dc	N+1 or N+2	3 or 4	2	20925 lbs(3 PCM)	236 X 48.5 x 106 (3 PCM)
100 mm	8000 A dc	N	4	2	24450 lbs(4 PCM)	275.5 x 48.5 x 106(4 PCM)

EX2100 Characteristics	Description	
Power Converter Module (PCM)		
Forcing requirements	150% of design Amperes (EDA) for 30 sec at 40ºC (typical)	
Power Sources		
Power for the PCM – Voltage source	Auxiliary bus Generator terminals Compound source 600, 1000 or 1400 V ac versions (300 V ac for PMG source)	
Power for the PCM - Frequency	3-phase 50/60 Hz (up to 480 Hz for 42 mm PMG source)	
Flashing power	Battery source 125 V dc or 250 V dc, with up to 200 A for at least 10 sec 240 or 480 V ac, 50/60 Hz single-phase auxiliary source	
Control power	For two ac sources, or one ac and one dc source: Nominal 120 or 220 V ac ±15%, with 1 DACA, 8 A rms max. Battery source, 125 V dc, range 80 – 140 V dc, 6 A dc max.	
Inputs/Outputs	**Qty**	
Potential transformers (PTs)	2	3-phase standard, single phase available 120 V ac nominal 1 VA nominal burden
Current transformers (CTs, 1 or 5 A)	2	Any two phases, single phase available, redundant available 1 VA nominal burden
86G dedicated contact input	1	Open for trip
52G dedicated contact input	1	Closed for online
Trip rated contact outputs	2	At 125 V dc with relay break characteristics: Resistive load 0.5 A Inductive load 0.2 A
General Purpose contact inputs	6	Customer contacts, 70 V dc supplied by ECTB
General Purpose Form C contact outputs	4	At 125 V dc with relay break characteristics: Resistive load 0.5 A Inductive load 0.1 A
± 10 V differential amplifier input Isolated 4-20 mA analog outputs	1 4	For LS2100 reference or customer use.(Optional) for monitoring or metering through DIN-rail mounted signal conditioners bandwith < 1ms ouput load upto 500 W accuracy <190 full scale
Thermal		
Base controls cabinet		Continuous operation in a 0 to 40ºC ambient environment, with 5 to 95% humidity, non-condensing
Base power conversion and auxiliary cabinet		Continuous operation in a 0 to 40ºC ambient environment, with 5 to 95% humidity, non-condensing
Cabinet Enclosures		
Cabinet type, control and auxiliary enclosures		NEMA 1 (IEC IP 20), convection cooled
Cabinet type, power conversion		NEMA 1 (IEC IP 20), forced air cooled or convection (42 mm)
Power and Control Cable Access		Entrances from the top and/or bottom

How to Get Help

If technical assistance is required beyond the instructions provided in the documentation, contact the nearest GE Sales or Service Office or an authorized GE Sales Representative.

Related Documents

The following documents also apply to the exciter and may assist in understanding the system.

- GEI-100488 *EX2100 Thyristor Control 42, 53,77, 100 mm Product Description*
- GEI-100256C *Receiving, Handling, and Storage of GE Drive and Exciter Equipment*
- GEH-6631 *EX2100 Thyristor Control 77, 53, and 42 mm Installation and Startup Guide*
- GEH-6633 *EX2100 Thyristor Control 77, 53, and 42 mm Maintenance and Troubleshooting Guide*
- GEH-6694 *EX2100 Thyristor Control 100 mm Installation and Startup Guide*
- GEH-6695 *EX2100 Thyristor Control 100 mm Maintenance and Troubleshooting Guide*
- GEH-6696 *EX2100 Digital Front End (DFE) Control Application Guide*
- GEH-6697 *EX2100 Diode Bridge for Alterrex Applications*
- GEH-6414 *Control System Toolbox for Configuring an EX2100 Control*
- Printed Circuit Board (GEI) publications refer, to *Chapter 3*.

Document Distribution

GE Energy supplies product documents to its customers to support the equipment provided for each requisition. The contract documents define the terms of the document distribution. If provided (per contract), the following documents contain requisition information about the exciter system.

- Requisition drawings, including outline and elementary diagrams
- Renewal Parts listing

Note If differences exist between the general product documentation and the requisition documentation, the requisition documentation should be considered the more exact representation of your equipment or system configuration.

Notes

Chapter 2 Functional Description

Introduction

This chapter describes the function of the EX2100 static exciter and the individual control and protection circuits. Power supplies and the distribution of power is also covered. The functional description information is organized as follows.

Exciter Hardware

The EX2100 exciter consists of the following basic components:

- Power Conversion Module (PCM) and cooling fans
- Power potential transformer (PPT) (mounted separate from exciter)
- Line-to-line filters
- De-excitation module
- Diagnostic Interface (keypad)
- Controllers and I/O modules
- Control power supplies

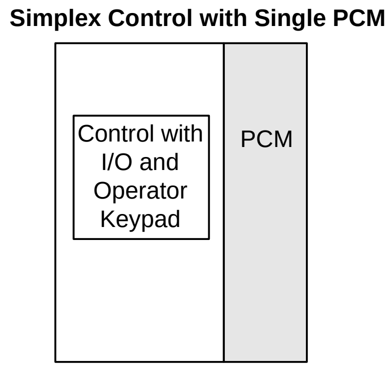
Optional components that can be added to the exciter are:

- Warm backup bridge configuration
- Multibridge configuration for high current requirements
- Compound power source (separate from exciter)
- PMG power source
- Auxiliary power source (bus-fed)
- Crowbar module (for hydro and other special applications)
- Dc Disconnect
- Field ground detector
- Redundant ac source for power supplies
- Redundant cooling fans
- Ac disconnect or circuit breaker
- Shaft voltage suppressor (not required for brushless exciters)
- Field flashing module
- Boost module (brushless applications)
- Redundant controllers providing a Triple Modular Redundant (TMR) system
- GE Control System Toolbox (toolbox) for configuration
- 4-20 mA analog outputs
- I/O expansion through VersaMax® modules

The control hardware is basically the same for the different types of excitation. The power conversion hardware is defined by application requirements, which determine the exciter bridge size.

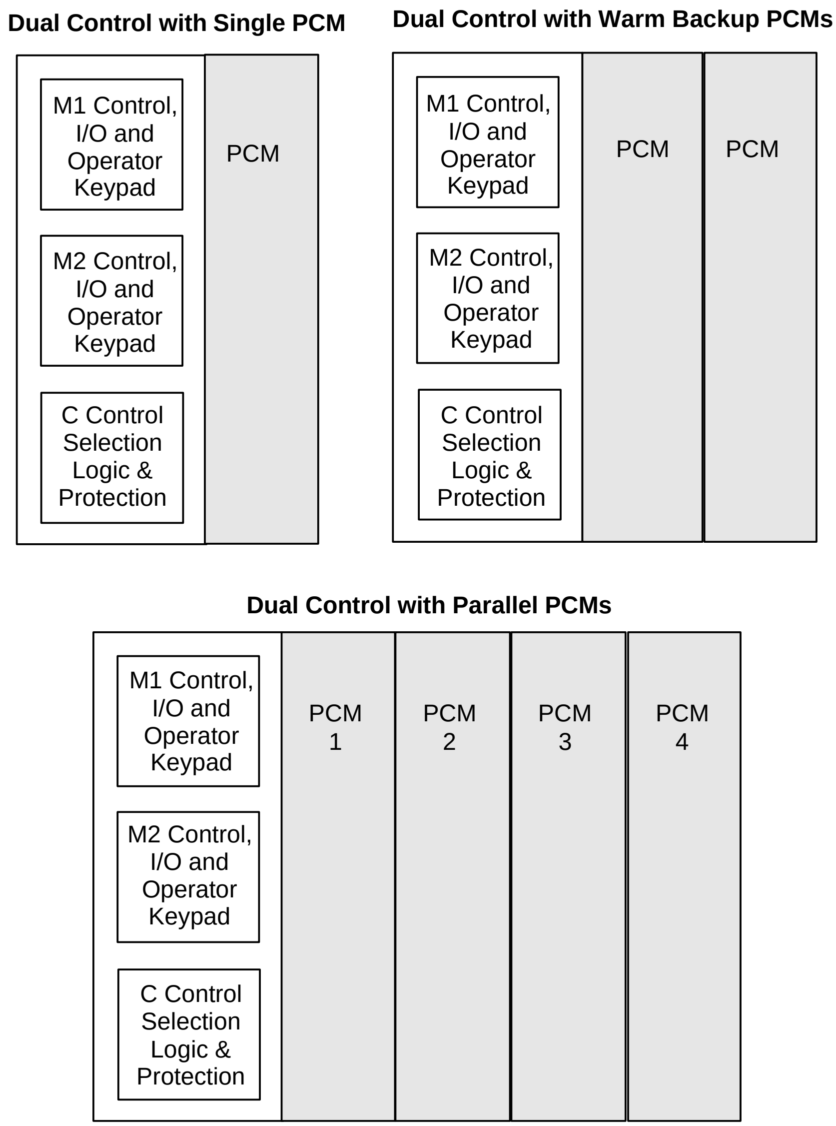
Exciter Configurations

EX2100 Exciters can be supplied with single or redundant control, and with single or redundant bridges. For single control applications, only a single bridge will be supplied. A single control with multiple bridges is not a supported option. The available single control and bridge configuration is shown in the figure *Simplex Control Configurations*.



Simplex Control Configurations

Exciter configurations with dual (redundant) control are shown in the figure *Dual Control System Configurations*. Multiple PCMs can be supplied with simplex, warm backup, or redundant n+1 or n+2 power conversion modules (with n+1 or n+2 equal to 4).



Dual Control System Configurations

Power Conversion Cabinet

The Power Conversion cabinet contains the Power Conversion Module (PCM), the Exciter Gate Pulse Amplifier (EGPA or EHPA) board, ac circuit breaker, and the dc circuit contactor. Three-phase power for the PCM comes from a PPT external to the exciter. The ac supply comes into the cabinet through the ac circuit breaker (if supplied), and is filtered by 3-phase line filters in the auxiliary cabinet.

Manual Ac Disconnect or Ac Breaker (Optional)

The manual ac disconnect switch serves as a disconnect device between the secondary of the power potential transformer and the static exciter. It is a molded case, 3-phase, non automatic, cabinet-mounted switch, which is manually operated for isolating the ac input supply. It is a no-load disconnect device.

An ac circuit breaker is also available in most EX2100 systems.

A manual 5 pole (3 ac, 2 dc) disconnect for online maintenance is available for 100 mm systems.

Power Conversion Module (PCM)

The exciter PCM includes the bridge rectifiers, dc leg or ac line fuses, thyristor protection circuitry (for example, snubbers, filters, and fuses) and leg reactor assemblies. The components vary for different bridge ratings based on the power output required.

Bridge Rectifier

Each bridge rectifier is a 3-phase full wave thyristor bridge. The bridge has six SCRs (thyristors) controlled by the EGPA or EHPA as shown in the figure *Power Bridge (typical)*. Optionally, the 42 mm thyristor bridge can be supplied as a non-inverting bridge with an integral free-wheeling diode. Heat is dissipated through large aluminum or copper cooling fins and forced airflow from fans.

Filters

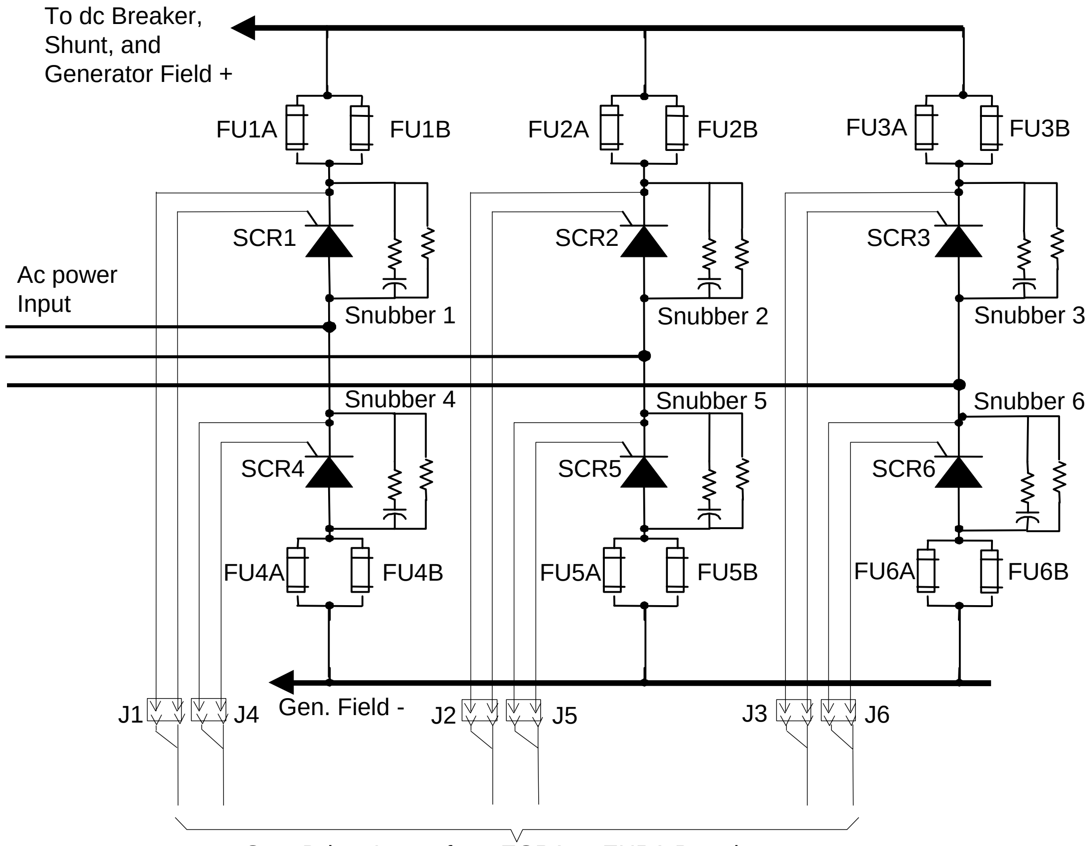
Three-phase input power is fed to the bridge from the secondary of the PPT, either directly or through an ac breaker or disconnect, and a line-to-line filter. With inverting bridge designs, the bridge is capable of negative forcing voltage, which provides fast response for load rejection and de-excitation. The dc current output of the bridge is fed through a shunt, and on some designs a contactor (41A or both 41A and 41B) to the generator field. The bridge design uses dc leg or ac line fuses to SCRs from overcurrrent.

Some EX2100 power conversion modules may contain leg commutating reactors, SCR snubbers, and voltage balancing resistors (PRV resistors). Other EX2100 systems integrate these filter components with the ac line filter.

Current Shunt

A dc shunt provides the bridge output current feedback signal. The mV output signal is input to a differential amplifier on the EDCF board. The amplifier output voltage controls the frequency of an oscillator, which generates a fiber-optic signal sent to the control module. The bridge output voltage feedback signal is generated in a similar way.

Note EDCF provides dc current and voltage feedback.



Power Bridge (typical)

Gate Pulse Amplifiers (EGPA or EHPA Board)

The EGPA board (or the EHPA board for 100mm systems) interfaces the control to the Power Bridge. EGPA or EHPA takes the gate commands from the ESEL board in the controller, and generates the gate firing pulses for six SCRs (Silicon Controlled Rectifiers). It is also the interface for current conduction feedback, and bridge airflow and temperature monitoring.

Note The gate pulse amplifiers directly control the SCRs.

An RTD is used to monitor the bridge temperature and generate alarms. Additional sensors actuated by fan rotation monitor cooling airflow across the bridge. On an exciter controls only retrofit, the exciter may have provisions for accepting feedback from two thermal switches mounted on the SCR heatsink assemblies. One thermal switch opens at the alarm level (170 °F (76°C)) and the other at the trip level (190 °F (87°C)). These switches are wired to the EGPA board and may require retrofitting into the existing bridge. If either switch opens, a bridge overtemperature alarm is generated. If both switches open, a fault and a trip are generated. This feature is not available on EHPA boards.

Cooling Fan Assembly

The SCR bridge assembly is cooled with forced air. One to six fans are used, depending on the bridge rating and redundancy requirements. The fans are powered by single-phase 115 V ac supplied by the customer. On 100 mm systems, three phase 480 V fans are used. A single fan per power converter can be supplied, providing redundancy at the power converter level. Alternately, 100 mm systems can be supplied with dual (lead/lag) fans per power converter, providing redundancy at the fan level. In redundant fan applications, a fan may be replaced while the exciter is running.

The 42 mm systems can be supplied without cooling fans. All other systems require forced cooling to meet the published current ratings for the product.

Main Dc Contactors - 41A or 41A/41B (Optional)

The main dc contactor (at the output of the power conversion module) provides a disconnect between the power conversion module and the generator field. The contactor picks up when the running mode is selected and no fault exists in the excitation. The contactor is normally actuated using pilot relays on the EXHS board driven by the controller. The auxiliary contacts from the contactor are routed back through the EXHS board as feedback signals.

Auxiliary Cabinet

The auxiliary cabinet contains modules to monitor exciter output, and provide startup dc power. Modules for filtering the incoming ac power, for de-excitation, shaft voltage suppression, and field flashing are mounted in this cabinet. In smaller systems these components are located within the power converter cabinet rather than in a separate auxiliary cabinet.

Ac Line-to-Line Filters

Fuse protected line-to-line series RC filter circuits (snubbers) are provided to damp the ac system to prevent voltage spikes at the completion of SCR commutation. There are several styles of filters employed depending on the voltage, including 300 V PMG, 600 V, 1000 V, and 1400 V. Each contain RC filter components and MOV transient suppressors, and may also contain PRV resistors. Refer to Chapter 4 for details and connections. In some systems, this filter may be located on top of the exciter.

De-excitation Module (EDEX) and Crowbar

During any shutdown, the energy stored in the generator field must be dissipated. In a normal shutdown, an operator initiates a stop. The bridge is fired at retard limit and sufficient time is allowed for the field to decay before the field contactors are opened. During a trip, the field contactors are opened immediately. The stored field energy must be dissipated through some other means.

The 42 mm non-inverting bridge provides a free-wheeling diode to carry current during de-excitation. In this topology the separate de-excitation is not required. Dc contactors must not be used since the free-wheeling diode on the bridge must remain connected to the generator field.

For customers requiring a rapid de-excitation, an SCR de-excitation module is provided. In the EDEX module, an SCR is fired to provide a conduction path through the field discharge resistor (or inductor) for the field current to flow and dissipate the field energy.

The de-excitation module has dual independent firing control circuits. Each is activated by a parallel combination of auxiliary contacts representing the status of the field contactor(s), bridge ac supply breaker, and exciter bridge operating state. Any one of these paths can gate the de-excitation SCR which does not conduct unless the field voltage is inverted. If neither firing control circuit can fire the SCR, it is fired on overvoltage when the anode to gate voltage on the SCR exceeds the break over voltage of the breakover diode string connected between the anode and gate. De-excitation modules can be paralleled for larger excitation systems.

Some applications may require a crowbar module to limit poleslip voltages. Crowbar and de-excitation may be combined into a single module.

Shaft Voltage Suppressor

Excitation systems, which produce a dc voltage from ac through a solid-state rectification process, produce ripple and spike voltages at the exciter output. Due to their rapid rise and decay times, these voltages are capacitively coupled from the field winding to the rotor body. This creates a voltage on the shaft relative to ground. Shaft voltage, if not effectively controlled, can be damaging to both journals and bearings. The shaft voltage suppressor is a filter that conducts the high frequency components of the induced voltages to ground. The shaft voltage suppressor is not used in brushless systems, and is optional in some static excitation applications.

Note The Shaft Voltage Suppressor protects the shaft bearings.

Field Flashing Module

The field flashing module is provided on generator terminal fed excitation systems. It supplies initial exciter current and builds generator voltage, supplying approximately 10 – 15 % of no-load field current from the station batteries during the startup sequence. On larger machines requiring significant flashing current, ac field flashing modules are used. The ac power is supplied through an isolation transformer. Both designs require customer-supplied power.

Boost Module

The boost module may be provided on terminal-fed brushless excitation systems. The boost module is used in conjunction with the field flashing module to provide exciter current from a station battery under generator fault conditions when the terminal voltage may have collapsed.

The boost module includes a bank of resistors, connected to provide the resistance necessary to limit the exciter field current to approximately 150-200% of rated current. Boost current is calculated as: Vbattery / (Rfield + Rboost)

Depending on the magnitude of Vbattery compared to rated field voltage, no boost resistor may be necessary to limit the current to an appropriate value. The module typically becomes active if the PPT voltage drops to 75% of rated, and provides boost current for up to 10 seconds, allowing time for the fault to clear and normal operation to resume.

Field Ground Detector (EXAM and EGDM)

The generator field winding is electrically isolated from ground. The existence of one ground usually does not damage the rotor. However, the presence of two or more grounds in the field winding path causes magnetic and thermal imbalances and localized heating, which may damage the rotor forging or other metallic parts.

Note The field ground detector is an active protection device.

The function of the field ground detector is to detect a ground path from any exciter component connected to and including the main field windings.

The Exciter Attenuator Module (EXAM) drives the electrical center of the field winding with a low frequency ac voltage relative to ground. To detect the current flow, the voltage across a sensing resistor is picked up by EXAM and measured by the EGDM module. This signal is sent over a fiber-optic link to the controller where it is monitored and alarmed. The EGDM boards (one for simplex and three for redundant) are mounted in the control power supply module located in the control cabinet.

Some exciters may use EROC boards instead of EGDM to provide the equivalent function. In addition, a standalone version of the EX2000 ground detector is available. This module is known as the PGDM and provides a separate terminal board user interface.

High Voltage Interface - HVI

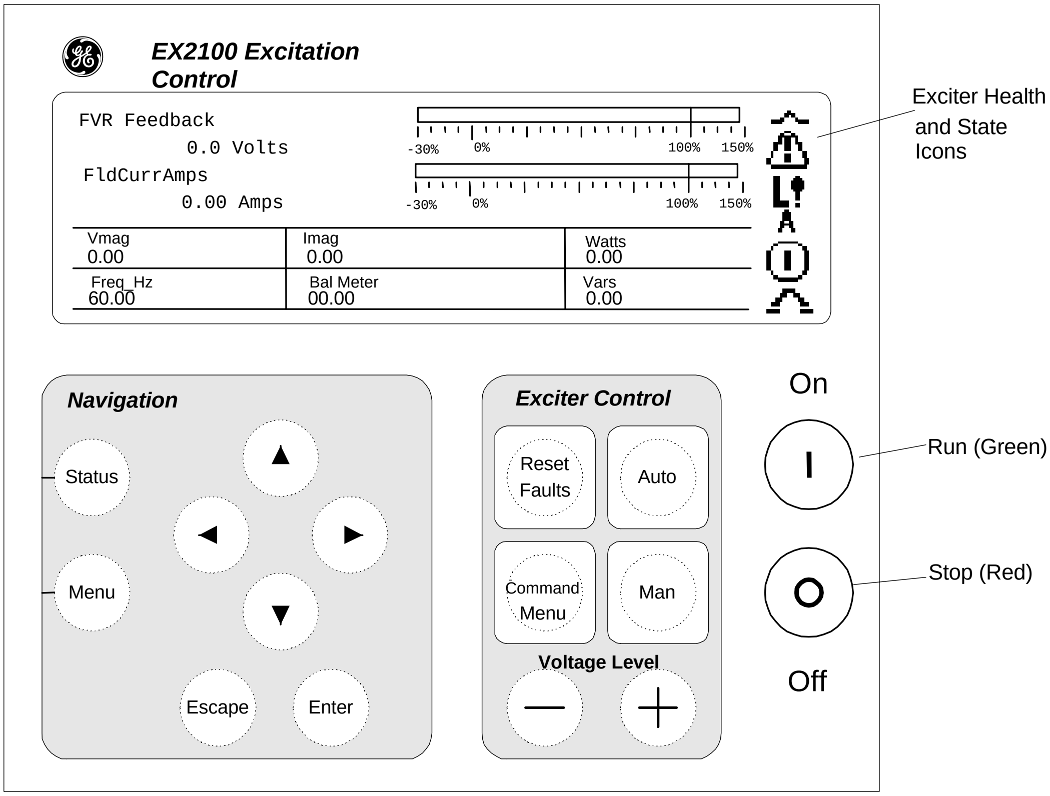
The HVI contains the ac line filter fuses. It also contains two terminal boards (EACF and EDCF) providing bridge feedback to the control and the EXAM board. The EACF board accepts incoming PPT ac voltage and air core CT current signals. It has transformers to isolate the voltages and produce low-level signals. The EDCF board measures the bridge dc current and voltage, and sends it over fiber-optics to the control.

Control Cabinet

The control cabinet contains the keypad control rack, control power distribution module and supplies, and I/O terminal boards.

Diagnostic Interface (Keypad)

The keypad is a local operator interface that is mounted on the control cabinet door. Refer to the figure *Diagnostic Interface – Keypad* for a view of the keypad and a summary of the operator and maintenance functions available. Chapter 5 describes the keypad in detail.



Display:

Status screens provide analog and digital representation of exciter functions and values.

Menu screens provide text-based access to parameters, wizards, and faults.

Pushbuttons:

Organized into functional groups:

Navigation buttons for using the menu
Exciter Control buttons
Run and **Stop** buttons

Diagnostic Interface – Keypad

Start/stop commands, regulator transfer commands, and regulator activation commands can be issued from the keypad. The keypad also includes meter displays indicating system conditions such as generator MW and MVARs, field current and voltage, and regulator balance. Diagnostic displays such as the alarm history display provide system information for maintenance and troubleshooting.

Note A second keypad may be provided for redundant controls.

Control Module

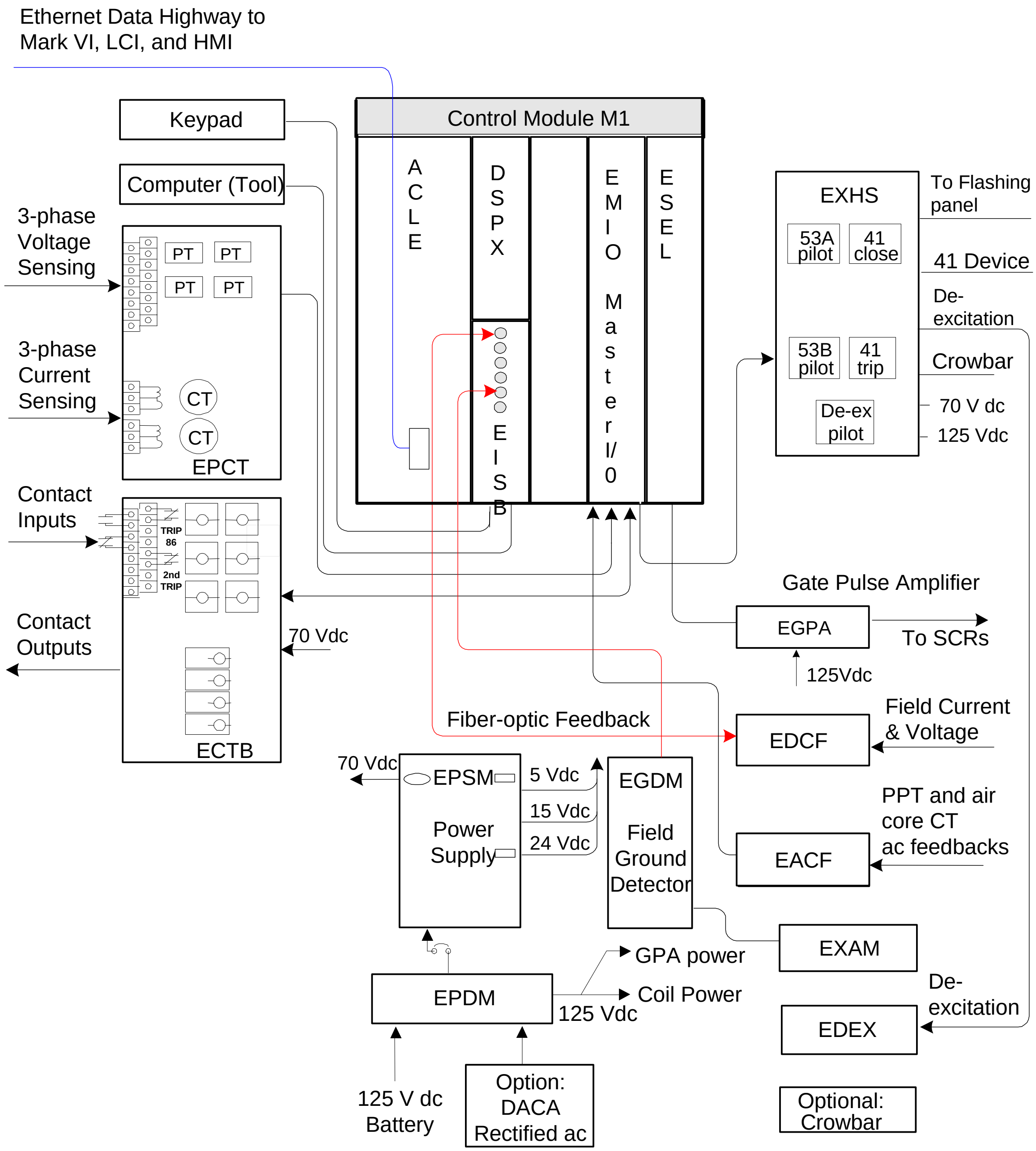
The control module is a VME-style rack with boards connected through cable to the I/O terminal boards. This rack is divided into three independently powered sections for the M1, M2, and C controllers. Each controller consists of control and I/O processor boards. If the rack contains only the M1 controller then it is a simplex control system and if it contains all three controllers then it is a redundant control system.

The control and I/O processor boards are as follows:

- Microprocessor-based Application Control Layer Module (ACLE or ACLA) controller, with LAN Ethernet port
- Microprocessor-based Digital Signal Processor (DSPX) controller
- Exciter ISBus Board (EISB), with fiber-optic communication with the bridge feedback board
- Exciter Main I/O Board (EMIO), with control of pilot relays and gating commands to the ESEL board
- Exciter Selector Board (ESEL), with gate pulse distribution from the active controller to the EGPA or EHPA
- Exciter Regulator Options Board (EROC) provides an interface for the ground detector module on simplex excitation systems only.

Simplex Control System

The interconnections between the simplex control and the terminal boards, generator protection modules, and power supply are shown in the figure *Simplex Control and Cabling to Terminal Boards*. Only one EPSM power supply is used but this can have both ac and dc supplies for increased reliability.

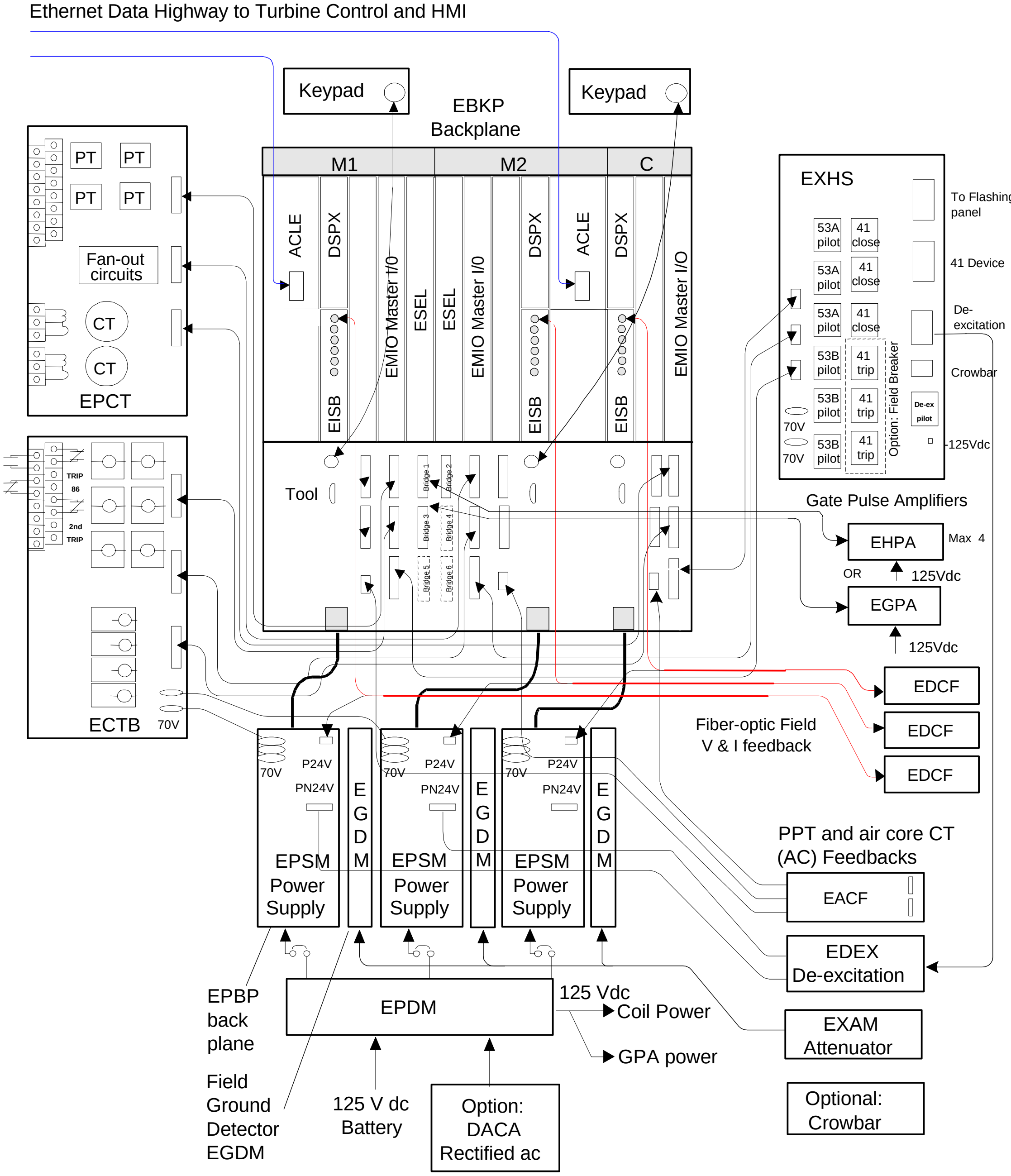


Simplex Control and Cabling to Terminal Boards

Redundant Control System

A redundant control system shown in the figure Redundant Control System Cabling has three controllers and three redundant power supplies, one for each controller. The power supply rack also holds three ground detector modules.

Up to two Ethernet cables are connected to the ACLE or ACLA controllers (one to M1 and one to M2) for redundant communication with the turbine control and HMIs. Two keypads are shown connected to M1 and M2. Both keypads have access to the information in controller C.



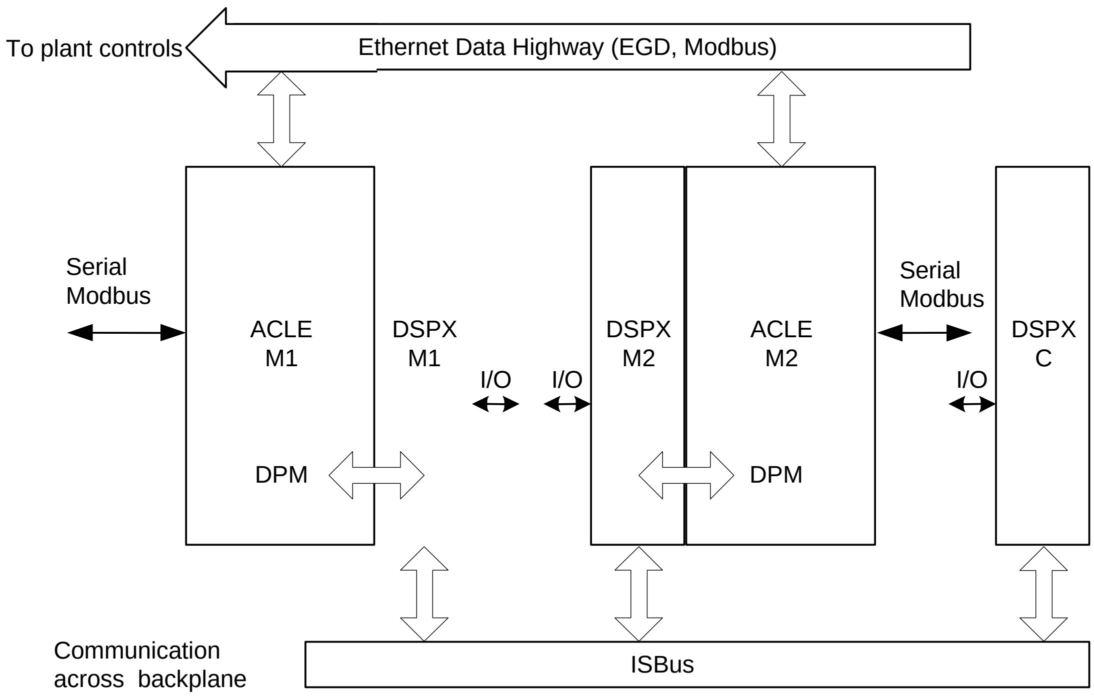
Redundant Control System Cabling

Controller C

Controller C is used only with redundant systems. It is mounted in the control rack and is physically similar to the M1 and M2 controllers, however, C is not responsible for bridge firing and therefore does not contain an ESEL or ACLE board.

Controller C receives the same feedback voltage and current inputs as the other controllers and contains similar software. Its purpose is to monitor the active and backup controllers (M1 or M2) and initiate appropriate protective responses if the system conditions exceed the defined regulation boundaries. Input and output signal voting takes place in all three controllers, which are linked in a TMR controller configuration.

Each controller contains up to six boards, interconnected through the backplane as shown in the figure *Communication between Redundant Control Boards*.



Communication between Redundant Control Boards

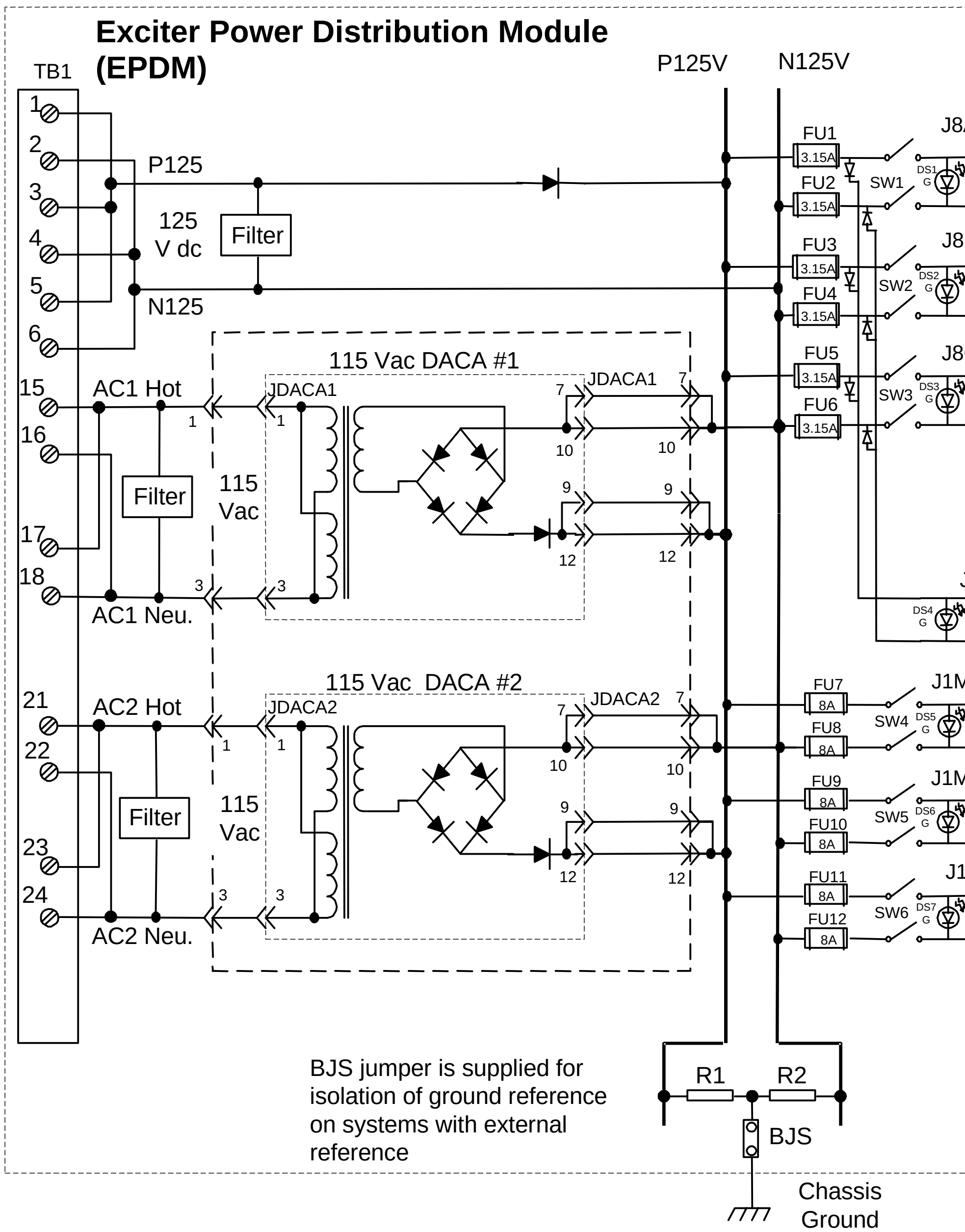
Control Power Supplies

Power for the controls come from the Exciter Power Distribution Module (EPDM). This is supplied by a 125 V dc source and one or two 115 or 220 V ac sources. The ac source is passed through an ac/dc converter (DACA) as shown in the figure *Exciter Power Distribution Module*. The resulting 125 V dc is diode coupled with the other dc sources to create a dc bus that feeds the control modules and gate pulse amplifier boards. Fused outputs from the EPDM feed power to the EGPA or EHPA boards, EXHS, and the Exciter Power Backplane (EPBP). Each output has an LED indication and an on/off isolation switch.

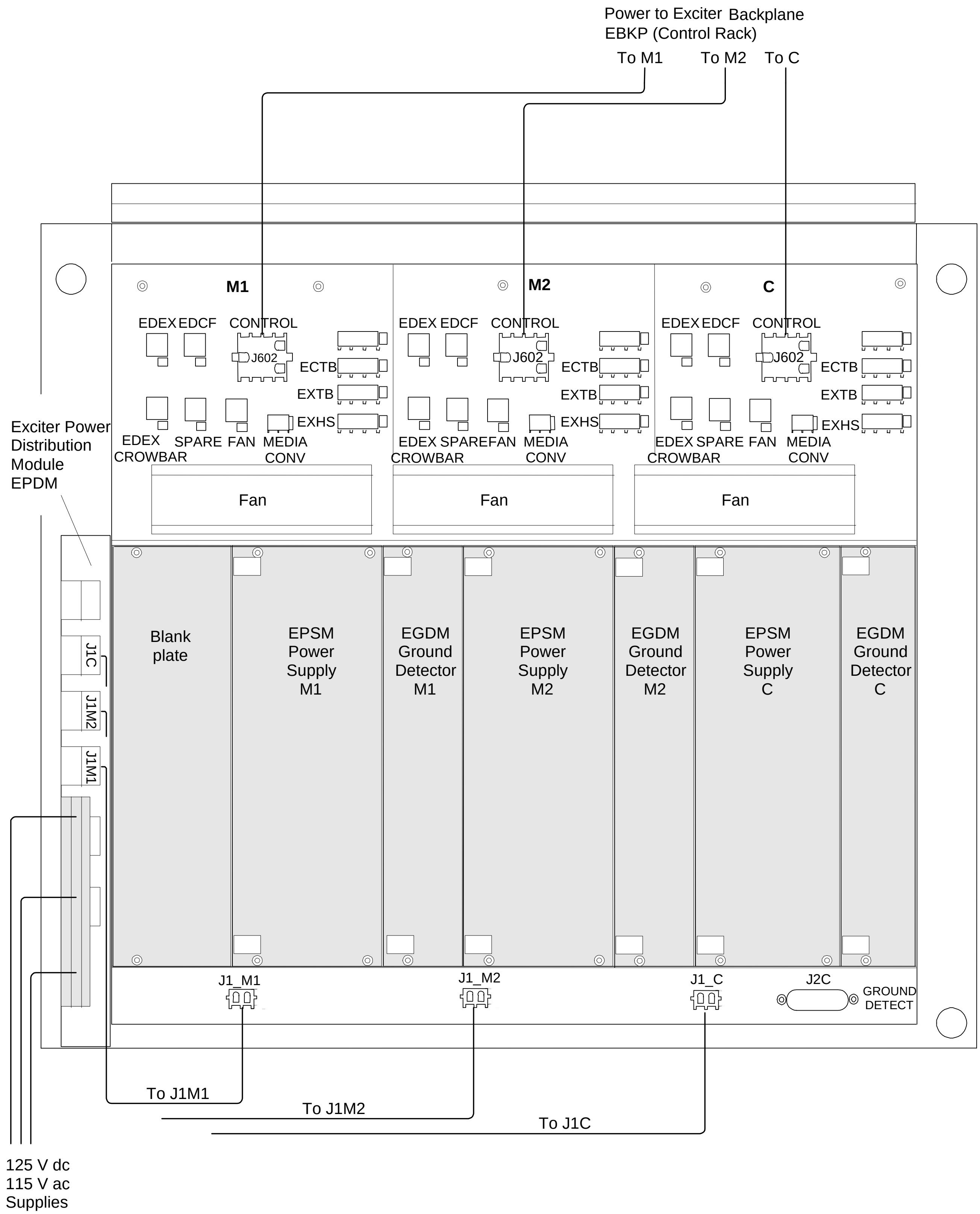
Note Redundant supplies provide high reliability. EPDM revision B or later boards are required to accommodate 220 V ac control power sources.

The EPDM mounts on the left side of the exciter power supply rack. Up to three Exciter Power Supply Modules (EPSM) mount in the EPBP backplane and provide logic level power to the controller(s). The EPSM are fed by 125 V dc from the EPDM, and generate supply voltages of +5 V dc, ± 15 V dc, and +24 V dc. In addition there is an isolated 70 V dc output for use by EXHS and ECTB for contact wetting. On simplex exciter applications, the EPSM board is mounted in the same control module as the control cards. A separate power supply module is not provided.

Up to three ground detection modules (EGDM) are also mounted in the EPBP, as shown in the figure *Exciter Power Backplane (EPBP) with EPDM, Power Supplies* and *Ground Detector Modules*. These communicate with the EXAM module, which is located in the auxiliary cabinet.



Exciter Power Distribution Module



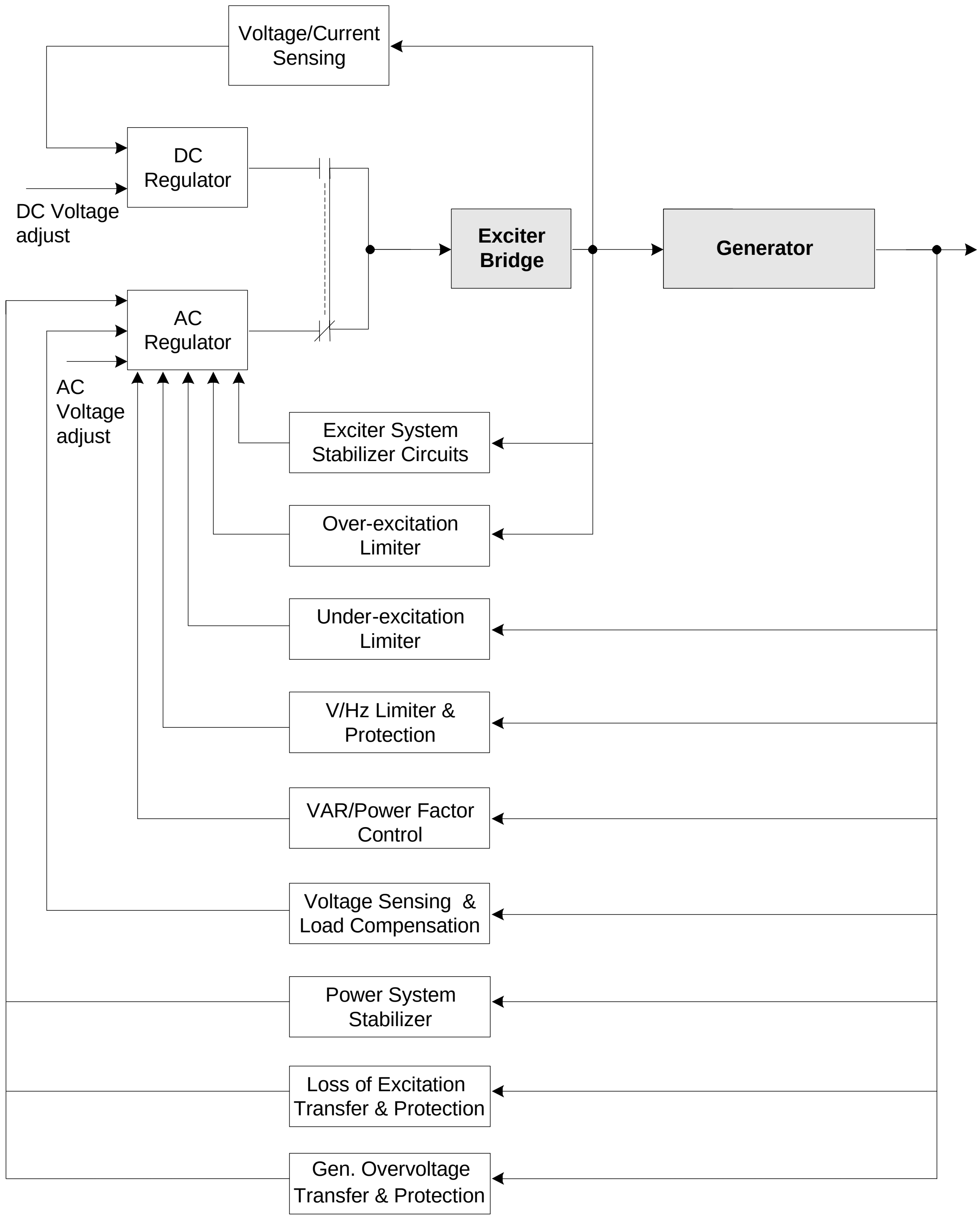
Exciter Power Backplane (EPBP) with EPDM, Power Supplies & Ground Detector Modules

Exciter Software

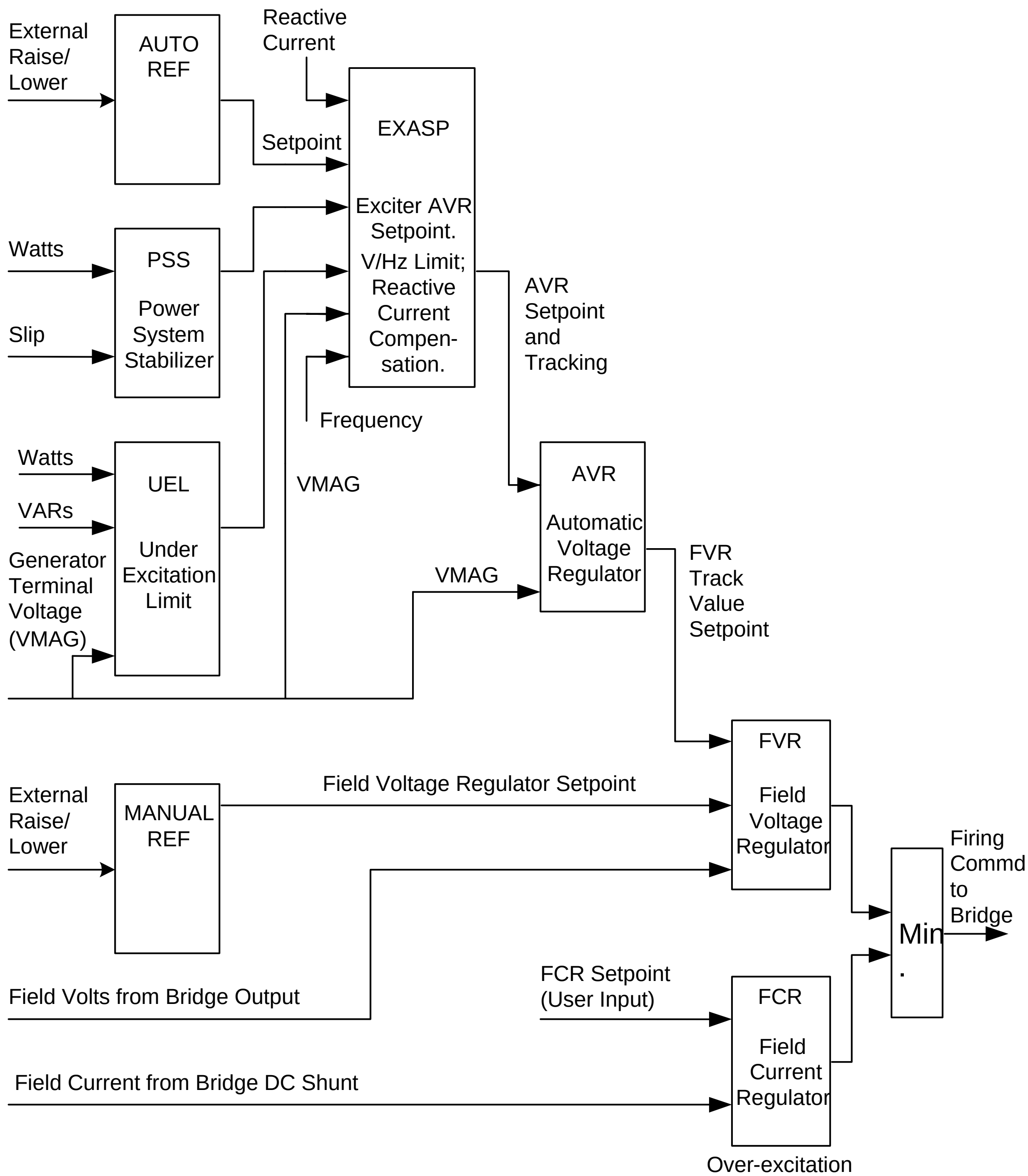
The exciter software is configured and loaded from the toolbox, and resides in the controllers. The software is represented on the toolbox screen by control blocks linked together to show the signal flow. Figure *Control Scheme* is a simplified overview of the exciter control system displaying the main control functions. Both the generator field and stator currents and voltages are measured and input to the control system. In normal operation the ac regulator is selected. Figure *Software Block Diagram* is the simplified software block diagram displaying the main control blocks.

The generator voltages and currents from the PTs and CTs are wired to the EPCT board, which acts as a signal conditioner to isolate and scale the signals. The conditioned signals are then fed to the controller. Software conversion algorithms use these signals to calculate system variables for use by the regulator, limiter, and protection functions. The outputs from these software calculations include the following:

- Generator voltage magnitude and generator frequency derived from the PTs
- Magnitude of generator current derived from the CTs
- Generator power, P
- Generator reactive volt amperes (VARs), Q
- Change in rotor speed calculated from the integral of accelerating power that is normally used as the input to the optional Power System Stabilizer (PSS)
- Generator active and reactive current
- Magnitude of generator flux (VHz)
- Line voltage derived from the PTs
- Line frequency derived from line PTs
- Phase angle correlation between the generator and line, derived from generator and line PTs



Control Scheme



Software Block Diagram

The output of the control software is the firing command, which is sent to the bridge to generate the field current. The individual function blocks are discussed in the following sections.

Auto Reference - AUTO REF

The AUTO REF block generates an auto (or Auto Control (AC)) setpoint for the Automatic Voltage Regulator (AVR) based on user-supplied parameters and conditions. Raise/lower inputs to AUTO REF come in from the other devices on the data highway such as the turbine control or HMI. A variable rate integrator generates the output setpoint within preset limits. The setpoint is combined with other auxiliary stabilizing and protective signals in the EXASP block to form the reference to the AVR block.

AVR Setpoint - EXASP

The EXASP block combines a number of functions to produce the setpoint (reference input) to the AVR, and the AVR tracking value. The EXASP inputs are as follows:

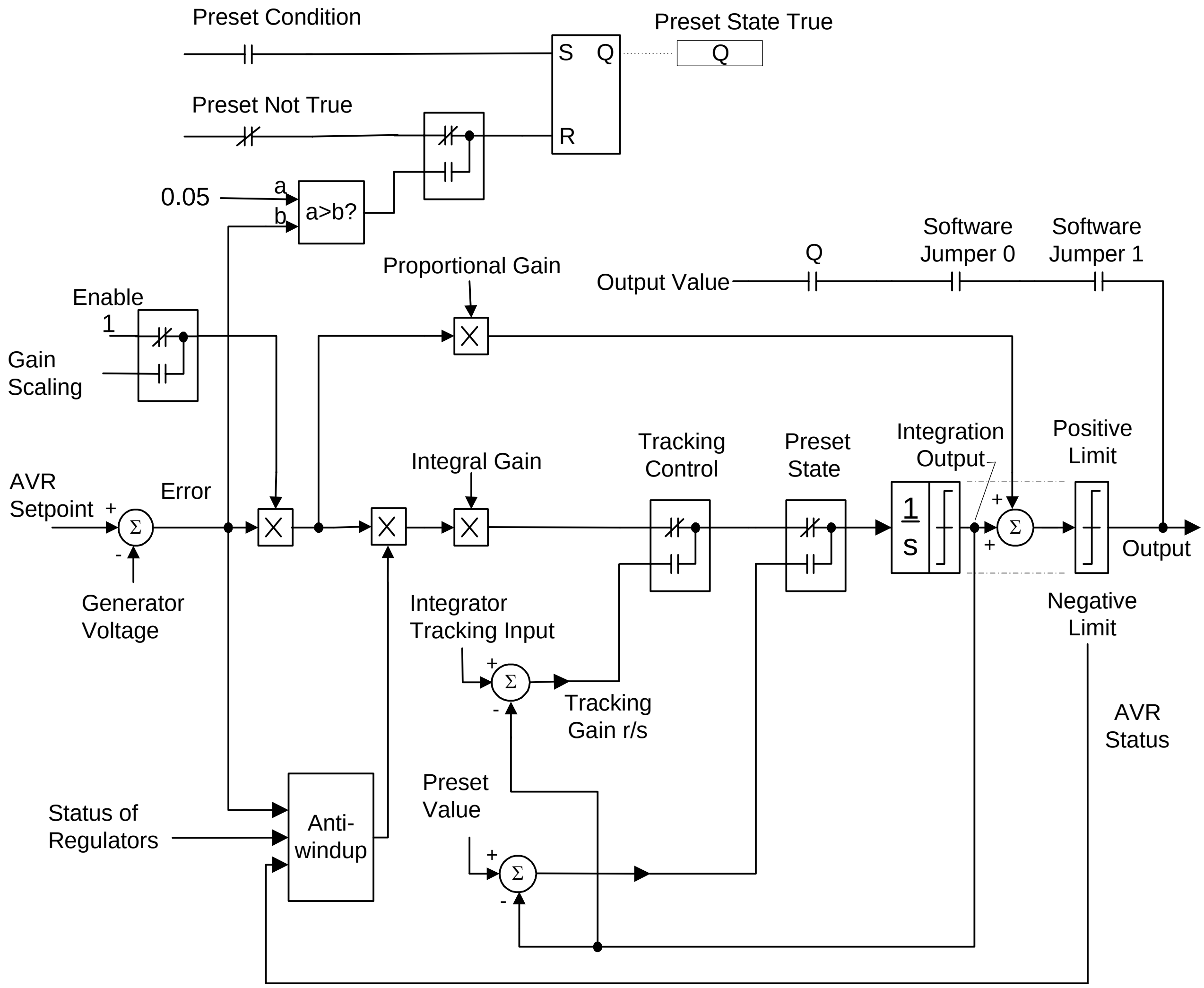
- Stabilizing signal from the PSS block
- Output from the AUTO REF block
- External test signal
- Control signal generated by the UEL block
- Reactive current input (feedback)
- Voltage magnitude input (feedback)
- Frequency input (feedback)

The outputs to the AVR block are the AVR setpoint and tracking value.

Automatic Voltage Regulator - AVR

The AVR block maintains the generator terminal voltage. The setpoint (reference) comes from the EXASP block, and the feedback is the generator voltage. The error value is input to a PI regulator with integrator windup protection, which produces an output signal. Figure *Automatic Voltage Regulator Block* shows the block diagram. When the AVR is enabled, the AVR output is passed through directly from the track input to the output of the Field Voltage Regulator (FVR).

Note Generator terminal voltage is controlled by the AVR.



Automatic Voltage Regulator Block

Manual Reference - MANUAL REF

The MANUAL REF block generates a manual setpoint for the FVR or FCR based on user-supplied parameters and conditions. Raise/Lower inputs to MANUAL REF come in from other control devices on the data highway such as the turbine control or HMI.

Field Voltage and Current Regulators - FVR & FCR

The Field Voltage Regulator (FVR) is the typical manual regulator supplied on most applications and uses the generator field voltage as the feedback input. While FVR permits the current to vary as a function of the field resistance, it makes the manual regulator completely independent from the overexcitation limiter. FVR uses the voltage from the generator field as feedback, with a setpoint from the MANUAL REF block. A PI regulator with integral windup protection generates the output. During operation in AVR mode, the output of the AVR is passed directly to the FVR output with no signal conditioning. On units that operate with an inner field voltage regulator loop such as compound exciters and some high ceiling exciters, the FVR uses a setpoint from either the AVR or the MANUAL REF block, and is always operational whether in manual or automatic operation.

The Field Current Regulator (FCR) is a special application of the manual regulator and uses the generator field current as the feedback input. The current setpoint is generally switched between a high level and lower level to provide transient forcing capability as well as steady state operation within the capability of the generator. Generally the setpoint is larger than expected field currents and the integral preset is operational. The FCR output is held at positive ceiling until *enable* becomes true which allows the output to follow the PI regulator. The bridge firing command is the smaller of the FVR and FCR outputs. While it regulates constant field current over varying field temperature, FCR is not the standard manual regulator.

Under Excitation Limiter - UEL

The UEL block is an auxiliary control to limit the automatic voltage regulator demand for underexcited reactive current (or reactive power). UEL prevents reduction of the generator excitation to a level where the small-signal (steady state) stability limit, or the stator core end-region heating limit is exceeded. Performance is specified by identifying the region of limiter action on the generator capability curve. There is both a setpoint section and regulator section of the UEL. The two key inputs are generator terminal voltage and real power.

Power System Stabilizer - PSS

The PSS block provides an additional input to the automatic regulator to improve power system dynamic performance. A number of different quantities may be used as inputs to the PSS, such as shaft speed, frequency, synchronous machine electrical power, accelerating power, or some combination of the above. The PSS used with the exciter is multi-input using a combination of synchronous machine electrical power and internal frequency (which approximates rotor speed) to arrive at a signal proportional to rotor speed. This comes from the integral of accelerating power, but with shaft torsional signals greatly attenuated. The input signal is derived entirely from generator terminal quantities without the need for shaft speed transducers. No additional external hardware is required.

V/Hz Limiter and Protection - V/Hz

The V/Hz limiter is an auxiliary control to limit the automatic voltage regulator demand for generator terminal voltage proportional to generator speed. V/Hz limiter prevents excessive fluxing of the generator and associated equipment such as auxiliary transformers and potential transformers. Typically the generator is considered to be operating acceptably within ± 5% of generator rated terminal voltage at rated frequency. The protection settings are an inverse time characteristic, which approximates the overexcitation capability of the generator.

Overexcitation Limiter and Protection - OEL, OET

The Overexcitation Limiter (OEL) protects the generator field from damage by events that require or produce abnormally high field currents. These high currents, over an extended time, can overheat the field and cause damage. Generator fields are designed to ANSI Standard C50.13, which specify an overvoltage as a function of time that the field is allowed to follow. This standard uses curves to describe the field overheating as a function of time and current. The OEL design approximates the curve of field voltage versus time.

The Overexcitation Trip function (OET) is a backup protection in the event of OEL failure. It also approximates the curves in ANSI C50.13 with appropriate times at appropriate current levels before generating an excitation trip signal.

Loss of Excitation Protection - LOE

A Loss of Excitation protection function is available with the warm backup control scheme. This function detects a loss of excitation on synchronous machines. It provides the GE-recommended settings, which require two separate relay characteristics. The function is performed within software code and can accommodate offset settings and two diameter settings. The recommended offset settings are both equal to one-half the machine transient reactance (X'd/2). The small diameter setting is equal to 1.0 per unit on the machine base, and the large diameter setting is equal to the machine synchronous reactance (Xd). The small diameter setting has no time delay and the large diameter setting has an adjustable time delay. Each of the two relay’s characteristics (offset, diameter, time delay) are independently adjustable and are used to initiate a transfer to the backup controller, and a TRIP signal if the condition persists.

Generator Overexcitation Protection - 59G

The Generator Overexcitation protection prevents an overvoltage on the machine that may arise from a load rejection that causes an overspeed while the regulator is in manual mode or an overspeed that may occur while the unit is offline and the voltage regulator is in manual mode.

Operator Interface

Operator and engineering workstations such as the Human-Machine Interface (HMI) communicate with the exciter. This allows operator monitoring and control of the exciter, and engineering access to system diagnostics and control block configuration.

Note The HMI contains exciter and turbine graphic displays.

Turbine Control HMI

On turbine generator sets that include Mark* VIe turbine controls, the exciter shares the HMI. The HMI is Windows NT® based with CIMPLICITY® operator display software and communication drivers for the data highways. From the HMI, the operator can initiate commands and view real-time data and alarms on the CIMPLICITY graphic displays. An HMI can be configured as a server or viewer, and can contain tools and utility programs.

Note An HMI can be mounted in a control console or on a tabletop.

The Unit Data Highway (UDH) connects the exciter with the HMI or HMI/Data Server. The network is 10BaseT Ethernet, and uses separately powered network switches. For longer runs, fiber-optic cables can be used.

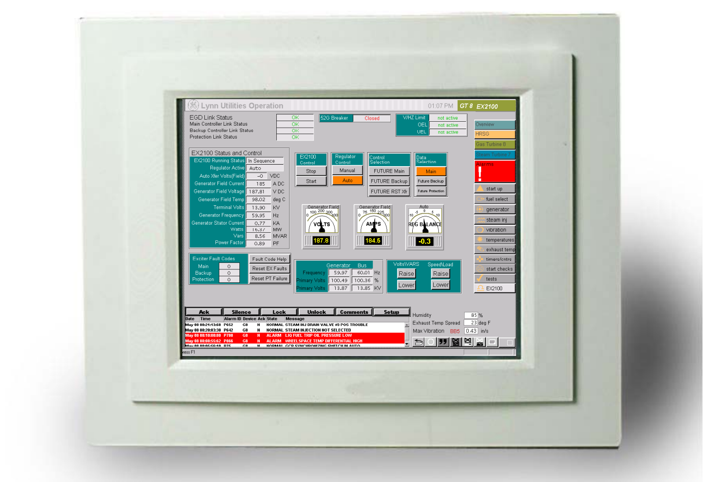
Note Redundant cable operation is optional and, if supplied, operation continues even if one cable is faulted.

Control System Toolbox (toolbox)

The toolbox is used to configure and maintain the exciter. Control blocks and diagrams can be modified by configuration and loaded into the control. With the exciter online, real-time data is available on the toolbox screen, including control system diagnostics for troubleshooting. The toolbox software runs on an HMI server or a separate maintenance computer on the UDH. Direct connection to the controller DSPX board is also possible through the tool port on the control rack backplane.

Control Operator Interface (COI)

The COI is a cabinet-mounted interface that displays and controls EX2100 signals wherever remote control is needed. The COI connects directly to the EX2100 through the UDH, and is a less functional, more cost-effective control interface than an HMI.



Notes

Chapter 3 Printed Circuit Boards Overview

Introduction

This chapter describes the EX2100 printed circuit boards and their operation. These boards fall into four functional groups; control rack boards including controller boards and I/O processors, I/O terminal boards, bridge control and protection modules, and power supply boards.

Control Boards

The control boards are located in the control module. This module consists of the exciter backplane (EBKP) and the metal chassis that holds the boards (refer to the figure Control Module (Redundant)). In simplex controls applications, an ESBP backplane is used (refer to the figure Control Module (Simplex)). The control boards are as follows:

- IS200DSPX Digital Signal Processor control board (DSPX)
- IS215ACLE Application Control Layer Module (ACLE or ACLA)
- IS200EISB Exciter ISBus Board (EISB)
- IS200EMIO Exciter Main I/O board (EMIO)
- IS200ESEL Exciter Selector board (ESEL)
- IS200EROC Exciter Regulator Options (EROC) (simplex only)

EBKP Backplane

The EBKP provides the backplane for the control boards and the connectors for the I/O terminal board cables. EBKP has three sections for controllers M1, M2, and C. Each section has its own independent power supply. Controllers M1 and M2 have the ACLE or ACLA, DSPX, EISB, EMIO, and ESEL boards. Section C only has the DSPX, EISB, and EMIO. Two overhead fans cool the controllers.

The upper part of the backplane contains DIN connectors for the plug-in control boards. The lower part of the backplane contains D-SUB connectors for I/O interface cables, and circular DIN connectors for keypad interface cables, power supply plugs, and test rings. Labels on the connectors in the figure *Control Module (Redundant)* refer to the boards and devices to which the cables are connected. For more information refer to *Chapter 4* and *GEI-100460.*

ESBP Backplane

The ESBP provides the backplane for the control boards and the connectors for the I/O terminal board cables in simplex (single controller) applications. ESBP has one section for controller M1 and also contains the EPSM power supply. Controller M1 has the ACLE, DSPX, EISB, EMIO, and ESEL boards as well as the EROC ground detector interface. A single overhead fan cools the controller.

The upper part of the backplane contains DIN connectors for the plug-in control boards. The lower part of the backplane contains D-SUB connectors for I/O interface cables, and circular DIN connectors for keypad interface cables, power supply plugs, and test rings. Labels on the connectors in the figure *Control Module (Simplex)* refer to the boards and devices to which the cables are connected. For more information refer to *Chapter 4* and *GEI-100585*.

Revision C and later EBKP backplane supports up to four Din-rail mounted 4-20 mA signal conditioner output modules, for metering or high-speed analog monitoring of EX2100 variables.

DSX Bard

The DSPX board is the main controller and shares control responsibility with the ACLE or ACLA. It is a single-slot, 3U high module located in the control rack next to the ACLE or ACLA. It provides functions including the bridge firing circuit control, I/O processing, and inner loop regulation as follows:

- Field Voltage Regulator (FVR)
- Field Current Regulator (FCR)
- SCR gating signals to the ESEL board
- Start-stop function
- Field flashing control
- Alarms and trip logic
- Generator instrumentation processing
- Generator simulator

For more information refer to Chapter 4 and GEI-100267.

Note The DSPX performs most of the I/O interface and inner loop bridge control and protection functions.

ACLE or ACLA Board

The ACLE is a double-slot, 6U high module located next to the DSPX. The ACLA board is a double-slot, 3U high module located next to the DSPX. ACLE or ACLA provides Ethernet communications with the turbine control, LS2100, and HMI, and runs outer loop control functions including the following:

- Automatic Voltage Regulator (AVR)
- Power System Stabilizer (PSS)
- Under Excitation Limit control (UEL)
- VAR/power factor regulator (VAR/PF)

The ACLE is an updated version of the ACLA module with the same features and functionality. An ACLE can be used in place of an ACLA with software updates. An ACLA cannot be used in place of an ACLE.

For more information refer to *Chapter 4* and *GEI-100434*.

Note ACLE or ACLA handles network communications and outer loop functions.

EISB Board

The EISB is a communication interface board for the M1, M2/C controllers. ISBus is a high-speed communication bus used in many GE systems. The EISB provides communication between the three DSPX boards in M1, M2, and C. EISB receives and transmits fiber-optic feedback signals through the backplane connectors. It also communicates between the DSPX and the toolbox and keypad ports using RS-232C. EISB is a single-slot, 3U high module that is located in the backplane below the DSPX. From six fiber-optic connectors on the front cabinet, it accepts current and voltage signals from the generator field (and from the exciter if required) using Exciter dc Feedback Board(s) (EDCF). For more information refer to Chapter 4 and GEI-100454.

Note EISB manages all the fiber-optic communication in the cabinets.

EMIO Board

The EMIO is a single-slot, double height VME-style board, that manages the I/O from the EPCT, ECTB, EACF, and EXHS terminal boards. The I/O includes PT and CT signals, contact inputs, output relay drivers, and pilot trip relay drivers. It also sends logic level gate pulse signals over the backplane to the ESEL board, which sends them to EGPA or EHPA in the power conversion cabinet. For more information refer to *Chapter 4* and *GEI-100453*.

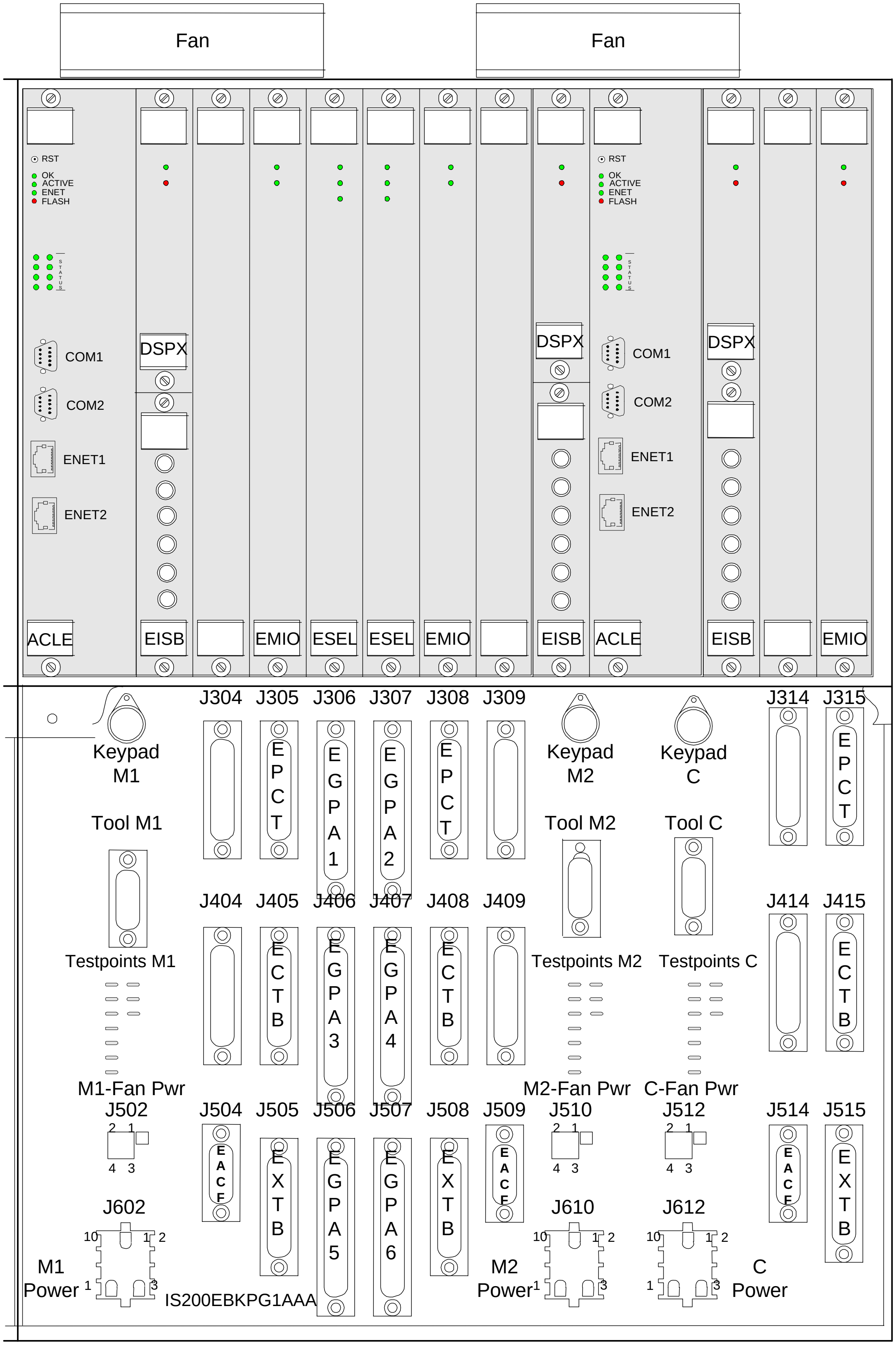
ESEL Board

The Exciter Selector board receives six logic level gate pulse signals from its corresponding EMIO. These pulse signals drive up to six sets of cables, which are distributed, to the EGPA or EHPA boards. The gate pulse amplifier boards are mounted in the power conversion cabinet. If there are redundant controls, two ESEL are used, one driven by M1 and the other by M2. The active ESEL, selected by controller C, sends the necessary control signals to the gate pulse amplifiers.

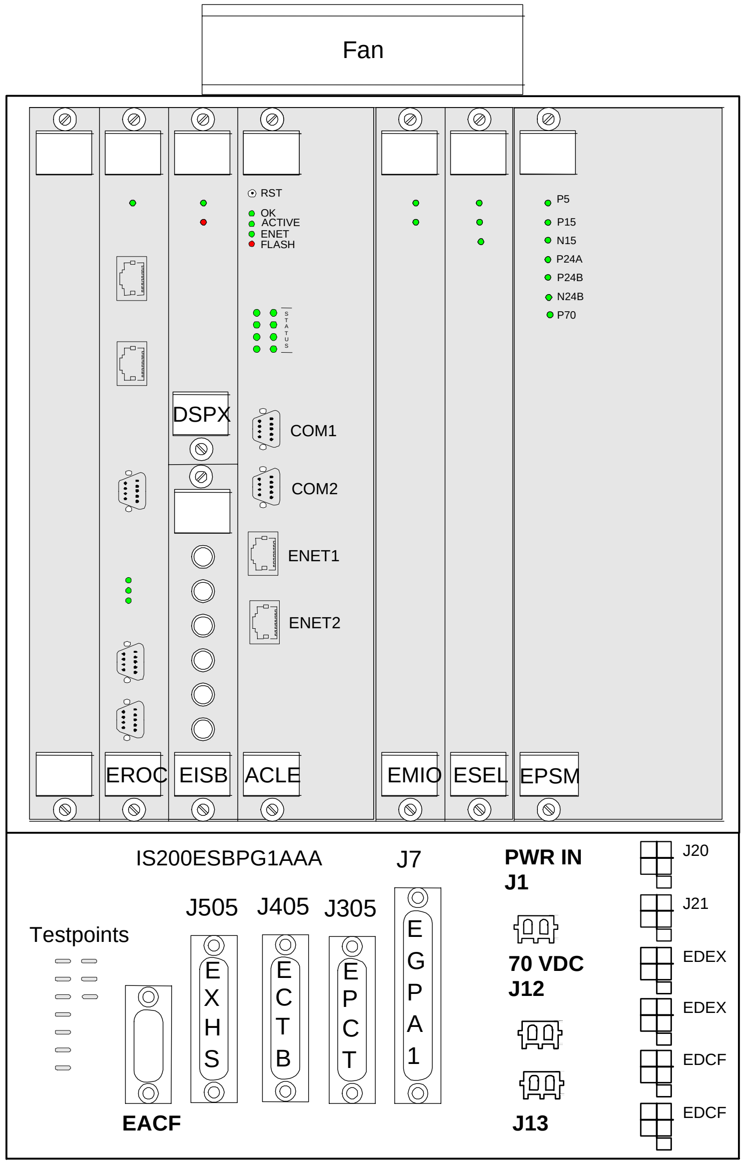
Three groups of ESEL boards are available supporting increasing redundancy levels. ESELH1 contains a single bridge driver used on single bridge and warm backup applications, ESELH2 contains three bridge drivers used on 100 mm two bridge n+0 and 3 bridge applications, and ESELH3 contains six bridge drivers used on all 100 mm 4 bridge applications. For more information refer to *Chapter 4* and *GEI-100456*.

EROC Board

The Exciter Regulator Options board is a single-slot, 6U high card mounted in the left most slot of the simplex control module card rack. In a simplex control rack, the EROC will provide the ground detector oscillator output and sensing voltages as described for the EGDM board. It interfaces with the EXAM board and sends information to the DSPX for ground detector functions. The EROC also provides the serial interface for the Control Systems Toolbox (toolbox) and the keypad interface connection. For more information refer to *Chapter 4* and *GEI-100526*.



Control Module (Redundant)



Control Module (Simplex)

I/O Terminal Boards

The exciter terminal boards are as follows:

- IS200EPCT Exciter PT/CT board (EPCT)
- IS200ECTB Exciter Contact Terminal Board (ECTB)
- IS200EXHS Exciter High Speed Board (EXHS)
- IS200EDCF Exciter Dc Feedback board (EDCF)
- IS200EACF Exciter Ac Feedback board (EACF)

EPCT Board

The EPCT contains isolation transformers for critical generator voltage and current measurements. Two three-phase generator PT voltage inputs are input to EPCT. Two generator CT current inputs, with current levels of 1 A or 5 A, are input. In addition, one analog input, which can be either 0 - 10 V or 4 - 20 mA, is brought into EPCT. All the signals are interfaced to the EMIO board. For more information, refer to *Chapter 4* and *GEI-100459*.

Note EPCT receives and conditions generator PT and CT feedbacks.

Exciter Customer Terminal Board (ECTB)

The ECTB supports excitation contact inputs and contact outputs. There are two versions: the ECTBG1 for redundant and the ECTBG2 for simplex applications. Each version contains two trip contact outputs for driving a customer lockout device (86G), and four general-purpose form-C relay contact outputs. Six auxiliary contact inputs are powered (wetted) with 70 V dc by ECTB. Also, the board processes 52G and 86G contact inputs.

EXHS Board

The EXHS board supports pilot relay contact outputs, contact inputs, and signal conditioning circuits. EXHS cables to the EMIO board through the EBKP backplane.

Note EXHS handles field flashing and protection functions.

Pilot relays for the breaker/contactor close 41, and flashing contactors 53A, and 53B are located on the board, plus pilot relays for the trip relay 41T and the de-excitation relay KDEP. Crowbar status signals and de-excitation status signals from the EDEX board are conditioned on EXHS and sent to EMIO. Three contact inputs from 41, 53A, and 53B are powered (wetted) by 70 V dc on EXHS. Power for the contacts is from the M1 and M2 power supplies (redundantly), and the resulting status signals are sent to EMIO in the control rack. Different groups of EXHS are available for controlling either a field breaker or a contactor in the field circuit. These groups are defined in *EXHS Board Groups*. For more information, refer to *GEI-100475*.

EXHS Board Groups

Type of Redundancy	Board	Control Mode	Trip Relay 41T used	Close Relay 41 used
Redundant control	EXHS G1	Contactor Mode	No	Yes
Redundant control	EXHS G3	Breaker Mode	Yes	Yes
Simplex control	EXHS G2	Contactor Mode	No	Yes
Simplex control	EXHS G4	Breaker Mode	Yes	Yes

EDCF Board

The EDCF board measures field current and field voltage at the SCR bridge and interfaces to the EISB board over a high-speed fiber-optic link. The fiber-optic link provides voltage isolation between the two boards, and high-noise immunity. Field current is measured using a shunt in the dc field circuit. The field voltage feedback circuit provides seven selector settings to scale the bridge voltage, depending on the type of bridge application. For more information refer to *Chapter 4* and *GEI-100464*.

Note EDCF handles bridge dc voltage and current feedback.

EACF Board

The EACF board measures the exciter PPT ac supply voltage and current. The EACF terminal board contains transformers for a 3-phase voltage measurement, and terminals for two Flux/Air core coils. The outputs of the voltage and current circuits are fanned out to three DB9 connectors for cables to controllers M1, M2, and C. These cables can be up to 90 m in length. There are three versions of this board, EACFG1 is for inputs up to 480 V rms, EACFG2 is for inputs up to 1000 V rms, and EACFG3 is used for inputs up to 1400 V rms. For more information refer to *Chapter 4* and *GEI-100465*.

Note EACF handles bridge ac voltage and current feedback.

Bridge and Protection Boards and Modules

The exciter bridge and protection boards are as follows:

- IS200EGPA Exciter Gate Pulse Amplifier board (EGPA)
- IS200EHPA Exciter Gate Pulse Amplifier board (EHPA)
- IS200EHFC 100 mm Fan Control board (EHFC)
- IS200EXCS Conduction Sensor board (EXCS or EMCS)
- IS200EDEX Exciter De-Excitation and crowbar board (EDEX)
- IS200EGDM Exciter Field Ground Detector Module (EGDM)
- IS200EXAM Exciter Attenuator Module (EXAM)

EGPA and EHPA Boards

The EGPA or EHPA board interfaces the control to the power bridge. The gate pulse amplifier board takes the six gate commands from the ESEL and controls the gate firing of up to six SCRs on the bridge. It is also the interface for current conduction feedback, and the bridge airflow and temperature monitoring.

Note Bridge control passes through EGPA or EHPA. One gate pulse amplifier board is required per PCM.

A nominal 125 V dc power source from EPDM supplies an on-board dc-to-dc converter that provides power for SCR gating over the full range of input supply voltage. LEDs provide visual indication of the status of the output firing, currents into the bridge, gate power supply, line filter, cooling fan rotation, and bridge temperature and alarm or fault conditions. EGPA card is used on all systems with 77 mm thyristors or smaller. The EHPA is used on 100 mm thyristors. For more information refer to Chapter 4 and GEI-100461 or GEI-100532.

EHFC Board

The EHFC board can be supplied to control cooling fans on the 100 mm EX2100. It can provide automatic start/stop control of a single power converter cooling fan, or lead/lag control of redundant power converter cooling fans. For more information, refer to *GEI-100548*.

EXCS Board

The EXCS board has four conduction sensors. It is used to detect the presence of current in the ac bus. The output is a logic signal. For more information, refer to *GEI-100510*. On 100 mm, a similar board EMCS is used.

EDEX Board

The EDEX board is the main board in the de-excitation module and is also used in the crowbar module. EDEX provides de-excitation SCR firing, conduction sense feedback of the de-excitation module, and voltage retention to ensure operation in the event of a power failure. EMIO initiates de-excitation on the EXHS board. The EXHS board opens the 41 dc contactor (41A/41B) or breaker, and then transfers de-excitation signals from the auxiliary contacts to SCR firing circuits on the EDEX. For more information refer to *Chapter 4* and *GEI-100466*.

Note EDEX is usually controlled by EXHS, but can initiate de-excitation if control fails.

EGDM or EROC Board

The EGDM or EROC is a double-slot, double height (6U) form factor board that mounts in the Exciter Power Backplane rack (EPBP). A simplex system typically has one EROC, while a redundant system has three EGDM boards. These boards detect field leakage resistance from any point in the field circuit of the generator to ground, either on the ac or dc side. The field ground detector applies a low frequency square wave to the sense resistor connected to the field circuit. EXAM, the attenuator module located in the auxiliary cabinet, senses the voltage across the ground resistor and sends the signal to the EGDM or EROC through a nine-conductor cable.

Note EGDM and EXAM work together to detect field ground leakage current.

In a redundant system, the set of three EGDM boards are configured as a Controller (C), Master 1 (M1) and Master 2 (M2). The configuration for each EGDM is controlled by a set of program pins on the P2 connector. The C controller receives information from the active DSPX on which EGDM master should provide the drive signal to the sense resistor in the attenuator module. The active master receives an oscillator signal over the fiber-optic link that it converts to a ±50 V signal. This is applied to one end of the sense resistor in the attenuator module.

The signal conditioner receives an attenuated (10:1) differential signal from the sense resistor. This is a simple unity gain differential amplifier with a high common-mode rejection ratio followed by an A-to-D converter (Voltage Controlled Oscillator VCO). This feeds a fiber-optic transmitter that is cabled to EISB. The signal conditioner circuitry is powered by an isolated power supply to maintain personnel and equipment safety due to the high common-mode voltage at the sense resistor. For more information refer to *Chapter 4* and *GEI-100467*.

EXAM Board

The EXAM mounts in the auxiliary cabinet and contains a sense resistor connected to a resistor network across the field. EXAM applies the low frequency ±50 V square-wave signal, supplied from the EGDM, to one end of the sense resistor. The resulting current generates a voltage across the resistor that is sent back to the EGDM.

In a redundant system, the test signal can come from either, M1 or M2. EXAM has a relay that switches between the two under the control of controller C. A single cable carries the control and sense signals between the EGDM and EXAM modules. For more information refer to *Chapter 4* and *GEI-100467*.

Alterrex applications may use two EXAM boards and two EROC boards to provide two simplex ground detectors. One is used for the exciter field circuit and the other is used for the generator field circuit.

Power Supply Boards and Modules

The exciter power supply boards are as follows:

- IS200EPDM Exciter Power Distribution Module (EPDM)
- IS200EPBP Exciter Power Backplane (EPBP)
- IS200EPSM Exciter Power Supply Module (EPSM)
- DACA Module

EPDM Module

The EPDM provides the power for the control, I/O, and protection boards. It is used in redundant control applications, and is mounted on the side of the EPBP. EPDM accepts a 125 V dc supply from the station battery, and one or two 115 or 220 V ac supplies. In simplex control applications, it is mounted on the side of the ESBP. All supply inputs are filtered. Each ac supply is rectified to 125 V dc in an ac-to-dc converter (DACA). The resulting two or three dc voltages are diode-coupled together to create the dc source supply, designated as P125V and N125V. With the center grounded, these voltages are nominally +62.5 V and –62.5 V to ground.

Note EPDM revision B or later is required to support 220 ac control power supplies. The DACA module must be set correctly for the supply voltage level.

Individual supply outputs to the exciter boards are fused. They have an on/off toggle switch, and a green LED indicator to display supply power availability. These outputs supply up to three EGPA boards, the EXHS board, and three EPSM modules serving the three controllers. Outputs are wired to the EPBP for distribution. For more information, refer to *Chapter 4*.

Note Any of the exciter power supply modules can be switched off from the EPDM.

EPBP Backplane

The EPBP holds three electrically isolated power supplies (EPSM) that supply power to the M1, M2, and C controllers. It also holds three EGDM. EPBP accepts 125 V dc from the adjacent EPDM, and distributes logic level power from the three EPSMs to the three controllers. Each power supply has an independent ON-OFF switch on the EPDM. The EPSM modules interface to the backplane through DIN connectors. 70 V dc and 24 V dc power is distributed from the locking connectors at the top of the backplane to the terminal boards. Refer to the figure *Exciter Power Backplane*. For more information, refer to *Chapter 4* and *GEI-100463*.

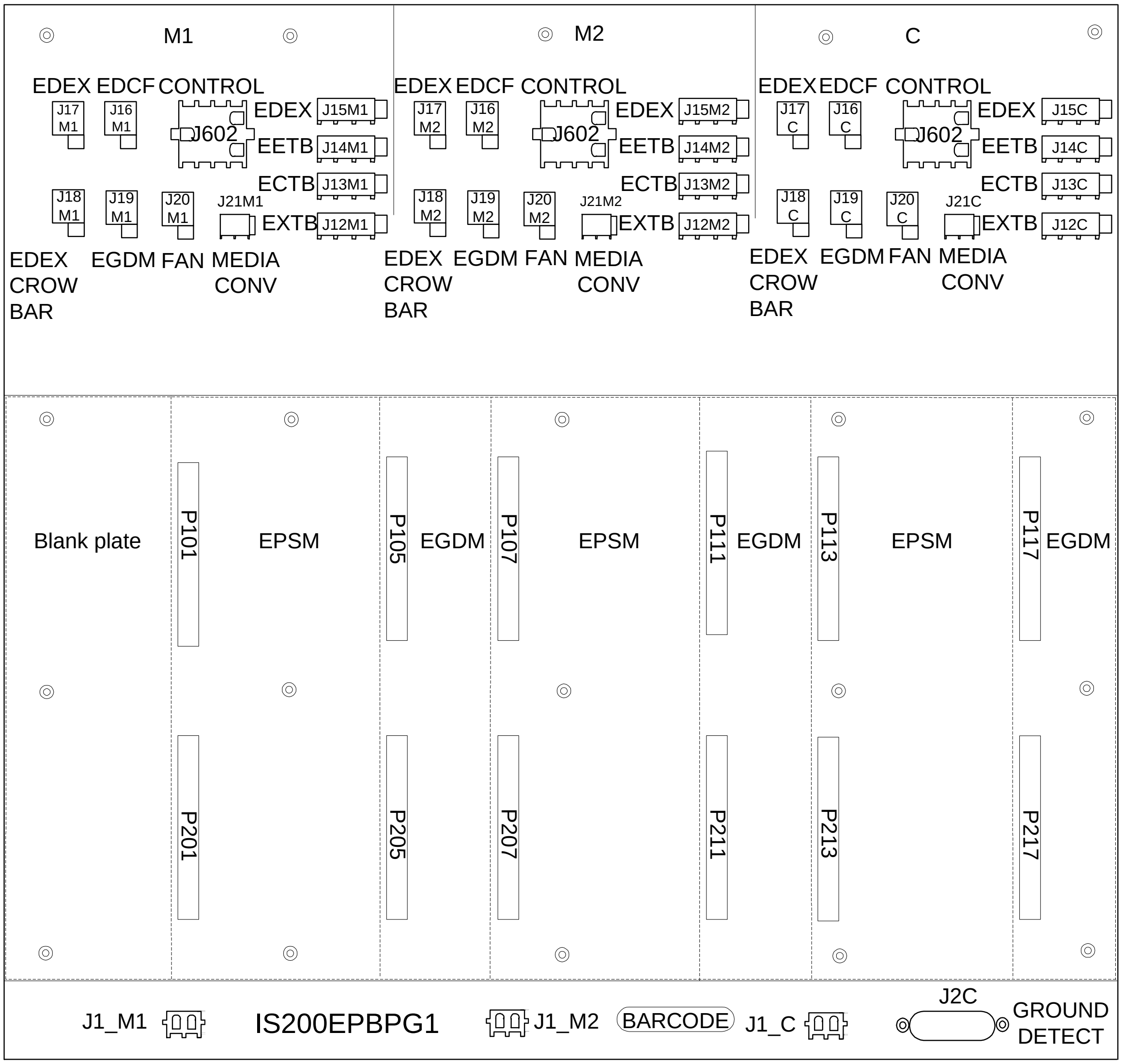
EPSM Module

The EPSM converts 125 V dc from the EPDM into the voltages required for the control system. For redundant control applications, there are three independent power supplies that supply power to each of the controllers M1, M2, and C. These supplies are located in the power supply module mounted below the control rack in the control cabinet.

The EPSM supplies +5 V dc, ±15 V dc, and +24 V dc to the controller. Power is also supplied to modules external to the control rack as follows:

- ±24 V dc to power the EDEX de-excitation module, crowbar module, EGDM, and EDCF
- Isolated +70 V dc for contact wetting to the EXHS and ECTB boards

For more information, refer to *Chapter 4* and *GEI-100462*.



Exciter Power Backplane

DACA - Ac-to-Dc Converter

The DACA or DACB is an ac-to-dc converter that is powered by a 115 or 220 V ac source and produces 125 V dc. The DACA and battery source provide a redundant 125 V dc supply for the EPDM. Two DACAs can be connected to the EPDM if required for greater power supply reliability.

Related Board Publications

For a more detailed description of each board's circuitry and application data, refer to the following documents:

- GEI-100267 IS200DSPX Digital Signal Processor Board
- GEI-100434 IS215ACLEH1 Application Control Layer Board
- GEI-100453 IS200EMIO Exciter Main I/O board
- GEI-100454 IS200EISB Exciter ISBus board
- GEI-100456 IS200ESEL Exciter Selector board
- GEI-100457 IS200ECTB Exciter Contact Terminal Board
- GEI-100459 IS200EPCT Exciter PT/CT board
- GEI-100460 IS200EBKP Exciter Backplane
- GEI-100461 IS200EGPA Exciter Gate Pulse Amplifier board
- GEI-100462 IS200EPSM Exciter Power Supply Module
- GEI-100463 IS200EPBP Exciter Power Backplane
- GEI-100464 IS200EDCF Exciter DC Feedback board
- GEI-100465 IS200EACF Exciter AC Feedback board
- GEI-100466 IS200EDEX Exciter De-Excitation board
- GEI-100467 IS200EGDM Exciter Ground Detector Module
- GEI-100475 IS200EXHS Exciter High Speed Contactor Driver board
- GEI-100509 IS200EXAM Exciter Attenuation board
- GEI-100510 IS200EXCS Exciter Conduction Sensor board
- GEI-100511 IS200EPDM Exciter Power Distribution board
- GEI-100526 IS200EROC Exciter Regulator Options board
- GEI-100532 IS200EHPA Exciter Gate Pulse Amplifier board
- GEI-100548 IS200EHFC Fan Controller board
- GEI-100601 IS200EMCS Exciter Conduction Sensor board

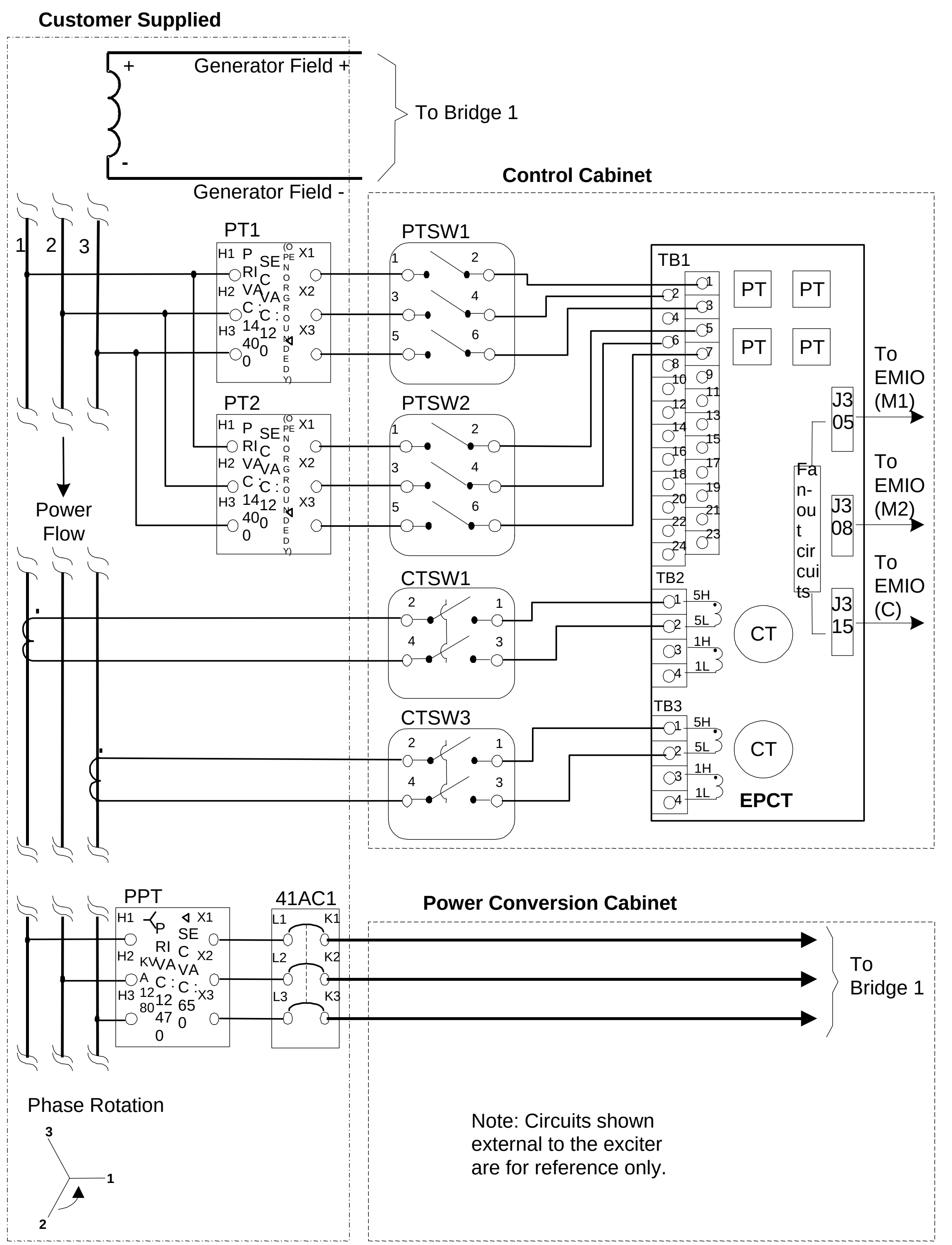
Chapter 4 Terminal Board I/O and Equipment Connections

Introduction

This chapter describes the customer's equipment connections, and inputs and outputs (I/O) available through terminal board wiring. System cabling to provide desired functionality is also defined.

Power Connections and Analog I/O

Figure *Exciter AC Power Supply and PT/CT Wiring* displays a typical connection diagram of the common power and analog I/O for an excitation system.



Exciter AC Power Supply

Power Potential Transformer Inputs

In the EX2100 excitation system, a 3-phase source of ac power is converted to a controlled dc output. This ac input can be from one of several sources. Most common is a generator terminal connected Y-Delta power potential transformer. The primary and secondary voltages as well as kVA ratings are sized for the particular application. An auxiliary bus fed PPT is also commonly used. In industrial applications where forcing is needed for large motor starting, a compound source (current and voltage) input can be used. This ac input is connected to the bus in the power conversion cabinet and can be isolated by the 41AC1 device for maintenance. It is monitored by the controls through the EACF board.

Potential and Current Transformer Inputs

Customer supplied 3-phase PT and CT are wired to switches in the control cabinet as shown in the figure Exciter AC Power Supply and PT/CT Wiring. The switches are wired to the EPCT. High frequency noise suppression near the point of signal entry is provided on all input signals to EPCT. On the board, the two 3-phase generator voltage inputs, nominal 115 V ac, are brought into PT transformers. Two generator CTs (phases A and C), with either 1 A or 5 A secondaries, are brought into CT transformers. The resulting low voltage transformer output signals are cabled to the EMIO board in the control rack.

Note A redundant PT input for PT failure detection is possible, and single-phase sensing can be supported. Redundant CT inputs are also available.

Generator Voltage Measurement

The cable lengths from the generator PTs can be up to 1000 ft of #12 AWG wire. The PT secondary outputs are nominally 115 V rms at 50/60 Hz and are fused. On EPCT, the two transformers make a three-wire open delta voltage measurement, yielding 1.533 V rms for a 115 V rms input.

In case of a simplex system, the voltage signals are sent through the J305 connector to the EMIO board in the M1 controller. In the case of a redundant system, the signals are fanned to connectors J305, J308, and J315, and sent to controllers M1, M2, and C.

Item	PT Inputs	CT Inputs
Number of Inputs	2, 3 phases each	2, Phases A and Controller: C
Volts or Current	10 - 200 V rms, 115 V rms nominal	0 - 2 A, nominal 1 A, or
		0 - 10 A, nominal 5 A
Frequency	50/60 Hz nominal	50/60 Hz nominal
Burden	Less than 1 VA	Less than 1 VA

Generator Current Measurement

Two generator current inputs from the CTs are wired to non-pluggable terminal blocks, TB2 and TB3 that support ring terminals. The CTs do not have fused secondaries. There is a choice of a 0 - 1 A rms CT input, or a 0 - 5 A rms CT input. The cable length from the CT to the EPCT board can be up to 1000 ft, and the wire gage can be up to #10 AWG. The resulting signals are sent to the EMIO board through the same connectors as the voltage signals.

Analog Input

The EPCT board provides an analog input for customer use. This input is jumper selectable for either ±10 V dc or 4 - 20 mA. The EMIO samples the input at 2000 samples per second, and the accuracy is better than 1% full scale.

Customer Contact I/O

Customer contact inputs and relay contact outputs are wired to the ECTB board.

In addition to six general purpose contact inputs, there are two dedicated contact inputs, wetted by 70 V dc from the exciter, as follows:

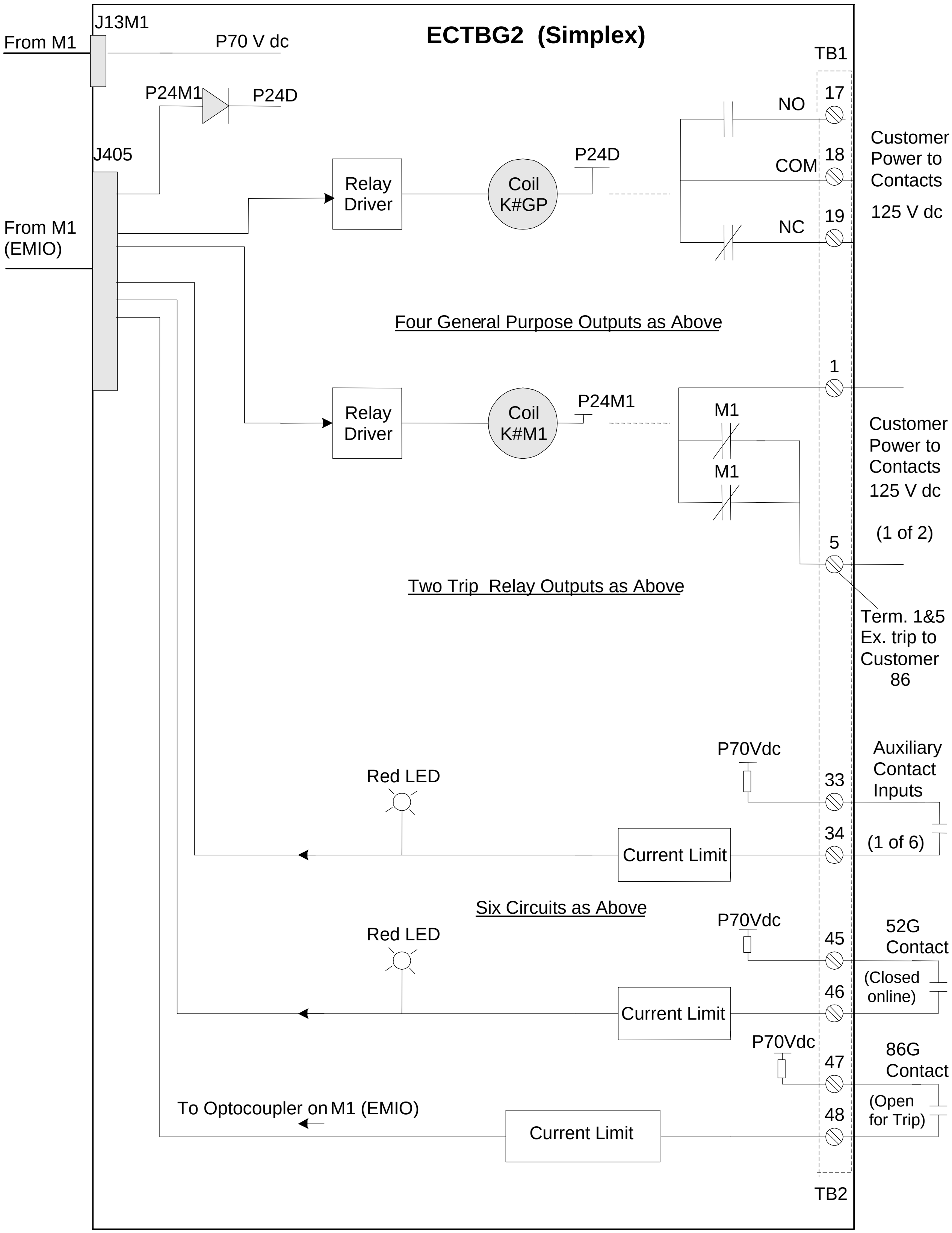
- 86G contact input used as a lockout during normal operation
- 52G contact input gives the online status of the generator

ECTB provides four general purpose Form C contact outputs controlled by EMIO. These are used for 94EX and 30EX and other outputs. For each relay, the coil current and the status of a relay auxiliary contact is monitored. These feedbacks are cabled to EMIO in the controller. Refer to the figure *Customer I/O wired to ECTBG2 Simplex Board* and the table *General Purpose Relay Contact Characteristics.*

General Purpose Relay Contact Characteristics

Item	Description			
Customer Power	125 V dc nominal (24 V dc min)			
Relay break characteristic	Resistive load	2 A	28 V dc	
		0.5 A	125 V dc	
	Inductive	1 A	28 V dc	0.007 s (L/R)
		0.1 A	125 V dc0.007 s (L/R)	
Suppression	External suppression supplied by customer on induction loads			

ECTBG1 is the redundant control version of the ECTB. This fans inputs to three connectors J405, J408, and J418 that are cabled to the three controllers. For relay control, the board does two-out-of three voting, and the 70 V dc and 24 V dc inputs are redundant.

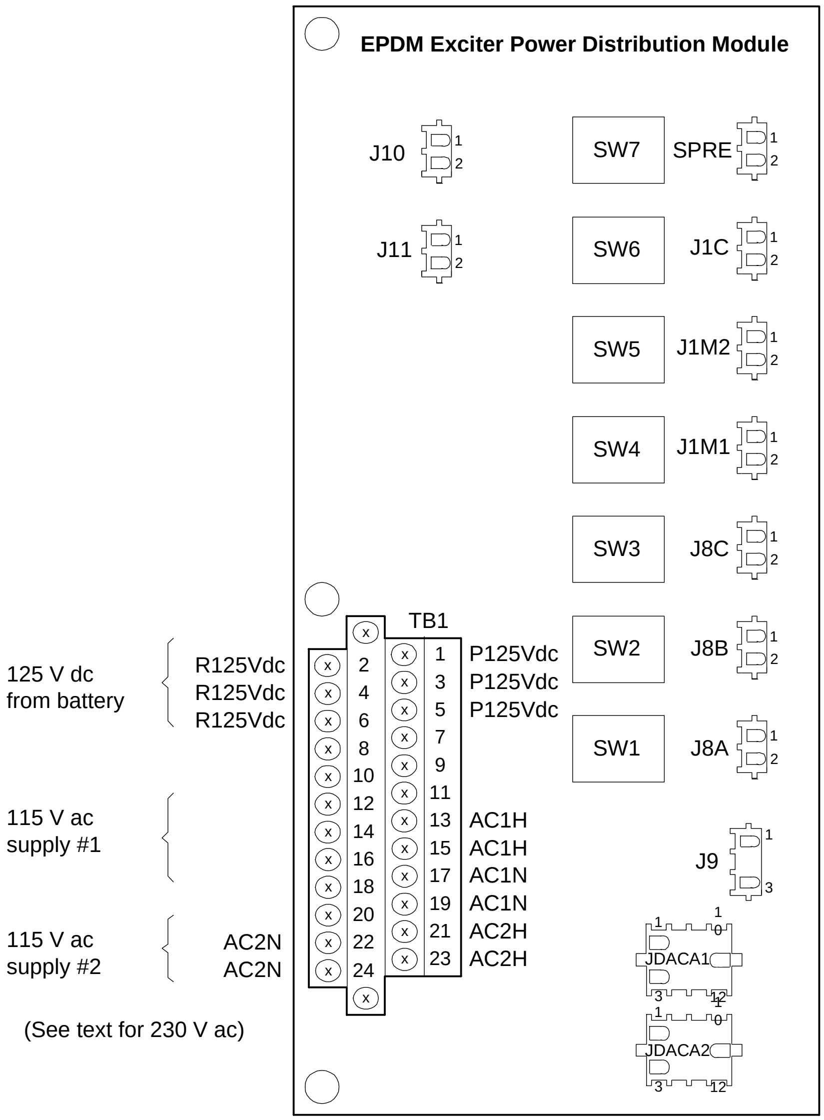


Customer I/O wired to ECTBG2 Simplex Board

Power Supply Inputs

The customer's ac and dc power inputs are wired to the EPDM, which is located on the lefthand side of the exciter power backplane rack. Figure *Power Wiring Connections to EPDM* shows the screw terminals for the 125 V dc battery source, and the 115 or 220 V ac supply, AC1. A second ac supply, AC2, can also be connected. Other ac inputs including cooling fan power, convenience lights and outlet, and cabinet heater are wired to separate terminal blocks, fuse blocks, or circuit breakers.

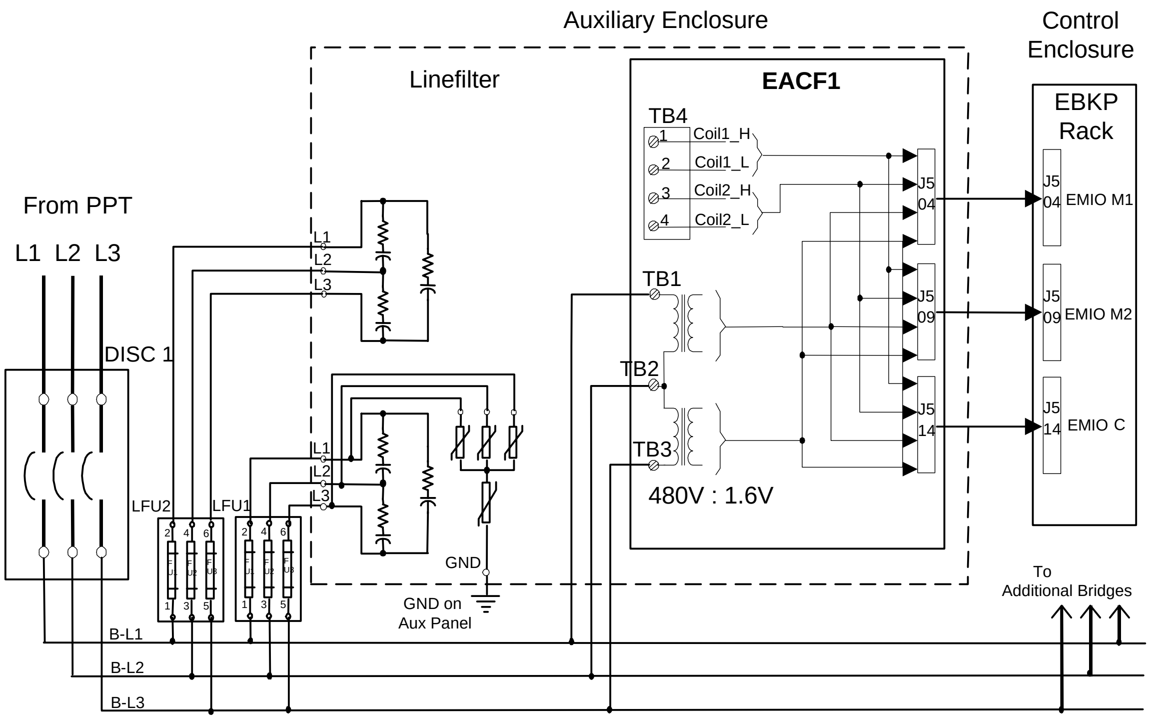
Note Revision B and later EPDM boards can accept either 115 or 220 V ac control power inputs. The connector on the face of the associated DACA module must be set to match the input voltage



Power Wiring Connections to EPDM

Line Filter Connections

The ac line filter is internally connected to the power converter source bus through one or more fuse blocks, typically located in the exciter auxiliary cabinet. The filters are located at the top of the auxiliary cabinet. In the 100 mm EX2100, the line filters and fuses are located in the ac termination cabinet. Typical connections to the line filter are shown in the figure *AC Feedback and Line Filters*.



AC Feedback and Line Filters

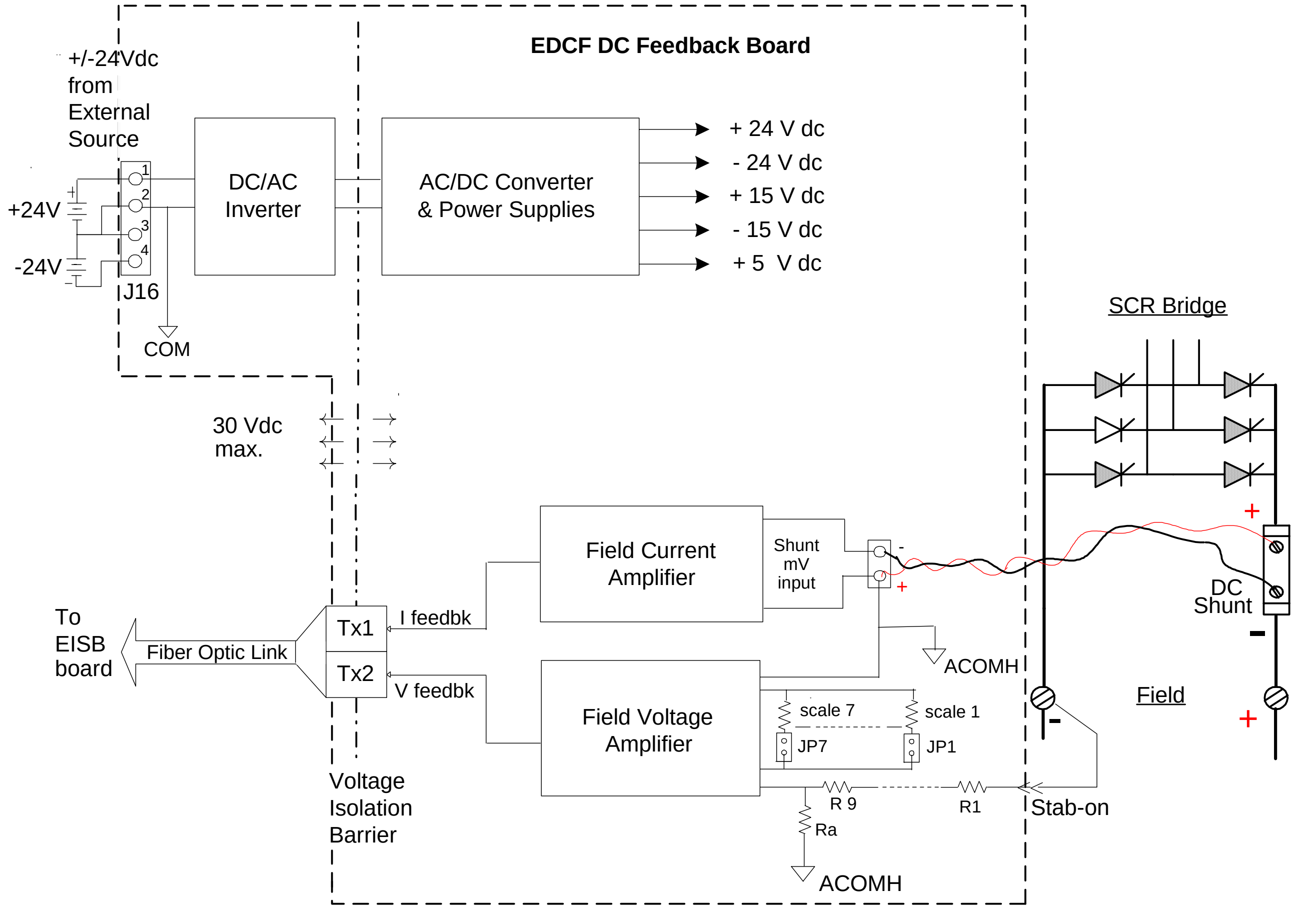
Exciter Internal I/O

Exciter ac Feedback

The EACF board measures the exciter ac supply voltage and current. The terminal board contains transformers for a 3-phase voltage measurement, and terminals for two flux/air core coils. The cable between EACF and the EBKP and ESBP control backplane can be up to 90 m in length. Cable shield terminal screws attached to chassis ground are located within three in. of the input screws where applicable. Version EACFG1 is used for up to 480 V rms inputs, with EACFG2 for up to 1000 V rms inputs and EACFG3 for up to 1400 V rms inputs. Refer to the figure *AC Feedback and Line Filters*.

Exciter dc Feedback

The EDCF board measures field current and field voltage at the SCR bridge, and interfaces to the EISB board in the controller over a high-speed fiber-optic link. The fiber optics provides voltage isolation between the two boards, and high noise immunity. For a circuit block diagram, refer to the figure *Field Voltage and Current Measurement*. The field voltage feedback circuit provides seven selector settings to scale down the bridge voltages appropriate to the application.



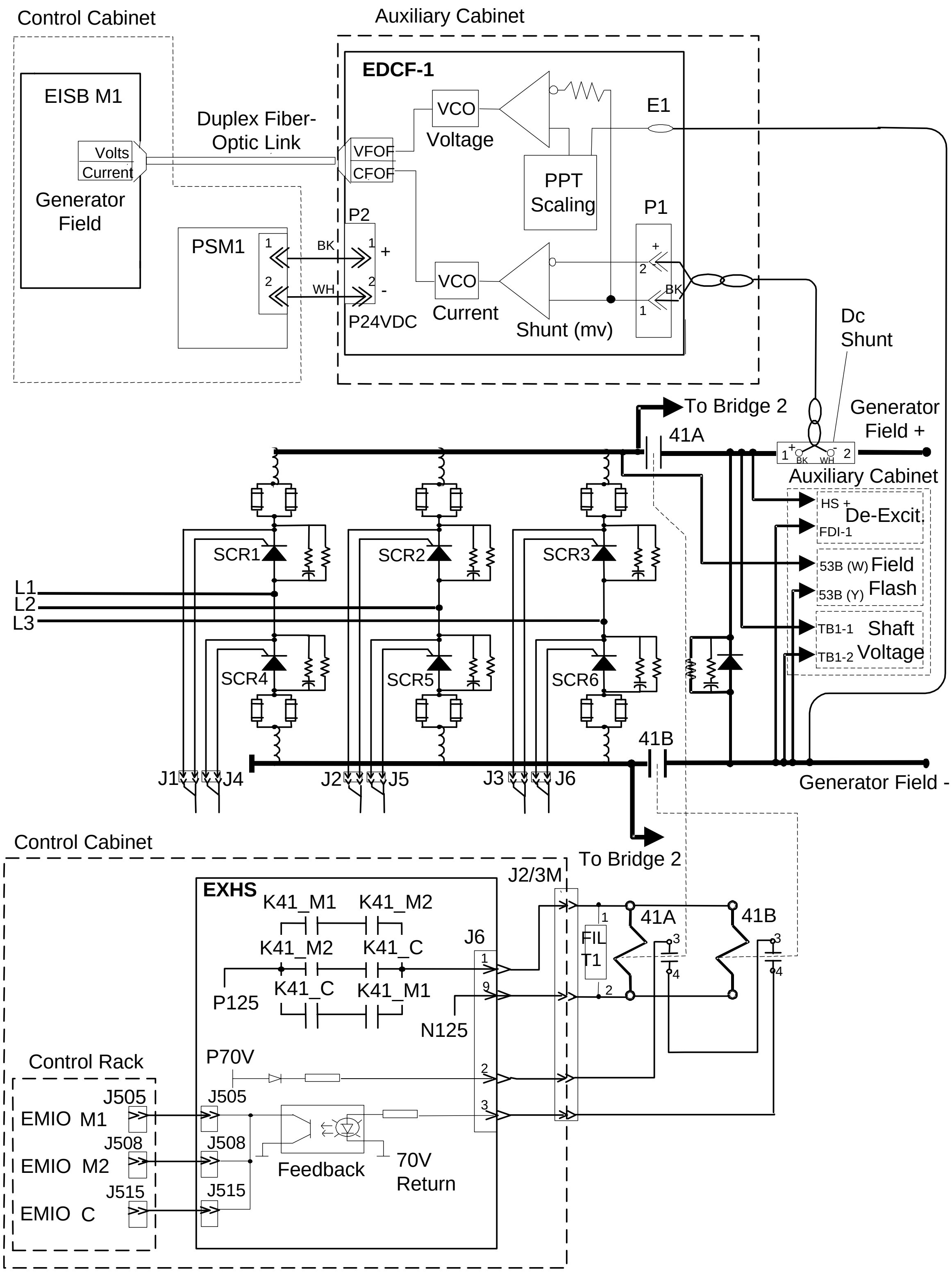
Field Voltage and Current Measurement

Field Current Feedback

The field current is measured across a dc shunt at the output of the power converters. This generates a nominal 100 mV signal, which is input to a differential amplifier. The output voltage from the amplifier ranges from –5 V to +5 V. A VCO produces a linear proportional frequency of 0 - 2 MHz with an accuracy of 1% of full scale reading. These pulses drive the LED in the optical isolator coupled to the fiber-optic cable.

Field Voltage Feedback

The bridge voltage is measured across the output of the power converter modules. After scaling the voltage with the jumpered resistors, the signals are input into a differential amplifier, which controls the VCO. The VCO produces a linear proportional frequency of 0 - 2 MHz with an accuracy of 1% of full-scale reading. The pulses drive the LED in the optical isolator coupled to the fiber-optic cable.



Dc Field Circuit Contactor and Control Board

De-excitation

During shutdown of the generator, the stored energy of the generator field inductance must be dissipated. In the EX2100 exciter, this is the function of the EDEX de-excitation module and field discharge resistor or inductor (when supplied).

Standard de-excitation is provided by a thyristor (33, 53, or 77 mm cell size) mounted in an assembly with attached snubber network and control board EDEX.

Note In the 42 mm optional non-inverting topology, de-excitation is provided through the free-wheeling diode located on the thyristor bridge heatsink.

The EDEX board contains Hall effect conduction sensors. The sensors are mounted in the air gap of a circular steel core attached to the board. They sense the magnetic field produced by the field discharge current flowing through the thyristor. Two independent sensor circuits are used. The EDEX fires the SCR when either of two control inputs is true or when the anode to cathode voltage of the SCR exceeds a certain value. The two firing control circuits on the board are powered from separate power supplies and use separate conduction sensors making them mutually independent.

The actual control logic inputs used are dependent on the application. When the exciter shuts down, a P24 V firing control signal is sent to both de excitation module firing control circuits. Both firing control circuits send gate pulses to fire the de-excitation SCR. At this point, the main field polarity reversal has occurred making the SCR anode positive with respect to the cathode. Therefore the SCR conducts and dissipates the stored energy of the generator field through the field discharge device.

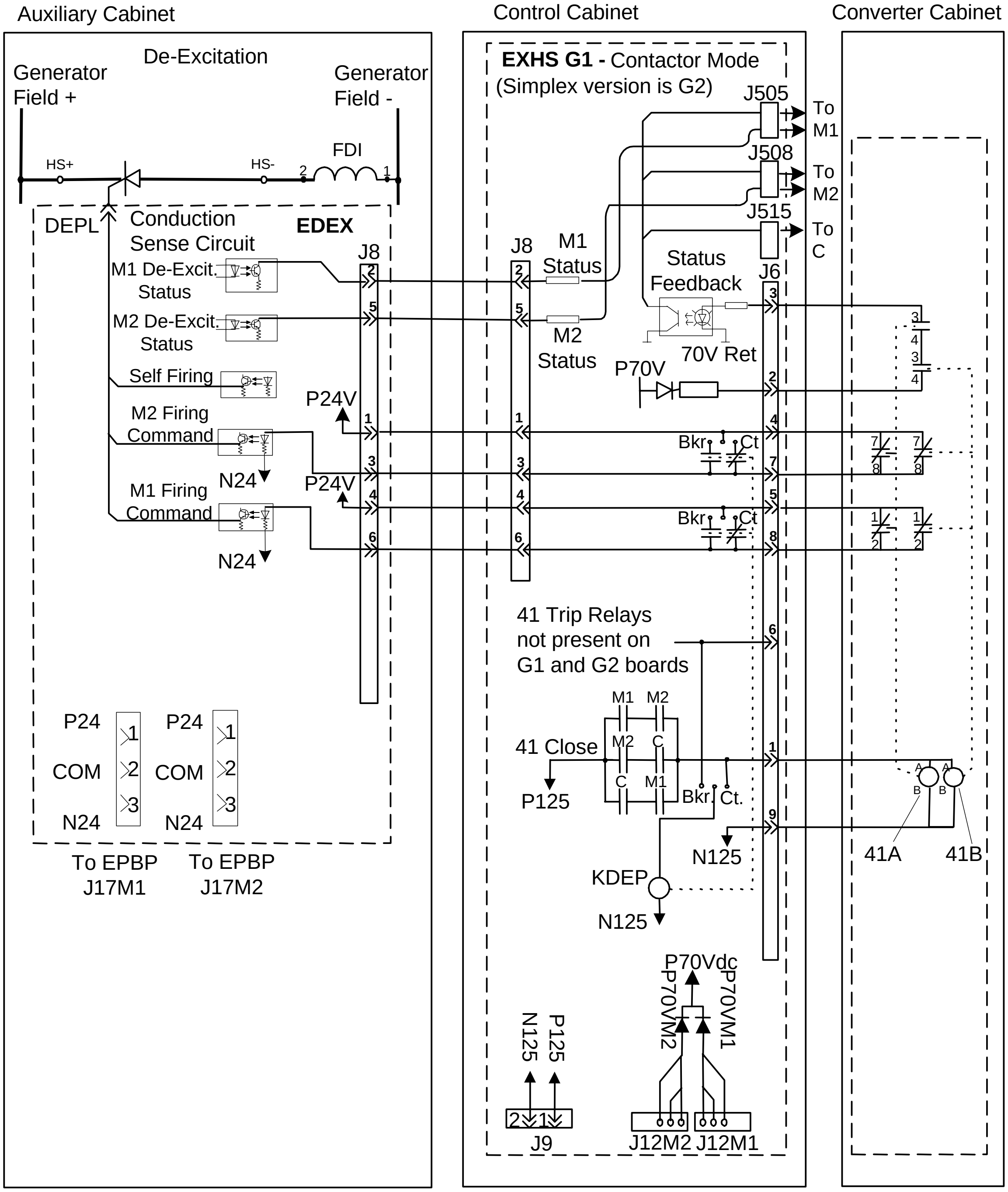
Feedback from either conduction sensor verifies that the discharge circuit has operated successfully. If both independent firing control circuits fail to fire, the SCR is fired by the anode firing circuit when the anode to cathode voltage has exceeded the selected level.

For large exciters, it is possible to connect multiple de-excitation modules together with one EDEX board configured to be the *Master* and the other boards configured to be *Slaves.* In this case, a firing control signal sent to the master is relayed to the slave modules, firing all modules simultaneously.

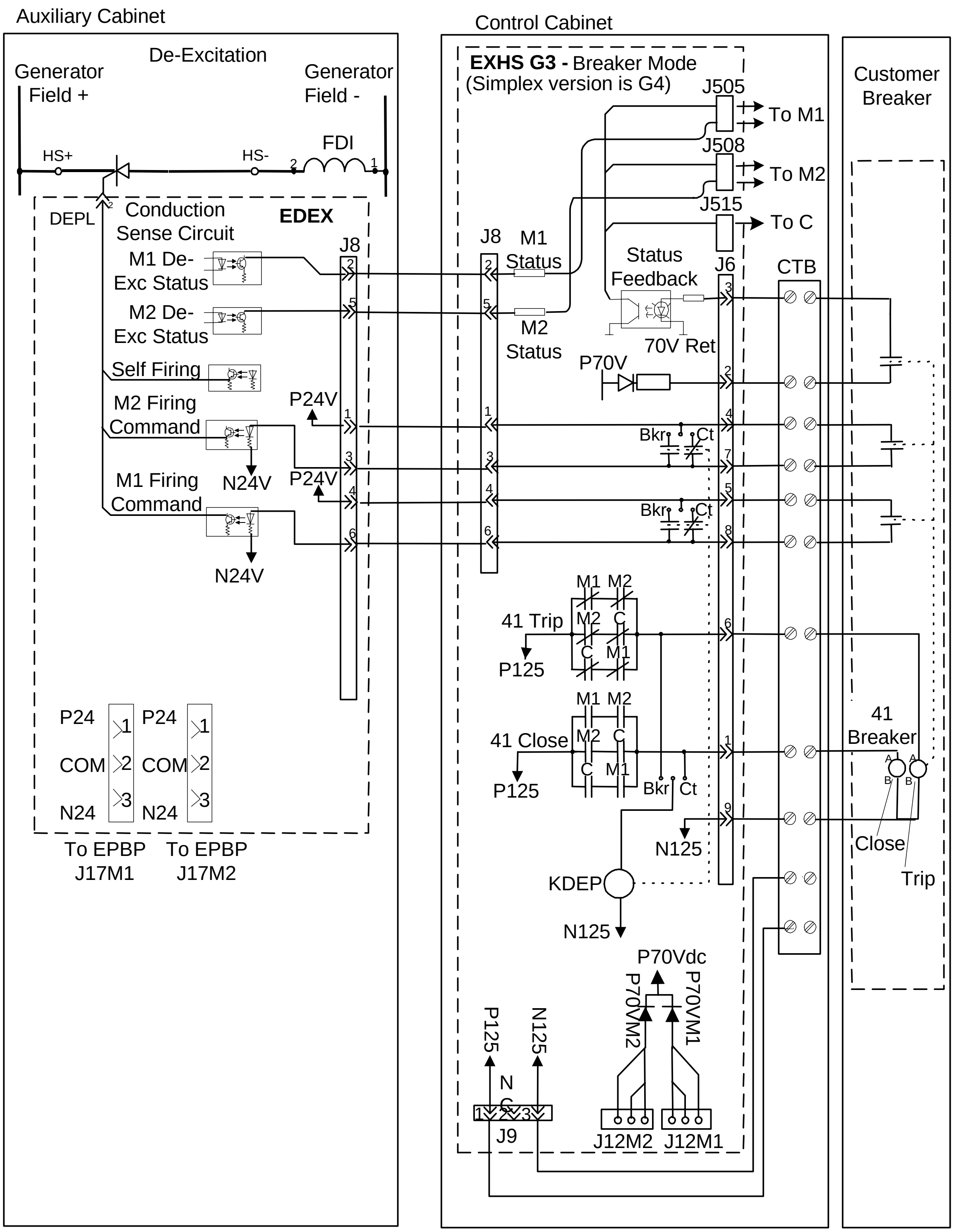
EXHS controls the main breaker or contactor in the field circuit. When this opens, the auxiliary contacts cause an immediate de-excitation commanded by EDEX. De-excitation controlled by EXHS in both the contactor and breaker mode is shown in the figures *Dc Contactor Control and Wiring to De-Excitation Board*, and *Ac or Dc Breaker Control and Wiring to De-Excitation Board.*

Location of the 41A dc contactor in the field circuit is shown in the figure *Dc Field Circuit Contactor and Control Board*. Contactor 41B is optional. Both contactors are located in the power conversion cabinet (Dc exit case for 100 mm), and are driven from the 41 Close pilot on the EXHS board. Several auxiliary contacts are used to provide status feedback to the control, and firing commands to the de-excitation board, EDEX.

An alternative to 41A and 41B contactor is to use a breaker in the excitation ac supply or dc output field circuit. Normally, the breaker would be a dc field breaker that could break the output while inserting a discharge resistor with the normally open contact. But, an ac breaker with the SCR based de-excitation module could also be applied. The breaker has two coils, 41 Close and 41 Trip, and auxiliary contacts for de-excitation. Figure *Ac or Dc Breaker Control and Wiring to De-Excitation Board* shows an example breaker interface with the EXHS control board and EDEX.



Dc Contactor Control and Wiring to De-Excitation Board



Ac or Dc Breaker Control and Wiring to De-excitation Board

Crowbar

The optional crowbar subsystem limits high negative voltages that can be induced into the PCM during a pole slip (loss of synchronization) event. Like the de-excitation module, the crowbar will self-fire based on selective field voltage limits. It includes a discharge resistor, which may be shared with the de-excitation function when the two are supplied together. This is typically provided only on generators with salient poles (hydro applications). For the connections to the field, refer to the figure *Shaft Voltage Suppressor, Thyrite, and Crowbar*. The crowbar and de-excitation functions may be provided as a combined module in some EX2100 systems.

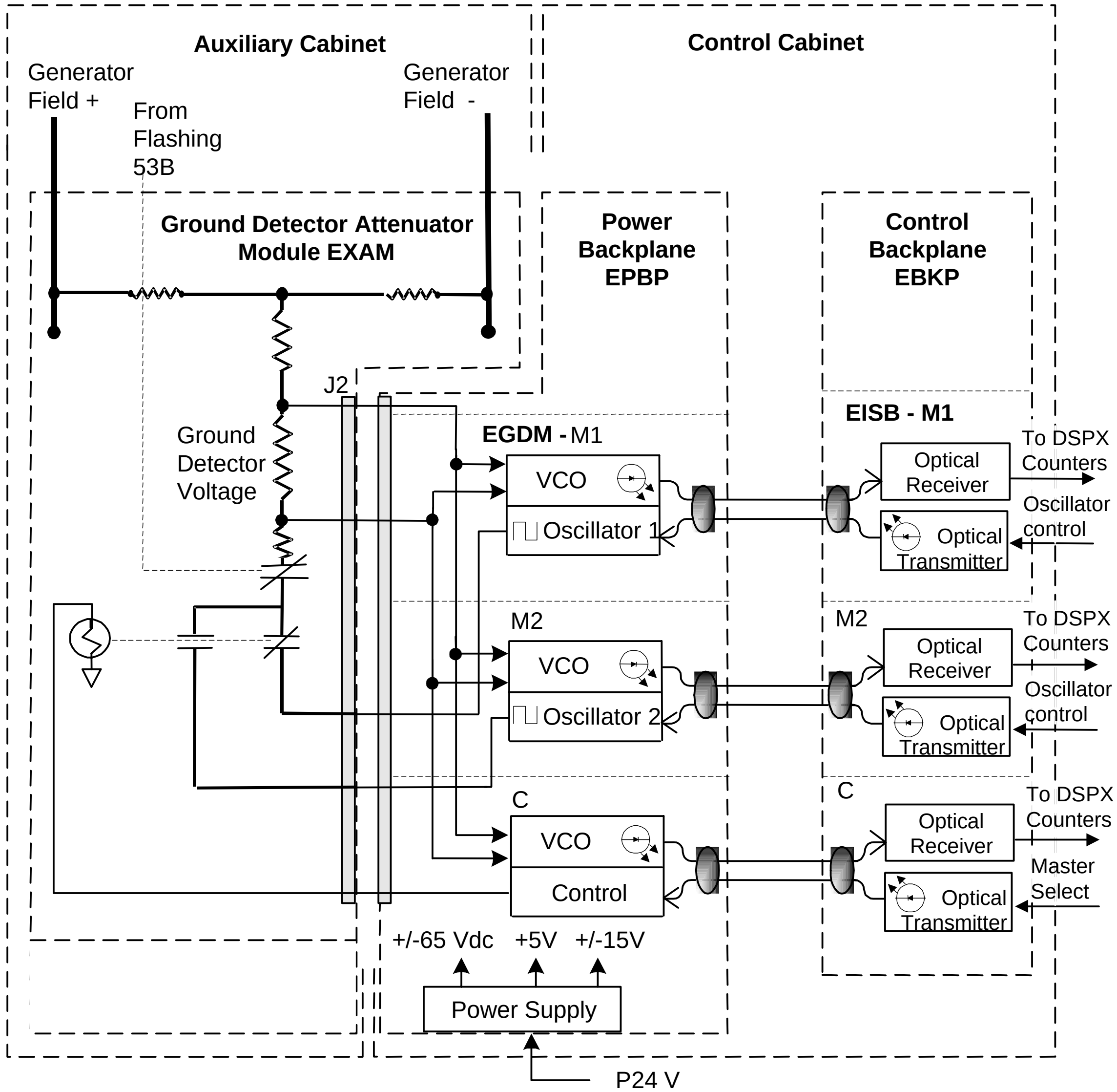
Field Ground Detector

The generator field is an ungrounded system. The field ground detector (EGDM) detects field leakage resistance between any point in the field circuit of the generator and ground. The active detection system shown in the figure *Field Ground Detector* applies a low frequency square wave voltage with respect to ground, and monitors for current flow through a high impedance ground resistor. The square wave is ± 50 V dc at 0.2 Hz frequency. If PRV resistors are present, grounds anywhere in the system can be detected even while the exciter is not gating cells, from the PPT secondary to any point in the generator field.

Note The EGDM is an active system that applies a voltage to the field circuit.

The ground detector feedback voltage is sent over a fiber-optic link to the DSPX where it is monitored and alarmed. The DSPX controls the oscillator voltage over an adjacent fiber-optic link. In the case of redundant control, if the M1 controller fails, the oscillator in the M2 channel takes over, as commanded by controller C.

One or three EGDMs are mounted next to the power supplies in the power backplane. On simplex control applications, the ground detector function is provided by the EROC board.



Field Ground Detector

Field Flashing

Field flashing relays 53A and 53B are controlled from drivers on the EMIO board, through pilot relays on EXHS. In redundant control, the three driver signals actuate pilot relays on EXHS that are contact voted to output a single voltage. These outputs actuate the 53A and 53B relays in the auxiliary cabinet. The 53A and 53B contacts put dc voltage from the station battery across the generator field, as shown in the figure *Field Flashing Control from EMIO and EXHS.* The field flashing module supplies approximately 15 to 20% of AFNL to the generator field during the startup sequence.

Note The station battery is used to initiate the field current. An auxiliary ac source can also be used.

For ac field flashing, the ac voltage is rectified by a diode bridge and filtered. The startup sequences and logic are the same.

Dc Field Flashing Settings

Field flashing cabinets are used to supply a wide range of flashing currents. Configuring a maximum and minimum allowable value in the control module sets the flashing current magnitude required for a generator.

The current values are preset in the factory based on information supplied. These values define the envelope in which the hysteretic flashing control holds the field current during the flashing sequence.

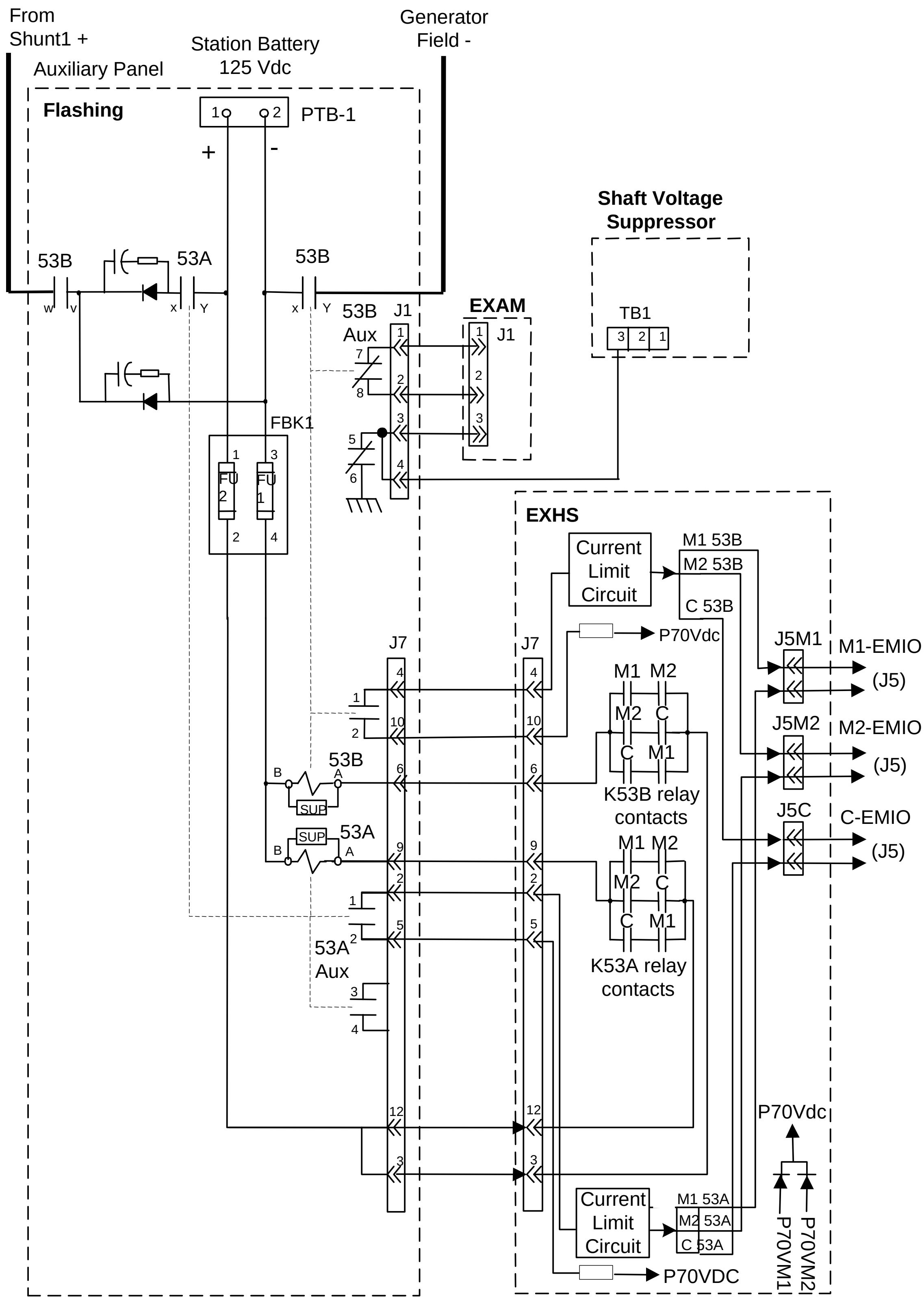
Flashing Control Sequence

A start request is issued by the operator. The optional field contactor(s) closes, followed by contactor 53B, then 53A. When the field current reaches the maximum allowable field flash value (typically 15 - 20% of AFNL), contactor 53A opens and the field current decays through the freewheeling diodes. If the control has not taken over before the current decays to the minimum field flash current setting, typically 10% AFNL, the sequence is repeated. If the current magnitude exceeds approximately 25% AFNL, or the control has not taken over after a fixed time delay, the startup is stopped and a diagnostic alarm is issued.

Note Flashing current flow is monitored by the control through the field shunt.

Boost Operation

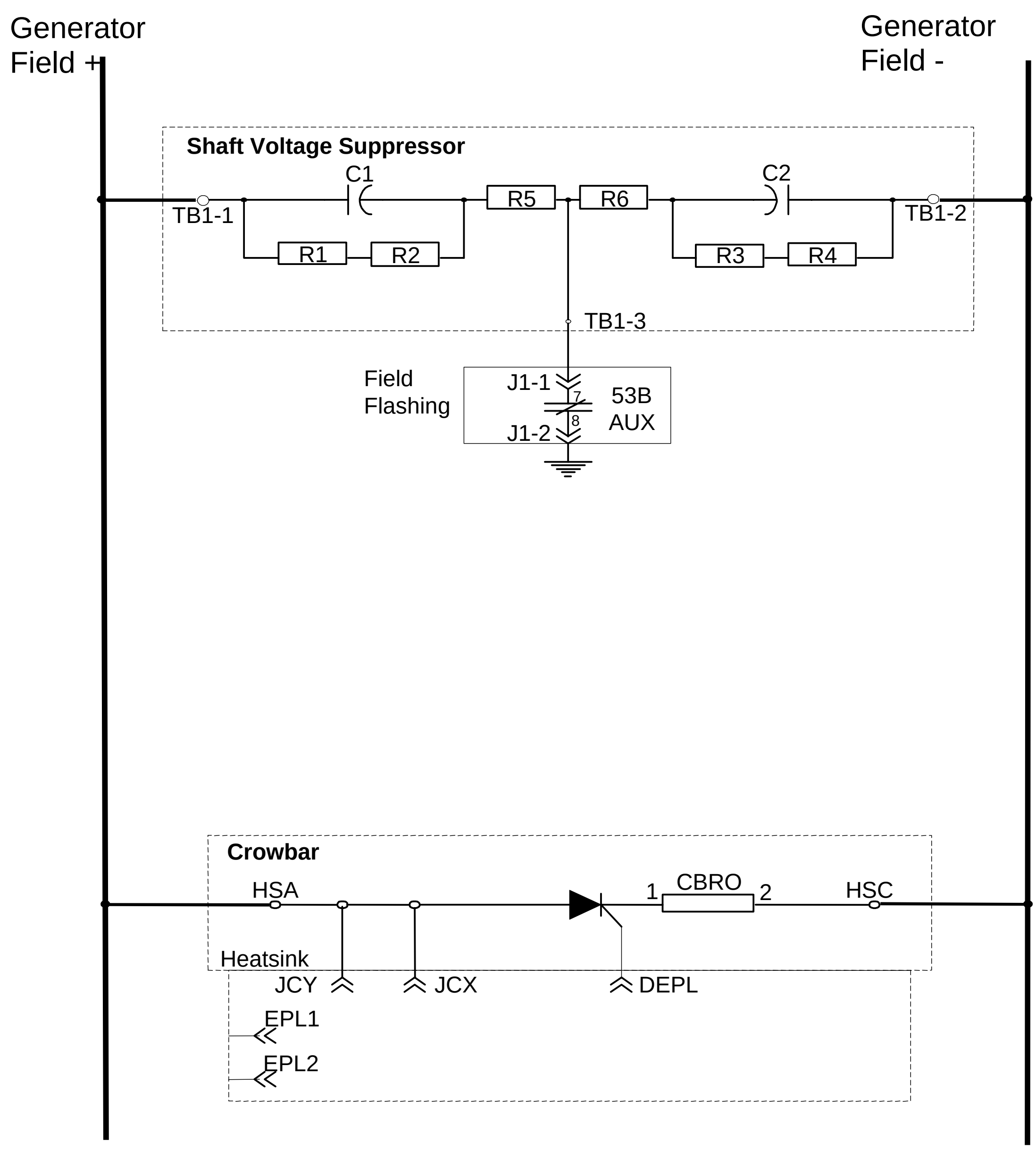
In brushless applications, the field flashing module may be used to support the boost function, whether flashing is required or not. Boost is used to power the field from the stationary battery when the PPT voltage has collapsed due to a terminal fault condition. A boost module may be present to limit the current applied. If so, both flashing current and boost current pass through the boost resistor module. Boost is typically applied for a maximum of 10 seconds should the PPT voltage fall below 75% of rated. Control software is included to protect the boost resistor from overload.



Field Flashing Control from EMIO and EXHS

Shaft Voltage Suppressor

Excitation systems, which produce a dc voltage from an ac supply through a solid-state rectification process, cause ripple and spike voltages at the exciter output. Due to their rapid rise and decay times these voltages are capacitively coupled from the field winding to the rotor body. This creates a voltage on the shaft relative to ground that, if not effectively controlled, can damage both journals and bearings. The shaft voltage suppressor is a filter that conducts the high frequency components of the induced voltages to ground and limits shaft voltage caused by thyristor commutation to less than 7 V zero to peak. For the connections to the field, refer to the figure *Shaft Voltage Suppressor and Crowbar.* Brushless applications and some static exciters do not require the shaft voltage suppressor.



Shaft Voltage Suppressor and Crowbar

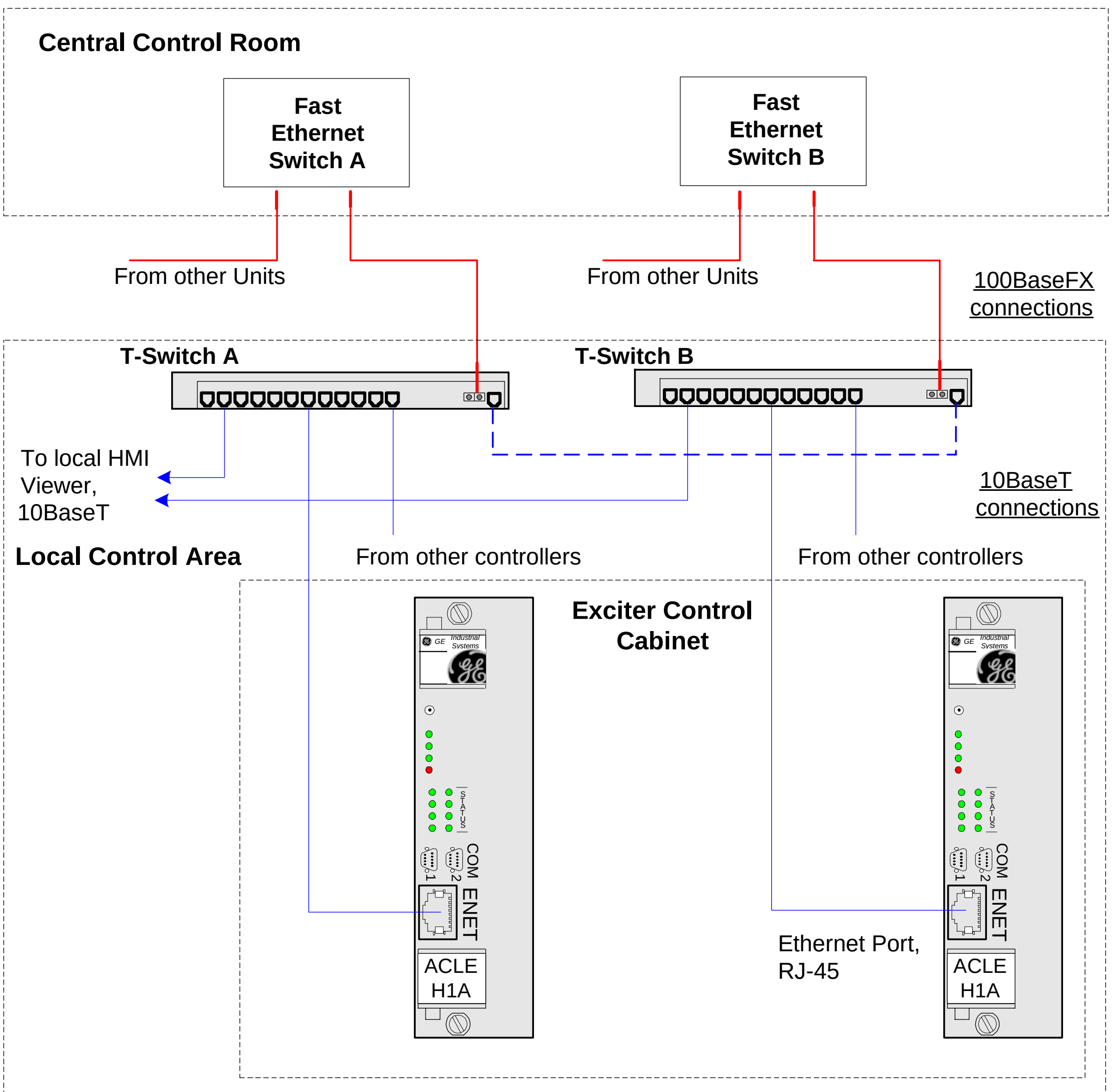
Data Highway Connections

The EX2100 exciter communicates over the same data highway as the Mark* VIe turbine control and the HMI. A typical exciter connection to the redundant Unit Data Highway (UDH) network is shown in the figure Unit Data Highway Connections. This shows redundant control with two ACLEs. The UDH is implemented using commercially available fast Ethernet switches.

Note The Data Highway integrates several different single control systems.

10BaseT cabling is used for short distances between the controller and the T-switch, and any local HMI. The 10BaseT ports in the ACLE or ACLA and the T-switch are for RJ-45 connectors. The maximum distance for local traffic at 10 Mbps using unshielded twisted pair cable is 100 m.

100BaseFX fiber optics can be used for longer distance communication between the local controllers and the central control room. The 100BaseFX ports in the T-switch and the Ethernet switch are for SC type fiber-optic connectors. The maximum distance at 100 Mbps using 100BaseFX fiber-optic cables is 2 km. Redundancy can be obtained by using two T-switches with an interconnecting cable.

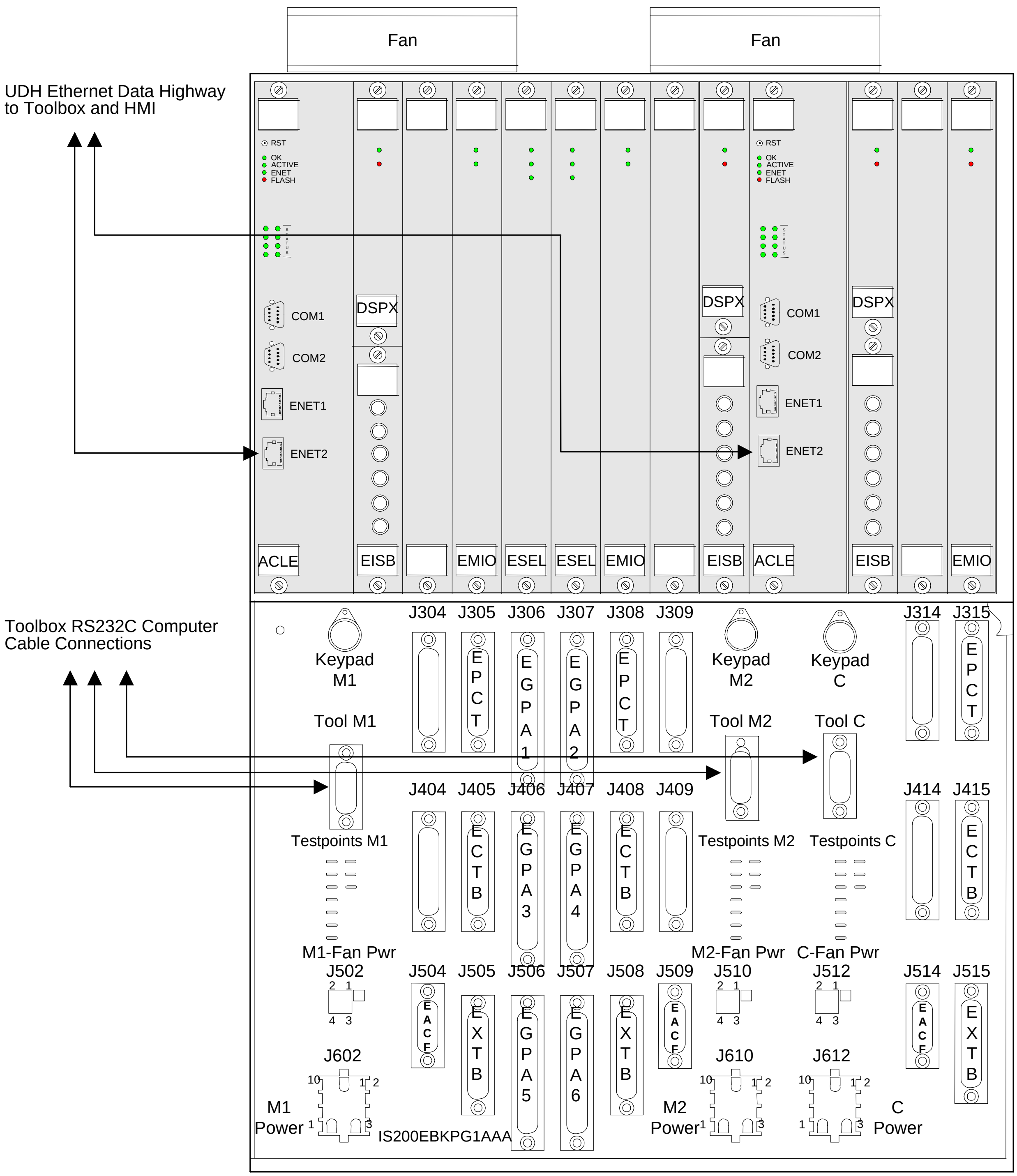


Unit Data Highway Connections

Control System Toolbox Connection

The toolbox connector on the exciter backplane supports an RS-232C cable, which connects an external computer to the DSPX board. This connection is for maintenance purposes. There are three 9-pin connectors located at J303B, J310B, and J313B to support communication with controllers M1, M2, and C. (Refer to the figure *Toolbox Connections*).

The UDH can also provide a toolbox interface using the Ethernet port on the ACLA. This is a 10BaseT port and uses an RJ-45 connector for unshielded twisted pair cable.



Toolbox Connections

Notes

Chapter 5 Diagnostic Interface-Keypad

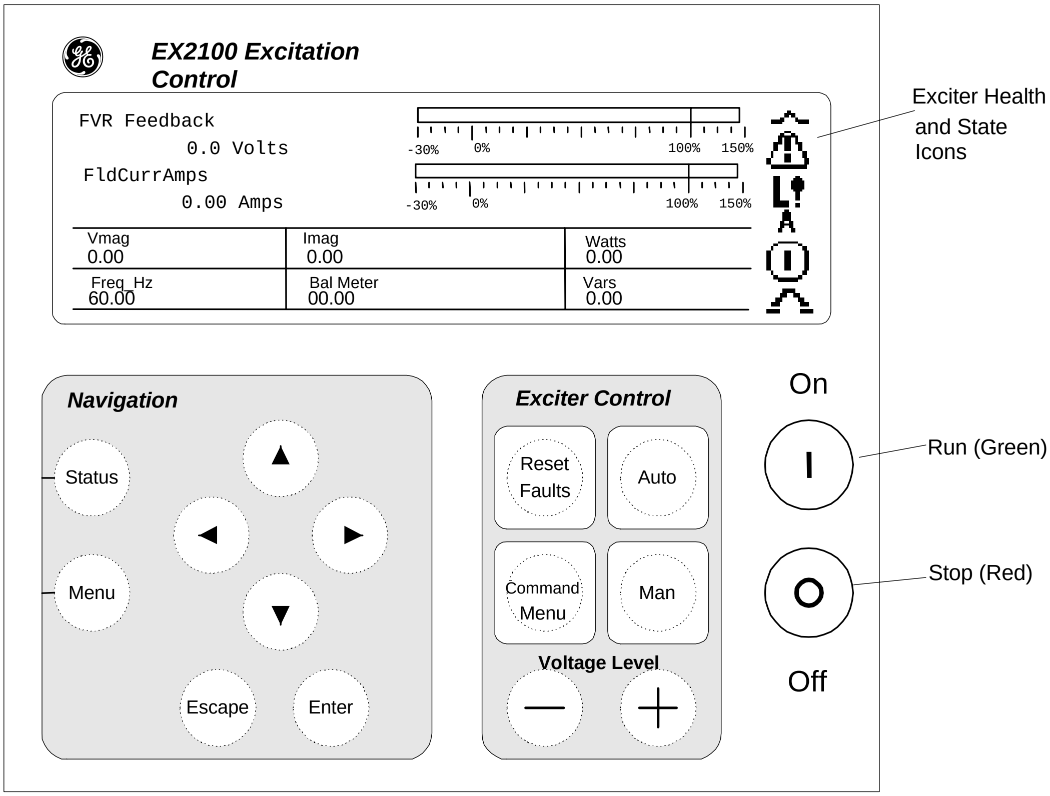
Introduction

This chapter provides operating guidelines for the Diagnostic Interface, more commonly called the *keypad.* The keypad is a door-mounted, local control unit that enables you to:

- Monitor frequency, current, power, and voltage
- Start and stop the exciter
- Set and adjust configuration parameters
- Examine and reset fault conditions

Using the Pushbuttons

The keypad includes membrane-type pushbuttons to access exciter values and to control the exciter. *Navigation Pushbuttons and Exciter Control Pushbuttons* define the pushbutton functions for menu navigation and exciter control (see the figure *Diagnostic Interface - Keypad*).



Display:

Status screens provide analog and digital representation of exciter functions and values.

Menu screens provide text-based access to parameters, wizards, and faults.

Pushbuttons:

Organized into functional groups:

Navigation buttons for using the menu
Exciter Control buttons
Run and **Stop** buttons

Diagnostic Interface - Keypad

Navigation Pushbuttons

Button	Function
Status	Displays the default Status Screen, which shows eight parameters as numbers or bargraphs. A set of Health icons (displayed at all times; see *Exciter Health and State Icons*) provides additional exciter status information.
Menu	If pressed while displaying a Menu screen (see *Menu Selections*), displays the Main Menu. If pressed while displaying a Status screen, displays the last Menu screen. If held down, the up and down arrow keys adjust screen contrast
▲ ▼	Menu Navigation: Used to highlight (reverse image) an item in a menu of options. Adjust Contrast, if menu key is held down. Entry of Numeric Parameter: Used to index through numbers (0-9, ., -) when editing a parameter. Entry of Option Parameter: Used to index through 1 – n choices. (See *Parameter Configuration*.)
◄ ►	Menu Navigation: Right Arrow button displays the next selected level down in a menu tree. Left Arrow button displays next level up in menu tree. Entry of Numeric Parameter: Used to select a digit when editing a parameter. Entry of Option Parameter or Command Execution: Not functional.
Escape	Menu Navigation: Displays the next level up in menu tree. Entry of Parameter: Displays the parameter list.
Enter	Menu Navigation: Displays the next level down in menu tree. Entry of Parameter: Accepts editing of parameter.

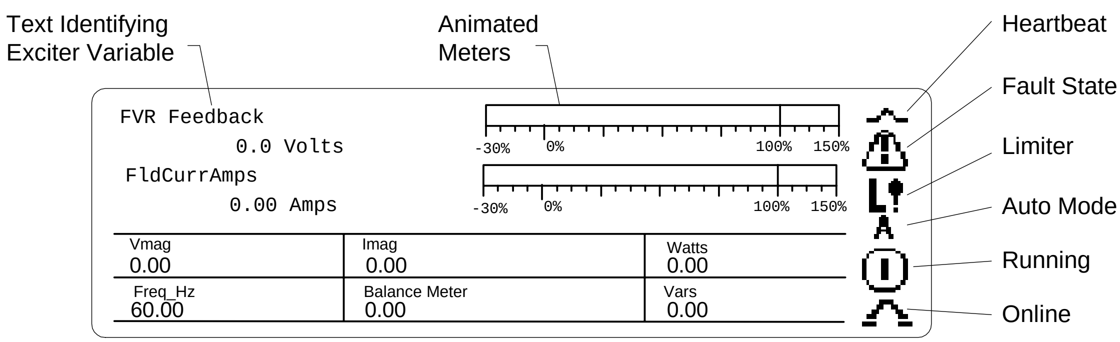
Exciter Control Pushbuttons

Button	Function
Reset Faults	Resets faults
Command Menu	Quick access to a list of commonly used commands
Auto	Selects Auto mode (AC regulator or AVR)
Man	Selects Manual mode (DC regulator or FVR)
+	Increase voltage, VARS, PF
—	Decrease voltage, VARS, PF
I	Run
O	Stop

Reading the Display

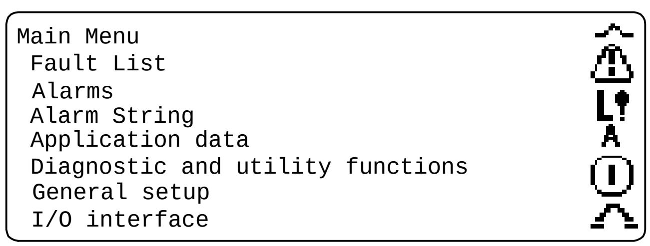
The keypad displays information as both text and animated graphics. There are two types of content screens, selected by pressing the corresponding Navigation button: **Status** and **Menu.**

The **Status Screen** (see the figure *Status Screen Example*) is the default screen that displays after exciter startup, following an initialization screen. It uses animated meters with associated text to present exciter performance data. An alternate status screen can also be accessed (see *Status Screen*).



Status Screen Example

The **Menu Screen** (see the figure *Menu Screen Example*) lists and provides access to menu-based functions for adjusting parameters, running wizards, and viewing faults (see *Menu Selections*).



Menu Screen Example

The **Exciter Health and State Icons** continually show on the right hand side of all display screens. They indicate if the exciter is functioning correctly and show its running state. These icons are displayed in five functional groups, as shown below. You can change the **display units** and adjust the **display contrast**, if needed.

Exciter Health and State Icons

Group	Icon	Indication	Description
Heartbeat		Communications OK	Animated line (its center raises and lowers) shows that there is communication between the keypad and the exciter.
		Communications not established	Animated metronome icon shows that the keypad is attempting to establish communication with the exciter, but cannot.
Control		Auto Mode	Regulates terminal voltage
		Manual Mode	Regulates field voltage
		Test Mode	The exciter is performing a diagnostic test
Fault State	Blank	Exciter OK	When no icon displays, the exciter is operating correctly
		Abnormal	Displayed when there are over-ridden parameters.
		Alarm State	Displayed when an alarm condition occurs
	Blinking	Trip fault	Displayed when a fault state occurs
Status		Stopped	Exciter is stopped
		Running	Exciter is running
		Limiting	Field voltage regulator output is greater than field current regulator or V/Hz or UEL limits are active.
		Offline	Exciter is offline
		Online	Exciter is online

Changing Display Units

➢ **To change the type of measurement units displayed**

1 From the **Main** menu, select **General Setup**.

2 Select **Display Units**.

3 Select the display units parameter to edit it (see below).

4 Highlight, and then select the preferred display units.

```
Press ENTER to accept, ESC to leave

Display units
New Value     = Metric (SI)
Present Value = Metric (SI)
```

Adjusting Display Contrast

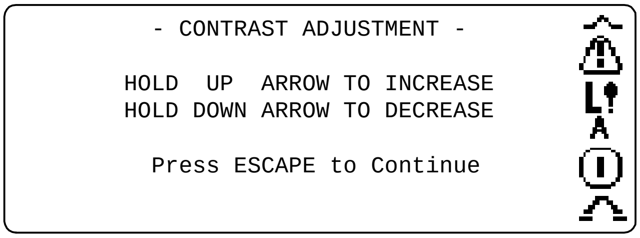
➢ **To adjust the display contrast**

1 From the **Main** menu, select **General Setup**

2 Select **Keypad, Keypad Functions**, and then **Adjust Screen Contrast**

> **Note** Shortcut – Press and hold the **Menu** key. Press the **Up** and **Down** arrows to adjust the display contrast.

3 This displays the following screen.

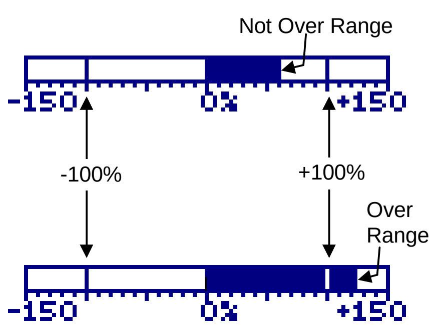


4 Press the **Escape** button to save the contrast value and return to the previous menu.

Status Screen

The status screen displays up to eight variables (parameters). The first two parameters are displayed both in text and animated meters. *Animated Meter Characteristics (Default) for Status Screen* defines the characteristics of the bar graphs for these parameters.

Reading the Meters



Animated Meter Characteristics (Default) for Status Screen

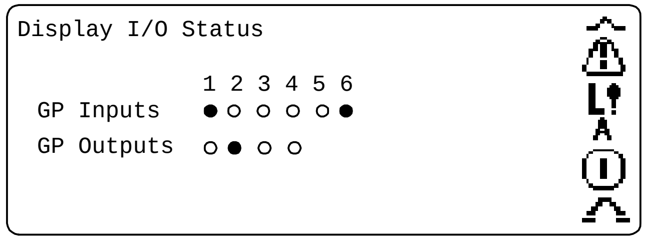
Bar Graph Variable	Numeric Display	Units in Bar Graph
Dc Bus Voltage	Magnitude of dc bus voltage (FVR feedback)	Percentage of dc per unit volts (VDC_PU)
Ac line current	Magnitude of ac line current (I_Mag_Fil)	Percentage of source top-rated current (I_PU)

Alternate Status Screen (Display I/O)

The keypad has an *alternate* status screen that displays the status of the general purpose inputs and outputs. To toggle between the Meter Status screen and the I/O Status screen, press any of the **Arrow** buttons.

The circle under each heading indicates the status of the corresponding I/O variable, as follows:

- ● – True
- ○ – False

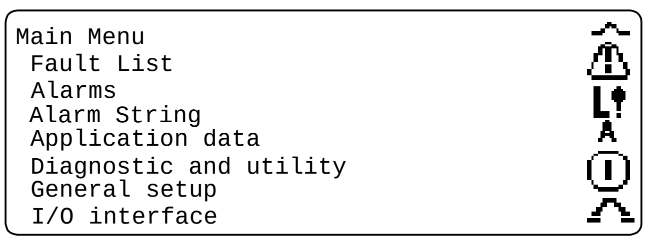


Using the Menus

The main menu of the keypad leads to other menu screens, where you can review or modify data. You can access the main menu from any screen, as follows:

1 If you are already in a *Menu* screen, press the **Menu** button.

2 If you are in a *Status* screen, press the **Menu** button once or twice.



Note The Main Menu selections may vary from product to product.

3 Use the navigation buttons to move through the menus, select items and adjusts values as follows:

- Use **Up** and **Down Arrow** to move through and highlight menu items.
- Press **Enter** to select a highlighted item.
- To return to a previous menu screen, press **Escape, Left Arrow** or follow the instructions on the screen.
- When menu items go beyond the visible region, move to the next screen by highlighting the last item in the screen and pressing **Down Arrow**. When the last menu item is reached, press the **Down Arrow** again to come back to the first item on that menu. Use the **Navigation** buttons to move through the menus, select items, and adjust values

Viewing and Resetting Faults

When the display indicates either a *Trip* or an *Alarm* fault (refer to *Reading the Display*), you can view information and reset (clear) current faults, as follows:

1 From the **Main** menu, select **Fault List**, and then **Display Active Faults**. The following screen displays.

```
        ACTIVE FAULT DISPLAY
 86 Trip     DC Over-current Trip
115 Trip     Bridge 1 Fan 1 BAD
 58 Brief    Low AC V
 95          Field temp alarm
       --- RESET FAULTS NOW ---
```

Note Faults are displayed in order of occurrence with the most recent fault at the top.

2 Refer to GEH-6633 *Troubleshooting, Preventive and Online Maintenance*, for a list of faults.

3 To view detail on a particular fault, select that fault (listed on the *Active Fault Display* screen). The following screen displays.

```
    SELECTED FAULT - PRESS
Low AC V, B
    006:40:11.008
Low AC input volts detected on
the field exciter.
```

4 Reset the faults either of two ways:

– Select Reset Faults Now in the Fault Display screen.

– Press the Reset Faults button.

➢ **To view the exciter's Fault History (a list of previously cleared faults and fault resets)**

◆ From the **Main** menu, select **Fault List**, and then **Display Fault History**.

Note This display list may be multiple screens long.

```
        FAULT HISTORY DISPLAY
  0 Cleared   Fault reset
 86  Trip     DC Over-current trip.
 115 Trip     Bridge 1 Fan 1 BAD
 58 Brief     Low AC V
 95           Field temp alarm

       --- RESET FAULTS NOW ---
```

Editing Parameters

Two types of parameters that can be changed using the keypad are:

- Option parameter lists items (options) for you to select. For example, *True/False* is an option parameter.
- Numeric parameter lists valid digits that you select to create a number.

➢ **To edit a parameter**

1 From an exciter **Parameters** screen, select the parameter that is to be changed.

```
Parameters
GPT_Vrms             =   <No Value>
VHiTripLev           =   1.2
AFFL                 =   100
TripVHiTrip          =   Trip enabled
VFFL                 =   100
100.0
```

2 This displays either an *Option* or *Numeric* parameter screen (see both below) with the *New Value* line highlighted.

3 For an *Option* parameter:

a) Use the **Up** or **Down Arrow** buttons to select a new parameter value.

b) Press the **Enter** button to accept the change or **Escape** to exit and keep the present value.

```
Press ENTER to accept, ESC to leave

TripVHiTrip
New Value     = Trip disabled
Present Value = Trip enabled
```

4 For a *Numeric* parameter:

a) Use the **Left** or **Right Arrow** buttons to highlight the digit to be changed. If you continue pressing the **Left Arrow** button after reaching the left-most digit of the field, the field fills with blanks. Pressing **Enter** when the entire number is blanked out saves a <*No Value*>.

b) Use the **Up** and **Down Arrow** buttons to index through the valid digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, e, ., -). The e in the digit selection represents the start of the exponent in scientific notation. If the e is used, all digits to the right of the e make up the number's exponent.

```
Press ENTER to accept, ESC to leave

VHiTripLev
New Value     =       1.3
Present Value =       1.2
Low Limit     =      0.0000000
High Limit    =   3.4028239e38
```

5 When all the digits are changed, press **Enter** to accept the new value or press **Escape** to exit and keep the present value.

Parameter Backup

It is good practice to keep a backup copy of the working parameter configuration of the exciter. You can then restore this file, if needed, or compare it with a re-configured file to determine differences.

➢ **To save active parameters**

1 From the **Main** menu, select **Parameter Backup Functions**, and then **Save Parameters to Backup**.

```
    Save Parameters to Backup


  Save current parameter values.



Press ENTER to continue.  ESC cancels.
```

Note Each new backup overwrites the previous backup copy, which cannot be restored.

2 Press **Enter** to make a backup copy of the parameters or **Escape** to cancel.

➢ **To restore a parameter from backup**

1 Stop the exciter. (This function cannot be run while the exciter is running.)

2 From the **Main** menu, select **Parameter Backup Functions**, and then **Restore Parameters from Backup**.

```
    Press to restore Parameters from Backup

             -- WARNING --
The active parameter values will be
replaced, and can not be recovered.


Press ENTER to continue.  ESC cancels.
```

3 Press **Enter** to restore the backup parameters or **Escape** to cancel.

Caution

Restoring parameters from a backup file overwrites the currently active parameter values, which cannot then be restored.

➢ **To compare the active parameter set to the backup parameter set**

1 From the **Main** menu, select **Parameter Backup Functions**, and then **Compare Current Parameters to Backup**.

```
   BACKUP DIFFERENCES      <More ↑>
VHiTripLev        = 1.3
   Backup value   = 1.2
AFFL              = 112.0
   Backup value   = 100.0
VFFL              = 110.0
   Backup value   = 100.0
                           <More ↓>
```

2 Use the **Up** and **Down Arrow** buttons to scroll through the list of backup differences.

3 Press **Escape** to return to the previous menu.

Firmware and Hardware Information

➢ **To view the firmware versions for the DSPX board and the keypad**

- From the **Main** menu select **General Setup, Firmware Version & Hardware Info**, and then **Display Firmware Version**.

The following screen displays:

```
         GE Generator Control

        EX2100
DSPX Firmware Version:     V02.06.00B
DSPX Boot Monitor Version: V02.02.00C
DDI  Firmware Version:     V02.00.00B

Press ESC to exit
```

➢ **To view exciter hardware information**

- From the **Main** menu select **General Setup**, **Firmware Version & Hardware Info**, and then **Display Hardware Information**.

  The following screen displays:

```
         GE Generator Control
Hardware Information:
 IS200ESELH1APR 5473716
 IS215ACLAH1AL  8790070
 IS200DSPXH1CAA 7611193
 IS200EMIOH1APR 7360814
 IS200EISBH1APR 5673766   <More ↓>
ESC to exit
```

Protecting the Keypad

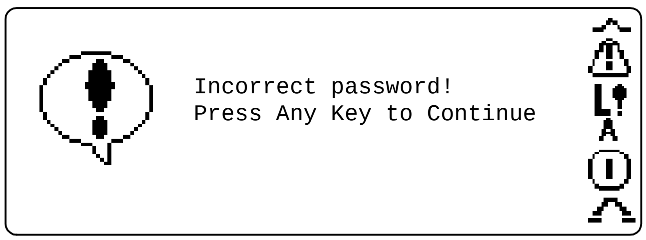
To protect the exciter from unauthorized operation or reconfiguration, the keypad includes two security controls, Password and Privilege Level.

The *Password* is a 5-digit number that protects the password and privilege Level from being changed by unauthorized personnel. The default Password is 00000.

Privilege Level specifies which operational and configuration functions are disabled in the keypad. There are three levels:

- *Read Only* disables both the exciter control and the configuration functions. An operator can view but not edit parameters.
- *Operate & Read Only* enables the exciter control function, but disables configuration functions. An operator can view, but not edit parameters.
- *Configure & Operate* enables both the exciter control and the configuration functions. This is the default setting.

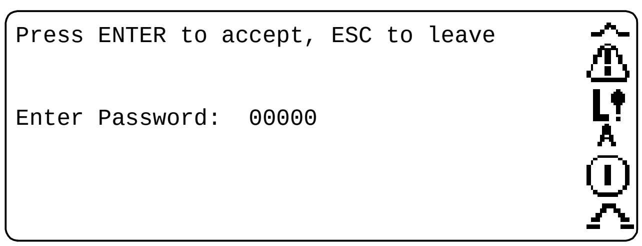
If you try to run a function that is disabled in the active privilege level, the keypad displays the following error message.



Modifying the Protections

➢ **To modify the Password and Privilege Levels**

1 From the **Main** menu, select **General Setup, Keypad**, and then **Keypad Security**.The following screen displays:

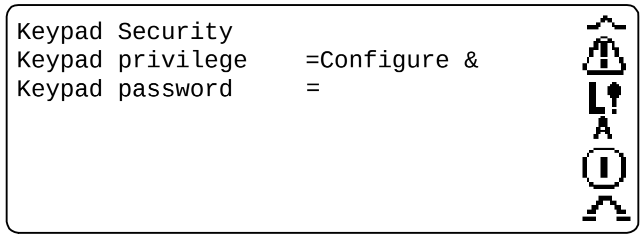


2 Enter the password as follows:

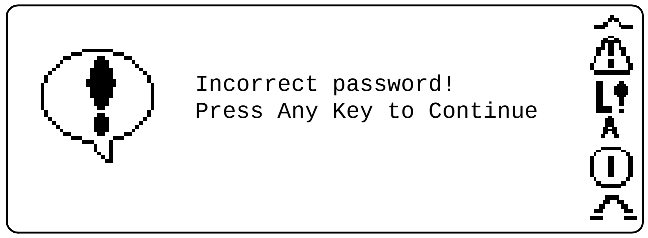
a) Use the **Up** and **Down Arrow** buttons to index through the valid digits (0 through 9).

b) Use the **Right** and **Left Arrow** buttons to move the cursor to the digit to edit.

3 Press **Enter** to accept the password. If the password entered matches the saved password value, you can modify the privilege level or password.



4 If it does not match, the keypad displays an error message.



5 Use the **Up** and **Down Arrow** buttons to select either the privilege level or password.

6 Press **Enter** to edit the parameter. (See **Editing Parameters**.)

Note When you modify the keypad password, be sure to select **Save Parameters To Backup**. Otherwise, the password stored in the active parameter will not match the backup parameter set. That causes the **Compare Current Parameters to Backup** to identify the keypad password parameter as different.

Notes

Appendix A Warranty and Renewal Parts

Introduction

When ordering a replacement part for a GE exciter, the customer needs to know:

- How to accurately identify the part
- If the part is under warranty
- How to place the order

This information helps ensure that GE can process the order accurately and as soon as possible.

To minimize system downtime if repair is needed, GE recommends that the customer keep a set of spare parts on hand. The Renewal Parts Quotation lists recommended spares.

Appendix A of this manual provides information to help the user identify and obtain replacement parts.

Identifying the Part

An exciter component, or part, is identified by its assigned *part number* and *description.* The part number is normally found on a nameplate on the component. The description is included in the system renewal parts list.

Renewal Parts List

The Renewal Parts List is a separate document that lists the parts of a complete system. This list applies specifically to the equipment furnished on a customer's particular application (requisition) at the time of shipment. It includes:

- Part numbers and descriptions
- Quantity used
- Recommended spares to keep on hand
- Normal delivery cycle for obtaining each part

GE provides the Renewal Parts List with the exciter's custom instructions. If this document is missing, contact the nearest GE sales office or service representative to obtain a replacement copy. You need to provide the following information to correctly identify the system:

- Requisition number
- Model number

Part Number Structure

A GE part number is structured so that different portions of the number identify the *type of equipment* and *location of manufacture*. A part falls into one of four categories:

- Order-specific assemblies – Major assemblies or items that make up a specific exciter, constructed from common assemblies
- Common assemblies – Subassemblies used in many GE exciter products, not just a specific exciter
- Components – Individual parts that make up assemblies
- Printed circuit boards

These categories and the makeup of their part numbers are defined under *Order Specific Assemblies*.

Order Specific Assemblies

These parts make up the particular exciter. Other items obtained specifically for the order may also use a similar part number structure, which provides information about the equipment.

3V AAA 123 XX###

Unit & sequence number of components:

Sequence/project

Order month/year/ product line

Unique to req'n

Identifies manufacturer as GE Industrial Systems, Salem, VA

Sample Part Number for Order-Specific Assembly

Common Assemblies

Common assemblies are subassemblies used as components of order-specific assemblies. Common assemblies are not designed for a particular exciter, but provide a function used in other GE products.

For example, *36C774524AAG48* is the part number for a cable.

Components

Components are the basic parts that make up assemblies. They represent the lowest discrete level of a system. Component part numbers consist of a combination of alphanumeric characters that define the class and specific item. A sample number is shown below.

104X 109 1ADO38

Item or rating (500 V, 3.2 A FNQ)

Component type (fuse)

Component

Sample Part Number for Component

Printed Circuit Boards

A printed circuit board is identified by an alphanumeric part (catalog) number stamped near its edge. The structure of a board's part number is described below.

Note All digits are important when ordering or replacing any board. The factory may substitute later versions of boards based on availability and design enhancements. However, GE Energy ensures compatibility of replacement boards.

IS 200 DSPX G# A A A

- A — Artwork revision [1]
- A — Functional revision [1]
- A — Functional revision [2]
- G# — Group (variation, G or H)
- DSPX — Functional acronym
- 200 — Assembly level [3]
- IS — Manufacturer (*DS* & *IS* for GE in Salem, VA)

[1]Backward compatible
[2]Not backward compatible
[3]*200* indicates a base-level board; *215* indicates a higher-level assembly or added components (such as PROM)

Sample Board Part Number

Warranty Terms

The GE *Terms and Conditions* brochure details product warranty information, including warranty period and parts and service coverage. The brochure is included with customer documentation. It may be obtained separately from the nearest GE Sales Office or authorized GE Sales Representative.

Note Standard warranty is 18 months from shipment or 12 months from when power is first applied, whichever comes first.

How to Order Parts

Renewals (spares or those not under warranty) should be ordered by contacting the nearest GE Sales or Service Office, or an authorized GE Sales Representative. Be sure to include:

- Complete part number, located in the renewal parts list
- Part name
- Exciter model, located in its nameplate

Data Nameplate

The data nameplate is located on the back of the cabinet door. It provides information needed when ordering parts or contacting GE for assistance.

ML Number

Each GE lineup, cabinet, and core unit has a unique identifying catalog number, also called the part or material list (ML) number. This number is structured to provide information about that equipment. The catalog number links the equipment to its requisition, drawings, components, materials, specification item, and shipping documents.

3V AAA 123 XX###

- XX### — Unit & sequence number of components:
  - CA## = Case assembly
  - CD## = Core dc drive controller
  - CI### = Core ac drive controller
  - LU### = Lineup, multiple case assembly
  - PN## = Panel assembly
  - RL## = Requisition-level assembly
- 123 — Sequence/project
- AAA — Order month/year/ product line

Sequence/project and Order month/year/product line: Unique to req'n

- 3V — Identifies manufacturer as GE Energy, Salem, VA

Sample Exciter ML (Catalog) Number

Appendix B Ratings and Specifications

Caution

The actual equipment rating is on your exciter nameplate. This appendix indicates the range of possible product offerings but not necessarily the capability of your exciter.

EX2100 SCR	Approximate Exciter Current Capability	PCM Type	Number of PCMs	Number of Shipping Splits	Approximate Weight (pounds)	Approximate Dimensions (l x w x h)(inches)
42 mm	165 A dc	Simplex or WBU, Conv.	1	1	1875 lbs (simplex)3200 lbs (wbu)	71 x 31.5 x 104.5 (simplex)
42 mm	500 A dc200 A dc (PMG)	Simplex or WBU, Forced	1	1	1875 lbs (simplex)3200 lbs (wbu)	118.5 x 31.5 x 104.5 (WBU)
53 mm	1000 A dc	Simplex or WBU	1 or 2	1	4000 lbs (simplex) 5600 lbs (wbu)	112 x 31.5 x 104.5 (simplex, no aux)
77 mm	2000 A dc	Simplex or WBU	1 or 2	1	4000 lbs (simplex) 5600 lbs (wbu)	142 x 31.5 x 104.5(wbu)
100 mm	2800 A dc	Simplex or WBU	1 or 2	2	17400 lbs(2 PCM)	198.5 x 48.5 x 106(2 PCM)
100 mm	6000 A dc	N+1 or N+2	3 or 4	2	20925 lbs(3 PCM)	236 X 48.5 x 106 (3 PCM)
100 mm	8000 A dc	N	4	2	24450 lbs(4 PCM)	275.5 x 48.5 x 106(4 PCM)

EX2100 Specification	Description
Power Conversion Module (PCM)	
Forcing requirements	150% of design Amperes (EDA) for 30 sec at 40ºC standard. Other requirements available with evaluation.
Power Sources	
Power for the PCM – Voltage source	Auxiliary bus (potential source)Generator terminals (potential source)Compound Source (generator terminals and power current transformers)PMG source (300 V ac)600 or 1000 V or 1400 V versions available
Power for the PCM - Frequency	3-phase 50/60 Hz (Up to 480 Hz for 42 mm PMG source)
Power to the Cooling Fans 42 mm 53 mm and 77 mm 100 mm	40 W per fan at 115 v ac, single phase, 50/60 hz 400 W per fan at 125 V ac single phase, 50/60 hz 1700 W per fan at 480 V ac, three phase, 50/60 hz
Flashing power	125-250 V dc battery source, with up to 200 A for at least 10 s 380-480 V ac, 50/60 Hz single-phase auxiliary source
Control power (redundant with 2 bridges, warm backup)	For two ac sources, or one ac and one dc source Nominal 120 V ac ±15%, with 1 DACA, 8 A rms max. Optional 220 V ac ± 1590 , with 1 DACA 6 A rms max. Battery source 125 V dc, range 80-140 V dc, 10.6 A dc max.

EX2100 Specification	Description	
Control power (simplex controls and bridges)	For two ac sources, or one ac and one dc source Nominal 120 V ac ±15%, with 1 DACA, 4 A rms max. Optional 220 V ac ± 1590, with 1 DACA 3 A rms max. Battery source 125 V dc, range 80 - 140 V dc, 4 A dc max.	
Heat loss in single PCM cabinet	Specific to requisition. Provided on unit outline drawings.	
Input/Output	**QTY**	
Potential transformers (PTs)	2	3-phase standard, single-phase available 120 V ac nominal 1 VA nominal burden
Current transformers (CTs, 1 or 5 A)	2	Any two phases standard, single-phase or redundant available 1 VA nominal burden
86G dedicated contact input	1	Open for trip
52G dedicated contact input	1	Closed for online
Trip rated contact outputs	2	At 125 V dc the relay break characteristics are: Resistive load 0.5 A Inductive load 0.2 A
General Purpose contact inputs	6	Customer contact, 70 V dc supplied by ECTB
General Purpose Form C contact outputs	4	At 125 V dc the relay break characteristics are: Resistive load 0.5 A Inductive load 0.1 A
± 10 V differential amplifier input 4-20 mA isolated analog output	14	Optional, through Din-rail signal conditioners
Control		
Automatic ac Voltage Regulation	Proportional + Integral, software implemented± 0.25 % over full voltage range	
Manual dc Voltage regulator	Proportional + Integral, software implemented± 2.0 % over full voltage range	
Protection Features	Under Excitation Limiter, (UEL) Over Excitation protection (76) Generator Field Ground detection (64F) Generator Overvoltage protection (24G) Loss of Excitation protection (40) V/Hz limit (24) and trip (24T) Bridge Over Temperature (26) Field Over Temperature (49) Phase Unbalance (22) PT Failure (60)	
Environmental Control & Protection		
Operating Temperature	Continuous operation in a 0 to 40ºC ambient environment. Operation to 50ºC with 0.85% per ºC (100 mm, 77 mm, 53 mm), 1% per ºC for fan cooled 42 mm, 1.5% per ºC convection cooled 42 mm.	
Storage Temperature	-40 ºC to +70 ºC	
Humidity	5 to 95% humidity, non-condensing	
Altitude	Normal operation at 0 to 1000 m. Derate 6% per 1000 m above 1000 m	
Cooling	Forced-air cooling required for all PCM cabinets except 42mm when supplied convection cooled.	
Contaminants, withstand 10 PPB of these:	Reactive Sulfur, Reactive Chlorine, Hydrogen Sulfide, Sulfur DioxideChlorine Dioxide, Sulfuric Acid, Hydrochloric Acid, Hyrdogen Chloride, Ammonia	
Vibration		
Seismic	Universal Building Code (UBC) 1997 – Seismic Code section 2312 Zone 4	
Sinusoidal	0.075 mm displacement from 10 to 57 Hz & 1 g from 57 to 150 Hz in each of three mutually perpendicular axes	
Cabinet		
Cabinet type, control & auxiliary	NEMA 1 (IEC IP 20), convection cooled	
Cabinet type, power conversion	NEMA 1 (IEC IP 20), forced air cooled	
Power and Control Cable Access	Entrances from the top and/or bottom	

EX2100 Specification	Description
Reliability	
MTBF - Mean Time Between Failures	Simplex system 49,000 hrs
MTBF - Mean Time Between Failures	Redundant system (77 mm, 53 mm, 42 mm) 183000 hrs.
MTBF - Mean Time Between Failures	Redundant system (100 mm) 175,000 hrs
MTTR - Mean Time to Repair	Any subsystem 4 hrs
Generated Acoustic Noise	
42 mm Convection	Average 60.1 dB
42 mm Fan cooled (2 fans)	Average 77.2 dB
53 mm Fan cooled (4 fans)	Average 76.4 dB simplex, Average 78.4 dB redundant
77 mm Fan cooled (6 fans)	Average 76.6 dB simplex, Average 79.6 dB redundant
100 mm Fan cooled, 60 Hz, 480 V rms	Average 82.7 dB wbu, Average 83.2 dB (3 bridge), Average TBD dB (4 bridge)
100 mm Fan cooled, 50 Hz,380 V rms	Average 78.2 dB wbu, Average 78.9 dB (3 bridge), Average TBD dB (4 bridge)
100 mm Fan cooled, 50 Hz,400 V rms	Average 78.4 dB wbu, Average 79.0 dB (3 bridge), Average TBD dB (4 bridge)
Codes and Standards	
Safety Standards	
UL 508C	Power Conversion Equipment
CSA C22.2 No. 14	Industrial Control Equipment
CSA C22.2 No. 0.4	Grounding and Bonding of Electrical Equipment
IEC 60529	Enclosure Degrees of Protection/ IP20/NEMA 1
IEEE 421.3	High-Potential Test Requirements for Excitation Systems
Printed Circuit Board Assemblies	
UL 796	Printed Wire Boards
ANSI / IPC / EIA	Guidelines
Electromagnetic Compatibility Directive (EMC) 2004/108/EC	

Attention

Equipment is not approved for use in a residential, commercial or light industrial environment and should not be connected to a residential electric power network.

EN 61000-6-4:2001	Generic Emissions Industrial Environment
EN 61000-6-2:2001	Generic Immunity Industrial Environment
EN 61000-4-2:1995	Electrostatic Discharge Susceptibility
EN 61000-4-3:2006	Radiated RF Immunity
EN61000-4-4:2005	Electrical Fast Transient Susceptibility
EN 6100-4-5:2006	Surge Immunity
EN 61000-4-6:1996	Conducted RF Immunity
EN 61000-4-11:2004	Voltage Dip, Interruptions and Fluctuations
Authorized Representative and Responsible Person	
Eurolink (Europe) Ltd.	
Avalon House	
Marcham Road	
Oxfordshire OX14 1UD UK	
Low Voltage Directive 2006/95/EC	
EN 50178	Electronic Equipment for use in Power Installations

Notes

Glossary of Terms

6U

Full height Versa Module Eurocard (VME) board

application code

Software that controls the machine or process, specific to the application.

ASCII

American Standard Code for Information Interchange. An 8-bit code used for data.

automatic voltage regulator (AVR)

AVR is controller software that maintains the generator terminal voltage through the Field Voltage Regulator..

auxiliary source

A source of three-phase ac power for the exciter, but not from the generator being controlled.

baud

A unit of data transmission. Baud rate is the number of bits per second transmitted.

BIOS

Basic input/output system that performs the controller startup, which includes hardware self-tests and the file system loader.

bit

Binary Digit. The smallest unit of memory used to store only one piece of information with two states, such as One/Zero or On/Off.

block

Instruction blocks contain basic control functions, which are connected together during configuration to form the required machine or process control. Blocks can perform math computations, sequencing, or regulator (continuous) control.

board

Printed circuit board

bumpless

No disruption to the exciter when transferring control.

bus

Upper bar for power transfer, also an electrical path for transmitting and receiving data.

byte

A group of binary digits (bits); a measure of data flow when bytes per second.

CMOS

Complementary metal-oxide semiconductor.

COM port

Serial controller communication ports (two). COM1 is reserved for diagnostic information and the Serial Loader. COM2 is used for I/O communication.

configure

To select specific options, either by setting the location of hardware jumpers or loading software parameters into memory.

crowbar

The crowbar limits the high negative voltages that can be induced into the PCM during a pole slip (loss of synchronism) event. It includes a discharge resistor, and is self firing.

CT

Current Transformer, used to measure current in an ac power cable.

DACA or DACB

Ac to dc converter for power supply, produces 125 V dc.

DCS (Distributed Control System)

Control system, usually applied to control of boilers and other process equipment.

de-excitation

The de-excitation circuit produces a conduction path through a discharge resistor or inductor to dissipate the field current after a unit trip.

device

A configurable component of a control system.

DRAM

Dynamic Random Access Memory, used in microprocessor-based equipment.

EGD

Ethernet Global Data, a control network and protocol for the controller. Devices share data through EGD exchanges (pages).

EMI

Electro-magnetic interference; this can affect an electronic control system.

EPBP Backplane

Exciter Power Backplane holds power supply modules, ground detect modules, and connectors for power distribution.

EPDM

Exciter Power Distribution Module distributes 125 V dc to the power supplies.

Ethernet

LAN with a 10/100 M baud collision avoidance/collision detection system used to link one or more computers together. Basis for TCP/IP and I/O services layers that conform to the IEEE 802.3 standard.

EX2100 Exciter

GE static exciter; regulates the generator field current to control the generator output voltage.

fanned input

A termination board input that is connected to all three redundant controllers.

fault code

A message from the controller to the HMI indicating a system warning or failure.

field flashing

The supply of initial exciter current during startup, usually from station batteries.

field ground detector

The field ground detector is an active circuit that detects a ground in either the ac or dc sections of the exciter and field wiring.

field voltage regulator (FVR)

FVR is controller software that maintains the generator terminal voltage using inputs from the Automatic Voltage Regulator (AVR) and the field voltage feedback.

firmware

The set of executable software that is stored in memory chips that hold their content without electrical power, such as EEPROM or Flash.

flash

A non-volatile programmable memory device.

FVR

Field Voltage Regulator, software controlling the voltage across the field.

gating

Controlling the conduction of the power SCRs with an input pulse train (or a voltage).

health

A term that defines whether a signal is functioning as expected.

heartbeat

A signal emitted at regular intervals by software to demonstrate that it is still active.

HMI

Human Machine Interface, usually a computer running Windows NT and CIMPLICITY HMI software.

hot backup

Two bridges are used but only one is connected to the field, the other (the backup) is connected to a small dummy load. If the active bridge fails it is disconnected from the field by relays, and the backup is connected.

I/O

Input/output interfaces that allow the flow of data into and out of a device.

I/O drivers

Software that interfaces the controller with input/output devices, such as communication networks, sensors, and solenoid valves.

ICS

Integrated Control System. ICS combines various power plant controls into a single system.

IEEE

Institute of Electrical and Electronics Engineers. A United States-based society that develops standards.

IP address

The address assigned to a device on an Ethernet communication network.

line filter

Filter networks across the three-phase input lines to the exciter to minimize the voltage spikes that result from the abrupt decay of current during SCR commutations.

logical

A statement of a true sense, such as a Boolean.

LS2100 Static Starter

Electric power device that runs the generator as a motor to bring a gas turbine up to starting speed.

Mark* VI turbine controller

A control system hosted in one or more VME racks that performs turbine-specific speed control, logic, and sequencing.

Modbus

A serial communication protocol developed by Modicon, which can be used between PLCs and other computers.

multiple bridges

Several power producing bridges operate in parallel to produce a high field current. These share the exciter current load to provide redundancy and increased reliability.

NEMA

National Electrical Manufacturers Association; a U.S. standards organization.

non-volatile

Memory specially designed to store information even when the power is off, for example Flash memory.

OLR

On-Line Repair, capability provided by redundant control elements.

over-excitation limit (OEL)

OEL software limits the excitation current to prevent overfluxing the generator.

Permanent Magnetic Generator (PMG) source

Power used by the exciter to excite the main generator field is taken from a PMG connected to the generator shaft. The PMG typically produces 400-480 Hz 3-phase output.

power conversion module (PCM)

The PCM or Bridge consists of six thyristors connected in a three-phase bridge, with associated protection and control devices, to generate the dc field voltage.

power current transformer (PCT)

A PCT can be attached to the generator line to provide a portion of the three-phase power for the exciter, part of a compound source.

power distribution module (EPDM)

The PDM distributes 125 V dc to the power supplies for the controllers and I/O termination boards.

power potential transformer (PPT)

A PPT is attached to the generator terminals or an auxiliary bus to provide three-phase power for the exciter; referred to as a potential source.

power system stabilizer (PSS)

PSS software produces a damping torque on the generator to reduce generator oscillations.

product code (runtime)

Software stored in the controller's Flash memory that converts application code (pcode) to executable code.

PRV

Peak Reverse Voltage is limited with pole slip resistors, wired across the SCRs.

PT

Potential Transformer, used for measuring voltage in a power cable.

real-time

Immediate response, referring to control systems that must respond instantly to changing conditions.

reboot

To restart the controller or toolbox.

Redundant

A system containing of duplicated components (boards or modules), which can transfer functionality from a failed component to one of the duplicate components without loss of the entire system's functionality.

relay ladder diagram (RLD)

A ladder diagram represents a relay circuit. Power is considered to flow from the left rail through contacts to the coil connected at the right.

RFI

Radio Frequency Interference; this is high frequency electromagnetic energy which can affect the control system.

RTD

Resistance Temperature Device, used for measuring temperature.

runtime

See product code

runtime errors

Controller problems indicated on the front cabinet by coded flashing LEDs, and also in the Log View of the toolbox.

sampling rate

The rate at which process signal samples are obtained, measured in samples/second.

serial loader

Connects the controller to the toolbox computer using the RS-232C COM ports. The Serial Loader initializes the controller flash file system and sets its TCP/IP address to allow it to communicate with the toolbox over Ethernet.

server

A computer, which gathers data over Ethernet from plant devices, and makes the data available to computer-based operator interfaces known as Viewers.

shaft voltage suppressor

The shaft voltage suppressor is a filter that conducts to ground the high frequency components of the induced voltages in the field current.

signal

The basic unit for variable information in the controller.

simplex

System with only one set of control and I/O modules. Contrast with redundant control systems.

simulation

Running the control system using a software model of the generator and exciter.

SOE

Sequence of Events, a high-speed record of contact closures taken during a plant upset to allow detailed analysis of the event.

Static Exciter

Produces a controlled dc field current without the use of a rotating generator.

TCP/IP

Communications protocols developed to inter-network dissimilar systems. It is a defacto UNIX standard, but is supported on almost all systems. TCP controls data transfer and IP provides the routing for functions.

TMR

Triple Modular Redundancy. An operation that uses three sets of control and I/O (channels M1, M2, and C) and votes the results.

toolbox

A Windows-based software package used to configure the EX2100 and Mark* VIe turbine controller.

under-excitation limit (UEL)

UEL software functions to prevent generator over-heating caused by under excitation.

unit data highway (UDH)

Connects the EX2100, Mark* VIe turbine controllers, LS2100, PLCs, and other GE provided equipment to the HMI servers; runs at 10/100 Mbaud and supports peer-to-peer communications.

V/Hz

V/Hz is the ratio of generator voltage to the frequency; this is limited to prevent overfluxing the generator.

VME Board

Versa Module Eurocard, a European standard for printed circuit boards and backplane.

warm backup

Two bridges are connected to the field but only one is actively producing power. The other bridge does not receive gating pulses until it is required to take over from the active bridge.

Windows NT

Advanced 32-bit computer operating system from Microsoft.

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