



DECS-2100 Digital Excitation Control System

APPLICATION

The DECS-2100 is the next generation multi-microprocessor digital excitation control system that provides advanced technology to precisely control, protect, and monitor synchronous generators and motors, for new and existing applications that are driven by all types of prime movers, such as steam, gas, hydro, and diesel. Its multifunctional design allows the DECS-2100 to operate as a voltage regulator or as a static exciter, providing excitation currents up to 10,000 Adc on systems ranging from 1 to 1300 MW.

FEATURES

- Multi-Microprocessor based DECS-2100 Digital Excitation Control System
- $\pm 0.1\%$ Voltage Regulation Accuracy
- Control Modes with Auto-following and Dual Gain Settings
 - AVR
 - VAR
 - PF
 - Manual (Field Current and Voltage)
- Dual Channel and Dual Channel with Supervisory Control (options)
- Six-SCR Power Rectifier Bridges - Fixed and Drawer Type (options)
- Power drawers with online maintenance capabilities in an N+1 configuration
- Multi-Bridge paralleling configurations up to 10,000 Adc
- Field forcing levels up to 1500 Vdc
- High Initial Response Per IEEE 421.2
- Patented Rectifier Bridge Active Temperature Balance Algorithm
- Integrated Dual Input Power System Stabilizer IEEE Type 2 (optional)
- Negative Field Forcing for best system performance
- High-Side Voltage Regulation Mode
- Multiple protection and limiting functions with on-line and off-line settings
- Built-in Exciter/Main Field Ground Protection (64F)
- Interactive Display Panel (IDP-1200) for local and/or remote monitor and control
- BESTCOMS™ Pro, an extremely flexible software configuration program for setup and testing
- Real-Time Monitoring of up to 6 parameters
- Sequence of Events (SOE) Recording
- Simulation mode for configuration and testing
- Auto-Synchronizing (optional)
- Auto-Tuning feature calculates preliminary gain settings
- Multi-Port Ethernet communication capability
- IRIG-B time synchronization
- USB communication allows for removable storage media up/download
- 61850 Protocol Compliance (optional)
- Programmable input/output terminations
- Programmable Sequencing provisions

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DESCRIPTION

The Basler DECS-2100 Digital Excitation System is designed to provide digital voltage regulation, control, protection, and monitoring functions for a synchronous generator or motor. It achieves high levels of performance through a multiple microprocessor-based platform using digital signal processing for required computational speed of advanced control functions and algorithms. The DECS-2100 can be scaled to generation units of all sizes with minimal changes except to the power electronics and the excitation power potential transformer. Its software tool, BESTCOMS™ Pro, is used to change settings for the various limiting and protection functions, download new system firmware, and retrieve diagnostic information.

The Basler system consists of one or more thyristor power converters, each with its own digital firing control. A single

converter or multiple converters operate with single-channel or multi-channel control logic for increased reliability. Operator control can be provided through a single-cable interconnection to a local and/or remote Interactive Display Panel (IDP-1200), interface to PLC, SCADA, plant DCS (Distributed Control System), or traditional discrete switches and meters.

Power to the DECS-2100 can be supplied via a power potential transformer (PPT) from the generator terminals with field flashing for black start applications. Alternately, power to the DECS-2100 Digital Excitation Control System can be taken from a reliable three-phase, 50 or 60 Hz station auxiliary source or from a Permanent Magnet Generator (PMG) with a frequency up to 500 Hz.

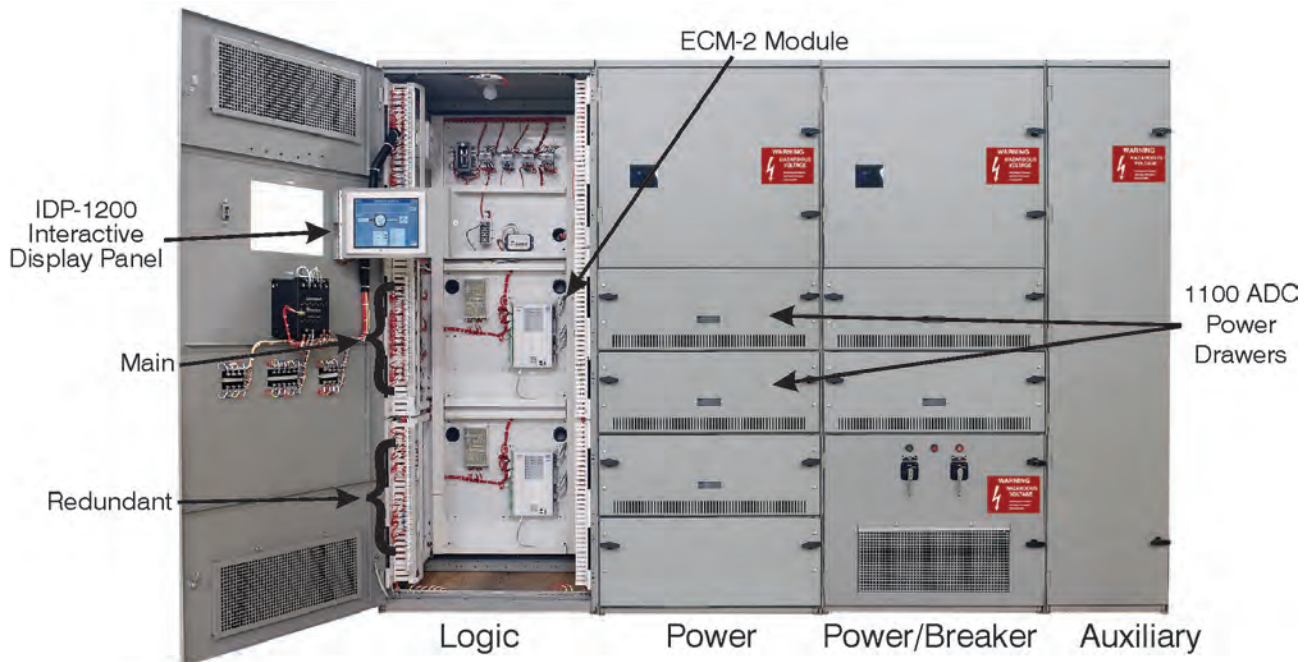


Figure 1 - Typical Dual Channel Five Power Drawer DECS-2100

STANDARD SYSTEM FUNCTIONAL DESCRIPTION

General

The design of the DECS-2100 Digital Excitation System creates flexibility in the system architecture to be better suited in meeting all the needs of your most stringent applications. Proposed configurations include a single-channel system and alternatives for a dual-channel or three-channel system with each type of system capable of using redundant power converters. The cabinet lineup includes a logic cabinet and the required number of cabinets for the power converters and auxiliary devices. See Fig. 1. It should be noted that not all items will be utilized in all applications; therefore, some components may only be applicable to certain applications. It is recommended to discuss specific options with Basler Electric's Application Specialists.

DIGITAL VOLTAGE REGULATOR CHANNEL CONTROL LOGIC (HARDWARE)

Excitation Control Module (ECM-2)

The Excitation Control Module (ECM-2) is the next generation of optimal performance, flexibility, and reliability of excitation control systems packaged in a single controller.

The ECM-2 contains the intelligence to implement all of the regulators, limiters, protection, communication, and system functions, along with integrating the firing command and sensing/metering input quantities for precise control.

Each system utilizes one ECM-2 module per channel. The function of a module as a main controller or a redundant

STANDARD SYSTEM FUNCTIONAL DESCRIPTION

controller is selectable in the software of its microprocessors. The software functions/settings are stored in nonvolatile flash memory. ECM-2 modules in dual channel or with supervisory configuration also offer protection schemes to detect or announce when failures occur from within or outside the excitation system to aid troubleshooting and recovery time.

The ECM-2 has the capability to synchronize the system clock using either Network Time Protocol (NTP) or IRIG-B time code format and standards within 1ms, with any failure to synchronize indicated by alarm status.

The ECM-2 generates a firing command signal while gathering signals from the Field Isolation Transducers (FIT) for field voltage and the excitation transformer (PPT) secondary voltage.

Each module contains 24 analog-to-digital converters for taking measurements from these transformers and other inputs. Fiber optic connections are made from the ECM-2 to expansion lower-speed analog (AIOM) and digital (DIOM) input/output modules.

CONTROL CHANNEL OPTIONS

Each ECM-2 control channel with redundant power supply interfaces through fiber optic cable to the firing control of one or more thyristor power converters. Each power converter is equipped with its own Bridge Control Module (BCM) that provides digital firing pulses. See Fig. 2.

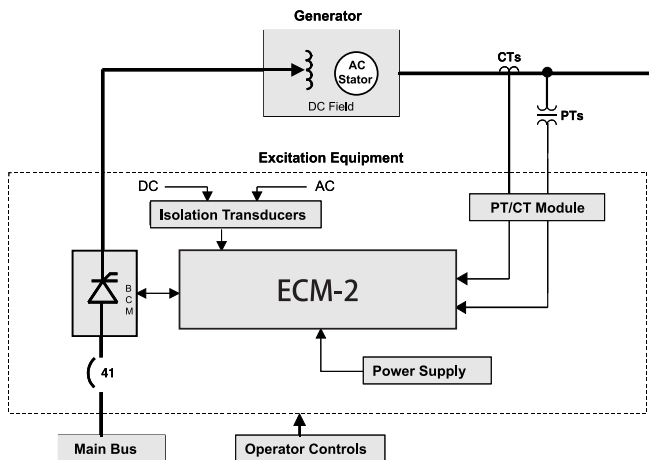


Figure 2 - DECS-2100 One-Line Diagram, Single Channel Control Scheme

Dual-Control Channel System

Should the internal diagnostics in the main channel detect a failure, an external relay will be energized, which in turn will direct the BCM to ignore the control signal from the other channel. A remote switch may be used to transfer control from the main to redundant channel for maintenance. See Fig. 3.

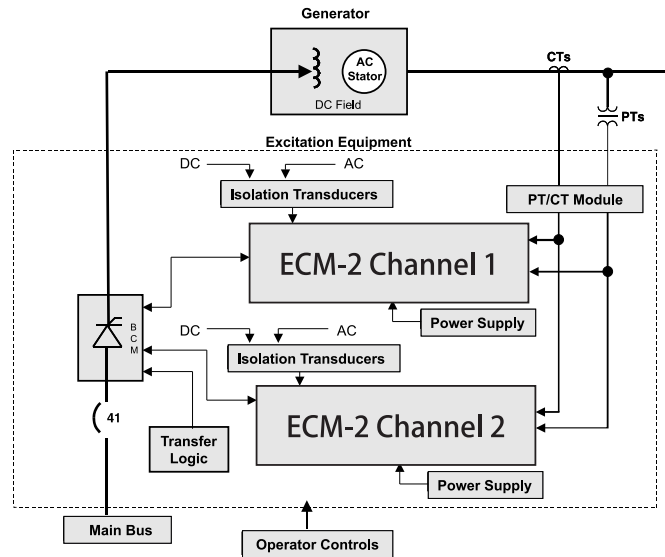


Figure 3 - DECS-2100 One-Line Diagram, Dual Channel Control Scheme

Dual-Control Channel with Supervision

The three-channel system consists of the dual-channel configuration plus a third channel that supervises the other two. All three channels monitor limiting and protection functions. When conditions call for a unit trip, the combined logic of the three controllers using two-of-three voting logic determines when the unit is tripped. This two-out-of-three voting process with the third channel (Supervisory) is also used to determine which of the dual channel controllers is selected to be in control and regulate the generator's output.

POWER SECTION DESCRIPTION

Digital Firing Logic

Digital firing control of the thyristor bridges in the DECS-2100 utilizes field programmable gate arrays that are supervised by a microprocessor with diagnostic capabilities located on each Bridge Control Module (BCM).

Monitoring functions of each BCM include the conduction of thyristors, the temperature of the bridge, and a magnitude of bridge current feature.

Each power converter is a three-phase, six-pulse, thyristor-controlled full converter whose ac input line frequency can be in the range of 5 to 500 Hz. A range of Power Converters are available to accommodate excitation forcing requirements up to 1500 Vdc.

Analog Firing Output

The ECM-2 also contains analog firing capability via two channels to provide 4-20 ma or ± 10 Vdc output signals for firing of external bridges.

STANDARD SYSTEM FUNCTIONAL DESCRIPTION, continued

Active Temp Balance

The patented active temp balancing algorithms (known as "Skip Firing") are preferred for multi-bridge schemes. By monitoring the temperature of each SCR in the Power Converter, this special algorithm facilitates an electronic method for rectifier bridge current firing. This unique approach allows total excitation currents to reach up to 10,000 A dc continuously, and helps ensure a long life expectancy for each of the power components.

Power Redundancy

The DECS-2100 is configured to optionally add an additional operating power converter (N+1 configuration) and associated BCM.

Although fixed designs are available, the preferred power converter bridge design is constructed of drawout, compact module subassemblies that can be electrically isolated to facilitate maintenance under full load (in an N+1 configuration). This permits easy removal of a complete power converter for repair. These modular bridges are stacked to limit the cubicle floor space required for the DECS-2100 Digital Excitation Control System.

Thyristor Protection

RC snubber networks protect the thyristors against excessive rate of change of current and voltage. Nonlinear resistor assemblies protect against excessive transient reverse voltage. For large static exciter systems, ac line filters are typically used. Thyristor overtemperature is monitored by thermal sensors (RTD's) embedded in the heatsinks.



Figure 4 - 1100 A dc Power Drawer

Cooling System

For drawout converters, a main fan with a backup fan supplies forced-air cooling. An automatic fan transfer circuit is included should the main fan fail and the fan assembly is designed to allow for removal under load.

SYSTEM OPERATION

Regulation Modes

A variety of feedback control functions can be implemented to hold the particular regulated quantity at a set point. The set point is adjustable by operator action. The regulator gain, range of the set point, and the slew rate of the set point are adjustable for all regulators. Transient gain reduction is included with each regulator channel for the static applications and Proportional, Integral, and Derivative (PID) gain control is also available.

There are four regulation modes of operation that can utilize the various feedback control functions.

Automatic Voltage Regulation Mode

In this mode, the DECS-2100 maintains the generator's voltage to <math><0.1\%</math> of the set point from no load to full load of the generator. High-side voltage regulation mode is also available with some configurations.

Manual Regulation Mode – Generator/Exciter Field Current

When the system is in this mode, the generator/exciter field current is regulated by the DECS-2100 to within $\pm 0.5\%$ of the generator/exciter field current (5% no-load to 125% full-load).

Manual Regulation Mode – Generator/Exciter Field Voltage

When the system is in the Manual Regulation-Generator/Exciter Field Voltage mode, generator/exciter field voltage is held to within $\pm 0.5\%$ of the generator/exciter field voltage (5% no-load to 125% full-load).

VAR Control Mode

In VAR Control mode, the system maintains the average VAR output of the generators output within $\pm 0.5\%$ for -100% to +100% of the MVA rating.

Power Factor Control Mode

In Power Factor (PF) Control mode, the system holds the average power factor within $\pm 0.5\%$ for -0.5 to -1.0 leading and 0.5 to 1.0 lagging.

Operating Mode Set Point Followers

The Set Point Followers function provides a virtually bumpless change in the newly regulated quantity when a transfer is made from automatic voltage regulation to manual regulation and from manual regulation to automatic regulation under steady conditions.

The var/power factor controller takes raise or lower signals and generates the referenced set point for the automatic var/power factor regulator. The adjuster followers (when enabled) operate to raise or lower this reference set point until the difference between the automatic voltage regulator and automatic var/power factor regulator error signals is within a desired deadband.

Programmable Sequence Control (PSC)

Programmable Sequence Control (PSC) is the BESTCOMS™ Pro software function that performs startup, running, and shutdown control of the DECS-2100 Digital Excitation Control System.

STANDARD SYSTEM FUNCTIONAL DESCRIPTION, continued

HARDWARE AND SOFTWARE FEATURE DESCRIPTION

Digital I/O Module (DIOM)

The purpose of the Digital Input / Output Module (DIOM) is to provide a means to interface the DECS-2100 excitation control system with external devices. Each DIOM has the capability to sense twelve digital inputs ($\pm 24 - 125$ Vdc or 120 Vdc).

Eight digital form C relay outputs are also provided on each module. The digital outputs are each connected to form C relays with ratings of 10 A, 120 Vac or 10 A, 30 Vdc. These outputs are used to drive external relays and indicator lights, or to interface with DCS's and PLC's. Each DECS-2100 control channel may be equipped with a maximum of four DIOMs that are connected using an isolated bi-directional fiber optic communication link. Utilizing the BESTCOMS™ *Pro* software, the digital input and output data can be connected to any control software block input or output in the ECM-2.

Analog I/O Module (AIOM)

The purpose of the Analog Input / Output Module (AIOM) is to provide a means to interface the DECS-2100 excitation control system with external devices. Each AIOM has the capability to sense two analog inputs (± 10 Vdc) that could be used to interface the DECS-2100 to PLC's or DCS systems. The AIOM also has one 100 ohm Platinum RTD input that is commonly used to provide temperature and hydrogen gas pressure feedback to the system for use in generator optimization functions.

The AIOM provides four individually configurable (± 10 Vdc / 4-20 mAdc) analog outputs on each module. Each DECS-2100 control channel may be equipped with a maximum of four AIOMs that are connected using an isolated bi-directional fiber optic communication link. These outputs are commonly used to drive existing panel meters or to interface with DCS systems or chart recorders. Utilizing the BESTCOMS™ *Pro* software, the analog input and output data can be connected to any control software block input or output in the ECM-2.

Dual Source Power Supplies

The Digital Excitation Control System contains dual-source power supplies that provide reliable control power from both the ac excitation source and the dc battery. Thus, control power is available regardless of machine speed or terminal voltage.

Generator and/or Exciter Field Ground Detection

The function of the ground detector panel is to detect a ground current flowing from the machine dc field winding to the grounded machine shaft.

Rapid De-Excitation

The field is de-excited by phasing back the firing pulses to the static exciter amplifier. This action causes stored energy in the field to be inverted back to the source, which quickly

reduces the field excitation to zero. Upon opening the ac field contactor, the remaining field energy will be dissipated very rapidly in a nonlinear resistor permanently connected across the field.

De-excitation Module (DX)

The DX module is a thyristor-controlled circuit that provides an alternate path for the generator field current when the normal path is not available. The normal path is through the PPT, 41 A-supply breaker, and the generator field. To provide the alternate path, the DX thyristor is triggered by a control signal and/or excessive negative field voltage.

Crowbar Module (CB)

Generator pole slip is a source of positive high voltage. The Crowbar module (CB) with series resistor protects the generator field and exciter power converter from excessive high positive field voltages. The Crowbar self-triggers any time a high voltage occurs. The system automatically recovers once the voltage starts to go negative.

Field Flashing (Optional)

Field flashing is required (AC or DC powered) when the static exciter receives all of its energy supply from the machine terminals and the machine terminal voltage is zero at startup. It is necessary to flash the machine field to raise the machine terminal voltage to a suitable level that is sufficient for the static exciter to begin to build up the machine voltage.

CONTROL FUNCTIONS

Reactive Compensation

Reactive compensation, either droop or rise, is included with the DECS-2100 system. These functions modify generator voltage by regulator action to compensate for the impedance drop from the machine terminals to a fixed point in the system. Four methods of reactive compensation are available with the DECS-2100.

- Generator Reactive Current Compensation - Using One Set of CTs
- Generator Cross-Current Compensation – Via communication link
- Generator Cross-Current Compensation - Using Two Sets of CTs
- Line Drop Compensation Using a Line CT - Responds to both Resistive and Reactive currents

Power System Stabilizer (Optional)

The stabilizing signal provides positive damping of the electro-mechanical oscillations that occur as a result of system disturbances. Without supplementary control, a continuously acting voltage regulator can contribute negative damping to system swings, and these oscillations may be sustained or may even increase in amplitude.

The DECS-2100 utilizes a predefined IEEE Type 2 "Integral of Accelerating Power" Dual Input PSS power system stabilizer algorithm. The function produces a stabilizing

STANDARD SYSTEM FUNCTIONAL DESCRIPTION, continued

signal derived from two inputs: the deviation in synchronous machine speed and electrical power. Dual pre-position setpoints and dual gain settings, as well as ramping output limiters are included to minimize the adverse effects of the PSS on system voltage. The Type 2 PSS requires inputs from three line CTs to achieve the best accuracy. The PSS also incorporates a low power threshold and will automatically disable the PSS function when the generators power drop below a predetermined level. Additionally, the capability of generating-motoring applications is realized through logic capability in inverting the output for these specialized modes of operation.

Auto-synchronizing (Optional)

An optional automatic synchronizer monitors the bus and generator voltages and supplies discrete raise/lower correction signals to synchronize the generator frequency and slip angle with that of the bus. Two methods of generator synchronization are offered: phase lock loop and anticipatory.

PROTECTION

Protection functions operate whether in manual or auto. *For every Limiting Function, there is an associated Protection Function.* The protection elements, provided with on-line and off-line settings groups, are intended to back up the Limiting Functions in an effort to take control and attempt to avoid a system trip.

LIMITERS

The purpose of limiters is to remove control from any of the regulators, either manual or auto, then regulate the particular quantity at the pickup point of the limiter. The limiters provide an alternate feedback control loop to the regulators, and each limiter is provided with its own adjustable gain, adjustable transient gain reduction, or damping algorithm as needed to provide stable loop operation when the limiter is in control. Limiters operate whether the unit is in automatic or manual regulation modes. All limiters contain alarms and online/offline settings groups for further customization through user status and/or logic input, as well as being configured for use either as a Summing or Takeover Type.

Minimum Excitation Limiter- Steady State Stability Limit (MEL)

The Minimum Excitation Limiter (MEL) is based on the generator stability limit. The limiter keeps the operating point of the generator within adjustable MW and Mvar curves. The shape of the MW and Mvar operating curves is constructed in a 5-point piece-wise-linear fashion. Gain is adjustable, with the ability while in operation to keep MVA within +/-1% of the MEL pickup point.

Under Excitation Limiter- Generator Capability Curve (UEL)

The Under Excitation Limiter (UEL) prevents excitation reduction in the ac generator to levels that would result in damage to the generator while it is operating in an underexcited mode. The UEL is based on the generator capability curve. The shapes of the MW and Mvar operating curves are constructed in a 5-point piecewise-linear fashion made up of straight-line segments.

Note: The following pickup modification (recalibration) functions are available as optional configurations to the UEL:

- **Hydrogen Gas Pressure Recalibration**
- **Temperature Recalibration**

Over Excitation Limiter (OEL)

The Over Excitation Limiter (OEL) acts through the regulator to return the value of excitation to a preset value after an adjustable time delay during which overexcitation is permitted for field forcing. The limiter operates on an inverse time characteristic that permits lower values of overexcitation for longer time intervals and limits higher values of over-excitation for shorter time intervals. The Over Excitation Limiter keeps the generator field current or voltage below a desired value of field voltage or field current that is adjustable between 100% and 130% of either voltage or current. This limiter functions with the Instantaneous Limiter to provide a two step operation.

The OEL provides a “memory” of the time-dependent nature of the residual and cumulative effects of rotor heating with a cooldown curve.

Note: The following pickup modification (recalibration) functions are available to the Over Excitation Limiter:

- **Hydrogen Gas Pressure Recalibration**
- **Temperature Recalibration**

Instantaneous Field Current Limiter

The Instantaneous Field Current Limiter keeps the generator line current below a desired level.

Volts/Hertz Limiter (HXL)

The Volts/Hertz Limiter keeps the ratio of generator terminal voltage to line frequency below a desired value to avoid the heating effects of excessive magnetic flux in the generator, transformers, or other magnetic devices.

Generator Under/ Overvoltage Limiter

The generator voltage is regulated to a pickup point above or below a desired line voltage from set percentages of the generator full-load rating.

Generator Line Current Limiter

The Generator Line Current Limiter keeps the generator line current below a desired level.

Hydrogen Gas Pressure Recalibration for Generator Line Current Limiter (Optional Configuration)

The curve will be varied as a function of the generator hydrogen pressure and is reduced as the hydrogen pressure is being reduced.

STANDARD SYSTEM FUNCTIONAL DESCRIPTION, continued

INTERFACE AND SOFTWARE FEATURES

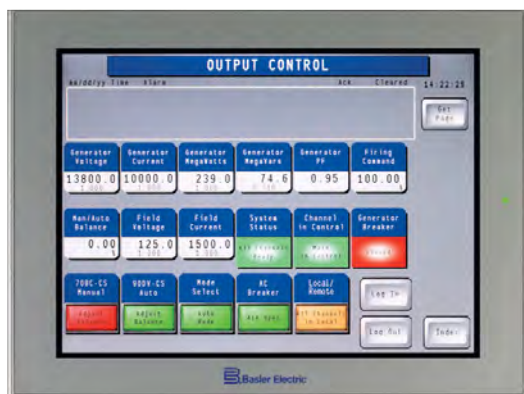
Operator Interface

Flexibility in the DECS-2100 control room interface capability permits the operator to monitor status, perform control operations (optional), and make routine adjustments in the voltage regulator. For replacement installations, the customer may choose to use an existing control room panel or switch to a new HMI for control known as the Interactive Display Panel (IDP-1200). See Fig. 5. This 12.1 inch color touch screen can be mounted locally on the excitation cubicle, remotely in the control room, or at both locations. Critical switches such as the ac supply breaker can be direct connected to a relay via a terminal block.

Alternately, control may be performed through the plant digital control system via a communication processor in that system. The excitation control system can also be interfaced to a SCADA remote terminal unit, a process controller, or a backup set of control room switches, lights, and meters.

Features of the IDP-1200 Interactive Display Panel

- 12.1 in (307.3 mm) TFT LCD, 65K color display
- Generator operation overview screen
- Ethernet, USB and CompactFlash™ communication interfaces
- Digital or analog metering views
- Horizontal or vertical Generator Capability Curve
- Generator parameters and rectifier bridge trending
- Trending and alarm data retention in nonvolatile memory
- Data is downloadable in .csv format to USB storage device for external viewing in MS Excel®
- Easier feature upgrades via USB Flash port
- Multilevel password protection
- Set point adjustment provisions



**Figure 5 - Interactive Display Panel
(Model: IDP-1200)**

Controller Configuration Tool (BESTCOMS™ Pro)

BESTCOMS™ Pro is an easy-to-use software tool for configuring, monitoring, and maintaining the DECS-2100 Digital Excitation Control System. It provides users with password access to the operational parameters and optional configura-

tion management through a laptop or desktop PC.

Level 1: View, the basic access capability, includes the ability to monitor generator system values, digital regulator operating parameters such as gains, time constants, and limiting and protective set points, and view job-specific drawings, instruction books, help menus and help screens.

Level 2 (includes Level 1): Settings allows a user to modify selectable and adjustable parameter settings.

Level 3 (includes Levels 1 and 2): Configuration Management includes capabilities for the reconfiguration/adding of software regulator function blocks and sequence control connections.

BESTCOMS™ Pro can be accessed locally or from a remote location through the RS232, Ethernet, or USB ports on the ECM-2 module and is compatible with industry standard software such as Embedded Windows NT (32-bit), XP (32-bit), and 7 (32- and 64-bit), along with provisions for compatibility with future Windows® platforms.

Real-Time Monitoring

The DECS-2100 integrates a Real Time Monitor for commissioning, troubleshooting, and NERC validation testing. Up to 6 parameters monitored, with features including:

- Breakdown data evaluator.
- Cursors, back scroll, saving, adjustable X & Y axis
- Metered amounts as cursor moves, limiters identified when limiting

Auto-Tuning

During commissioning, excitation system parameters are not initially known, traditionally causing the commissioning process to consume a large amount of time and fuel. With the development of auto-tuning, the preliminary excitation system parameters are automatically identified and the AVR PID gains are calculated using well-developed algorithms, reducing overall commissioning time and cost.

Simulation Mode

A useful tool to aid in settings validation and performance testing, the internal Simulator models a virtual generator and power grid as well as the performance of the Signal Input (SI) of the ECM-2, Bridge Control Module (BCM), and power Converter Bridge. The input of the simulator is the signal representing the command to the Bridge Control Module, and simulates the following conditions:

- Starting of a potential source static exciter
- Starting of a brushless exciter
- Synchronizing of a generator to the power grid
- Ramping up of a turbine from no load to full load
- Starting of a large motor
- Switching on of a transmission line
- Switching off of a transmission line
- Line faults

STANDARD SYSTEM FUNCTIONAL DESCRIPTION, continued

TRANSIENT EVENT RECORDERS

The Transient Event Recorder is a software package that consists of three applications programs for recording and processing transient events and viewing of alarm history.

Event and Alarm History Recorder (Sequence of Events)

The Event and Alarm History Recorder generates a time and date stamped list of events. The events and alarms included in the list are preselected and stored in nonvolatile memory. The following items are included:

- Pickup of limiters
- Operation of limiter
- Pickup of protection functions
- Operation of protection functions
- Internal failure alarms in the controllers
- Use selected logic/programmable state changes

Up to 16,000 events/alarms may be recorded, then uploaded to a personal computer file using BESTCOMS™ Pro. A CSV file may be used for viewing or printout. Up to 64 user programmable events can be set and displayed with the common system alarms.

Single Event Recorder and Analyzer

The Single Event Recorder records up to eight simultaneous

signals from any input, output or internal signal. The record shows both pre-trigger and post-trigger information with time-stamping and synchronization in non-volatile memory. A selectable trigger can initiate the event recording.

A maximum of up to 100,000 points are available per block for up to 8 channels per block with 4 Event Recorder blocks total. The resolution allows a cycle-by-cycle analysis for an event.

Data Logger (Trending)

The Data Logger is a continuously running log of the value of selected inputs. The input channels to be logged are selectable from 1 to 12 inputs with an adjustable number of recorded points (100,000 total). Once the maximum number of samples have been recorded among the selected inputs, the newest samples of a channel are logged and oldest samples removed using a circular buffer method. The following is a list of items that, as a minimum, may be logged:

- Generator output such as watts, vars, power factor
- Excitation cubicle output, amps, and volts
- Field temperature

Using BESTCOMS™ Pro, data can be uploaded to computer hard drive or USB storage in either COMTRADE or CSV format, and viewed directly via computer or the IDP-1200.

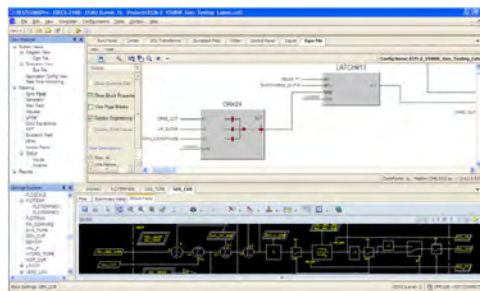


Figure 6 - BESTCOMS™ Pro Logic Screen

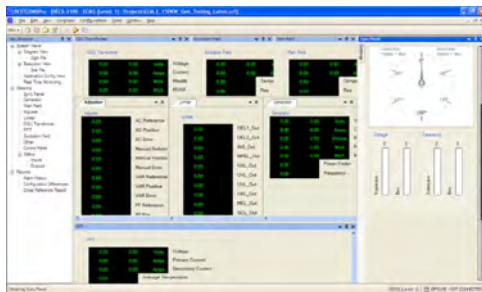


Figure 7 - BESTCOMS™ Pro Metering Screen

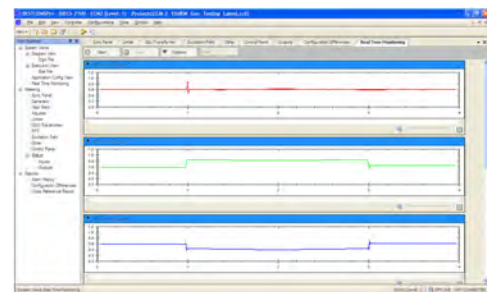


Figure 8 - BESTCOMS™ Pro Oscillography Screen



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