INTRODUCTION

This instruction manual provides information about the operation and installation of the DECS-400 Digital Excitation Control System. To accomplish this, the following information is provided:

- General Information and Specifications
- Controls and Indicators
- Functional Description
- Installation
- Commissioning
- Maintenance
- Modbus™ Protocol

WARNING!
To avoid personal injury or equipment damage, only qualified personnel should perform the procedures in this manual.

NOTE
Be sure that the device is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the ground terminal on the rear of the unit case. When configured in a system with other devices, it is recommended to use a separate lead to the ground bus from each unit.
It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Should further information be required, contact Basler Electric.
REVISION HISTORY

The following information provides a historical summary of the changes made to the DECS-400 hardware, firmware, and BESTCOMS software. The corresponding revisions made to this instruction manual (9369700990) are also summarized. Revisions are listed in chronological order.

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<thead>
<tr>
<th>Hardware Version and Date</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>—, 01/05</td>
<td>• Initial release</td>
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<tr>
<td>A, 08/05</td>
<td>• Firmware revised to accommodate LCD variations.</td>
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<tr>
<td>B, 09/05</td>
<td>• Adjusted case for easier extraction and insertion of draw-out assembly.</td>
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<td>C, 10/05</td>
<td>• I/O circuit board revised.</td>
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</tbody>
</table>

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<thead>
<tr>
<th>Firmware Version and Date</th>
<th>Change</th>
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<tr>
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<td>1.01, 06/05</td>
<td>• Corrected/enhanced operation of two-step V/Hz limiter</td>
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<td>• Adjusted increment for 24 V/Hz Inverse Time Pickup Setpoint</td>
</tr>
<tr>
<td></td>
<td>• Changed setting range and increment of 24 V/Hz Definite Time Pickup #1 and #2</td>
</tr>
<tr>
<td>1.02, 10/05</td>
<td>•Minor improvements</td>
</tr>
<tr>
<td>1.03, 02/06</td>
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<tr>
<td>1.04, 10/06</td>
<td>• Decreased contact input recognition time</td>
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<td>• Expanded setting range of rated generator voltage</td>
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<td></td>
<td>• Added Var/PF to PSS circuitry points where a test signal can be applied</td>
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<td></td>
<td>• Added field temperature to the available parameters for meter drivers 1 and 2</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>BESTCOMS Version and Date</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
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<td>• Initial Release</td>
</tr>
<tr>
<td>1.00.01, 06/05</td>
<td>• Frequency response function of Analysis screen enhanced</td>
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<tr>
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<td>• Adjusted increment for 24 V/Hz Inverse Time Pickup Setpoint</td>
</tr>
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<tr>
<td>1.01.00, 09/05</td>
<td>• Enhanced Test Signal screen by adding FCR Summing as a Signal Input option.</td>
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<td>• Improved order of settings on RTM Step Response screen, VAR tab.</td>
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<td>• Improved Pole Ratio Calculator.</td>
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</tr>
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| A, 07/05                | • Added cURus certification note to Section 1  
• Completed missing entries in Table 2-5  
• Added functional description of modem to Section 3  
• Updated BESTCOMS screen illustrations and setting descriptions in Section 4  
• Added missing bit flag status information to Table B-12 |
| B, 10/05                | • Corrected DECS-400 terminal numbering in Figure 5-6, *Typical AC Connection Diagram*.  
• Updated Figure 5-4, *Rear Panel Terminations*, to show cURus and CE logos.  
• Updated BESTCOMS screens. See BESTCOMS changes above for more details. |
| C, 10/06                | • Added backup battery specifications and burden specifications for generator voltage sensing, bus voltage sensing, and generator current sensing to Section 1.  
• Updated the HMI menu shown in Figure 2-7  
• Added *Field Temperature* to the available metering parameters listed in Sections 3 and 4.  
• Updated Figure 4-42, *Test Signal Screen* with new screen that adds Var/PF to the list of available signal inputs.  
• Widened the rated generator voltage range stated in Section 4.  
• Added information to Section 5 regarding available mounting hardware and an available isolation transformer.  
• Replaced Figures A-2 through A-13 with revised, predefined logic schemes  
• Added mode descriptions for registers 40611, 40612, 40613, and 40617 in Table B-14. |
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GENERAL INFORMATION</td>
<td>1-1</td>
</tr>
<tr>
<td>2</td>
<td>HUMAN-MACHINE INTERFACE</td>
<td>2-1</td>
</tr>
<tr>
<td>3</td>
<td>FUNCTIONAL DESCRIPTION</td>
<td>3-1</td>
</tr>
<tr>
<td>4</td>
<td>BESTCOMS SOFTWARE</td>
<td>4-1</td>
</tr>
<tr>
<td>5</td>
<td>INSTALLATION</td>
<td>5-1</td>
</tr>
<tr>
<td>6</td>
<td>COMMISSIONING</td>
<td>6-1</td>
</tr>
<tr>
<td>7</td>
<td>MAINTENANCE</td>
<td>7-1</td>
</tr>
<tr>
<td>A</td>
<td>PROGRAMMABLE LOGIC</td>
<td>A-1</td>
</tr>
<tr>
<td>B</td>
<td>MODBUS™ COMMUNICATION</td>
<td>B-1</td>
</tr>
</tbody>
</table>
# SECTION 1 • GENERAL INFORMATION

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTION 1 • GENERAL INFORMATION</td>
<td>1-1</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1-1</td>
</tr>
<tr>
<td>FEATURES</td>
<td>1-1</td>
</tr>
<tr>
<td>Voltage Regulation</td>
<td>1-2</td>
</tr>
<tr>
<td>Control Output</td>
<td>1-2</td>
</tr>
<tr>
<td>Stability</td>
<td>1-2</td>
</tr>
<tr>
<td>Power System Stabilizer (Style 1XXX)</td>
<td>1-2</td>
</tr>
<tr>
<td>Underfrequency Limiter or Volts per Hertz Limiter</td>
<td>1-2</td>
</tr>
<tr>
<td>Soft-Start Voltage Buildup</td>
<td>1-3</td>
</tr>
<tr>
<td>Reactive Droop and Line Drop Compensation</td>
<td>1-3</td>
</tr>
<tr>
<td>Setpoint Control</td>
<td>1-3</td>
</tr>
<tr>
<td>Dual Pre-Position Inputs</td>
<td>1-3</td>
</tr>
<tr>
<td>Field Current Regulation Operating Mode</td>
<td>1-3</td>
</tr>
<tr>
<td>Var/Power Factor Operating Mode</td>
<td>1-3</td>
</tr>
<tr>
<td>Overexcitation Limiters</td>
<td>1-3</td>
</tr>
<tr>
<td>Minimum Excitation Limiter</td>
<td>1-4</td>
</tr>
<tr>
<td>Stator Current Limiter</td>
<td>1-4</td>
</tr>
<tr>
<td>Autotracking Between DECS-400 Operating Modes</td>
<td>1-4</td>
</tr>
<tr>
<td>Autotracking Between DECS-400 Units</td>
<td>1-4</td>
</tr>
<tr>
<td>Protective Functions</td>
<td>1-4</td>
</tr>
<tr>
<td>Programmable Logic</td>
<td>1-4</td>
</tr>
<tr>
<td>Metering</td>
<td>1-5</td>
</tr>
<tr>
<td>Sequence of Events Recording</td>
<td>1-5</td>
</tr>
<tr>
<td>Oscillography</td>
<td>1-5</td>
</tr>
<tr>
<td>Real-Time Monitoring</td>
<td>1-5</td>
</tr>
<tr>
<td>Internal Testing Provisions</td>
<td>1-5</td>
</tr>
<tr>
<td>Communication</td>
<td>1-5</td>
</tr>
<tr>
<td>Password Protection</td>
<td>1-5</td>
</tr>
<tr>
<td>MODEL AND STYLE NUMBER</td>
<td>1-6</td>
</tr>
<tr>
<td>Style Number</td>
<td>1-6</td>
</tr>
<tr>
<td>SPECIFICATIONS</td>
<td>1-6</td>
</tr>
<tr>
<td>Operating Power</td>
<td>1-6</td>
</tr>
<tr>
<td>Generator Voltage Sensing</td>
<td>1-6</td>
</tr>
<tr>
<td>Bus Voltage Sensing</td>
<td>1-7</td>
</tr>
<tr>
<td>Generator Current Sensing</td>
<td>1-7</td>
</tr>
<tr>
<td>Field Voltage and Current</td>
<td>1-7</td>
</tr>
<tr>
<td>Field Isolation Module</td>
<td>1-7</td>
</tr>
<tr>
<td>Contact Inputs</td>
<td>1-7</td>
</tr>
<tr>
<td>Accessory Input (Remote Setpoint Control)</td>
<td>1-8</td>
</tr>
<tr>
<td>Control Outputs</td>
<td>1-8</td>
</tr>
<tr>
<td>Metering Outputs</td>
<td>1-9</td>
</tr>
<tr>
<td>Contact Outputs</td>
<td>1-9</td>
</tr>
<tr>
<td>Communication Ports</td>
<td>1-9</td>
</tr>
<tr>
<td>IRIG</td>
<td>1-10</td>
</tr>
<tr>
<td>Regulation Accuracy</td>
<td>1-10</td>
</tr>
<tr>
<td>Metering Accuracy</td>
<td>1-10</td>
</tr>
<tr>
<td>Power System Stabilizer (PSS)</td>
<td>1-11</td>
</tr>
<tr>
<td>Setpoint Traverse Rate</td>
<td>1-11</td>
</tr>
<tr>
<td>Setpoint Tracking</td>
<td>1-11</td>
</tr>
<tr>
<td>Soft Start</td>
<td>1-11</td>
</tr>
<tr>
<td>Sequence of Events Recording</td>
<td>1-11</td>
</tr>
<tr>
<td>Data Logging (Oscillography)</td>
<td>1-11</td>
</tr>
<tr>
<td>Trending</td>
<td>1-11</td>
</tr>
<tr>
<td>Limiters</td>
<td>1-11</td>
</tr>
<tr>
<td>Protection Functions</td>
<td>1-13</td>
</tr>
<tr>
<td>Type Tests</td>
<td>1-13</td>
</tr>
</tbody>
</table>
Agencies Recognition ......................................................................................................................... 1-14
CE Compliance ................................................................................................................................. 1-14
GOST-R Certification ....................................................................................................................... 1-14
Real-Time Clock Backup Battery .................................................................................................. 1-14
Environment ..................................................................................................................................... 1-14
Physical ............................................................................................................................................ 1-14

Figures
Figure 1-1. DECS-400 Style Chart ............................................................................................................ 1-6
SECTION 1 • GENERAL INFORMATION

INTRODUCTION
The DECS-400 Digital Excitation Control System is a microprocessor-based controller that offers excitation control, logic control, and optional power system stabilization in an integrated package. The DECS-400 controls field excitation by providing an analog signal used to control the firing (output) of an external power bridge. The DECS-400 monitors generator or motor parameters and acts to control, limit, and protect the machine from operating outside its capability.

The optional, onboard power system stabilizer is an IEEE-defined PSS2A, dual-input, “integral of accelerating power” stabilizer that provides supplementary damping for low-frequency, local mode and power system oscillations.

Integral programmable logic provides excitation system control and annunciation based on DECS-400 contact inputs, operating mode status, excitation system parameters, and user-defined programming. Setup and initial operation are facilitated by Basler Electric’s user-friendly BESTCOMS PC software that incorporates a test mode, flexible oscillography, and a graphic display of PSS test results.

The DECS-400 is designed for use with Basler Electric’s Interface Firing Module (IFM) and SSE or SSE-N power bridges. However, it will work equally well with any power bridge with a firing circuit that is compatible with the control signal output of the DECS-400.

FEATURES
DECS-400 features and capabilities are listed below. The paragraphs following the list describe major DECS-400 features and functions in more detail.

- Four excitation control modes
  - Automatic Voltage Regulation (AVR)
  - Field Current Regulation (FCR)
  - Power Factor (PF)
  - Var
- Two pre-position setpoints for each excitation control mode
- Two PID groups
- Programmable analog control output selectable for 4 to 20 mAdc, –10 to +10 Vdc, or 0 to +10 Vdc
- Remote setpoint control input accepts analog voltage or current control signal
- Real-time metering
- Integrated power system stabilizer (PSS)
  - Generator or motor control modes, accommodates phase rotation changes between modes
  - Speed and power sensing or speed-only sensing
  - Two-wattmeter or three-wattmeter methods of power measurement
- Soft start and voltage buildup control
- Four limiting functions
  - Stator current
  - Overexcitation
  - Underexcitation
  - Underfrequency compensation
- Ten protection functions
  - Field overvoltage
  - Field overcurrent
  - Generator undervoltage
  - Generator overvoltage
  - Loss of sensing voltage
  - Generator frequency less than 10 hertz
  - Loss of field (40Q)
  - Field overtemperature
  - Volts per hertz (24)
  - Exciter diode failure
- IRIG time synchronization
Sixteen contact inputs
  o Six fixed-function inputs: AVR, FCR, Lower, Raise, Start, and Stop
  o Ten user-programmable inputs
Eight contact outputs
  o Two fixed-function outputs: Watchdog, On/Off
  o Six user-programmable outputs, configurable for maintained, latched, or momentary operation
Four communication ports
  o Front RS-232 port for interface with PC running BESTCOMS software
  o Rear RS-485 port for dedicated communication with secondary, redundant DECS-400
  o Rear RS-485 port using Modbus™ protocol for communication with remote terminal
  o Rear RJ-45 port connects to onboard modem that provides dial-in and dial-out capability
Data logging, sequence of events recording, and trending

Voltage Regulation
By utilizing digital signal processing and precise regulation algorithms, the DECS-400 regulates the generator rms voltage to within 0.2% of the setpoint from no-load to full-load.

Control Output
The DECS-400 supplies an isolated control output signal of 4 to 20 mAdc, 0 to 10 Vdc, or ±10 Vdc to the firing or control circuits of external power stages. The dc current produced by the power stages provides excitation to the field of the generator, motor, or exciter. The DECS-400 can control virtually any bridge that is capable of accepting these signals and is suitable for use on synchronous generators or motors.

Stability
PID (proportional + integral + derivative) stability control is utilized by the DECS-400. Preprogrammed stability (PID) settings are provided for both main field and exciter field applications. A suitable, standard stability set is available for most machines and applications. An additional, customizable setting group is provided optimum generator transient performance. A PID selection/calculation program supplied with the DECS-400 assists in selecting the correct PID settings. Additional stability adjustments are provided for customizing the stability and transient performance of the minimum and maximum excitation limiters and the var/power factor controllers.

PID Setting Groups
The DECS-400 provides for two sets of PID settings to optimize performance under two distinct operating conditions, such as with a power system stabilizer (PSS) in or out of service. A fast controller provides optimum transient performance with the PSS in service, while a slower controller can provide improved damping of first swing oscillations with the PSS offline.

Power System Stabilizer (Style 1XXX)
An optional, integrated PSS duplicates the excellent performance of the Basler PSS-100 power system stabilizer without the complications of an additional control device. The PSS provides damping for local mode, inter-area, and inter-unit oscillations in the 0.1 to 5.0 hertz range. The PSS incorporated in the DECS-400 is a dual-input, IEEE type PSS2A stabilizer that utilizes the “integral of accelerating power” algorithm. The PSS can also be set up to respond only to frequency if required for unusual applications. Inputs required for PSS operation include three phase voltages and two or three phase line currents.

Underfrequency Limiter or Volts per Hertz Limiter
An underfrequency limiter or a V/Hz ratio limiter can be selected to avoid overfluxing the generator or other connected magnetic devices.

The underfrequency limiter slope can be set a 0 to 3 PU V/Hz in 0.1 hertz increments. The frequency roll-off kneepoint can be set across a range of 15 to 90 hertz in 0.1 hertz increments.

The V/Hz ratio limiter regulates voltage based on a user-defined V/Hz slope that is adjustable between zero and 3.0 PU. The V/Hz ratio limiter includes two limiting levels to permit operation above the primary V/Hz range for a user-adjustable time limit to inhibit limiter response during transient frequency or voltage excursions.
Soft-Start Voltage Buildup
A user-adjustable voltage soft-start feature controls the rate of generator voltage buildup and prevents voltage overshoot during generator system startup. The soft-start feature is active in both AVR and FCR operating modes.

Reactive Droop and Line Drop Compensation
The DECS-400 has provisions for paralleling two or more generators by using reactive droop. Reactive differential compensation can be used with the addition of an external current transformer (CT) with a nominal secondary rating of 1 Aac or 5 Aac. The current input burden is less than 1 VA, so existing metering CTs can be used. Inputting a negative value for droop provides line drop compensation to offset line or transformer impedance drops and move the regulation point beyond the terminals of the machine.

Setpoint Control
External adjustment of the active DECS-400 setpoint is possible through:
- Raise and lower contact inputs
- An auxiliary analog control input of 4 to 20 mA dc or ±10 V dc
- A PC operating BESTCOMS software (provided with the DECS-400) and connected to the RS-232 communication port
- A controller using Modbus™ protocol and connected to the RS-485 port

The traverse rates of all operating modes are independently adjustable, so the operator can customize the rate of adjustment and “feel” to meet his or her needs.

Dual Pre-Position Inputs
Two user-adjustable sets of predetermined operating points are provided for each mode of operation. At startup, and with the appropriate contact inputs applied to the DECS-400, the operating mode is driven to one of two preset operating or regulation levels (depending on the configuration of the system). This feature allows the DECS-400 to be configured for multiple system and application needs.

Field Current Regulation Operating Mode
A manual mode of operation is provided and is called Field Current Regulation (FCR). In this mode, the DECS-400 regulates the dc output current of the power bridge. It is not dependent on the generator voltage sensing input to the DECS-400. Therefore, FCR provides backup excitation control when loss of sensing is detected. In FCR mode, as the load varies, the operator must manually vary field current to maintain nominal generator voltage.

Var/Power Factor Operating Mode
Var and Power Factor control modes are available when the generator is operating in parallel with the utility power grid. In Var control mode, the DECS-400 regulates the generator's var output at a user-adjustable setting. In Power Factor control mode, the DECS-400 regulates the generator's var output to maintain a specific power factor as the kW load varies on the generator.

Overexcitation Limiters
Overexcitation limiters monitor the field current output of the voltage regulator or static exciter and act to limit the field current to prevent field overheating. The Overexcitation Limiter (OEL) function includes a cool-down feature to avoid damage to the rotor caused by repeated high forcing. The OEL is active in all modes except FCR mode. In FCR mode, limiter action is optional. The DECS-400 provides a choice of two types of overexcitation limiters: Summing Point and Takeover. The output of the Summing Point limiter is applied to the summing junction of the AVR control loop in addition to the AVR controller output. The output of the Takeover limiter overrides the normal AVR output.

Summing Point OEL
Three OEL current levels are defined for on-line operation: high, medium, and low. The generator can operate continuously at the low OEL current level and for programmed times at the medium and high OEL current levels. Two OEL current levels are defined for off-line (main breaker open) operation: high and low. The generator can operate continuously at the low OEL current level and for a programmed time at the high OEL current level.
Takeover OEL

The Takeover OEL determines the field current level at which limiting occurs by using an inverse time characteristic. Two current levels and a time dial setting are defined for the Takeover OEL. Separate curves may be selected for on-line and off-line operation. If the system enters an overexcitation condition, the field current is limited and made to follow the selected curve. Selection of on-line or off-line OEL levels and curves is determined by an OEL option selection.

Minimum Excitation Limiter

The Minimum Excitation Limiter prevents the excitation, being supplied to the generator field, from decreasing below safe operating levels. This prevents pole slip and possible machine damage. This action also limits the amount of vars being absorbed by the machine, based on user-defined settings. An internally-generated Underexcitation Limiting (UEL) curve based on a permissible var level at 0 kW can be utilized. Alternately, a five point UEL curve can be created to match specific generator characteristics. UEL action is optional in FCR mode.

Stator Current Limiter

The stator current limiter (SCL) senses the level of stator current and limits it to prevent stator overheating. The SCL operates in all modes except FCR. In FCR mode, the DECS-400 provides indication that a stator overcurrent condition exists, but limiter action is inhibited.

Two SCL current levels are provided: high and low. The generator can operate continuously at the low SCL level, but only for a programmed time at the high SCL level.

Autotracking Between DECS-400 Operating Modes

The DECS-400 can provide autotracking (automatic following) of the controlling mode by the non-controlling modes. This allows the operator to initiate a controlled, bumpless transfer of the DECS-400 between operating modes with minimal disturbance to the power system. This feature can be used in conjunction with a set of protective relays to initiate a transfer to a backup mode of operation (such as FCR mode) upon the detection of a system failure or fault (such as loss of sensing).

Autotracking Between DECS-400 Units

The DECS-400 is also designed to automatically track a second DECS-400 unit using dedicated communication ports on the two units. A backup DECS-400 controller can be placed in service and programmed to track the control output of the primary DECS-400. In the unlikely event of a failure of the first DECS-400, protective relays can initiate a transfer of control from the first to the second DECS-400 with minimal system disturbance.

Protective Functions

Protective functions built into the DECS-400 may be used as a backup to the primary protection relays and can be assigned to as many as six programmable output contacts via BESTCOMS software. The protective functions offer fully adjustable tripping levels and time delays. DECS-400 protective functions include:

- Field overcurrent
- Field overtemperature *
- Field overvoltage *
- Generator overvoltage *
- Generator undervoltage *
- Loss of field *
- Loss of Field Isolation Module
- Loss of sensing voltage
- Microprocessor watchdog
- Open exciter diode (brushless application)
- Shorted exciter diode (brushless application)
- Volts per hertz protection

Functions marked with an asterisk (*) have dual setting groups.

Programmable Logic

The DECS-400 utilizes programmable logic functionality in the form of multiplexors, AND gates, OR gates, NOT gates, and timer gates. Inputs to the logic are in the form of discrete information including switching inputs, system status data, protection status data, limiter status data, alarm status data, and PSS status data. The outputs of the programmable logic module can be used to control the relay outputs as well as various other functions inside the DECS-400 such as control functions (start/stop, mode select, etc.), protection functions (Field Overvoltage Enable, Field Overcurrent Enable, etc.), limiter functions
Metering
Two programmable, 4 to 20 mAdc, analog meter drivers are provided. The meter side is isolated from DECS-400 circuitry. Either driver can be programmed to meter a broad range of generator and system parameters.

Sequence of Events Recording
An integrated sequence of events recorder (SER) can be used to reconstruct the exact time of an event or disturbance. The DECS-400 monitors its contact inputs and outputs for changes of state, system operating changes, and alarm conditions. If any of these events occurs, the DECS-400 logs that event with a date and time stamp. The resulting event record allows the user to analyze a chain of events with accurate information regarding the sequence in which they occurred. Up to 127 events can be stored in DECS-400 volatile memory and those events are retrievable through BESTCOMS software.

Oscillography
The data recording feature can record up to six oscillographic records and store them in volatile memory. Up to six variables can be selected for monitoring. These variables include generator voltage, generator current (single-phase), frequency, kW, power factor, field voltage, and field current. Oscillographic records can be triggered through BESTCOMS or by a logic trigger or level trigger.

During commissioning, BESTCOMS can be used to trigger and save a record of a voltage step response. At the completion of commissioning, a logic trigger or level trigger can be used to activate the data recorder to capture the occurrence for review at a later time. DECS-400 alarms can also be used to start the data recorder. When an alarm condition occurs, an oscillographic record can be stored. A level trigger will initiate a record to be saved when a variable (such as field current) exceeds a predetermined setting. Oscillographic records are recorded in accordance with the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) or log file format. Basler Electric provides BESTWAVE, a COMTRADE viewer, that enables viewing of oscillography records saved by the DECS-400.

Real-Time Monitoring
Real-time monitoring is possible for any of the parameters available for oscillography. The HMI real-time monitoring screen will display up to two parameters simultaneously. This data can be stored in a file for later reference.

Internal Testing Provisions
Using BESTCOMS, the user can configure and run both frequency and step response tests to facilitate commissioning or demonstrate system performance. The frequency response test has a frequency range of 0.1 to 10 hertz, and gain/phase information is generated in the form of a Bode plot. The DECS-400 also allows injection of test signals at various points in the PSS/voltage regulation loop for a high level of testing flexibility.

Communication
The DECS-400 is supplied with BESTCOMS software which makes DECS-400 programming and customization fast and easy. BESTCOMS includes a PID selection utility that provides a user-friendly format for selecting stability settings. BESTCOMS has monitoring screens for viewing all settings, metering screens for viewing all machine parameters, and control screens for remote control of the excitation system.

An RS-485 port on the rear panel supports Modbus™ (floating point) communication protocol. ModbusTM is an open protocol, with all registers and operating instructions available in this instruction manual. This makes it simple for the user to develop custom communication software.

An internal modem is also provided to remotely access DECS-400 settings and alarms.

Password Protection
All DECS-400 parameters can be viewed at the front panel display, through BESTCOMS, or through Modbus™ without the need of a password. If the user wishes to change a setting, the proper password must be entered to allow access to the parameter. Two levels of password protection exist. One level
provides global access to all parameters. The other level provides limited access to parameters normally associated with operator control.

MODEL AND STYLE NUMBER

DECS-400 electrical characteristics and operational features are defined by a combination of letters and numbers that make up the style number. The model number, together with the style number, describe the options included in a specific device and appear on a label affixed to the rear panel.

Style Number

The style number identification chart in Figure 1-1 defines the electrical characteristics and operational features available in the DECS-400.

![DECS-400 Style Chart](image)

SPECIFICATIONS

DECS-400 electrical and physical specifications are listed in the following paragraphs.

Operating Power

**AC Input (Style XCXX Only)**

Nominal:
120 Vac

Range:
82 to 132 Vac

Frequency:
50/60 Hz

Burden:
50 VA

Terminals:
C2 (N), C3 (L)

**DC Input (Style XCXX, XLXX)**

Nominal

Style XCXX: 125 Vdc

Style XLXX: 24/48 Vdc

Range

Style XCXX: 90 to 150 Vdc

Style XLXX: 16 to 60 Vdc

Burden:
30 W

Terminals:
C4 (BATT–), C5 (BATT+)

Generator Voltage Sensing

Configuration:
1-phase (A-phase (E1) to C-phase (E3)) or 3-phase

Ranges:
120 V or 240 V, automatically selected

Burden:
<1 VA

Terminals:
A9, (E1), A10 (E2), A11 (E3)

**50 Hertz Sensing**

Range 1:
85 to 127 Vac

Range 2:
170 to 254 Vac
60 Hertz Sensing
Range 1: 94 to 153 Vac
Range 2: 187 to 305 Vac

Bus Voltage Sensing
Configuration: 1-phase (A-phase (BUS1) to C-phase (BUS3))
Ranges: 120 V or 240 V, automatically selected
Burden: <1 VA
Terminals: A13 (BUS1), A14 (BUS3)

50 Hertz Sensing
Range 1: 85 to 127 Vac
Range 2: 170 to 254 Vac

60 Hertz Sensing
Range 1: 94 to 153 Vac
Range 2: 187 to 305 Vac

Generator Current Sensing
Configuration: 2-, or 3-phases.
Separate cross-current compensation input.
Sensing Ranges: 2 (up to 400% of nominal)
Nominal Sensing Current: 1 Aac or 5 Aac
Burden: <1 VA
Terminals
CTA: A1, A2
CTB: A3, A4
CTC: A5, A6
CCCT: A7, A8

Field Voltage and Current
Field sensing values are supplied to DECS-400 connector P1 from the Isolation Module (supplied with the DECS-400). See Field Isolation Module.

Field Isolation Module

Electrical Specifications
Operating Power: +5 Vdc, ±12 Vdc from DECS-400
Sensing Ranges
Field Voltage: ±300% of the five nominal ranges: 32 Vdc, 63 Vdc, 125 Vdc, 250 Vdc, and 375 Vdc
Field Current: 0 to 300% of the two nominal shunt ranges: 50 mVdc and 100 mVdc
Signal Output
Field Voltage: 0.9 to 9.1 Vdc (5.0 Vdc = zero field voltage)
Field Current: 2.0 to 9.5 Vdc (2.0 Vdc = zero field current)

Physical Specifications
Temperature
Operating: –40 to 60 °C (–40 to 140°F)
Storage: –40 to 85°C (–40 to 185°F)
Weight: 680 g (1.5 lb)
Size: Refer to Section 4, Installation for isolation module dimensions.

Contact Inputs
Sixteen contact inputs accept dry switch/relay contacts or open-collector outputs from a PLC. There are six fixed-function contact inputs and 10 programmable contact inputs.
Interrogation Voltage: 12 Vdc
Fixed Function Inputs

- AVR *
- FCR *
- Lower †
- Raise †
- Start *
- Stop *

* Functions are activated by a momentary input.
† Functions are active only when the corresponding contact input is active.

Programmable Inputs

Any of the 10 programmable inputs can be configured, through the integrated programmable logic, with the following functions.

- 2nd PID Settings Selection
- 2nd Pre-Position
- Phase Rotation
- Pre-Position
- PSS Enable
- PSS Motor/Generator Mode
- PSS Parameters Set Selection
- Reactive Differential Compensation Enable
- Reactive Droop Compensation Enable
- Secondary Enable
- Speed Switch Enable
- Unit/Parallel Operation (52 L/M)
- Var/Power Factor Enable (52 J/K)

Terminals

Start: B1 (START), B2 (COM)
Stop: B3 (STOP), B2 (COM)
AVR: B4 (AVR), B5 (COM)
FCR: B6 (FCR), B5 (COM)
Raise: B7 (RAISE), B8 (COM)
Lower: B9 (LOWER), B8 (COM)
Programmable 1: B10 (SW1), B11 (COM)
Programmable 2: B12 (SW2), B11 (COM)
Programmable 3: C23 (SW3), C24 (COM)
Programmable 4: C25 (SW4), C24 (COM)
Programmable 5: C26 (SW5), C27 (COM)
Programmable 6: C28 (SW6), C27 (COM)
Programmable 7: C29 (SW7), C30 (COM)
Programmable 8: C31 (SW8), C30 (COM)
Programmable 9: C32 (SW9), C33 (COM)
Programmable 10: C34 (SW10), C33 (COM)

Accessory Input (Remote Setpoint Control)

Voltage Input

Range: –10 Vdc to +10 Vdc
Terminals: A16 (V+), A17 (V–)

Current Input

Range: 4 mAdc to 20 mAdc
Terminals: A19 (I+), A20 (I–)

Control Outputs

The excitation setpoint is controlled by either an analog voltage output or analog current output.
**Voltage Control Output**
Range: ±10 Vdc or 0 to +10 Vdc
Terminals: D14 (VC+), D15 (RTNC)

**Current Control Output**
Range: 4 to 20 mAdc
Terminals: D13 (IG+), D15 (RTNC)

**Metering Outputs**
Two programmable metering outputs can be configured to meter a broad range of generator and system parameters. Each metering output is electrically isolated from DECS-400 internal circuitry.
Output Range: 4 to 20 mAdc
Terminals
- Metering Output 1: A21 (M1+), A22 (M1–)
- Metering Output 2: A24 (M2+), A25 (M2–)

**Contact Outputs**
Two dedicated contact outputs and six programmable contact outputs.

* Dedicated Outputs
  - Functions: Watchdog, On/Off

* Programmable Outputs
  - Annunciation Selections: DECS-400 status, active alarms, active protection functions, and active limiter functions, all programmed by integrated programmable logic
  - Output Actions: Maintained, latched, or momentary
  - Momentary Closure Duration: >0.1 s

**Contact Ratings**
- Make: 30 A for 0.2 seconds per IEEE C37.90
- Carry: 7 A continuous
- Break (Resistive or Inductive): 0.3 A at 125 Vdc or 250 Vdc (L/R = 0.04 maximum)

**Terminal Assignments**
- Watchdog: C6 (WTCH1 (NO)), C7 (WTCH (COM)), C8 (WTCH2 (NC))
- On/Off: C9, C10
- Programmable 1: C11, C12
- Programmable 2: C13, C14
- Programmable 3: C15, C16
- Programmable 4: C17, C18
- Programmable 5: C19, C20
- Programmable 6: C21, C22

**Communication Ports**

* Com 0
  - Interface: RS-232
  - Connection: Front-panel female DB-9
  - Protocol: ASCII
  - Data Transmission: Full duplex
  - Baud: 1200 to 19200
  - Data Bits: 8
  - Parity: None
  - Stop Bits: 1

* Com 1
  - Interface: RS-485
  - Connection: Rear-panel screw terminals
  - Terminals: D5 (A), D6 (B), D7 (C)
  - Protocol: ASCII
  - Data Transmission: Half duplex
Baud: 1200 to 19200
Data Bits: 8
Parity: None
Stop Bits: 1

**Com 2**
Interface: RS-485
Connection: Rear-panel screw terminals
Terminals: D10 (A), D11 (B), D12 (C)
Protocol: Modbus™
Data Transmission: Half duplex
Baud: 4800 to 19200
Data Bits: 8
Parity: None
Stop Bits: 2

**J1**
Interface: FCC part 68 approved modem
Connection: Rear-panel RJ-11

**IRIG**
Standard: 200-98, Format B002
Input Signal: Demodulated (dc level-shifted digital signal)
Logic High Level: 3.5 Vdc, minimum
Logic Low Level: 0.5 Vdc, maximum
Input Voltage Range: –10 Vdc to +10 Vdc
Input Resistance: Nonlinear, approximately 4 k\(\Omega\) at 3.5 Vdc, 3 k\(\Omega\) at 20 Vdc
Terminals: D1 (IRIG +), D2 (IRIG –)

**Regulation Accuracy**

**AVR Mode**
Voltage Regulation: ±0.2% over the load range, at rated power factor and constant generator frequency
Steady-State Stability: ±0.1% at constant load and frequency
Temperature Stability: ±0.5% between 0 and 50°C (32 and 122°F) at constant load and frequency
Response Time: <1 cycle

**FCR Mode**
Field Current Regulation: ±1% of the nominal value for 10% of the rectifier bridge input voltage change or 20% of the field resistance change

**Var Control Mode**
Reactive Power Regulation: ±2.0% of the nominal VA rating at rated frequency

**Power Factor Control Mode**
Power Factor Regulation: ±0.02%

**Metering Accuracy**
Generator and Bus Voltage: ±1.0%
Generator and Bus Frequency: ±0.1 Hz
Generator Line Current: ±1.0%
Generator Power
  Apparent Power (VA): ±2.0%
  Active Power (W): ±2.0%
  Reactive Power (var): ±2.0%
Power Factor: ±0.02 PF
Field Current and Voltage: ±2.0%
Assy. Voltage & Current Input: ±1.0%
Power System Stabilizer (PSS)
Operating Mode: Generator or Motor, ABC or ACB phase sequence
Sensing Configuration: Power and Speed or Speed only
Power Measurement: Two-wattmeter method or three-wattmeter method
Frequency Range: Responds to power oscillations from 0.1 to 5 Hz. Low-pass and high-pass filtering prevents unwanted PSS action outside this range.

Setpoint Traverse Rate
Setting Range: 10 to 200 s
Setting Increment: 1 s

Setpoint Tracking

Delay
Range: 0 to 8.0 s
Increment: 0.1 s

Traverse Rate
Range: 1 to 80 s
Increment: 0.1 s

Soft Start
Two sets of soft start settings are available when operating in AVR or FCR mode.

Soft Start Bias Level
Range: 0 to 90%
Increment: 1%

Soft Start Time Delay
Range: 1 to 7,200 s
Increment: 1 s

Sequence of Events Recording
Events are time- and date-stamped and stored in volatile memory.
Event Capacity: 127
Scan Interval: 50 ms
Logic Triggers: Input state change, output state change, alarm annunciation, or system operating status change

Data Logging (Oscillography)
Record Capacity: 6
Variables per Record: 6
Sampling Rate: 600 data points per record
Pre-Trigger Points: Up to 599
Record Duration: 2.4 s to 6,000 s
Interval: 4 ms to 10 s

Trending
Record Capacity: 1
Variables per Record: 6
Sampling Rate: 1,200 data points per record
Record Duration: 1 hr to 30 d

Limiters
Underfrequency Compensation
Slope Adjustment Range: 0 to 0.3 PU
Knee Frequency Range: 15 to 90 Hz
**Volts per Hertz**

Slope Adjustment Range: 0 to 3 PU  
Time Delay Range: 0 to 10 s  

**Summing Point Overexcitation Limiter**

Three on-line setpoint levels: 1 (high), 2 (medium), and 3 (low). Limiter response is less than 3 cycles.

Setpoint Range  
Level 1, 2, 3: 0 to 11,999 Adc  
Setpoint Increment  
Level 1, 2, 3: 0.1% of the rated field current  

Limiting Time Range  
Level 1: 0 to 60 s  
Level 2: 0 to 120 s  
Level 3: Indefinite  

Limiting Time Increment  
Level 1, 2: 1 s  
Level 3: N/A  

Two off-line setpoint levels: 1 (high) and 2 (low). Limiter response is less than 3 cycles.

Setpoint Range  
Level 1, 2: 0 to 11,999 Adc  
Setpoint Increment  
Level 1, 2: 0.1% of the rated field current  

Limiting Time Range  
Level 1: 0 to 60 s  
Level 2: Indefinite  

Limiting Time Increment  
Level 1: 1 s  
Level 2: N/A  

**Takeover Overexcitation Limiter**

Two on-line setpoint levels: High and Low. Limiter response is less than 3 cycles.

Setpoint Range  
High, Low Level: 0 to 11,999 Adc  
Setpoint Increment  
High, Low Level: 0.1 Adc  

Time Dial  
Range: 0.1 to 20 s  
Increment: 0.1 s  

Two off-line setpoint levels: High and Low. Limiter response is less than 3 cycles.

Setpoint Range  
High, Low Level: 0 to 11,999 Adc  
Setpoint Increment  
High, Low Level: 0.1 Adc  

Time Dial  
Range: 0.1 to 20 s  
Increment: 0.1 s  

**Underexcitation**

User-selectable, summing-point type of takeover limiter. UEL curve is selected by specifying the acceptable reactive power level at zero active power output or by entering a five-point UEL characteristic. UEL adjusts characteristic according to changes in generator terminal voltage.

Reactive Power  
Setting Range: 0 to 41 kvar (leading)  
Setting Increment: 1 kvar  

Real Power  
Setting Range: 0 to 41 kW  
Setting Increment: 1 kW
**Stator Current**

Single- or three-phase summing-point limiter with PI control loop. Limiter has two steps: High and Low.

<table>
<thead>
<tr>
<th>Setpoint Range</th>
<th>Definite Time Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>High, Low:</td>
<td>100 to 300% of nominal generator output current</td>
</tr>
<tr>
<td>High:</td>
<td>0 to 60 s, 1 s increments</td>
</tr>
</tbody>
</table>

**Protection Functions**

**Field Overvoltage**

Setting Range: 1 to 2,000 Vdc  
Time Delay: 0.2 to 30 s

**Field Overcurrent**

Setting Range: 0.1 to 9,999 Adc  
Time Delay: 0.1 to 20 s

**Generator Undervoltage**

Setting Range: 0 to 34,500 Vac  
Time Delay: 0.5 to 60 s

**Generator Overvoltage**

Setting Range: 0 to 34,500 Vac  
Time Delay: 0.1 to 60 s

**Loss of Sensing Voltage**

Pickup Level: 0 to 100%, balance or imbalance condition  
Time Delay: 0 to 30 s

**Generator Underfrequency**

Pickup Level: Fixed at 10 Hz  
Time Delay: N/A

**Loss of Field (40Q)**

Setting Range: 0 to 3,000 Mvar  
Time Delay: 0 to 9.9 s

**Field Overtemperature**

Calculated from field voltage and current data.  
Setting Range: 0 to 572°C  
Time Delay: 0.1 to 60 s

**Volts per Hertz (24)**

Setting Range: 0.5 to 6 V/Hz  
Integrating Reset Range: 0 to 9.9 V/Hz

**Exciter Diode Failure**

Protection Modes: Shorted and/or Open  
Exciter to Stator Poles Ratio: \( \leq 10 \)  
Generator Frequency Range: 40 to 70 Hz

**Type Tests**

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Standard/Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock</td>
<td>IEC 60255-21-2</td>
</tr>
<tr>
<td>Vibration</td>
<td>IEC 60255-21-1</td>
</tr>
<tr>
<td>Humidity</td>
<td>IEC 68-1, IEC 68-2-28</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>IEEE 421.3</td>
</tr>
<tr>
<td>Transients</td>
<td>IEEE C37.90.1-1989</td>
</tr>
<tr>
<td>Surge Withstand Capability</td>
<td>IEEE C37.90.1-1989</td>
</tr>
<tr>
<td>Impulse</td>
<td>IEC 60255-5</td>
</tr>
<tr>
<td>Electrostatic Discharge</td>
<td>IEEE C37.90.3 Draft 2.3</td>
</tr>
<tr>
<td>Radio Frequency Interference</td>
<td>IEEE C37.90.2</td>
</tr>
</tbody>
</table>
Agency Recognition

cURus recognition per UL Standard 508, File E97035 and CSA Standard C22.2 No. 14

CE Compliance

Meets or exceeds the standards required for distribution in the European community

GOST-R Certification

GOST-R certified No. POCC US.ME05.B03391; is in compliance with the relevant standards of Gosstandart of Russia. Issued by accredited certification body POCC RU.0001.11ME05.

Real-Time Clock Backup Battery

Type: Lithium, ½ AA size
Rating: 3.6 Vdc, 1.0 Ah nominal capacity
Replacement Interval: 5 yr
Part Number: Basler Electric 37819
Tadiran TL-2150/S

Environment

Operating Temperature: –40 to 60°C (–40 to 140°F)
Storage Temperature: –40 to 85°C (–40 to 185°F)

Physical

Weight: 6.01 kg (13.25 lb)
Size: Refer to Section 4, Installation for DECS-400 dimensions.
SECTION 2 • HUMAN-MACHINE INTERFACE

TABLE OF CONTENTS

SECTION 2 • HUMAN-MACHINE INTERFACE ................................................................. 2-1
INTRODUCTION .................................................................................................................. 2-1
CONTROLS AND INDICATORS ....................................................................................... 2-1
MENU SYSTEM .................................................................................................................. 2-2
   Menu Navigation .......................................................................................................... 2-2
   Menu Structure ............................................................................................................ 2-2
EDITING SETTINGS .......................................................................................................... 2-19
   Screens with Special Editing Modes ............................................................................. 2-19
PASSWORD PROTECTION ................................................................................................. 2-19
METERING SCREEN ........................................................................................................... 2-21
   Metering Values .......................................................................................................... 2-21
   Setpoint ....................................................................................................................... 2-22
   Percent of Range ........................................................................................................ 2-22
   Alarms Message ......................................................................................................... 2-22
   Operating Mode ......................................................................................................... 2-23

Figures
   Figure 2-1. Controls and Indicators ............................................................................... 2-1
   Figure 2-2. Operating Modes Menu ............................................................................... 2-3
   Figure 2-3. Setpoints Menu .......................................................................................... 2-4
   Figure 2-4. Loop Gains Menu ....................................................................................... 2-5
   Figure 2-5. Metering Menu .......................................................................................... 2-6
   Figure 2-6. Protection Menu (Part 1 of 2) .................................................................. 2-7
   Figure 2-7. Protection Menu (Part 2 of 2) .................................................................. 2-8
   Figure 2-8. Limiters Menu (Part 1 of 2) .................................................................... 2-9
   Figure 2-9. Limiters Menu (Part 2 of 2) .................................................................... 2-10
   Figure 2-10. PSS Parameters Menu (Part 1 of 4) ......................................................... 2-11
   Figure 2-11. PSS Parameters Menu (Part 2 of 4) ......................................................... 2-12
   Figure 2-12. PSS Parameters Menu (Part 3 of 4) ......................................................... 2-13
   Figure 2-13. PSS Parameters Menu (Part 4 of 4) ......................................................... 2-14
   Figure 2-14. System Parameters Menu (Part 1 of 3) .................................................... 2-15
   Figure 2-15. System Parameters Menu (Part 2 of 3) .................................................... 2-16
   Figure 2-16. System Parameters Menu (Part 3 of 3) .................................................... 2-17
   Figure 2-17. General Settings Menu ............................................................................ 2-18
   Figure 2-18. Metering Screen Information .................................................................. 2-21

Tables
   Table 2-1. Control and Indicator Descriptions .............................................................. 2-1
   Table 2-2. Settings Protected by Setpoint Password ..................................................... 2-20
   Table 2-3. Selectable Metering Parameters ................................................................ 2-21
   Table 2-4. Setpoint Field Operating Mode Cross-Reference ......................................... 2-22
   Table 2-5. Alarm Messages ......................................................................................... 2-22
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SECTION 2 • HUMAN-MACHINE INTERFACE

INTRODUCTION
This section describes the DECS-400 human-machine interface (HMI) and illustrates navigation of the menu tree accessed through the front panel and LCD.

CONTROLS AND INDICATORS
DECS-400 controls and indicators are illustrated in Figure 2-1 and described in Table 2-1. The locators and descriptions of Table 2-1 correspond to the locators shown in Figure 2-1.

Table 2-1. Control and Indicator Descriptions

<table>
<thead>
<tr>
<th>Locator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Null Balance Indicator. This LED lights when the setpoint of the inactive operating modes (AVR, FCR, Var, or Power Factor) match the setpoint of the active mode.</td>
</tr>
<tr>
<td>B</td>
<td>PSS Active Indicator. This LED lights when the integrated power system stabilizer is enabled and can generate a stabilizing signal in response to a power system disturbance.</td>
</tr>
<tr>
<td>C</td>
<td>Pre-Position Indicator. This LED lights when the setpoint of the active operating mode is at either of the two pre-position setting levels.</td>
</tr>
<tr>
<td>D</td>
<td>Lower Limit Indicator. This LED lights when the setpoint of the active operating mode is decreased to the lower setpoint limit.</td>
</tr>
<tr>
<td>E</td>
<td>Upper Limit Indicator. This LED lights when the setpoint of the active operating mode is increased to the upper setpoint limit.</td>
</tr>
<tr>
<td>F</td>
<td>Latch. Two lever-style latches (locators F and M) secure the DECS-400 draw-out assembly in its case. A captive Phillips screw in each latch can be tightened to lock the draw-out assembly in place.</td>
</tr>
<tr>
<td>G</td>
<td>Communication Port. This RS-232 port has a female DB-9 connector for local communication with a PC operating BESTCOMS software (supplied with the DECS-400).</td>
</tr>
</tbody>
</table>
**Reset Pushbutton.** This button is pressed to reset DECS-400 alarms or cancel a settings editing session.

**Scrolling Pushbuttons.** These four buttons are used to scroll up, down, left, and right through the menu tree displayed on the front panel display (locator K). During an editing session, the left and right scrolling pushbuttons select the variable to be changed and the up and down scrolling pushbuttons change the value of the variable.

**Edit Pushbutton.** Pressing this button starts an editing session and enables changes to DECS-400 settings. When the Edit pushbutton is pressed to open an editing session, an LED on the button lights. At the conclusion of the editing session, the Edit pushbutton is pressed to save the setting changes and the LED turns off.

**Display.** The display consists of a 128 by 64 pixel, liquid crystal display (LCD) with LED backlighting. It serves as a local source of information provided by the DECS-400 and is used when programming settings through the front panel. The LCD displays operations, setpoints, loop gains, metering, protection functions, system parameters, and general settings.

**Identification Label.** The identification label contains information such as the model, style, and serial numbers and operating power and sensing current ratings.

**Latch.** Two lever-style latches (locators F and M) secure the DECS-400 draw-out assembly in its case. A captive Phillips screw in each latch can be tightened to lock the draw-out assembly in place.

## MENU SYSTEM

The front panel menu system consists of a network of screens that enable the user to edit DECS-400 settings and view system parameters.

### Menu Navigation

Movement through the front panel menu system is achieved by pressing the four, front-panel scrolling pushbuttons (locator I in Figure 2-1).

Navigation aids assist the user in moving from screen to screen and are provided at the top and bottom lines of each screen.

The top line of each screen contains the menu path which is similar to the path of a file on a PC. When the menu path exceeds the width of the LCD, the first part of the menu path is replaced with two periods (..) so that the last part of the path remains visible.

The bottom line indicates which menu screens can be accessed from the current screen by using the left, lower, or right scrolling pushbuttons. The screens accessed by the left, lower, and right scrolling pushbuttons are indicated by a <, v, and > symbol followed by an abbreviated menu name.

The front panel Reset pushbutton (locator H in Figure 2-1) provides a shortcut to the metering screen when a settings editing session is not in progress.

### Menu Structure

The front panel menu system has eight branches:

1. **Operating.** Start/stop, mode, and pre-position setpoint status.
2. **Setpoints.** Mode setting values such as AVR, FCR, droop, var, and power factor.
3. **Loop Gains.** PID settings.
4. **Metering.** Real-time metering of user-selected parameters and alarm messages.
5. **Protection.** Protective Function setting parameters.
6. **Limiters.** System limiters such as overexcitation and underexcitation.
7. **PSS.** Power system stabilizer settings.
8. **System Parameters.** The system parameters menu consists of nine sub-menus.
9. **General Settings.** Communication port parameters, real-time clock setup, and LCD contrast.

From the DECS-400 title screen, the Operating menu branch is accessed first by pressing the Down pushbutton. Then, the remaining branches are accessed by pressing the left or right scrolling pushbuttons.

The menu system structure is illustrated in Figure 2-2 through 2-9.

---

**Figure 2-2. Operating Modes Menu**
Figure 2-3. Setpoints Menu
Figure 2-4. Loop Gains Menu
Figure 2-5. Metering Menu
Figure 2-7. Protection Menu (Part 2 of 2)
Figure 2-8. Limiters Menu (Part 1 of 2)
Figure 2-9. Limiters Menu (Part 2 of 2)
Figure 2-10. PSS Parameters Menu (Part 1 of 4)
Figure 2-11. PSS Parameters Menu (Part 2 of 4)
Figure 2-12. PSS Parameters Menu (Part 3 of 4)
Figure 2-13. PSS Parameters Menu (Part 4 of 4)
Figure 2-14. System Parameters Menu (Part 1 of 3)
Figure 2-15. System Parameters Menu (Part 2 of 3)
Figure 2-16. System Parameters Menu (Part 3 of 3)
Figure 2-17. General Settings Menu
EDITING SETTINGS

DECS-400 settings can be edited through the front panel. An editing session is initiated by navigating to the screen containing the setting to be changed and pressing the Edit pushbutton. Edit mode is indicated by a lit LED on the Edit pushbutton. A prompt to enter a password will appear on the display. Additional information about using passwords is provided in Password Protection.

When security access is obtained through entry of the appropriate password, the first editable field of the current screen is underlined. The underlined setting can be changed by pressing the up or down scrolling pushbuttons to increase or decrease the setting. To edit another setting on the current screen, the left or right scrolling pushbuttons are pressed to move the underline to the other editable setting fields.

NOTE

Most setting changes are used immediately by the DECS-400. However, the changes are not saved in nonvolatile memory until the Edit pushbutton is pressed to terminate the editing session.

After all desired editing on a screen is completed, the changes can be saved or discarded. Changes are saved by pressing the Edit pushbutton, which ends the edit session and saves the changes in nonvolatile memory. Changes are discarded by pressing the Reset button, which ends the edit session and restores the settings active prior to editing by reading them from nonvolatile memory. In both cases, the Edit pushbutton LED turns off to indicate that the editing session is terminated.

Security (password) access is not immediately lost when a settings editing session is terminated. Security access ends after 10 minutes of no pushbutton activity. To modify settings on another screen with the same access level, the user merely navigates to that screen and presses the Edit pushbutton to start a new edit session.

This security access timeout differs from an edit session timeout. If 10 minutes of inactivity elapses during an edit session, any changes that were made will be saved in nonvolatile memory and will be used by the DECS-400. At this time, both edit access and security access are terminated.

Screens with Special Editing Modes

Several screens operate differently while in the edit mode. Examples of these screens are \D400\OPER\OPERATE_1, ..\COMMS\BAUD_RATE, and ..\COMMS\MODBUS. Changes made to settings on these screens are not used by the DECS-400 (nor saved in nonvolatile memory) until the Edit pushbutton is pressed again.

Other examples of screens with different behavior in edit mode include the loop gains screens, which are used to establish PID values (\D400\GAIN\PRI_GAINS and \D400\GAIN\SEC_GAINS). The first four parameters on these screens represent tables (one table for primary gains and one table for secondary gains) containing 20 sets of predefined PID (proportional + integral + derivative) values and one set of user-definable values. The first parameters, PRI STB RG and SEC STB RG, represent the stability setting number and are the index for the tables. Stability setting numbers 1 through 20 select predefined values from the table and a setting of 21 enables the selection of user-defined values. The second, third, and fourth parameters, AVR/FCR Kp, AVR/FCR Ki, and AVR/FCR Kd, are the actual entries in the table.

As long as the stability setting number is set at 21, then the Kp, Ki, and Kd parameters may be individually edited. Changed values are not used by the DECS-400 until they are saved by pressing the Edit pushbutton. Kp, Ki, and Kd may not be edited when the stability setting number is set at 1 through 20.

If the DECS-400 is operating with user-defined PID values and the stability setting number is changed to a value of 1 to 20, the user-defined Kp, Ki, and Kd values are lost. The next time that user-defined values for a stability setting of 21 are required, they must be manually entered and saved.

PASSWORD PROTECTION

All DECS-400 settings that can be edited at the front panel are password protected. A password is required at the start of any settings editing session. Password access expires 10 minutes after the last entry is received at the front panel.
There are two levels of password access: global and setpoint. Global password access permits changes to all settings that can be edited through the front panel. Setpoint password access permits changes to a limited selection of settings. Settings that can be changed with setpoint password access are listed in Table 2-2. All editable settings on a single menu screen have the same password access level.

### Table 2-2. Settings Protected by Setpoint Password

<table>
<thead>
<tr>
<th>Screen</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>\D400\OPER\OPERATE_1</td>
<td>Start/Stop control</td>
</tr>
<tr>
<td></td>
<td>AVR/FCR mode</td>
</tr>
<tr>
<td></td>
<td>Power Factor/Var mode</td>
</tr>
<tr>
<td></td>
<td>Pre-position 1 enable</td>
</tr>
<tr>
<td></td>
<td>Pre-position 2 enable</td>
</tr>
<tr>
<td>\D400\OPER\OPERATE_2</td>
<td>Voltage matching enable</td>
</tr>
<tr>
<td></td>
<td>Internal tracking enable</td>
</tr>
<tr>
<td></td>
<td>External tracking enable</td>
</tr>
<tr>
<td></td>
<td>Cross-current compensation enable</td>
</tr>
<tr>
<td></td>
<td>Line drop compensation enable</td>
</tr>
<tr>
<td></td>
<td>Droop enable</td>
</tr>
<tr>
<td>\D400\SETPT\MODE_SET</td>
<td>AVR mode setpoint</td>
</tr>
<tr>
<td></td>
<td>FCR mode setpoint</td>
</tr>
<tr>
<td></td>
<td>Droop setpoint</td>
</tr>
<tr>
<td></td>
<td>Var mode setpoint</td>
</tr>
<tr>
<td></td>
<td>Power Factor mode setpoint</td>
</tr>
<tr>
<td></td>
<td>Line drop setpoint</td>
</tr>
<tr>
<td>\D400\SETPT\PREP_SET1</td>
<td>Fine voltage band setting – pre-position 1</td>
</tr>
<tr>
<td></td>
<td>Minimum AVR mode setpoint – pre-position 1</td>
</tr>
<tr>
<td></td>
<td>Maximum AVR mode setpoint – pre-position 1</td>
</tr>
<tr>
<td></td>
<td>Minimum FCR mode setpoint – pre-position 1</td>
</tr>
<tr>
<td></td>
<td>Maximum FCR mode setpoint – pre-position 1</td>
</tr>
<tr>
<td>\D400\SETPT\PREP_SET2</td>
<td>AVR mode setpoint – pre-position 2</td>
</tr>
<tr>
<td></td>
<td>FCR mode setpoint – pre-position 2</td>
</tr>
<tr>
<td></td>
<td>Var mode setpoint – pre-position 2</td>
</tr>
<tr>
<td></td>
<td>Power Factor setpoint – pre-position 2</td>
</tr>
</tbody>
</table>

DECS-400 units are delivered with the same global and setpoint access password: *DECS4*. When the global and setpoint passwords are identical, the DECS-400 grants global access when the correct password is entered. In order to permit setpoint-only access, the setpoint access password must differ from the global access password. If the user attempts to start an edit session on a screen requiring global access while only setpoint access is granted, the setpoint access is revoked and the user is prompted to enter a global access password.

Passwords may be changed using BESTCOMS software (provided with the DECS-400) and a password can contain from one to six alphanumeric characters. To provide security against unauthorized setting changes, the passwords should be changed after commissioning. Once changed, the passwords should be stored in a secure location. If the user-defined passwords are lost or forgotten, the default password (DECS4) can be restored by simultaneously pressing the Edit and Reset pushbuttons during DECS-400 power-up.

**CAUTION**

Pressing the Edit and Reset pushbuttons during DECS-400 power-up replaces all user-programmed settings with the default settings.
Restoring the default password also replaces all user-programmed settings with the default values. Before performing this procedure, BESTCOMS software should be used to save a DECS-400 settings file. After the default settings are loaded while restoring the default password, the settings file can be uploaded to the DECS-400 and new passwords can be assigned.

**METERING SCREEN**

Metering screen information is displayed in five fields: metering values, alarms message, setpoint value, setpoint—percent of range, and operating mode. The metering screen fields are illustrated in Figure 2-2.

![Figure 2-18. Metering Screen Information](image)

**Metering Values**

Metering values for three user-selectable parameters are displayed. Table 2-3 lists the metering parameters available for display on the DECS-400 metering screen.

<table>
<thead>
<tr>
<th>Metering Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Hz</td>
<td>Bus frequency</td>
</tr>
<tr>
<td>Bus V</td>
<td>Bus voltage</td>
</tr>
<tr>
<td>EDM OC</td>
<td>Exciter diode monitor open-circuit percent ripple</td>
</tr>
<tr>
<td>EDM SC</td>
<td>Exciter diode monitor short-circuit percent ripple</td>
</tr>
<tr>
<td>F Temp</td>
<td>Field temperature</td>
</tr>
<tr>
<td>Field V</td>
<td>Field voltage</td>
</tr>
<tr>
<td>Fld I</td>
<td>Field current</td>
</tr>
<tr>
<td>Gen Hz</td>
<td>Generator frequency</td>
</tr>
<tr>
<td>I Avg</td>
<td>Average of three generator line currents</td>
</tr>
<tr>
<td>Ia</td>
<td>A-phase generator line current</td>
</tr>
<tr>
<td>Ib</td>
<td>B-phase generator line current</td>
</tr>
<tr>
<td>Ic</td>
<td>C-phase generator line current</td>
</tr>
<tr>
<td>NSeq I</td>
<td>Negative sequence current</td>
</tr>
<tr>
<td>NSeq V</td>
<td>Negative sequence voltage</td>
</tr>
<tr>
<td>PF</td>
<td>Power factor</td>
</tr>
<tr>
<td>PSeq I</td>
<td>Positive sequence current</td>
</tr>
<tr>
<td>PSeq V</td>
<td>Positive sequence voltage</td>
</tr>
<tr>
<td>V a-b</td>
<td>A-phase to B-phase generator rms voltage</td>
</tr>
<tr>
<td>V Aux</td>
<td>Accessory input voltage</td>
</tr>
<tr>
<td>V Avg</td>
<td>Average of three generator line-to-line voltages</td>
</tr>
<tr>
<td>V b-c</td>
<td>B-phase to C-phase generator rms voltage</td>
</tr>
<tr>
<td>V c-a</td>
<td>C-phase to A-phase generator rms voltage</td>
</tr>
<tr>
<td>VA</td>
<td>Generator load VA</td>
</tr>
<tr>
<td>VAr</td>
<td>Reactive power</td>
</tr>
<tr>
<td>Watts</td>
<td>Generator load watts</td>
</tr>
</tbody>
</table>
The DECS-400 uses auto-ranging to display up to four digits of resolution plus a decimal point. If needed, a multiplier such as k for kilo (1,000) or M for mega (1,000,000) is used. Negative values with magnitudes greater than 999.9 are displayed with three digits of resolution.

Setpoint
The setpoint field displays the setpoint for the active mode of operation. Table 2-4 lists the relationship between the mode of operation and the setpoint field quantity.

<table>
<thead>
<tr>
<th>Operating Mode</th>
<th>Mode Message</th>
<th>Setpoint Field Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>UNIT IS OFF</td>
<td>Setpoint from last mode</td>
</tr>
<tr>
<td>Voltage Matching</td>
<td>VOLTAGE MATCHING</td>
<td>AVR setpoint</td>
</tr>
<tr>
<td>FCR (Manual)</td>
<td>FCR (MANUAL)</td>
<td>FCR setpoint</td>
</tr>
<tr>
<td>AVR (Auto)</td>
<td>AVR (AUTO)</td>
<td>AVR setpoint</td>
</tr>
<tr>
<td>Droop</td>
<td>DROOP</td>
<td>AVR setpoint</td>
</tr>
<tr>
<td>Var Control</td>
<td>VAR CONTROL</td>
<td>Var setpoint</td>
</tr>
<tr>
<td>Power Factor Control</td>
<td>POWER FACTOR CONTROL</td>
<td>PF setpoint</td>
</tr>
</tbody>
</table>

Percent of Range
This field displays the setpoint expressed as a percentage of the available adjustment range. The relationship between this field and the setpoint field is linear. For example, a setpoint adjusted to the minimum value would be displayed as 0.0%, a setpoint adjusted to the middle of the adjustment range would be displayed as 50.0%, and a setpoint adjusted to the maximum value would be displayed as 100.0%.

Alarms Message
The alarms message line remains blank during normal operating conditions. If an enunciable condition occurs, “ALARMS (PRESS < OR >)” is displayed. Information about the condition is obtained by viewing the alarm message screen.

Alarm Message Screen
Pressing either the left or right scrolling pushbuttons, while viewing the metering screen, displays the alarm message screen. This screen displays up to six messages identifying the conditions that led to the most recent annunciations. Table 2-5 lists the annunciations that may appear on the alarm message screen. When more than one message is listed, the newest messages are added to the bottom of the list. Once the list contains six messages, any further annunciations will cause the oldest message to be deleted from the top of the list.

Table 2-5. Alarm Messages

<table>
<thead>
<tr>
<th>Annunciation Message</th>
<th>Duration of Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIELD OVERVOLTAGE</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>FIELD OVERCURRENT</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>GEN. UNDERVOLTAGE</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>GEN. OVERVOLTAGE</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>UNDERFREQUENCY</td>
<td>Clears 2 s after end of event</td>
</tr>
<tr>
<td>OVEREXCITATION LIMIT</td>
<td>Clears 2 s after end of event</td>
</tr>
<tr>
<td>UNDEREXCITATION LIMIT</td>
<td>Clears 2 s after end of event</td>
</tr>
<tr>
<td>LOST VOLTAGE SENSING</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>FAILED TO BUILD UP</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>SYSTEM BELOW 10 HZ</td>
<td>Clears 2 s after end of event</td>
</tr>
<tr>
<td>FIELD OVER TEMP</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>EXCITER DIODE OPEN</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>EXCITER DIODE SHORT</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>LOSS OF FIELD</td>
<td>Maintained until reset</td>
</tr>
</tbody>
</table>
### Annunciation Message Duration of Message

<table>
<thead>
<tr>
<th>Annunciation Message</th>
<th>Duration of Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATOR CURRENT LIMIT</td>
<td>Clears 2 s after end of event</td>
</tr>
<tr>
<td>EXCESSIVE V/HZ</td>
<td>Maintained until reset</td>
</tr>
<tr>
<td>LOSS ISOLATION MODULE</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>POWER SUPPLY LOW</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>VOLTAGE UNBALANCE</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>CURRENT UNBALANCE</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>POWER BELOW THRESHOLD</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>SPEED FAILURE</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>VOLTAGE LIMIT</td>
<td>Automatically reset</td>
</tr>
<tr>
<td>CLOCK RESET</td>
<td>Maintained until reset</td>
</tr>
</tbody>
</table>

The list of alarm messages can be cleared by pressing the Reset pushbutton. Pressing the Reset pushbutton also sends the display back to the metering screen and clears the metering screen alarms message. If a condition that led to an annunciation is still present when the alarm message screen is cleared, then a new annunciation message will be generated. The list of annunciations on the alarm message screen is retained if the user exits the screen by using the left, right, or up scrolling pushbuttons. However, the metering screen will not indicate when a new annunciation occurs because the alarms message will always be present.

### Operating Mode

This line of the metering screen indicates the DECS-400’s current mode of operation. Table 2-4 lists the message displayed for each DECS-400 operating mode.
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# SECTION 3 • FUNCTIONAL DESCRIPTION

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>3-1</td>
</tr>
<tr>
<td>DECS-400 FUNCTION BLOCKS</td>
<td>3-1</td>
</tr>
<tr>
<td>Analog Input Circuits</td>
<td>3-1</td>
</tr>
<tr>
<td>Generator Voltage</td>
<td>3-2</td>
</tr>
<tr>
<td>Bus Voltage</td>
<td>3-2</td>
</tr>
<tr>
<td>Line Current</td>
<td>3-2</td>
</tr>
<tr>
<td>Cross-Current Compensation</td>
<td>3-2</td>
</tr>
<tr>
<td>Accessory Input</td>
<td>3-2</td>
</tr>
<tr>
<td>Field Voltage and Current</td>
<td>3-3</td>
</tr>
<tr>
<td>Front Panel Keyboard</td>
<td>3-3</td>
</tr>
<tr>
<td>Contact Input Circuits</td>
<td>3-3</td>
</tr>
<tr>
<td>AVR</td>
<td>3-3</td>
</tr>
<tr>
<td>FCR</td>
<td>3-3</td>
</tr>
<tr>
<td>Raise</td>
<td>3-3</td>
</tr>
<tr>
<td>Lower</td>
<td>3-3</td>
</tr>
<tr>
<td>Start</td>
<td>3-4</td>
</tr>
<tr>
<td>Stop</td>
<td>3-4</td>
</tr>
<tr>
<td>SW1 – SW10</td>
<td>3-4</td>
</tr>
<tr>
<td>Digital Signal Processor</td>
<td>3-4</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>3-4</td>
</tr>
<tr>
<td>Memory Circuits</td>
<td>3-4</td>
</tr>
<tr>
<td>Digital to Analog Converter</td>
<td>3-4</td>
</tr>
<tr>
<td>Control Output Circuits</td>
<td>3-5</td>
</tr>
<tr>
<td>Meter Driver Circuits</td>
<td>3-5</td>
</tr>
<tr>
<td>Relay Output Contacts</td>
<td>3-5</td>
</tr>
<tr>
<td>On/Off</td>
<td>3-5</td>
</tr>
<tr>
<td>Watchdog</td>
<td>3-5</td>
</tr>
<tr>
<td>Programmable</td>
<td>3-5</td>
</tr>
<tr>
<td>Front Panel LEDs</td>
<td>3-6</td>
</tr>
<tr>
<td>Front Panel LCD</td>
<td>3-6</td>
</tr>
<tr>
<td>Front Panel RS-232 Communication Port</td>
<td>3-6</td>
</tr>
<tr>
<td>Rear Panel RS-485 Communication Ports</td>
<td>3-6</td>
</tr>
<tr>
<td>Modem</td>
<td>3-6</td>
</tr>
<tr>
<td>Power Supply</td>
<td>3-6</td>
</tr>
<tr>
<td>STARTUP FUNCTIONS</td>
<td>3-6</td>
</tr>
<tr>
<td>Soft Start Function</td>
<td>3-6</td>
</tr>
<tr>
<td>Field Flash/Buildup</td>
<td>3-6</td>
</tr>
<tr>
<td>Failure to Build Up</td>
<td>3-7</td>
</tr>
<tr>
<td>Voltage Matching</td>
<td>3-7</td>
</tr>
<tr>
<td>CONTROL MODES</td>
<td>3-7</td>
</tr>
<tr>
<td>AVR</td>
<td>3-8</td>
</tr>
<tr>
<td>FCR</td>
<td>3-8</td>
</tr>
<tr>
<td>Var</td>
<td>3-8</td>
</tr>
<tr>
<td>PF</td>
<td>3-8</td>
</tr>
<tr>
<td>Control Mode Pre-Position Setpoints</td>
<td>3-8</td>
</tr>
<tr>
<td>PROTECTION FUNCTIONS</td>
<td>3-9</td>
</tr>
<tr>
<td>Field Overcurrent</td>
<td>3-9</td>
</tr>
<tr>
<td>Field Overvoltage</td>
<td>3-10</td>
</tr>
<tr>
<td>Generator Undervoltage</td>
<td>3-10</td>
</tr>
<tr>
<td>Generator Overvoltage</td>
<td>3-10</td>
</tr>
<tr>
<td>Loss of Sensing Voltage</td>
<td>3-10</td>
</tr>
<tr>
<td>Loss of Field Isolation Transducer</td>
<td>3-10</td>
</tr>
<tr>
<td>Generator Frequency Less Than 10 Hertz</td>
<td>3-10</td>
</tr>
<tr>
<td>Power Supply Low</td>
<td>3-10</td>
</tr>
</tbody>
</table>
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SECTION 3 • FUNCTIONAL DESCRIPTION

INTRODUCTION
This section describes how the DECS-400 functions and explains its operating features. To ease understanding, DECS-400 functions are illustrated in the block diagram of Figure 3-1. A detailed description of each function block is provided in the paragraphs under the heading of DECS-400 Function Blocks.

DECS-400 FUNCTION BLOCKS
The following paragraphs describe each of the function blocks illustrated in Figure 3-1. The function of each block is explained along with the operation of all function block inputs and outputs.

Analog Input Circuits
The DECS-400's analog sensing inputs are described in the following paragraphs.
Generator Voltage

Generator sensing voltage is supplied to DECS-400 terminals A9 (E1), A10 (E2), and A11 (E3) through external, user-supplied, isolation transformers with a nominal output rating of 120 Vac or 240 Vac. The DECS-400 automatically selects the proper generator voltage sensing range based on the generator voltage sensing transformer’s secondary voltage value entered in the DECS-400.

DECS-400 generator voltage sensing inputs consist of an A-phase to B-phase (VAB) voltage input, a B-phase to C-phase voltage input (VBC), and a C-phase to A-phase voltage input (VCA).

The VCA voltage sensing input is used by the DECS-400 to calculate generator frequency. Sensed voltage is filtered (through a zero-crossing detector) to eliminate multiple zero crossings during one fundamental period.

Bus Voltage

Bus sensing voltage is supplied to DECS-400 terminals A13 (BUS1) and A14 (BUS3) through external, user-supplied isolation transformers with a nominal output rating of 120 Vac or 240 Vac. The DECS-400 automatically selects the proper bus voltage sensing range based on the bus voltage sensing transformer’s secondary voltage value entered in the DECS-400.

The sensed bus voltage is filtered (through a zero-crossing detector) to eliminate multiple zero crossings during one fundamental period. This input is compared with the generator sensing voltage for the purpose of voltage matching.

Line Current

The line current sensing inputs consist of an A-phase current input (IA), a B-phase current input (IB), and a C-phase current input (IC).

Generator sensing current is supplied to DECS-400 terminals A1 and A2 (CTA), A3 and A4 (CTB), and A5 and A6 (CTC) through external, user-supplied current transformers (CTs) with a secondary rating of 1 Aac (DECS-400 style XX1X) or 5 Aac (DECS-400 style XX5X).

When only one phase of generator current is sensed, the IB input (terminals A3 and A4) must be used. A minimum of two generator current phases must be sensed for PSS applications.

Cross-Current Compensation

This input (CCC) is used when generators are operating in cross-current compensation (reactive differential) mode.

B-phase generator sensing current is supplied to DECS-400 terminals A7 and A8 through an external, user-supplied CT with a secondary rating of 1 Aac (DECS-400 style XX1X) or 5 Aac (DECS-400 style XX5X).

Accessory Input

The accessory input can be configured to receive an external excitation setpoint control signal, the control signal from an external PSS, or for limiter scaling. (For more information about limiter scaling, see Limiter Functions, Limiter Scaling later in this section.) The accessory input accepts either a –10 Vdc to +10 Vdc signal at DECS-400 terminals A16 (+) and A17 (–) or a 4 mAdc to 20 mAdc control signal at A19 (+) and A20 (–).

When a current input type is selected, the input current is converted by the DECS-400 to a voltage signal in the range of –5 to +5 Vdc. The following equation is used by the DECS-400 when converting the applied current into a voltage.

\[ V_{aux} = 0.625 (I - 12) \]

where: 
- \( V_{aux} \) = the calculated voltage signal 
- I = current applied to the accessory input (in milliamperes)

For setpoint control, \( V_{aux} \) is multiplied by the appropriate accessory gain setting: AVR mode gain, FCR mode gain, Var mode gain, or Power Factor mode gain. The accessory input can be active in all four operating modes.

In AVR mode, the accessory input signal is multiplied by the AVR mode gain setting, which defines the setpoint change as a percentage of the rated generator voltage.

In FCR mode the accessory input signal is multiplied by the FCR mode gain setting, which defines the setpoint change as a percentage of the rated field current.

In Var mode, the accessory input signal is multiplied by the Var mode gain setting, which defines the setpoint change as a percentage of the rated apparent power for the generator.
In Power Factor mode, the accessory input signal is multiplied by the Power Factor mode gain setting and then divided by 100 to define the power factor setpoint change.

Field Voltage and Current

The DECS-400 receives field voltage and current signals from the field isolation module supplied with the DECS-400. Field voltage and current signals are transmitted from the field isolation module through a dedicated cable terminated at DECS-400 connector J1.

For field voltage sensing, the field isolation module accepts a range of nominal voltages of 63 Vdc, 125 Vdc, 250 Vdc, 375 Vdc, or 625 Vdc. The applied field voltage may be \( \pm 300\% \) of the nominal value. The field isolation module supplies the DECS-400 with a field voltage signal over the range of 0.9 to 9.1 Vdc, where 5.0 Vdc equals zero field voltage.

For field current sensing, the field isolation module accepts nominal current shunt output voltages of 0 to 50 mVdc or 0 to 100 mVdc. The applied shunt voltage may be up to 300\% of either range. The field isolation module supplies the DECS-400 with a field current signal over the range of 2.0 to 9.5 Vdc, where 2.0 Vdc equals zero field current.

Front Panel Keyboard

The front panel keyboard consists of six pushbuttons.

Four of the pushbuttons are designated for scrolling up, down, left, and right through the menu tree displayed on the front panel display. During an editing session, the left and right scrolling pushbuttons select the variables to be changed and the up and down scrolling pushbuttons change the value of the variable.

The Reset pushbutton is pressed to reset DECS-400 alarms or cancel a settings editing session.

The Edit pushbutton is pressed to begin an editing session and enables changes to DECS-400 settings. When the Edit button is pressed to open an editing session, an LED on the button lights. At the conclusion of the editing session, the Edit pushbutton is pressed to save the editing changes.

Contact Input Circuits

Sixteen contact inputs are provided for initiating DECS-400 actions. Six of the contact inputs are fixed-function inputs: AVR, FCR, Lower, Raise, Start, and Stop. The remaining ten contact inputs are programmable inputs.

Each contact input has an isolated, interrogation voltage of 12 Vdc and accepts dry relay-switch contacts or an open-collector output from a PLC.

DECS-400 contact inputs are described in the following paragraphs.

**AVR**

This input accepts a momentary contact closure that places the DECS-400 in AVR (automatic voltage regulation) mode. If the DECS-400 receives AVR and FCR contact inputs simultaneously, the FCR input has priority. AVR contact input connections are made at terminals B4 (AVR) and B5 (COM).

**FCR**

This input accepts a momentary contact closure that places the DECS-400 in FCR (field current regulation or manual) mode. If the DECS-400 receives AVR and FCR contact inputs simultaneously, the FCR input has priority. FCR contact input connections are made at terminals B6 (FCR) and B5 (COM).

**Raise**

This input increases the active, operating setpoint. The raise setpoint function is active as long as the contact is closed. The raise increment is a function of the setpoint range of adjustment and the active mode traverse rate. The increments are directly proportional to the adjustment range and inversely proportional to the traverse rate. This input has no effect when the active pre-position mode is Maintain. Raise contact input connections are made at terminals B7 (RAISE) and B8 (COM).

**Lower**

This input decreases the active, operating setpoint. The lower setpoint function is active as long as the contact is closed. The lower increment is a function of the setpoint range of adjustment and the active mode traverse rate. The increments are directly proportional to the adjustment range and inversely proportional to the traverse rate. This input has no effect when the active pre-position mode is Maintain. Lower contact input connections are made at terminals B9 (LOWER) and B8 (COM).
**Start**

This input accepts a momentary contact closure that enables the DECS-400. If the DECS-400 receives Start and Stop contact inputs simultaneously, the Stop input has priority. Start contact input connections are made at terminals B1 (START) and B2 (COM).

**Stop**

This input accepts a momentary contact closure that disables the DECS-400. If the DECS-400 receives Stop and Start contact inputs simultaneously, the Stop input has priority. Stop contact input connections are made at terminals B3 (STOP) and B2 (COM).

**SW1 – SW10**

These user-programmable inputs can be connected to monitor the status of excitation system contacts and switches. Then, using BESTCOMS, these inputs can be used as part of a user-configured logic scheme to control and annunciate a variety of system conditions and contingencies. Information about using SW1 through SW10 is provided in Section 5, **BESTCOMS**.

**Digital Signal Processor**

The digital signal processor (DSP) supports measurement, control (output and converters), metering functions, and filtering. It controls both the analog-to-digital converter (ADC) and the digital-to-analog converter (DAC). All analog input signals from the ADC are filtered by finite impulse response (FIR) filters. AC signals are also filtered by infinite impulse response (IIR) filters, and dc signals (field voltage and current) are filtered by averaging filters. Output data to the DAC are used to generate the control output signals.

**Microprocessor**

The microprocessor performs control, measurement, computation, self-test, and communication functions by using its embedded programming (firmware) and the nonvolatile settings stored in its memory.

**IRIG Port**

When a valid time code signal is detected at the IRIG port, it automatically synchronizes the DECS-400’s internal clock with the time code signal. Because the IRIG time code signal does not contain year information, it is necessary for the user to enter the date even when using an IRIG source. Year information is stored in nonvolatile memory so that when operating power is restored after an outage and the clock is re-synchronized, the current year is restored.

The IRIG input is fully isolated and accepts a demodulated (dc level-shifted) signal. For proper recognition, the IRIG signal applied to the DECS-400 must have a logic high level of no less than 3.5 Vdc and a logic low level that is no higher than 0.5 Vdc. The input signal voltage range is –10 Vdc to +10 Vdc. Input resistance is nonlinear and approximately 4 kΩ at 3.5 Vdc and 3 kΩ at 20 Vdc. IRIG signal connections are made at terminals D1 (IRIG+) and D2 (IRIG–).

**Memory Circuits**

The DECS-400 has three types of memory circuits: flash memory, random access memory (RAM), and electrically-erasable, programmable, read-only memory (EEPROM). Flash memory is nonvolatile and retains the operating software (firmware). RAM is volatile and serves as temporary storage for data. EEPROM is nonvolatile and stores DECS-400 settings.

**Digital to Analog Converter**

Digital input data from the digital signal processor (DSP) is converted by the digital-to-analog converter (DAC) into analog signals for controlling the excitation level. Output data from the DAC may be either a voltage signal or current signal. Signal selection is made through BESTCOMS or the front panel HMI.

A second pair of DACs supply metering signals to the DECS-400 meter driver output terminals.

**Control Output Circuits**

Analog signals from the DAC are output to switches controlled by the DSP. There are three control signal options. A control signal over the range of 0 to 10 Vdc, –10 to 10 Vdc, or 4 to 20 mA may be selected. Control signal selection is made through BESTCOMS or the front panel HMI.
Meter Driver Circuits

Two analog signals from a second DAC are output from the microprocessor. A meter driver signal over the range of 4 to 20 mAdc may be configured to represent one of the DECS-400 metered values. Each driver circuit can be configured for a different metered value and configured to represent a specific range of the metered value. The parameters available for metering are listed below:

- Auxiliary Voltage Input
- AVR PID Error Signal Input
- Bus Frequency
- Bus Voltage
- Comp. Freq. Deviation
- Control Output
- Cross Current Input
- Field Current
- Field Temperature
- Field Voltage
- Frequency Response
- Generator Apparent Power
- Generator Average Current
- Generator Average Voltage
- Generator Current Ia
- Generator Current Ib
- Generator Current Ic
- Generator Frequency
- Generator Power Factor
- Generator Reactive Power
- Generator Real Power
- Generator Voltage Vab
- Generator Voltage Vbc
- Generator Voltage Vca
- Negative Sequence Current
- Null Balance Level
- OEL Controller Output
- PF Mode Output
- Phase Angle Ia – Vca
- Phase Angle Ib – Vca
- Phase Angle Ic – Vca
- Phase Angle Vab
- PID Integrator State
- Position Indication
- Positive Sequence Current
- Positive Sequence Voltage
- PSS Electrical Power
- PSS Filtered Mech. Power
- PSS Final Output
- PSS Lead-Lag #1
- PSS Lead-Lag #2
- PSS Lead-Lag #3
- PSS Lead-Lag #4
- PSS Lead-Lag #5
- PSS Lead-Lag #6
- PSS Lead-Lag #7
- PSS Lead-Lag #8
- PSS Lead-Lag #9
- PSS Lead-Lag #10
- PSS Lead-Lag #11
- PSS Lead-Lag #12
- PSS Lead-Lag #13
- PSS Lead-Lag #14
- PSS Lead-Lag #15
- PSS Lead-Lag #16
- PSS Lead-Lag #17
- PSS Lead-Lag #18
- PSS Lead-Lag #19
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- PSS Lead-Lag #95
- PSS Lead-Lag #96
- PSS Lead-Lag #97
- PSS Lead-Lag #98
- PSS Lead-Lag #99
- PSS Lead-Lag #100
- PSS Mechanical Power
- PSS Mech. Power LP #1
- PSS Mech. Power LP #2
- PSS Mech. Power LP #3
- PSS Mech. Power LP #4
- PSS Post-Limit Output
- PSS Power HP #1
- PSS Pre-Limit Output
- PSS Speed HP #1
- PSS Synthesized Speed
- PSS Terminal Voltage
- PSS Torsional Filter #1
- PSS Torsional Filter #2
- PSS Washed Out Power
- PSS Washed Out Speed
- SCL Controller Output
- Terminal Freq. Deviation
- Time Response
- UEL Controller Output

Relay Output Contacts

DECS-400 output contacts consist of a dedicated On/Off output, a dedicated Watchdog output, and six programmable outputs.

On/Off

The SPST On/Off output contacts close when the DECS-400 is enabled and open when the DECS-400 is disabled. On/Off output connections are made at terminals C9 and C10.

Watchdog

The SPDT Watchdog output contacts change state during the following conditions:
- No operating power is applied to the DECS-400
- DECS-400 power-up (approximately 8 seconds)
- DECS-400 firmware ceases normal execution

Watchdog output connections are made at terminals C6 (NO), C7 (COM), and C8 (NC).

Programmable

The programmable output contacts (Relay #1, #2, #3, #4, #5, and #6) can be user-configured to annunciate DECS-400 status, active alarms, active protection functions, and active limiter functions. Each programmable output can be individually configured as normally-open (NO) or normally-closed (NC). Each programmable output can also be configured as momentary, maintained as long as the triggering condition is present, or latched until manually reset. The duration of a momentary contact's annunciation is programmable from 0.10 to 5 seconds in 50 millisecond increments. Relay #1 connections are made at terminals C11 and C12, Relay #2 connections are made at terminals C13 and C14, Relay #3 connections are made at terminals C15 and C16, Relay #4 connections are made at terminals C17 and C18, Relay #5 connections are made at terminals C19 and C20, and Relay #6 connections are made at terminals C21 and C22.

To make output identification easier, each programmable output may be assigned a user-selected name.
Front Panel LEDs
Six LEDs indicate setpoint status (Null Balance, Pre-Position, Lower Limit, and Upper Limit), power system stabilizer status (PSS Active), and Edit mode status (Edit).

Front Panel LCD
The backlit liquid crystal display serves as a local source of information provided by the DECS-400 and is used when programming settings through the front panel. The LCD displays operations, setpoints, loop gains, metering, protection functions, system parameters, and general settings.

Front Panel RS-232 Communication Port
This ASCII communication port, designated Com 0, consists of a female DB-9 connector intended for local communication with a PC operating BESTCOMS software.

Rear Panel RS-485 Communication Ports
The DECS-400 has two rear-panel, RS-485 communication ports designated Com 1 and Com 2.
Com 1 is dedicated for ASCII communication with a secondary, redundant DECS-400. Com 1 connections are made at terminals D5 (A), D6 (B), and D7 (C).
Com 2 is intended for communication with a remote terminal using the Modbus protocol. Com 2 connections are made at terminals D10 (A), D11 (B), and D12 (C).
Refer to Section 1, General Information, Specifications for the available range of communication settings for Com 1 and Com 2.

Modem
An internal telephone modem enables an off-site PC operating BESTCOMS software to dial into a DECS-400 view and modify DECS-400 settings, metering values, and system status information. Modem access is read-only; this prevents system control or the changing of DECS-400 settings. Information about initiating modem communication is provided in Section 4, BESTCOMS Software, Communication.
The FCC part 68 approved modem connects through a rear-panel, RJ-11 connector designated J1. The modem communication baud rate is fixed at 9600.

Power Supply
DECS-400 units with a style number of XLXX, accept nominal operating power of 24 Vdc or 48 Vdc at terminals C4 (BATT–) and C5 (BATT+). DECS-400 units with a style number of XCXX have two operating power inputs. One input accepts 125 Vdc at terminals C4 (BATT–) and C5 (BATT+). A second input accepts 120 Vac at terminals C2 (N) and C3 (L). Refer to Section 1, General Information, Specifications for the acceptable input voltage ranges.
The power supply provides 5 Vdc, ±12 Vdc, and 24 Vdc operating power for DECS-400 circuitry and ±12 Vdc operating power for the Field Isolation Module.

STARTUP FUNCTIONS
DECS-400 startup functions include a soft start function, field flashing function, voltage matching, and a buildup failure annunciation function.

Soft Start Function
During startup, the soft start function prevents voltage overshoot by controlling the rate at which the generator terminal voltage builds toward the setpoint. Soft start is active in AVR (automatic) and FCR (manual) control modes. During system startup, the voltage reference adjustment is based on two parameters: level and time. The Soft Start Level is adjustable from 0 to 90%. Soft Start Time is adjustable from 1 to 7,200 seconds. Figure 3-2 illustrates a plot of the voltage reference when the soft start level is 30%, the soft start time is 8 seconds, and the voltage setpoint is at 100%.

Field Flash/Buildup
During startup, the field flashing/buildup function applies and removes field flashing from an external field flashing source. Field flashing/buildup is active in AVR (Auto) and FCR (Manual) control modes. During system startup, the application of field flashing is based on two parameters: level and time. The field flash dropout level is adjustable from 0 to 100% of the active mode setpoint and determines when field flashing is removed. The maximum field flash time is adjustable from 1 to 50 seconds and defines the maximum duration that field flashing is applied. In FCR control mode, the field flash dropout level is expressed as a
percentage of the field current setpoint and uses the field current level to determine when buildup has occurred. In AVR control mode, the field flash dropout level is expressed as a percentage of the generator voltage setpoint and uses the generator voltage level to determine when buildup has occurred.

Figure 3-2. Soft Start Voltage Reference

Failure to Build Up
The failure to build up function monitors if the active control mode parameter—generator voltage in AVR mode or field current in FCR mode—has reached the field flash dropout level prior to the maximum field flash time expiring. If the active control mode parameter does not reach the field flash dropout level before the maximum field flash time expires, a failure to build up is annunciated and the DECS-400 is disabled (placed in Stop mode).

A failure to build up is annunciated at the front panel display, through BESTCOMS software, and the RS-485 Modbus interface (Com 2). Any of the DECS-400's six programmable output relays can be configured to annunciate a failure to build up.

Voltage Matching
Voltage matching is active in AVR (Automatic) control mode and automatically adjusts the AVR mode setpoint to match the sensed bus voltage. Voltage matching is based on two parameters: band and matching level.

The band is adjustable from 0 to 20% of the sensed bus voltage and defines the window in which the generator voltage must be for voltage matching to occur.

The generator to bus PT matching level is adjustable from 90 to 120% and defines the percentage of the sensed bus voltage to which the generator sensed voltage will be adjustable. The voltage matching function utilizes the metered generator and bus voltage values to determine band and matched levels.

CONTROL MODES
The DECS-400 provides four control modes: Automatic Voltage Regulation (AVR), Field Current Regulation (FCR), Power Factor (PF), and Reactive Power (Var).
AVR

AVR mode is selected by a momentary contact input applied to terminals B4 and B5. AVR mode may also be selected through BESTCOMS. When operating in AVR mode, the DECS-400 adjusts the level of excitation to maintain the desired generator terminal voltage level. The desired terminal voltage level is entered (in primary generator voltage) through BESTCOMS or the front panel HMI as the AVR Setpoint setting. The setting range of the AVR Setpoint depends on the generator ratings entered and the minimum and maximum AVR settings. Once the AVR Setpoint is established, it can be fine tuned by applying a contact input to terminals B7 and B8 (raise) or B8 and B9 (lower). Raise and lower inputs may also be applied through BESTCOMS or Modbus. AVR Min and AVR Max settings control the range of adjustment for the AVR setpoint. The AVR Min setting has a setting range of 70 to 100% of the rated generator voltage and the AVR Max setting has a setting range of 100 to 110% of the rated generator voltage. The length of time required to adjust the AVR setpoint from one limit to the other is controlled by the AVR Traverse Rate setting. The AVR Traverse Rate is adjustable from 10 to 200 seconds.

FCR

FCR mode is selected by a momentary contact input applied to terminals B5 and B6. FCR mode may also be selected through BESTCOMS. FCR mode may be automatically selected (if enabled) when a loss of sensing condition occurs. When operating in FCR mode, the DECS-400 adjusts the control output to maintain the desired level of field current. The desired level of field current is entered through BESTCOMS or the front panel HMI as the FCR Setpoint setting. The setting range of the FCR Setpoint depends on the field type selected and other associated settings. Once the FCR setpoint is established, it can be fine tuned by applying a contact input to terminals B7 and B8 (raise) or B8 and B9 (lower). Raise and lower inputs may also be applied through BESTCOMS or Modbus. FCR Min and FCR Max settings control the range of adjustment for the FCR setpoint. The FCR Min setting has a setting range of 0 to 100% of the rated field current and the FCR Max setting has a setting range of 0 to 120% of the rated field current. The length of time required to adjust the FCR setpoint from one limit to the other is controlled by the FCR Traverse Rate setting. The FCR Traverse Rate is adjustable from 10 to 200 seconds.

Var

Var mode is selected through BESTCOMS and enabled by a contact closure received at one of the programmable contact inputs configured to enable Var/PF mode. When operating in Var mode, the DECS-400 controls the reactive power (var) output of the generator. The desired var level, expressed in kvar, is entered through BESTCOMS or the front panel HMI as the Var Setpoint setting. The setting range of the Var Setpoint depends on the generator settings and the minimum and maximum var settings. Once the var setpoint is established, it can be fine tuned by applying a contact input to terminals B7 and B8 (raise) or B8 and B9 (lower). Raise and lower inputs may also be applied through BESTCOMS or Modbus. The Var Min and Var Max settings control the range of adjustment for the var setpoint. The Var Min setting has a setting range of –100 to 0% of the generator rated kVA output and the Var Max setting has a setting range of 0 to 100% of the generator kVA output. The length of time required to adjust the var setpoint from one limit to the other is controlled by the Var Traverse Rate setting. The Var Traverse Rate is adjustable from 10 to 200 seconds.

PF

Power Factor mode is selected through BESTCOMS and enabled by a contact closure received at one of the programmable contact inputs configured to enable Var/PF mode. When operating in PF mode, the DECS-400 controls the var output of the generator to maintain a specific power factor as the kW load varies on the generator. The desired power factor is entered through BESTCOMS or the front panel HMI as the PF Setpoint setting. The setting range of the PF Setpoint is determined by the PF (Leading) and PF (Lagging) settings. Once the PF setpoint is established, it can be fine tuned by applying a contact input to terminals B7 and B8 (raise) or B8 and B9 (lower). Raise and lower inputs may also be applied through BESTCOMS or Modbus. The PF (Leading) and PF (Lagging) settings control the range of adjustment for the power factor setpoint. The PF (Leading) setting has a setting range of –0.500 to -1.000 and the PF (Lagging) setting has a setting range of 1.000 to 0.500. The length of time required to adjust the PF setpoint from one limit to the other is controlled by the PF Traverse Rate setting. The PF Traverse Rate is adjustable from 10 to 200 seconds.

Control Mode Pre-Position Setpoints

Each control mode has two pre-position setpoints which allow the DECS-400 to be configured for multiple system and application needs. Each pre-position setpoint can be assigned to a programmable contact input. When the appropriate contact input is closed, the setpoint is driven to the corresponding pre-
position value. The Pre-Position 1 and Pre-Position 2 functions of each control mode have two settings: Setpoint and Mode. The setting range of the Pre-Position Setpoints is identical to that of the corresponding control mode setpoint. The Mode setting determines whether or not the DECS-400 will respond to further setpoint change commands once the operating setpoint is driven to the corresponding pre-position value. If the pre-position mode is Release, subsequent setpoint change commands are accepted to raise and lower the setpoint. Additionally, if the non-active pre-position mode is Release and internal tracking is enabled, the pre-position value will respond to the tracking function. If the pre-position mode is Maintain, further setpoint change commands are ignored while the appropriate contact input is closed. Additionally, if the non-active pre-position mode is Maintain and internal tracking is enabled, the non-active mode will maintain the non-active setpoint at the pre-position value and override the tracking function.

PROTECTION FUNCTIONS

Twelve protection functions within the DECS-400 protect against the following conditions.

- Field overcurrent
- Field overvoltage
- Generator undervoltage
- Generator overvoltage
- Loss of sensing voltage
- Loss of Field Isolation Transducer
- Generator frequency less than 10 hertz
- Loss of field (40Q)
- Field overtemperature
- Volts per hertz (24)
- Exciter diode failure

An active protection function is annunciated at the front panel display, through the BESTCOMS interface, and through the RS-485 Modbus interface (Com 2). Any of the DECS-400’s six programmable output relays can be configured to annunciate an active protection function. DECS-400 protection functions are described in the following paragraphs.

Field Overcurrent

Field overcurrent is annunciated when the field current level increases above the Field Overcurrent Pickup Level setting for a definite amount of time. The Dial setting acts as a linear multiplier for the time to an annunciation. The Pickup Level setting and Dial setting are related by an inverse function. This means that the higher the field current climbs above the pickup level, the shorter the time to annunciation will be. The Pickup Level setting is adjustable from 0.1 to 9,999 Adc in 0.1 Adc increments. The Dial setting is adjustable from 0.1 to 20.0 seconds in 0.1 second increments. Field overcurrent protection can be enabled and disabled without altering the Pickup Level and Dial settings.

Typical field overcurrent timing curves are illustrated in Figure 3-3. Notice that field current levels below 103% cause an annunciation in the same amount of time as field current at the 103% level. Also, field current levels greater than 250% of the setpoint cause an annunciation in the same amount of time as field current at the 250% level. The field current must fall below the dropout ratio (95%) for the function to begin timing to reset.

![Figure 3-3. Field Overcurrent Timing Curves](image)

The following equations are used to calculate the field overcurrent pickup and reset time delays. In each equation, MOP stands for multiple of pickup.
Field Overvoltage
Field overvoltage is annunciated when the field voltage increases above the Field Overvoltage Pickup Level setting for the duration of the Field Overvoltage Delay setting. The Pickup Level setting is adjustable from 1 to 2,000 Vdc in 1 Vdc increments. The Delay setting is adjustable from 0.2 to 30 seconds in 0.1 second increments. Field overvoltage protection can be enabled and disabled without altering the Pickup Level and Delay settings.

Generator Undervoltage
Generator undervoltage is annunciated when the generator terminal voltage decreases below the Generator Undervoltage Pickup Level setting for the duration of the Generator Undervoltage Delay setting. The Pickup Level setting is adjustable from 0 to 34,500 Vac in 1 Vac increments. The Delay setting is adjustable from 0.5 to 60 seconds in 0.1 second increments. Generator undervoltage protection can be enabled and disabled without altering the Pickup Level and Delay settings.

Generator Overvoltage
Generator overvoltage is annunciated when the generator voltage terminal voltage increases above the Generator Overvoltage Pickup Level setting for the duration of the Generator Overvoltage Delay setting. The Pickup Level setting is adjustable from 0 to 34,500 Vac in 1 Vac increments. The Delay setting is adjustable from 0.1 to 60 seconds in 0.1 second increments.

Loss of Sensing Voltage
Loss of sensing voltage is annunciated when the generator voltage decreases below the appropriate Loss Of Sensing Voltage Level setting for the duration of the Loss of Sensing Voltage Delay setting. The DECS-400 can be configured to transfer to FCR mode when a loss of sensing voltage condition is detected. Two Level settings are provided: Balanced Level and Unbalanced Level. When all three phases of sensing voltage decrease below the Balanced Level setting, the Delay timer begins timing out. When any one of the three phases of sensing voltage decreases below the Unbalanced Level setting, the Delay timer begins timing out. Both Level settings are adjustable from 0 to 100% (of nominal generator voltage) in 0.1 second increments. Loss of sensing voltage protection can be enabled and disabled without altering the Level and Delay settings.

Loss of Field Isolation Transducer
A loss of field isolation transducer condition is annunciated when the field voltage or field current signal from the isolation module decreases below a predetermined level for the duration of the Loss of Field Isolation Transducer Delay setting. The Delay setting is adjustable from 0 to 9.9 seconds in 0.1 second increments.

Generator Frequency Less Than 10 Hertz
A below 10 Hz condition is annunciated when the generator frequency, measured across phases A and C (VCA), decreases below 10 Hz. A below 10 Hz annunciation is automatically reset when the generator frequency increases above the 10 Hz threshold.

Power Supply Low
A low power supply condition is annunciated when the internal power supply levels decrease below a predetermined level. A low power supply annunciation is automatically reset when the internal power supply voltage increases above the preset threshold.

Loss of Field (40Q)
A loss of field (excitation) condition is annunciated when the reactive power absorbed by the generator exceeds the Loss of Field Pickup Level setting for the duration of the Loss of Field Delay setting. The
Loss of Field condition will continue timing until the reactive power absorbed by the generator decreases below the dropout ratio (95%). The Pickup Level setting is adjustable from 0 to 3,000,000 kvar (leading) in 1 kvar increments. The Delay setting is adjustable from 0 to 9.9 seconds in 0.1 second increments. Figure 3-4 illustrates the generator capability curve versus the loss of field function's response. Figure 3-5 illustrates the motor/condenser capability curve versus the 40Q function's response.

Field Overtemperature
Field overtemperature is annunciated when the field temperature exceeds the Field Overtemperature Pickup Level setting for the duration of the Field Overtemperature Delay setting. The Pickup Level setting is adjustable from 0 to 572°C in 1°C increments. The Delay setting is adjustable from 0.1 to 60 seconds in 0.1 second increments. The DECS-400 calculates field temperature based on the generator main field resistance, the field ambient temperature, and the voltage drop across the generator main field brushes. Field overtemperature protection is intended for static exciter applications supplying a generator's main field. It is not intended for rotary exciter applications.

Volts per Hertz (24)
Volts per hertz protection is annunciated if the ratio of the per-unit voltage to the per-unit hertz (volts/hertz) exceeds one of the Volts per Hertz Pickup Level settings for a definite amount of time. If the Volts per Hertz Pickup level is exceeded, timing will continue until the Volts per Hertz ratio drops below the dropout ratio (95%). Volts per hertz protection also guards against other potentially damaging system conditions such as a change in system voltage and reduced frequency conditions that can exceed the system's excitation capability.

Several volts per hertz settings enable the DECS-400 to provide flexible generator and generator step-up transformer overexcitation protection. An inverse square timing characteristic is provided through the 24 Volts/Hertz Pickup Setpoint setting and 24 Volts/Hertz Pickup Time Dial. These settings enable the DECS-400 to approximate the heating characteristic of the generator and generator step-up transformer during overexcitation. The Pickup Setpoint has a per-unit setting range of 0.5 to 6.0 with increments of 0.01. A Pickup Time Dial setting of 0 to 9.9 may be entered in increments of 0.1. A linear reset characteristic is provided through the 24 Volts/Hertz Reset Time Dial setting. A Reset Time Dial setting of 0 to 9.9 may be entered in increments of 0.1.

Two sets of fixed-time, overexcitation pickup settings are available through the 24 Volts/Hertz Definite Time Pickup #1, #2 and Definite Time Pickup #1, #2 settings. Both pickup settings have a setting range of 0.5 to 6.0 with an increment of 0.01. Both time delay settings may be set over a range of 0.50 to 600 seconds in 0.05 second increments.

The following equations represent the trip time and reset time for a constant V/Hz level.
Where:

- $T_T = $ time to trip
- $T_R = $ time to reset
- $D_T = $ time dial trip
- $D_R = $ time dial, reset
- $E_T = $ elapsed time
- $n = $ curve exponent (0.5, 1, 2)
- $FST = $ full scale trip time ($T_T$)
- $E_T/FST = $ fraction of total travel toward trip that integration had progressed to. (After a trip, this value will be equal to 1.)

$$T_T = \frac{D_T}{\left(\frac{V/Hz_{MEASURED}}{V/Hz_{NOMINAL}} - 1\right)^n}$$

$$T_R = D_R \times \frac{E_T}{FST} \times 100$$

Figure 3-6. V/Hz Characteristic—Time Shown on Vertical Axis

Figure 3-7. V/Hz Characteristic—Time Shown on Horizontal Axis
Exciter Diode Failure

Exciter diode failure protection in the DECS-400 monitors for an open or shorted brushless, rotating exciter power semiconductor and can annunciate the condition so that action can be taken to protect the system from possible damage. An open diode will cause the level of excitation to be drastically increased to maintain the desired operating level. A shorted diode causes high current to flow through the associated exciter armature winding which can cause excessive heating.

Exciter diode failures are detected by monitoring the output of the exciter output diodes and measuring the induced ripple in the exciter field current. The fundamental harmonic of the exciter field current is estimated by using discrete Fourier transforms (DFTs). The harmonic, expressed as a percentage of the field current, is then compared to the EDM Open Diode Pickup Level setting and EDM Shorted Diode Pickup Level setting. If the percentage of field current exceeds either setting, then the appropriate time delay (EDM Open Diode Delay or EDM Shorted Diode Delay) begins. If the percentage of field current exceeds the open- or shorted-diode pickup setting at the conclusion of the appropriate time delay, a failed exciter diode annunciation is issued. The EDM Open Diode and EDM Shorted Diode Pickup Level settings have a setting range of 0 to 100% with 0.1% increments. The EDM Open Diode Delay setting has a setting range of 10 to 60 seconds with 0.1 second increments. The EDM Shorted Diode Delay setting has a setting range of 5 to 30 seconds with 0.1 second increments.

A Disable Level setting prevents nuisance failed diode indications due to low excitation current and the generator frequency being out of range. The Disable Level setting disables both open and shorted-diode protection and has a setting range of 0 to 100% with 0.1% increments.

The EDM function is automatically disabled if the field type configuration is Main Field.

**NOTE**
The exciter diode monitor may not be able to detect:
- A shorted diode on a brushless exciter having individually fused diodes
- An open diode on a brushless exciter having parallel diodes in each leg of the diode bridge

**LIMITER FUNCTIONS**

DECS-400 limiter functions consist of a stator current limiter, an overexcitation limiter, and underexcitation limiter, an underfrequency limiter, and a volts per hertz limiter.

**Stator Current Limiter**

The stator current limiter (SCL) monitors the level of stator current and limits it to prevent stator overheating. The SCL operates in all modes except FCR. When operating in FCR mode, the DECS-400 announces a stator overcurrent condition but does not act to limit the stator current.

Stator current limiting is provided at two levels (Figure 3-5).

High-level stator current limiting is controlled by the High SCL Level and High SCL Time settings. When the stator current increases above the High SCL Level setting, the DECS-400 acts to limit the level of stator current. After the High SCL Time setting expires, the DECS-400 acts to limit the level of stator current to the Low SCL Level setting value. The High SCL Level setting has a setting range of 0 to 66,000 Aac with 0.1 Aac increments. The High SCL Time setting has a setting range of 0 to 60 seconds with 0.1 second increments.
Low-level stator current limiting is controlled by the Low SCL Level setting, which serves as an annunciation that the stator current is at an elevated level. The generator is permitted to operate indefinitely at the low SCL level. The Low SCL Level setting range is identical to that of the High SCL Level setting range.

**Overexcitation Limiter**

The overexcitation limiter (OEL) monitors the level of field current supplied by the static exciter and limits the current to prevent field overheating. The OEL operates in all modes. Through user-configurable logic, the OEL can be disabled only when the DECS-400 is operating in FCR mode. The DECS-400 will announce an overexcitation condition but does not act to limit the excitation level.

There are two styles of overexcitation limiting available in the DECS-400: summing point and takeover.

**Summing Point OEL**

There are two sets of summing point OEL settings for off-line operation: a high-level setting and a low-level setting. Figure 3-6 illustrates the relationship of the high-level and low-level setting. The high-level, off-line OEL threshold is determined by the Off-Line High Level and Off-Line High Time settings. When the excitation level exceeds the High Level setting, the DECS-400 acts to limit the excitation. After the duration of the High Time setting expires, the DECS-400 acts to limit the excitation to the Low level setting. The Off-Line High Level setting has a setting range of 0 to 11,999 Adc with 0.01 Adc increments. The Off-Line High Time setting has a setting range of 0 to 10 seconds with 1 second increments. The low-level OEL threshold is determined by the Off-Line Low Level setting, which serves as an annunciation that off-line excitation is at an elevated level. The generator is permitted to operate indefinitely at the Off-Line Low Level setting. The Off-Line Low Level setting has a setting range of 0 to 11,999 Adc with 0.1 Adc increments.

There are three sets of summing point OEL settings for on-line operation: a high-level setting, a medium-level setting, and a low-level setting. Figure 3-7 illustrates the relationship of the high-, medium-, and low-level settings. The high-level, on-line OEL threshold is determined by the On-Line High Level and On-Line High Time settings. The On-Line High Level setting has a setting range of 0 to 11,999 Adc with 0.01 Adc increments. The On-Line High Time setting has a setting range of 0 to 60 seconds with 1 second increments. The medium-level, on-line threshold is determined by the On-Line Medium Level and On-Line Medium Time settings. The On-Line Medium Level setting has a setting range of 0 to 11,999 Adc with 0.01 Adc increments. The On-Line Medium Time setting has a setting range of 0 to 120 seconds with 1 second increments. The low-level, on-line OEL threshold is determined by the On-Line Low Level setting, which serves as an annunciation that on-line excitation is at an elevated level. The generator is permitted to operate indefinitely at the On-Line Low Level setting. The On-Line Low Level setting has a setting range of 0 to 11,999 Adc with 0.01 Adc increments.
Takeover OEL

There are two sets of takeover OEL settings for off-line and on-line operation: a low-level setting and a high-level setting. The field current level at which limiting occurs is determined by an inverse time characteristic similar to that shown in Figure 3-8. Separate curves may be selected for on-line and off-line operation. If the system enters an overexcitation condition, the field current is limited and made to follow the selected curve.

Underexcitation Limiter

The underexcitation limiter UEL senses the leading var level of the generator and limits any further decrease in excitation to prevent loss of synchronization and limit end-iron heating during. The (UEL) operates in all modes. Through user-configurable logic, the UEL can be disabled only in FCR mode. In this circumstance, underexcitation is only annunciated—not limited.

An internally-generated UEL curve or user-defined UEL curve may be specified. The internally-generated curve is based on the desired reactive power limit level at zero real power with respect to the generator voltage and current rating. The user-defined curve can have a maximum of five points. This curve allows the user to match a specific generator characteristic by specifying the coordinates of the intended leading reactive power (kvar) limit at the appropriate real power (kW) level. A typical user-defined UEL curve is shown in Figure 3-9.
The levels entered for the user-defined curve are defined for operation at the rated generator voltage. The user-defined UEL curve can be automatically adjusted based on generator operating voltage by using the UEL voltage dependency real-power exponent. The UEL voltage dependency real-power exponent has a setting range of 0 to 2 with an increment of 1. When a setting of 1 or 2 is entered, the user-defined UEL curve is automatically adjusted based on the ratio of the generator operating voltage divided by the generator rated voltage raised to the power of the UEL voltage dependency real-power exponent.

**Underfrequency Limiter**

When the generator frequency decreases below the corner frequency for the underfrequency slope (Figure 3-10), the DECS-400 adjusts the voltage setpoint so that the generator voltage follows the underfrequency slope. Settings for the corner frequency and slope enable the DECS-400 to precisely match the operating characteristics of the prime mover and the loads being applied to the generator. A Corner Frequency setting of 15 to 90 hertz may be entered in 0.1 hertz increments. A per-unit Slope setting of 0 to 3 may be entered in 0.01 increments.

When an underfrequency condition occurs, the DECS-400 issues an underfrequency annunciation through the front panel HMI. An annunciation may also be assigned to one of the DECS-400 programmable relay outputs.
**Volts per Hertz Limiter**

The volts per hertz limiter prevents the regulation setpoint from exceeding the volts per hertz ratio defined by the DECS-400 underfrequency slope setting. Volts per hertz ratio limiting guards against reduced frequency situations and changes in system voltage. A typical volts per hertz limiter curve is illustrated in Figure 3-14.

Beside the underfrequency slope setting, volts per hertz limiter operation is determined by the V/Hz High Limiter setting, the V/Hz Low Limiter setting, and the V/Hz Time Limiter setting. The V/Hz High Limiter setting establishes the maximum threshold for the volts per hertz limiter and can be adjusted from 0 to 3 in increments of 0.01. The V/Hz Low Limiter setting establishes the minimum threshold for the volts per hertz limiter and can be adjusted from 0 to 3 in increments of 0.01. The V/Hz Time Limiter setting establishes the time delay for the volts per hertz limiter and can be adjusted from 0 to 10 seconds in 0.1 second increments.

**Limiter Scaling**

When the accessory input signal is configured for limiter scaling, the stator current limiter (SCL) and overexcitation limiter (OEL) low-level values can be automatically adjusted. Automatic adjustment of the SCL and OEL is based on six parameters: signal and scale for three points. The signal value for each point represents the accessory input voltage and is adjusted from –10 to +10 Vdc in 0.01 steps. The scale value defines the limiter low level as a percentage of rated field current for the OEL and rated stator current for the SCL. The range of scale values is 0 to 200% with 0.1% increments. For accessory input voltages between two of the three defined points, the low-level limiter setting is linearly adjusted between the two scale values.
OPERATION WITH PARALLELED GENERATORS

DECS-400 units can be used to control the excitation level of two or more generators operating in parallel so that the generators share the reactive load. The DECS-400 accommodates either reactive droop compensation or reactive differential schemes for reactive load sharing. Line drop compensation can be used in either scheme.

Droop Compensation

When droop compensation is employed for a generator paralleled with the utility power grid, the bus voltage droops (decreases) as the reactive, lagging power factor load is increased. The DECS-400 droop compensation setting can be accessed through BESTCOMS or the front panel HMI. Droop compensation is expressed as a percentage of the generator rated terminal voltage and has an adjustment range of –30 to +30%.

Reactive Differential

Reactive differential (cross-current compensation) is facilitated in the DECS-400 by a dedicated current sensing input at terminals A7 and A8. The DECS-400 cross-current compensation setting can be accessed through BESTCOMS or the front panel HMI. Cross-current compensation is expressed as a percentage of the system CT rating and has an adjustment range of –30 to +30%.

Line Drop Compensation

Line drop compensation offsets line or transformer impedance drops and moves the regulation point beyond the terminals of the generator. The DECS-400 line drop compensation setting can be accessed through BESTCOMS or the front panel HMI. Line drop compensation is applied to both the real and reactive portion of the generator line current. Line drop compensation is expressed as a percentage of the generator terminal voltage and has an adjustment range of 0 to 30%.

AUTOTRACKING

The DECS-400 provides automatic tracking (following) of the controlling mode setpoint by the non-controlling setpoint. When a primary and secondary DECS-400 are used together, the secondary DECS-400 tracks the setpoint of the primary DECS-400.

Between DECS-400 Operating Modes

Autotracking between control modes of a DECS-400 enables an operator to initiate controlled, “bumpless” transfers between operating modes with minimal disturbance to the power system. Autotracking enables a set of protective relays to initiate a transfer to a backup mode (such as FCR mode) when a system failure or fault (such as a loss of sensing) is detected.

Between DECS-400 Units

A DECS-400 controller can be placed in service as a backup to a primary DECS-400 controller. The backup DECS-400 tracks the control output of the primary DECS-400 using dedicated communication port Com 1. In the unlikely event of a primary DECS-400 failure, excitation control is transferred to the secondary DECS-400 with minimal system disturbance.

DATA RECORDING AND REPORTING

DECS-400 data recording and reporting functions include sequence of events recording (SER), data logging, (oscillography), and trending.

Sequence of Events

A sequence of events recorder monitors the internal and external status of the DECS-400. Events are scanned at 50 millisecond intervals with 127 events stored per record. All changes of state that occur during each scan are time- and date-stamped. Sequence of events reports are available through BESTCOMS. A sequence of events record can be triggered by a change in an alarm state, a relay output, or contact input. All of the possible, user-selected state changes are listed below.
**Alarm States**

- Clock Reset
- Excessive Volts per Hertz
- Failed to Build Up
- Field Overcurrent
- Field Overtemperature
- Field Overvoltage
- Generator Overvoltage
- Generator Undervoltage
- Loss of Field
- Loss of Field Isolation Transducer
- Loss of IRIG
- Loss of Sensing Voltage
- Open Exciter Diode
- Overexcitation Limiting (OEL)
- Power Supply Low
- PSS Current Unbalanced
- PSS Power Below Threshold
- PSS Speed Failure
- PSS Voltage Limit
- PSS Voltage Unbalanced
- Setpoint Lower Limit
- Setpoint Upper Limit
- Shorted Exciter Diode
- Stator Current Limiting (SCL)
- System Below 10 Hz
- Underexcitation Limiting (UEL)
- Underfrequency (V/Hz) Limit

**Relay Outputs**

- Relay Output 1
- Relay Output 2
- Relay Output 3
- Relay Output 4
- Relay Output 5
- Relay Output 6
- Start/Stop
- Watchdog

**Contact Inputs**

- AVR (Auto)
- FCR (Manual)
- Lower
- Raise
- Start
- Stop
- Switch Input 1
- Switch Input 2
- Switch Input 3
- Switch Input 4
- Switch Input 5
- Switch Input 6
- Switch Input 7
- Switch Input 8
- Switch Input 9
- Switch Input 10

**Data Logging**

The data logging function of the DECS-400 can record up to six oscillography records. DECS-400 oscillography records use the IEEE Standard Common Format for Transient Data Exchange (COMTRADE). Each record is time- and date-stamped. After six records have been recorded, the DECS-400 begins recording the next record over the oldest record. Because all oscillography records are stored in volatile memory, all records are lost if DECS-400 operating power is interrupted.

Each oscillography record can consist of up to six user-selectable variables with up to 600 data points recorded for each variable. The interval between records is adjustable from 4 milliseconds to 10 seconds.

Data points may be selected for pre-trigger operation in order to capture events prior to a fault. Up to 599 pre-trigger data points may be selected. Data points not designated for pre-trigger recording are assigned to the post-trigger portion of the fault record. This feature, combined with the adjustable sample rate, allows for flexible data sampling around the fault.

A maximum of six variables may be selected to trigger a sequence of events record. The available variables are listed below.

- Auxiliary Voltage Input
- AVR PID Error Signal Input
- Bus Frequency
- Bus Voltage
- Compensated Frequency Deviation
- Control Output
- Cross Current Input
- Field Current
- Field Voltage
- Frequency Response
- Generator Average Current
- Generator Average Voltage
- Generator Frequency
- Generator Ia
- Generator Ib
- Generator Ic
- Generator kVA
- Generator kvar
- Generator kw
- Generator Power Factor
Data recording may be triggered by logic triggers, level triggers, or manually through BESTCOMS.

Logic triggers allow data recording to occur as a result of an internal or external status change of the DECS-400.

Level triggering allows data record triggering based on the value of one of the internal variables. The value can be a minimum or maximum value and it can be specified to trigger a record when the monitored variable crosses a minimum threshold from above, or a maximum threshold from below. A minimum and maximum threshold may also be selected for the monitored variable, causing the monitored value to trigger a record when it rises above its maximum or decreases below its minimum.

Trending
The trend log records the activity of DECS-400 parameters over an extended period of time. Up to six parameters from the following list can be selected for monitoring over a period ranging from one hour to 30 days.

- Auxiliary Voltage Input
- AVR PID Error Signal Input
- Bus Frequency
- Bus Voltage
- Control Output
- Cross Current Input
- Field Current
- Field Voltage
- Frequency Response
- Generator Average Current
- Generator Average Voltage
- Generator Frequency
- Generator Ia
- Generator Ib
- Generator Ic
- Generator kVA
- Generator kvar
- Generator kW
- Generator Power Factor
- Generator Vab
- Generator Vbc
- Generator Vca
- Negative Sequence Current
- Negative Sequence Voltage
- Overexcitation Controller Output
- PF Mode Output
- Phase Angle Ia - Vca
- Phase Angle Ib - Vca
- Phase Angle Ic - Vca
- Phase Angle Vab
- Phase Angle Vbc
- PID Integrator State
- Positive Sequence Current
- Positive Sequence Voltage
- PSS Electrical Power
- PSS Filtered Mechanical Power
- PSS Final Output
- PSS Lead-Lag #1
- PSS Lead-Lag #2
- PSS Lead-Lag #3
- PSS Lead-Lag #4
- PSS Mechanical Power
- PSS Mechanical Power LP #1
- PSS Mechanical Power LP #2
- PSS Mechanical Power LP #3
- PSS Mechanical Power LP #4
- PSS Post-Limit Output
- PSS Power HP #1
- PSS Pre-Limit Output
- PSS Speed HP #1
- PSS Synthesized Speed
- PSS Terminal Voltage
- PSS Torsional Filter #1
- PSS Torsional Filter #2
- PSS Washed Out Power
- PSS Washed Out Speed
- Stator Current Limiter Output
- Terminal Frequency Deviation
- Time Response
- Underexcitation Controller Output
• PSS Mechanical Power LP #2
• PSS Mechanical Power LP #3
• PSS Mechanical Power LP #4
• PSS Post-Limit Output
• PSS Power HP #1
• PSS Pre-Limit Output
• PSS Speed HP #1
• PSS Synthesized Speed
• PSS Terminal Voltage

• PSS Torsional Filter #1
• PSS Torsional Filter #2
• PSS Washed Out Power
• PSS Washed Out Speed
• Stator Current Limiter Output
• Terminal Frequency Deviation
• Time Response
• Underexcitation Controller Output

The trend log has a sampling rate of 1,200 data points per record.

POWER SYSTEM STABILIZER

The optional, integrated PSS is an IEEE type PSS2A, dual input, “integral of accelerating power” stabilizer that provides supplementary damping for low-frequency, local-mode oscillations and power system oscillations.

PSS features include user-selectable, speed-only sensing, two- or three-wattmeter power measurement, optional frequency based operation, and generator and motor control modes.

PSS Theory of Operation

The PSS uses an indirect method of power system stabilization that employs two signals: shaft speed and electrical power. This method eliminates the undesirable components from the speed signal (such as noise, lateral shaft run-out, or torsional oscillations) while avoiding a reliance on the difficult-to-measure mechanical power signal.

PSS function is illustrated by the function blocks and software switches shown in Figure 3-12.
Figure 3-15. PSS Function Blocks and Software Switches
### Speed Signal

The speed signal is converted to a constant level that is proportional to the shaft speed (frequency).

Two high-pass (frequency washout) filter stages are applied to the resulting signal to remove the average speed level and produce a speed deviation signal. This ensures that the stabilizer reacts only to changes in speed and does not permanently alter the generator terminal voltage reference.

The frequency washout filter stages are controlled by time constant settings Tw1 and Tw2. Each time constant setting has a setting range of 1 to 20 seconds with 0.01 second increments. Tw1 and Tw2 are accessed on the Parameters tab of the BESTCOMS PSS screen.

Low-pass filtering of the speed deviation signal can be enabled or disabled through software switch SSW 0. SSW 0 is accessed on the Control tab of the BESTCOMS PSS screen. The low-pass filter time constant is adjusted by the T1 setting which has a setting range of 0 to 0.2 seconds with 0.01 second increments. T1 is accessed on the Parameters tab of the BESTCOMS PSS screen.

Figure 3-13 shows the high-pass and low-pass filter transfer function blocks in frequency domain form. (The letter s is used to represent the complex frequency or Laplace operator.)

![Figure 3-16. Speed Signal](image)

### Generator Electrical Power Signal

Figure 3-14 illustrates the operations performed on the power input signal to produce the integral of electrical power deviation signal.

The generator electrical power output is derived from the generator VT secondary voltages and generator CT secondary currents applied to the DECS-400.

The power output is high-pass (washout) filtered to produce the required power deviation signal. If additional washout filtering is desired, a second high-pass filter can be enabled by software switch SSW 1. The first high-pass filter is controlled by time constant setting Tw3 and the second high-pass filter is controlled by time constant setting Tw4. Each time constant has a setting range of 1 to 20 seconds with 0.01 second increments. Tw3 and Tw4 are accessed on the Parameters tab of the BESTCOMS PSS screen. Software switch SSW 1 is accessed on the Control tab of the BESTCOMS PSS screen.

After high-pass filtering, the electrical power signal is integrated and scaled, combining the generator inertia constant (2H) with the speed signal. Low-pass filtering within the integrator is controlled by time constant T12. T12 has a setting range of 1 to 20 seconds with 0.01 second increments. The primary PSS unit inertia, “H”, has a setting range of 1 to 25 MW-s/MVA with 0.01 Mw-s/MVA increments. T12 and “H” are accessed on the Parameters tab of the BESTCOMS PSS screen.

![Figure 3-17. Generator Electrical Power Signal](image)

### Derived Mechanical Power Signal

The speed deviation signal and integral of electrical power deviation signal are combined to produce a derived, integral of mechanical power signal.

An adjustable gain stage, Kpe, is provided and has a setting range of 0 to 2.00 with increments of 0.01. Kpe is accessed on the Parameters tab of the BESTCOMS PSS screen.
The derived integral of mechanical power signal is then passed through a mechanical-power, low-pass filter and ramp tracking filter. The low-pass filter is controlled by time constant TI3 and provides attenuation of torsional components appearing in the speed input path. TI3 has a setting range of 0.05 to 0.20 seconds with 0.01 second increments. The ramp tracking filter produces a zero, steady-state error to ramp changes in the integral of electric power input signal. This limits the stabilizer output variation to very low levels for the mechanical power rates of change that are normally encountered during operation of utility-scale generators. The ramp tracking filter is controlled by time constant Tr. Tr has a setting range of 0.05 to 1 second with 0.01 second increments. The low-pass filter and ramp tracking filter time constants are accessed on the Parameters tab of the BESTCOMS PSS screen.

Processing of the derived integral of mechanical power signal is illustrated in Figure 3-15.

### Stabilizing Signal Selection

Figure 3-16 illustrates how software switches SSW 2 and SSW 3 are used to select the stabilizing signal. Derived speed deviation is selected as the stabilizing signal when the SSW 2 setting is Derived Speed and the SSW 3 setting is Derived Frequency/Speed. Washed out speed is selected as the stabilizing signal when the SSW2 setting is Frequency and the SSW 3 setting is Derived Frequency/Speed. Washed out power is selected as the stabilizing signal when the SSW 3 setting is Power. (When the SSW3 setting is Power, the SSW 2 setting has no effect.) SSW 2 and SSW 3 are accessed on the Control tab of the BESTCOMS PSS screen.

### Torsional Filters

Two torsional filters, shown in Figure 3-17, are available after the stabilizing signal and before the phase compensation blocks. The torsional filters provide the desired gain reduction at a specified frequency. The filters compensate the torsional frequency components present in the input signal.

Software switch SSW 4 enables and disables torsional filter 1 and SSW 5 enables and disables torsional filter 2. SSW 4 and SSW5 are accessed on the Control tab of the BESTCOMS PSS screen.

Torsional filters 1 and 2 are controlled by a zeta numerator (Zeta Num), zeta denominator (Zeta Den), and a frequency response parameter (Wn). The zeta numerator and zeta denominator settings, Zeta Num 1, Zeta Num 2, Zeta Den 1, and Zeta Den 2, have a setting range of 0 to 1 with 0.01 increments.
frequency response settings, Wn 1 and Wn 2, have a setting range of 10 to 150 rad/s with 0.05 rad/s increments. All torsional filter parameters are accessed on the Parameters tab of the BESTCOMS PSS screen.

**Phase Compensation**

The derived speed signal is modified before it is applied to the voltage regulator input. Filtering of the signal provides phase lead at the electromechanical frequencies of interest (0.1 to 5 Hz). The phase lead requirement is site-specific and is required to compensate for phase lag introduced by the closed-loop voltage regulator.

Four phase compensation stages are available. Each phase compensation stage has a phase lead time constant and a phase lag time constant. Each time constant has a setting range of 0.001 to 6 seconds with 0.001 second increments. The time constant settings are accessed on the Parameters tab of the BESTCOMS PSS screen.

Normally, the first two lead-lag stages are adequate to match the phase compensation requirements of a unit. If needed, the third and fourth stages may be added through the settings of software switches SSW 6 and SSW 7. SSW 6 and SSW 7 are accessed on the Control tab of the BESTCOMS PSS screen. Figure 3-18 illustrates the phase compensation stages and associated software switches.

![](Image)

**Figure 3-21. Phase Compensation Stages**

**Washout Filter and Logic Limiter**

The output of the phase compensation stages is connected, through a stabilizer gain stage, to the washout filter and logic limiter.

Software switch SSW 9 enables and bypasses the washout filter and logic limiter. SSW 9 is accessed on the Control tab of the BESTCOMS PSS screen.

The washout filter has two time constants: normal and limit (less than normal). The normal time constant has a setting range of 5 to 30 seconds with 0.1 second increments. The limit time constant has a setting range of 0 to 1 second with 0.01 second increments. Washout filter time constants are accessed on the Output Limiter tab of the BESTCOMS PSS screen.

The logic limiter compares the signal from the washout filter with the logic limiter upper and lower limit settings. If the counter reaches the set delay time, the time constant for the washout filter changes from the normal time constant to the limit time constant. When the signal returns to within the specified limits, the counter resets and the washout filter time constant changes back to the normal time constant. The logic limiter upper limit has a per-unit setting range of 0.01 to 0.04 with 0.001 increments. The logic limiter lower limit has a per-unit setting range of –0.04 to –0.01 with 0.001 increments. The logic limiter time delay has a setting range of 0 to 2 seconds with 0.01 second increments. Logic limiter settings are accessed on the Output Limiter tab of the BESTCOMS PSS screen.

Figure 3-19 illustrates the washout filter and logic limiter.
Prior to connecting the stabilizer output signal to the voltage regulator input, adjustable gain and limiting are applied. The stabilizer output is connected to the voltage regulator input when the software switch SSW 10 setting is On. SSW 10 is accessed on the Control tab of the BESTCOMS PSS screen. Processing of the stabilizer output signal is illustrated in Figure 3-20.

**Terminal Voltage Limiter**

Since the PSS operates by modulating the excitation, it may counteract the voltage regulator’s attempts to maintain terminal voltage within a tolerance band. To avoid creating an overvoltage condition, the PSS has a terminal voltage limiter (shown in Figure 3-20) that reduces the upper output limit to zero when the generator voltage exceeds the terminal voltage setpoint. The limit setpoint is normally selected such that the limiter will eliminate any contribution from the PSS before the timed overvoltage or volts per hertz protection operates.
The limiter reduces the stabilizer’s upper limit, $V_{PSS,ULMT}$, at a fixed rate until zero is reached or overvoltage is no longer present. The limiter does not reduce the AVR reference below its normal level; it will not interfere with system voltage control during disturbance conditions. The terminal voltage limiter has a per-unit setting range of 0 to 10 with 0.01 increments. The error signal (terminal voltage minus limit the limit start point) is processed through a conventional low-pass filter to reduce the effect of measurement noise. The low-pass filter is controlled by a time constant which is adjustable from 0.02 to 5 seconds in 0.01 second increments. All terminal voltage limiter settings are accessed on the Output Limiter tab of the BESTCOMS PSS screen.

**FIELD ISOLATION MODULE**

A Field Isolation Module (Basler P/N 9372900100) is required for each DECS-400 unit. The Field Isolation Module receives isolated operating power from the DECS-400 and supplies the DECS-400 with isolated, field current and field voltage signals. A cable, supplied with the Field Isolation Module, connects the Field Isolation Module (connector J1) to the DECS-400 (connector P1).

Field current sensing is supplied to the Field Isolation Module by a user-supplied current shunt with an output rating of 50 mVdc or 100 mVdc. The field current sensing input is designed to accept up to 300% of the nominal current range. The field current signal is converted to a voltage signal in the range of 2 to 9.5 Vdc and sent to the DECS-400 through connector J1.

Field voltage sensing is supplied to the Field Isolation Module directly from the field. The Field Isolation Module accepts five ranges of field voltage: 63, 125, 250, 375, and 625 Vdc. The field voltage sensing input is designed to accept up to 300% of the nominal voltage range. The field voltage signal is low-pass filtered, converted to a voltage signal in the range of 0.9 to 9.1 Vdc, and sent to the DECS-400 through connector J1.
SECTION 4 • BESTCOMS SOFTWARE

TABLE OF CONTENTS

SECTION 4 • BESTCOMS SOFTWARE .................................................................................................................. 4-1
INTRODUCTION....................................................................................................................................................... 4-1
INSTALLATION.......................................................................................................................................................... 4-1
Installing BESTCOMS ........................................................................................................................................... 4-1
STARTING BESTCOMS........................................................................................................................................... 4-1
The BESTCOMS Interface......................................................................................................................................... 4-1
Title Bar............................................................................................................................................................... 4-1
Menu Bar ............................................................................................................................................................. 4-1
Tool Bar ............................................................................................................................................................... 4-2
Tabs ......................................................................................................................................................................... 4-2
Settings ............................................................................................................................................................... 4-2
Information Bar .................................................................................................................................................... 4-3
Maximized Viewing Mode ...................................................................................................................................... 4-3
COMMUNICATION.................................................................................................................................................... 4-3
Connecting the DECS-400 and PC.......................................................................................................................... 4-3
Configuring Communication .................................................................................................................................. 4-3
Establishing Communication ................................................................................................................................ 4-3
Connecting Through a Modem .............................................................................................................................. 4-3
SETTINGS, METERING VALUES, AND DATA RECORDS..................................................................................... 4-3
System Configuration.................................................................................................................................................. 4-4
Product Identification .............................................................................................................................................. 4-4
Rated Data.............................................................................................................................................................. 4-4
System Data ........................................................................................................................................................... 4-5
Options..................................................................................................................................................................... 4-6
Auxiliary Input .......................................................................................................................................................... 4-8
Meter Drivers .......................................................................................................................................................... 4-8
Settings .................................................................................................................................................................... 4-9
AVR/FCR.................................................................................................................................................................. 4-10
VAR/PF .................................................................................................................................................................. 4-11
Startup ..................................................................................................................................................................... 4-13
Gain Settings .......................................................................................................................................................... 4-14
AVR/FCR Gain ......................................................................................................................................................... 4-14
PID Calculator ........................................................................................................................................................ 4-15
Other Gain ............................................................................................................................................................. 4-16
Limiters .................................................................................................................................................................... 4-17
Configuration .......................................................................................................................................................... 4-17
Summing Point OEL .............................................................................................................................................. 4-18
Takeover OEL ......................................................................................................................................................... 4-18
UEL ....................................................................................................................................................................... 4-19
SCL ......................................................................................................................................................................... 4-20
Scaling ................................................................................................................................................................... 4-21
Protection ................................................................................................................................................................. 4-22
General Protection.................................................................................................................................................... 4-22
EDM ....................................................................................................................................................................... 4-22
Loss of Sensing ...................................................................................................................................................... 4-24
24 Volts/Hz.............................................................................................................................................................. 4-25
Relay Setup .......................................................................................................................................................... 4-26
PSS .......................................................................................................................................................................... 4-27
Control .................................................................................................................................................................... 4-27
Parameters ............................................................................................................................................................... 4-28
Output Limiter ......................................................................................................................................................... 4-30
Metering ................................................................................................................................................................. 4-31
Operation ................................................................................................................................................................. 4-31
System Alarms ........................................................................................................................................................ 4-32
System Status ........................................................................................................................................................ 4-33
I/O Status ............................................................................................................................................................... 4-34
Data Log ........................................................................................................................................... 4-35
Log Setup ...................................................................................................................................... 4-35
Logic Triggers Tab ......................................................................................................................... 4-37
Mode Triggers Tab ......................................................................................................................... 4-38
Level Triggers/Log Selection .......................................................................................................... 4-39
Trending ....................................................................................................................................... 4-42
Analysis ......................................................................................................................................... 4-42
Graph Settings .............................................................................................................................. 4-43
RTM Frequency Response ............................................................................................................. 4-44
Test Signal ................................................................................................................................... 4-44
RTM Step Response ...................................................................................................................... 4-46
Logic .............................................................................................................................................. 4-49

Figures
Figure 4-1. BESTCOMS Screen Components .................................................................................. 4-2
Figure 4-2. System Configuration Screen, Product Identification Tab ........................................... 4-4
Figure 4-3. System Configuration Screen, Rated Data Tab .............................................................. 4-5
Figure 4-4. System Configuration Screen, System Data Tab ............................................................ 4-6
Figure 4-5. System Configuration Screen, Options Tab ................................................................. 4-7
Figure 4-6. System Configuration Screen, Auxiliary Input Tab ...................................................... 4-8
Figure 4-7. System Configuration Screen, Meter Drivers Tab ........................................................ 4-9
Figure 4-8. Setting Adjustment Screen, AVR/FCR Tab ................................................................... 4-10
Figure 4-9. Setting Adjustment Screen, VAR/PF Tab ................................................................... 4-11
Figure 4-10. Setting Adjustment Screen, Startup Tab .................................................................... 4-13
Figure 4-11. Gain Settings Screen, AVR/FCR Gain Tab ................................................................. 4-14
Figure 4-12. PID Calculator .......................................................................................................... 4-15
Figure 4-13. Gain Settings Screen, Other Gain Tab ....................................................................... 4-16
Figure 4-14. Limiters Screen, Configuration Tab .......................................................................... 4-17
Figure 4-15. Limiters Screen, Summing Point OEL Tab ................................................................. 4-18
Figure 4-16. Limiters Screen, Takeover OEL Tab ....................................................................... 4-19
Figure 4-17. Limiters Window, UEL Tab ...................................................................................... 4-20
Figure 4-18. Limiters Screen, SCL Tab ......................................................................................... 4-21
Figure 4-19. Limiters Screen, Scaling Tab ..................................................................................... 4-21
Figure 4-20. Protection Screen, General Protection Tab ................................................................. 4-22
Figure 4-21. Protection Screen, EDM Tab ..................................................................................... 4-24
Figure 4-22. Pole Ratio Calculator ................................................................................................. 4-24
Figure 4-23. Protection Screen, Loss of Sensing Tab .................................................................... 4-25
Figure 4-24. Protection Screen, 24 Volts/Hz Tab ........................................................................ 4-26
Figure 4-25. Protection Screen, Relay Setup Tab ........................................................................... 4-26
Figure 4-26. PSS Screen, Control Tab ......................................................................................... 4-28
Figure 4-27. PSS Screen, Parameters Tab ................................................................................... 4-29
Figure 4-28. PSS Screen, Output Limiter Tab .............................................................................. 4-30
Figure 4-29. Metering Screen, Operation Tab ............................................................................. 4-32
Figure 4-30. Metering Screen, System Alarms Tab ..................................................................... 4-33
Figure 4-31. Metering Screen, System Status Tab ....................................................................... 4-34
Figure 4-32. Metering Screen, I/O Status Tab .............................................................................. 4-34
Figure 4-33. Data Log Screen, Log Setup Tab ............................................................................. 4-35
Figure 4-34. Sequence of Events Reporting Screen .................................................................... 4-36
Figure 4-35. Data Log Viewer Screen ........................................................................................... 4-37
Figure 4-36. Data Log Screen, Logic Triggers Tab ....................................................................... 4-38
Figure 4-37. Data Log Screen, Mode Triggers Tab ....................................................................... 4-38
Figure 4-38. Data Log Screen, Level Triggers/Log Selection Tab ................................................ 4-41
Figure 4-39. Data Log Screen, Trending Tab ............................................................................... 4-42
Figure 4-40. Analysis Screen ....................................................................................................... 4-43
Figure 4-41. RTM Frequency Response Screen ........................................................................... 4-44
Figure 4-42. Test Signal Screen .................................................................................................. 4-45
Figure 4-43. RTM Step Response Screen, AVR Tab ................................................................. 4-46
Figure 4-44. RTM Step Response Screen, FCR Tab .................................................................... 4-47
Figure 4-45. RTM Step Response Screen, VAR Tab ................................................................... 4-48
Figure 4-46. RTM Step Response Screen, PF Tab ...................................................................... 4-49
Tables
Table 4-1. Hardware Requirements for BESTCOMS and the .NET Framework ........................................... 4-1
Table 4-2. Data Log Report Parameter Triggers......................................................................................... 4-39
SECTION 4 • BESTCOMS SOFTWARE

INTRODUCTION

BESTCOMS-DECS400 is a Windows® based application that provides a user-friendly environment for programming and customizing the DECS-400. In addition to screens for configuring DECS-400 settings, BESTCOMS has metering screens for viewing machine and system parameters and control screens for remote control of the excitation system. An integrated PID calculator makes the selection of stability settings fast and easy.

INSTALLATION

BESTCOMS software is built on the Microsoft® .NET Framework. The setup utility that installs BESTCOMS on your PC also installs the .NET Framework. BESTCOMS operates with IBM-compatible personal computers (PCs) using Microsoft Windows® 98, Windows Me, Windows 2000, Windows XP, and Windows NT® SP6a. Microsoft® Internet Explorer 5.01 or later must be installed on your PC before installing BESTCOMS. Hardware requirements for the .NET Framework and BESTCOMS are listed in Table 4-1.

<table>
<thead>
<tr>
<th>Processor</th>
<th>Required RAM</th>
<th>Recommended RAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pentium-class 90 MHz</td>
<td>32 MB</td>
<td>96 MB or higher</td>
</tr>
</tbody>
</table>

A Windows user must have Administrator rights in order to install and run BESTCOMS. A Windows user with limited rights may not be permitted to save files in certain folders.

Installing BESTCOMS

1. Insert the BESTCOMS CD-ROM into the PC CD-ROM drive.
2. When the DECS-400 Setup and Documentation CD menu appears, click the Install button for the BESTCOMS application. The setup utility automatically installs BESTCOMS and the .NET Framework on your PC. If the .NET Framework is already installed on your PC, the setup utility will not overwrite it. However, you should verify (at www.microsoft.com) that you have the latest version of the .NET Framework.

STARTING BESTCOMS

BESTCOMS is started by clicking the Windows Start button, pointing to Programs, the Basler Electric folder, and then clicking the BESTCOMS-DECS400 icon. At startup, a screen with the program title and version number is displayed briefly. Then, the Product Identification tab of the System Configuration screen is displayed.

The BESTCOMS Interface

Figure 4-1 illustrates the components of a BESTCOMS screen. The following paragraphs describe the function of each screen component.

Title Bar

The title bar displays the full name of the application (BESTCOMS-DECS400) and the full name of the currently displayed screen (in brackets).

Menu Bar

The menu bar consists of six menus: File, View, Communications, Tools, Window, and Help. Clicking a menu heading (or pressing the Alt key and the F, V, C, T, W, or H key) exposes the menu contents and allows individual menu items to be selected. Shortcut keys for individual menu selections are also displayed, where applicable. Dimmed or grayed out menu selections aren't relevant to the current situation and cannot be selected.
**Tool Bar**

The tool bar consists of buttons with text labels and buttons displaying icons. The buttons with text labels are clicked to display the corresponding BESTCOMS screens. The label text of a button changes to bold when the corresponding screen is being viewed. Icon button functions are described in the following paragraphs.

---

**Open Settings From File.** Clicking this button displays an “Open Settings File” window that enables the user to navigate to and open a file containing DECS-400 settings. DECS-400 settings files have a `.de4` file extension.

**Save Settings to File.** Clicking this button displays a “Save Settings File As” window that enables the DECS-400 settings displayed in BESTCOMS to be saved in a file. DECS-400 settings files are saved with a `.de4` file extension.

**Print Settings.** Clicking this button displays a Print dialog box that enables the DECS-400 settings to be printed by the desired printer.

**Print Settings to File.** Clicking this button displays a “Print Settings to File” window that enables the user to save a list of DECS-400 settings in a readable text file.

**Preview Settings.** Clicking this button displays a print preview of DECS-400 settings. The print preview window allows the list of DECS-400 settings to be viewed and printed.

**Open File as Text.** Clicking this button displays an “Open File as Text” window that enables the user to navigate to, select, and view a DECS-400 settings file saved as a text file. (See Print Settings to File for information about saving DECS-400 settings in a readable text file.)

---

**Tabs**

Screen settings are organized by tabs. Clicking a tab’s label displays the settings of that tab.

---

**Settings**

Settings are displayed in fields with labels. Like settings are grouped together and labeled with a heading. Setting fields with a black background are read-only and cannot be altered. Setting fields with a white background are user-adjustable (after entering the appropriate password). A setting is changed by placing the cursor in the setting field and entering the new setting. If the setting entered is outside the setting range, a warning icon appears beside the setting field. During this condition, no other setting can be changed until the out-of-range setting is corrected.

---

**Figure 4-1. BESTCOMS Screen Components**

Open Settings From File. Clicking this button displays an “Open Settings File” window that enables the user to navigate to and open a file containing DECS-400 settings. DECS-400 settings files have a `.de4` file extension.

Save Settings to File. Clicking this button displays a “Save Settings File As” window that enables the DECS-400 settings displayed in BESTCOMS to be saved in a file. DECS-400 settings files are saved with a `.de4` file extension.

Print Settings. Clicking this button displays a Print dialog box that enables the DECS-400 settings to be printed by the desired printer.

Print Settings to File. Clicking this button displays a “Print Settings to File” window that enables the user to save a list of DECS-400 settings in a readable text file.

Preview Settings. Clicking this button displays a print preview of DECS-400 settings. The print preview window allows the list of DECS-400 settings to be viewed and printed.

Open File as Text. Clicking this button displays an “Open File as Text” window that enables the user to navigate to, select, and view a DECS-400 settings file saved as a text file. (See Print Settings to File for information about saving DECS-400 settings in a readable text file.)
Information Bar
When the cursor is placed in a setting field, the information bar displays the setting description, the setting limits (minimum and maximum), and the setting increment (step). (This information is also displayed in a dialog box if the setting field is double-clicked.)

Maximized Viewing Mode
All BESTCOMS screens are shown in the default, normal viewing mode. Selecting the maximized viewing mode (click View, Maximized) increases the size of the BESTCOMS window to full-screen and enables the user to select a cascaded view (click Window, Cascade All) or tiled view (click Window, Tile, Horizontally or Vertically) of BESTCOMS screens. Maximzed viewing mode also enables display of the explorer bar (click View, Explorer Bar), system status, and alarm status windows (click View, Alarms/Status). The explorer bar displays a navigation pane with a menu listing all available BESTCOMS screens and tabs. Navigation to a specific screen or tab is accomplished by clicking the appropriate link in the explorer bar. The system status and alarm status windows display the state of various DECS-400 operating modes and any active alarm conditions.

COMMUNICATION
Communication between BESTCOMS and the DECS-400 must be established before DECS-400 settings can be viewed or changed. BESTCOMS screen settings are updated only after communication is opened.

Connecting the DECS-400 and PC
Connect a communication cable between the front panel RS-232 connector of the DECS-400 and the appropriate port of the PC. Refer to Section 4, Installation for the required connections between the DECS-400 and PC.

Configuring Communication
Before communication between BESTCOMS and the DECS-400 is established, the PC communication port connected to the DECS-400 must be selected in BESTCOMS. Click Communications on the menu bar, followed by Configure. Select the appropriate PC communication port from the drop-down menu and click the OK button.

Establishing Communication
Communication between BESTCOMS and the DECS-400 is established by clicking Communications, Connect, and RS-232-COM0. BESTCOMS will display a Password dialog box and require entry of the correct password before communication is established and all DECS-400 settings are read. (The DECS-400 is delivered with a password of decs4.) When BESTCOMS receives a connect command, it automatically adjusts its communication settings (baud, parity, etc.) to match those of the DECS-400. Once communication is established, BESTCOMS reads and displays all DECS-400 settings.

Connecting Through a Modem
Clicking Communications, Connect..., and Modem displays a Modem Dial-Up Request dialog box where a telephone number can be entered and then dialed by clicking the Send button. If an extension number is to be called, commas may be required for line delays. Modem communication is read-only and has a fixed baud rate of 9600. Password access is not required for modem communication.

SETTINGS, METERING VALUES, AND DATA RECORDS
The settings, metering values, and data records available in BESTCOMS are arranged into ten groups:

- System Configuration
- Setting Adjustment
- Gain Settings
- Limiters
- Protection
- PSS (Power System Stabilizer)
- Data Log
- Metering
- Analysis
- Logic

Each group is contained on a BESTCOMS screen. A screen's settings, metering values, and data records are further organized by labeled tabs within the screen. In the following paragraphs, settings, metering values, and data records are arranged and defined according to the organization of the BESTCOMS screens and tabs.
System Configuration

The System Configuration screen consists of six tabs labeled Product Identification, System Data, Rated Data, Options, Auxiliary Input, and Meter Drivers. Click the Configure button on the tool bar, click Window, 1 System Configuration on the menu bar, or click the System Configuration link in the explorer bar to view the System Configuration screen.

Product Identification

Product Identification tab functions are shown in Figure 4-2 and described in the following paragraphs.

PC Version information. This read-only field indicates the version of BESTCOMS.

Unit Information. When communication between BESTCOMS and the DECS-400 is established, this read-only field displays the DECS-400 model number, style number, application code version and date, digital signal processor (DSP) code version and date, boot code version and date, and serial number.

![Figure 4-2. System Configuration Screen, Product Identification Tab](image)

Unit Style Number. When communication between BESTCOMS and the DECS-400 is established, this area of the product identification tab is read-only and displays the DECS-400 style number. When communication between BESTCOMS and the DECS-400 is closed, the style number digits can be adjusted to match the style number of a DECS-400. This feature is useful for adjusting DECS-400 settings in BESTCOMS and saving the settings in a file for uploading to a DECS-400 at a later time. Clicking the More Info... link displays a style number chart to reference when making style number selections.

Rated Data

Rated Data tab functions are shown in Figure 4-3 and described in the following paragraphs.

Generator Rated Data – Voltage. The rated terminal voltage for the generator is entered in this setting field. A setting of 85 to 500,000 Vac may be entered in 1 Vac increments.

Generator Rated Data – Rating (kVA). The apparent power rating of the generator, in kVA, is entered in this setting field. A setting of 0 to 1,000,000 kVA may be entered in 0.01 kVA increments.

Generator Rated Data – PF (Power Factor). The rated generator power factor is entered in this setting field. A setting of 0 to 1.000 may be entered in increments of 0.001.

Generator Rated Data – Current. This read-only field is calculated by dividing the real-power field by the product of the rated generator voltage field, rated power factor field, and the square root of 3.
Generator Rated Data – Rating \( [W] \). This read-only field is the calculated product of the rated generator voltage field, rated generator current field, rated power factor field, and the square root of 3.

Field Rated Data – Voltage. The rated main field or exciter field voltage is entered in this setting field. (The field type is selected on the Options tab of the System Configuration screen.) A setting of 1.0 to 1,000.0 Vdc may be entered in 0.1 Vdc increments.

Field Rated Data – Current. The rated main field or exciter field current is entered in this setting field. (The field type is selected on the Options tab of the System Configuration screen.) A setting of 0.1 to 9,999 Adc may be entered in 0.1 Adc increments.

Field Rated Data – Resistance. The level of field resistance at the nominal ambient temperature is entered in this setting field. A value of 0 to 99.999 ohms may be entered in 0.001 ohm increments. This setting field is enabled only for main field applications.

Field Rated Data – Ambient Temperature. The ambient field temperature is entered in this setting field and is used to calculate the generator main field temperature. A value of 0 to 572\( ^\circ C \) may be entered in 1\( ^\circ C \) increments. This setting field is enabled only for main field applications.

Field Rated Data – Brush Voltage Drop. The brush voltage drop, at the field ambient temperature, is entered in this setting field. A value of 0 to 99.99 V may be entered in 0.01 V increments. This setting field is enabled only for main field applications.

**System Data**

System Data tab functions are shown in Figure 4-4 and described in the following paragraphs.

Generator PT – Primary Voltage. The primary voltage rating of the generator potential transformer is entered in this setting field. A setting of 1 to 30,000 Vac may be entered in 1 Vac increments.

Generator PT – Secondary Voltage. The secondary voltage rating of the generator potential transformer is entered in this setting field. A setting of 1 to 240 Vac may be entered in 1 Vac increments.

Generator CT – Primary Current. The primary current rating of the generator CTs is entered in this setting field. A setting of 1 to 60,000 Aac may be entered in 1 Aac increments.

Generator CT – Secondary Current. The nominal, secondary current rating (either 1 or 5 Aac) of the generator CTs is displayed in this read-only field. The third digit of the style number (XX1X or XX5X) dictates the rating displayed.
**Bus PT – Primary Voltage.** The primary voltage rating of the bus potential transformer is entered in this setting field. A setting of 1 to 500,000 Vac may be entered in 1 Vac increments.

**Bus PT – Secondary Voltage.** The secondary voltage rating of the bus potential transformer is entered in this setting field. A setting of 1 to 240 Vac may be entered in 1 Vac increments.

*Figure 4-4. System Configuration Screen, System Data Tab*

**Internal Tracking – Delay.** When the DECS-400 switches from one control mode to another, this setting determines the time delay between the mode change and the start of setpoint tracking. A setting of 0 to 8.0 seconds may be entered in 0.1 second increments.

**Internal Tracking – Traverse Rate.** When tracking the active setpoint, this setting determines the amount of time required for the DECS-400 to traverse the full setting range of the active setpoint. A setting of 1 to 80.0 seconds may be entered in 0.1 second increments.

**External Tracking – Delay.** When a redundant DECS-400 system is implemented and setpoint control is transferred to a second DECS-400, this setting determines the time delay between the DECS-400 transfer and the start of tracking the second DECS-400 setpoint. A setting of 0 to 8.0 seconds may be entered in 0.1 second increments.

**External Tracking – Traverse Rate.** When tracking the setpoint of a second, active DECS-400, this setting determines the amount of time required for the DECS-400 to traverse the full setting range of the active DECS-400. A setting of 1 to 80.0 seconds may be entered in 0.1 second increments.

**Field Current Sensing – Shunt Rating.** The maximum current rating of the field shunt is entered in this setting field. (The field shunt maximum output must be 50 or 100 mVdc and is detected by the DECS-400 through the Field Isolation Module.) A shunt current rating of 1 to 9,999.0 Adc may be entered in 0.1 Adc increments.

**Field Voltage Isolation Transducer Input.** The nominal field voltage is entered in this setting field. The available setting selections match voltage inputs of the Field Isolation Transducer. A nominal voltage of 63, 125, 250, 375, or 625 Vdc may be selected.

**Options**

Options tab functions are shown in Figure 4-5 and described in the following paragraphs.

**Voltage Sensing.** This setting selects the generator voltage sensing configuration used and the phase rotation for three-phase sensing configurations. Three voltage sensing options may be selected from the drop-down menu. AC 1-Phase selects single-phase voltage sensing, connected across generator phases
A and C. ABC 3-Phase selects three-phase voltage sensing and ABC phase rotation. ACB 3-Phase selects three-phase voltage sensing and ACB phase rotation.

**Field Type.** This setting selects excitation control for either the generator main field or the exciter field. The mode selected determines the corresponding rated data and PID parameters for either main field or exciter field control. Either Main Field or Exciter Field may be selected from the drop-down menu.

**Bridge Control Signal.** This setting selects the control signal type and range supplied by the DECS-400. The control signal type and range is selected from the drop-down menu. 0->+10V selects a control signal with a range of 0 to 10 Vdc. –10V->+10V selects a control signal with a range of –10 Vdc to +10 Vdc. 4->20mA selects a control signal with a range of 4 to 20 mAcdc.

**Temperature Mode.** This setting determines the scale that BESTCOMS and the DECS-400 front panel HMI uses to display the field temperature and the overtemperature alarm level. The temperature mode is selected from the drop-down menu. DEG. C selects the Celsius temperature scale and DEG. F selects the Fahrenheit temperature scale.

**Underfrequency Mode.** This setting selects either underfrequency limiting (UF) or volts per hertz (V/Hz) limiting. The underfrequency mode is selected from the drop-down menu.

**Generator Frequency (Hz).** This setting selects the nominal system operating frequency as 50 hertz or 60 hertz. The generator frequency is selected from the drop-down menu.

![Figure 4-5. System Configuration Screen, Options Tab](image)

**Current Sensing.** This setting selects the number of phases used for sensing generator current. The current sensing configuration is selected from the drop-down menu and may be set at one, two, or three phases.

**CT Selection.** This setting is enabled only when the Current Sensing setting is “Two”. The drop-down menu is used to select which two generator phases are used to supply current sensing to the DECS-400. Phases A-B, B-C, or A-C may be selected.

**Voltage Matching.** This setting enables and disables matching of the generator voltage to the bus voltage. For voltage matching to occur, the DECS-400 must be in AVR mode, var and power factor modes must be disabled, and the system off line.

**Tracking Enable.** This setting enables and disables internal tracking and external tracking. Selecting Internal Tracking enables the inactive control modes to track the setpoint of the active control mode. When used as a secondary DECS-400 in a redundant DECS-400 system, selecting External Tracking enables the DECS-400 to track the active setpoint of the primary DECS-400.
**Auxiliary Input**

Auxiliary Input tab functions are shown in Figure 4-6 and described in the following paragraphs.

**Input Type.** This setting selects either voltage (–10 Vdc to +10 Vdc) or current (4 to 20 mAdc) as the control signal for the DECS-400 auxiliary input. Input type settings are selected from the drop-down menu.

**Input Function.** This setting configures the auxiliary input to control the excitation setpoint, the power system stabilizer (PSS), or limiter scaling. The input function is selected from the drop-down menu.

**Summing Type.** This setting selects the summing mode for the auxiliary input. When Inner Loop is selected, the operating mode is either AVR or FCR. When Outer Loop is selected, the operating mode is either var or power factor. Summing types are selected from the drop-down menu.

**Auxiliary Gain Settings.** The four auxiliary gain setting fields, AVR, FCR, var, and PF, select the gain which affects the setpoint of the selected operating mode. The signal applied to the auxiliary input is multiplied by the auxiliary gain setting. Each gain setting has a range of –99.00 to +99.00 with an increment of 0.01. A setting of zero disables the auxiliary input for that operating mode.

**Droop Compensation.** Enabling this setting allows the DECS-400 to provide droop compensation for paralleled generators. Droop compensation is adjustable from –30 to +30 percent (in 0.1 percent increments) of the generator rated terminal voltage.

**Line Drop Compensation.** Enabling this setting allows the DECS-400 to compensate for line drop between paralleled generators. Line drop compensation is adjustable from 0 to 30.0 percent in 0.1 percent increments.

**Cross Current Compensation.** Enabling this setting allows the DECS-400 to provide reactive differential gain for parallel generators. Cross current compensation is adjustable from –30.00 to +30.00 percent in 0.01 percent increments.

**Meter Drivers**

Meter Drivers tab functions are shown in Figure 4-7 and described in the following paragraphs.

**Meter Driver 1 and Meter Driver 2.** These settings enable and disable the meter driver outputs, select the system parameters to be metered, and define the minimum and maximum values of the metered parameters. The parameters to be metered are selected from the drop-down menus. The available parameters are listed below:
The Minimum Value setting fields establish the lowest parameter value to be metered and correspond to the 4 mAdc minimum output of the meter drivers. The Maximum Value setting field establishes the highest parameter value to be metered and corresponds to the 20 mAdc maximum output of the meter drivers.

**Settings**

The Settings screen consists of three tabs labeled AVR/FCR, VAR/PF, and Startup. Click the **Settings** button on the tool bar, click **Window, 2 Setting Adjustment** on the menu bar, or click the **Setting Adjustment** link in the explorer bar to view the Settings screen.
AVR/FCR tab functions are shown in Figure 4-8 and described in the following paragraphs.

**Automatic Voltage Regulator (AVR) – Setpoint.** The desired generator output terminal voltage is entered in this setting field. The Setpoint setting range depends on the Generator Rated Data – Voltage setting (System Configuration screen, Rated Data tab) and the AVR – Min and AVR – Max settings. Enter the desired AVR setpoint value using the primary generator voltage level intended to be maintained at the generator output.

**Automatic Voltage Regulator (AVR) – Min (% of rated).** The generator minimum voltage, expressed as a percentage, is entered in this setting field. A setting of 70 to 100 percent may be entered in 0.1 percent increments.

**Automatic Voltage Regulator (AVR) – Max (% of rated).** The generator maximum voltage, expressed as a percentage, is entered in this setting field. A setting of 100 to 110 percent may be entered in 0.1 percent increments.

**Automatic Voltage Regulator (AVR) – Traverse Rate.** The AVR setpoint traverse rate is entered in this setting field. This setting determines the time required to adjust the AVR setpoint from the minimum value to the maximum value of the adjustment range. A setting of 10 to 200 seconds may be entered in 1 second increments.

**AVR Pre-position 1 – Setpoint.** The first pre-position (predefined) generator output terminal voltage setpoint for AVR mode is entered in this setting field. The setting range is identical to that of the AVR – Setpoint.

**AVR Pre-position 1 – Mode.** This setting determines whether or not the DECS-400 will respond to further setpoint change commands once the operating setpoint is driven to the pre-position 1 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the setpoint.

**AVR Pre-position 2 – Setpoint.** The second pre-position (predefined) generator output terminal voltage setpoint for AVR mode is entered in this setting field. The setting range is identical to that of the AVR – Setpoint.
**AVR Pre-position 2 – Mode.** This setting determines whether or not the DECS-400 will respond to further AVR setpoint change commands once the operating setpoint is driven to the pre-position 2 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the AVR setpoint.

**Field Current Regulator (FCR) – Setpoint.** When operating in FCR (Manual) mode, this setting establishes the field dc current setpoint. The Setpoint setting range depends on the Field Type setting (Configure screen, Options tab) and the associated ratings.

**Field Current Regulator (FCR) – Min (% of rated).** This setting, expressed as a percentage of rated field current, establishes the minimum field current setpoint. A setting of 0 to 100 percent may be entered in 0.1 percent increments.

**Field Current Regulator (FCR) – Max (% of rated).** This setting, expressed as a percentage of rated field current, establishes the maximum field current setpoint. A setting of 0 to 120 percent may be entered in 0.1 percent increments.

**Field Current Regulator (FCR) – Traverse Rate.** This setting determines the time required for the FCR setpoint to be adjusted from the minimum value to the maximum value of the adjustment range. A setting of 10 to 200 seconds may be entered in 1 second increments.

**FCR Pre-position 1 – Setpoint.** The first pre-position (predefined) field current setpoint for FCR mode is entered in this setting field. The setting range is identical to the FCR setpoint.

**FCR Pre-position 1 – Mode.** This setting determines whether or not the DECS-400 will respond to further setpoint change commands once the operating setpoint is driven to the pre-position 1 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the FCR setpoint.

**FCR Pre-position 2 – Setpoint.** The second pre-position (predefined) field current setpoint for FCR mode is entered in this setting field. The setting range is identical to the FCR setpoint.

**FCR Pre-position 2 – Mode.** This setting determines whether or not the DECS-400 will respond to further setpoint change commands once the operating setpoint is driven to the pre-position 2 value. The available mode settings are identical to mode settings for pre-position 1.

**VAR/PF**

VAR/PF tab functions are shown in Figure 4-9 and described in the following paragraphs.

*Figure 4-9. Setting Adjustment Screen, VAR/PF Tab*
Fine Voltage Adjustment Band. This setting, expressed as a percentage of the generator nominal voltage, defines the upper and lower boundaries of voltage correction during var or power control. A setting of 0 to 30 percent may be entered in 0.01 percent increments.

Reactive Power Control (VAR) – Setpoint. This setting, expressed in kvar, establishes the reactive power setpoint for var mode. The range of this setting depends on the generator settings and the Min and Max settings for the Reactive Power Control setpoint.

Reactive Power Control (VAR) – Min (% of rated). This setting defines the generator minimum var setpoint and is expressed as a percentage of the generator rated VA output. A setting of –100 to +100 percent may be entered in 0.1 percent increments.

Reactive Power Control (VAR) – Max (% of rated). This setting defines the generator maximum var setpoint and is expressed as a percentage of the generator rated VA output. A setting of –100 to +100 percent may be entered in 0.1 percent increments.

Reactive Power Control (VAR) – Traverse Rate. This setting determines the time required for the var setpoint to be adjusted from the minimum value to the maximum value of the adjustment range. A setting of 10 to 200 seconds may be entered in 1 second increments.

VAR Pre-position 1 – Setpoint. The first pre-position (predefined) generator output terminal voltage setpoint for var mode is entered in this setting field. The setting range is identical to that of the var setpoint.

VAR Pre-position 1 – Mode. This setting determines whether or not the DECS-400 will respond to further var setpoint change commands once the operating setpoint is driven to the pre-position 1 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the var setpoint.

VAR Pre-position 2 – Setpoint. The second pre-position (predefined) generator output terminal voltage setpoint for var mode is entered in this setting field. The setting range is identical to that of the var setpoint.

VAR Pre-position 2 – Mode. This setting determines whether or not the DECS-400 will respond to further var setpoint change commands once the operating setpoint is driven to the pre-position 2 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the var setpoint.

Power Factor Control (PF) – Setpoint. This setting establishes the operating power factor for the generator. The Setpoint setting range is determined by the PF (Leading) and PF (Lagging) settings.

Power Factor Control (PF) – PF (Leading). The minimum desired leading power factor level is entered in this setting field. A setting of –1.000 to –0.500 may be entered in 0.005 increments.

Power Factor Control (PF) – PF (Lagging). The minimum desired lagging power factor level is entered in this setting field. A setting of 0.500 to 1.000 may be entered in 0.005 increments.

Power Factor Control (PF) – Traverse Rate. The power factor setpoint traverse rate is entered in this setting field. This setting determines the time required to adjust the AVR setpoint from the minimum value to the maximum value of the adjustment range. A setting of 10 to 200 seconds may be entered in 1 second increments.

PF Pre-position 1 – Setpoint. The first pre-position (predefined) power factor setpoint is entered in this setting field. The setting range is identical to the power factor setpoint.

PF Pre-position 1 – Mode. This setting determines whether or not the DECS-400 will respond to further setpoint change commands once the power factor setpoint is driven to the pre-position 1 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the power factor setpoint.

PF Pre-position 2 – Setpoint. The second pre-position (predefined) power factor setpoint is entered in this setting field. The setting range is identical to the power factor setpoint.

PF Pre-position 2 – Mode. This setting determines whether or not the DECS-400 will respond to further setpoint change commands once the power factor setpoint is driven to the pre-position 2 value. Two mode settings are available in the pull-down menu: Maintain and Release. If Maintain is selected, further setpoint change commands are ignored. If Release is selected, subsequent setpoint change commands are accepted to raise and lower the power factor setpoint.
Startup tab functions are shown in Figure 4-10 and described in the following paragraphs.

Soft Start – Soft Start Level (SS Level). This setting, expressed as a percentage of the nominal generator terminal voltage, determines the starting point for generator voltage buildup during startup. A setting of 0 to 90 percent may be entered in 1 percent increments.

The Primary and Secondary buttons select between the soft start settings used when the DECS-400 is functioning as the primary or secondary DECS-400 in a redundant system.

Soft Start – Soft Start Time (SS Time). This setting defines the amount of time allowed for the buildup of generator voltage during startup. A setting of 1 to 7,200 seconds may be entered in 1 second increments.

The Primary and Secondary buttons select between the primary and secondary Soft Start settings. In the default, non-PSS logic schemes provided with the DECS-400, a contact input is used to select either the primary or secondary Soft Start settings.

Startup Control – Field Flash Dropout Level. During startup, this setting controls the level of generator voltage where field flashing is withdrawn. The Field Flash Dropout Level setting is expressed as a percentage of the nominal generator terminal voltage. A setting of 0 to 100 percent may be entered in 1 percent increments.

Startup Control – Maximum Field Flash Time. This setting dictates the maximum length of time that field flashing may be applied during startup. A setting of 1 to 50 seconds may be entered in 1 second increments.

Voltage Matching – Band. This setting configures the generator voltage matching band as a percentage of the generator rated voltage. When the bus input voltage falls outside this band, no voltage matching occurs. A setting of 0 to 20.00 percent may be entered in .01 percent increments.

Voltage Matching – Gen to Bus PT Match Level. This setting ensures accurate voltage matching by compensating for the error between the generator and bus voltage sensing transformers. The Match Level is expressed as the relationship of the generator voltage to the bus voltage (expressed as a percentage). A setting of 90 to 120.0 percent may be entered in 0.1 percent increments.

Underfrequency Settings – Corner Frequency. The generator corner frequency for generator underfrequency and volts per hertz protection is entered in this field. A setting of 15 to 90 hertz may be entered in 0.1 hertz increments.
**Underfrequency Settings – Slope.** The generator frequency slope for generator underfrequency and volts per hertz protection is entered in this field. A per unit value of 0 to 3.00 may be entered in .01 increments.

**Volts/Hz Limiter Settings – V/Hz High Limiter.** This per unit setting establishes the maximum threshold for the volts per hertz limiter. A setting of 0 to 3.00 may be entered in .01 increments.

**Volts/Hz Limiter Settings – V/Hz Low Limiter.** This per unit setting establishes the minimum threshold for the volts per hertz limiter. A setting of 0 to 3.00 may be entered in .01 increments.

**Volts/Hz Limiter Settings – V/Hz Time Limiter.** The time delay for the volts per hertz limiter is entered in this setting field. A setting of 0 to 10.0 seconds may be entered in 0.1 second increments.

**Gain Settings**

The Gain Settings screen consists of two tabs labeled AVR/FCR Gain and Other Gain. Click the **Gain** button on the tool bar, click **Window, 3 Gain Settings** on the menu bar, or click the **Gain Settings** link in the explorer bar to view the Gain Settings screen.

**AVR/FCR Gain**

The AVR/FCR Gain tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary AVR/FCR Gain settings and PID settings. In the default, non-PSS logic schemes provided with the DECS-400, contact inputs are used to select between the primary and secondary AVR/FCR Gain settings and PID settings.

AVR/FCR Gain tab functions are shown in Figure 4-11 and described in the following paragraphs.

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**AVR/FCR – Kp- Proportional Gain.** This setting selects the proportional constant (Kp) stability parameter. The DECS-400 provides an output value that is equivalent to Kp multiplied by the error between the voltage setpoint and the actual generator output voltage. A setting of 0 to 1,000.0 may be entered in increments of 0.1. This setting is enabled only when Custom is selected as the Primary Gain Option of the PID Pre-Settings.

When tuning the proportional gain, consider the following guidelines. If the transient response has too much overshoot, then Kp should be decreased. If the transient response is too slow, with little or no overshoot, then Kp should be increased.

**AVR/FCR – Ki- Integral Gain.** This setting selects the integral constant (Ki) stability parameter. The DECS-400 provides an output value that is equivalent to Ki multiplied by the integral of the error between the voltage setpoint and the actual generator output voltage. A setting of 0 to 1,000.0 may be entered in increments of 0.1. This setting is enabled only when Custom is selected as the Primary Gain Option of the PID Pre-Settings.
If the time to reach steady-state is deemed too long, then $K_i$ should be increased.

**AVR/FCR – Kd-Derivative Gain.** This setting selects the derivative constant (Kd) stability parameter. The DECS-400 provides an output value that is equivalent to Kd multiplied by the derivative of the error between the voltage setpoint and the actual generator output voltage. A setting of 0 to 1,000.0 may be entered in increments of 0.1. This setting is enabled only when Custom is selected as the Primary Gain Option of the PID Pre-Settings.

If the transient response has too much ringing, then Kd should be increased.

**AVR/FCR – Td-AVR Derivative Time Constant.** This setting is used to remove the noise effect on numerical differentiation. A setting of 0 to 1.00 may be entered in increments of 0.01.

**AVR – Kg-AVR Loop Gain.** This setting adjusts the coarse loop-gain level of the PID algorithm for AVR mode. A setting of 0 to 1,000.0 may be entered in increments of 0.1.

**FCR – Kg-FCR Loop Gain.** This setting adjusts the coarse loop-gain level of the PID algorithm for FCR mode. The FCR Loop Gain setting is available only as part of the Primary AVR/FCR gain settings. A setting of 0 to 1,000.0 may be entered in increments of 0.01.

**PID Pre-Settings – Primary Gain Option.** This drop-down menu lists 20 predefined gain settings and an option for selecting custom PID settings. The predefined gain settings listed depend on whether Main Field or Exciter Field is selected as the Field Type (System Configuration screen, Options tab). Selecting Custom in the drop-down menu enables the PID Calculator button.

**PID Calculator Button.** Clicking this button opens the PID Calculator shown in Figure 4-13. Note that a PID Calculator exists for primary gain settings and secondary gain settings. The PID Calculator opened by the PID Calculator button depends on whether the Primary or Secondary button is selected on the AVR/FCR Gain tab.

**PID Calculator**

PID Calculator functions are shown in Figure 4-12 and described in the following paragraphs.

**Excitation Control Data – Generator Information.** This setting field is used to enter and display a descriptive name for the selected group of PID settings. The Generator Information field accepts up to 30 alphanumeric characters.

$T'do$ – *Gen. Time Constant (sec).* The time constant of the generator is entered in this field. The generator time constant and exciter time constant are used to calculate gain parameters $K_p$, $K_i$, and $K_d$. A setting of 1.00 to 15.00 may be selected from the pull-down menu.

$T_e$ – *Exciter Time Constant (sec).* The time constant of the exciter is entered in this field. The exciter time constant and generator time constant are used to calculate gain parameters $K_p$, $K_i$, and $K_d$. The exciter time constant setting range varies according to the generator time constant value selected. A checkbox is provided for setting the exciter time constant at the default value. The exciter time constant setting is disabled when Main Field is selected as the Field Type (System Configuration screen, Options tab).

**Gain Parameters – $K_p$-Proportional Gain.** This read-only field displays the calculated value of $K_p$ based on the generator time constant ($T'do$) and exciter time constant ($T_e$).
Gain Parameters – Ki-Integral Gain. This read-only field displays the calculated value of Ki based on the generator time constant (T’do) and exciter time constant (Te).

Gain Parameters – Kd-Derivative Gain. This read-only field displays the calculated value of Kd based on the generator time constant (T’do) and exciter time constant (Te).

Gain Parameters – Td-Derivative Time Constant. This AVR mode setting is used to remove the noise effect on numerical differentiation. A setting of 0 to 1.00 may be entered in increments of 0.01.

Gain Parameters – Kg-Loop Gain. This setting adjusts the coarse loop-gain level of the PID algorithm for the AVR setpoint. A setting of 0 to 1,000 may be entered in increments of 0.1.

PID Record List. This area of the PID Calculator displays the groups of available PID settings. Buttons at the bottom of the record list enable calculated settings to be saved in a record (Add Record button), enable existing records to be deleted (Remove Record), and the settings of a selected record to be invoked (Apply Gain Parameters). The Close button closes the PID Calculator and returns to AVR/FCR Gain tab.

Other Gain

Other Gain tab functions are shown in Figure 4-13 and described in the following paragraphs.

VAR – Ki Integral Gain. This setting adjusts the integral gain, which determines the characteristic of the DECS-400 dynamic response to a changed var setting. A setting of 0 to 1,000 may be entered in 0.01 increments.

VAR – Kg-Loop Gain. This setting adjusts the coarse loop-gain level of the PID algorithm for var control. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

PF – Ki-Integral Gain. This setting adjusts the integral gain, which determines the characteristic of the DECS-400 dynamic response to a changed power factor setting. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

PF – Kg-Loop Gain. This setting adjusts the coarse loop-gain level of the PID algorithm for power factor control. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

OEL – Ki-Integral Gain. This setting adjusts the rate at which the DECS-400 responds during an overexcitation condition. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

OEL – Kg-Loop Gain. This setting adjusts the coarse loop-gain level of the PID algorithm for the overexcitation limiter function. A setting of 0 to 1,000.0 may be entered in 0.1 increments.
**UEL – Ki-Integral Gain.** This setting adjusts the rate at which the DECS-400 responds during an underexcitation condition. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

**UEL – Kg-Loop Gain.** This setting adjusts the coarse loop-gain level of the PID algorithm for the underexcitation limiter function. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

**SCL – Ki-Integral Gain.** This setting adjusts the rate at which the DECS-400 limits stator current. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

**SCL – Kg-Loop Gain.** This setting adjusts the coarse loop-gain level of the PID algorithm for the stator current limiter function. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

**Voltage Matching – Kg-Loop Gain.** This setting adjusts the coarse loop-gain level of the PID algorithm for matching the generator voltage to the bus voltage. A setting of 0 to 1,000.0 may be entered in 0.1 increments.

### Limiters

The Limiters screen consists of five tabs labeled Configuration, Summing Point OEL, Takeover OEL, UEL, SCL, and Scaling. Click the Limiters button on the tool bar, click Window, 4 Limiters on the menu bar, or click the Limiters link in the explorer bar to view the Limiters screen.

**Configuration**

Configuration tab settings are shown in Figure 4-14 and described in the following paragraphs.

**Limiter Mode(s).** Three types of limiters may be enabled: OEL (overexcitation limiter), UEL (underexcitation limiter), and SCL (stator current limiter).

**Styles – OEL.** This setting allows selection of either the summing point or takeover style of overexcitation limiting.

**Styles – UEL.** This setting allows selection of either the summing point or takeover style of underexcitation limiting.

**UEL Voltage Dependency.** These settings allow the adjustment of the generator voltage dependence on the underexcitation limiter type UEL2 model from IEEE standard P421.5.

**UEL Voltage Dependency – Real Power Exponent.** This setting affects how the underexcitation limiter responds to the level of generator voltage. This setting is used to apply an exponent of 0, 1, or 2 to the generator voltage.
**UEL Voltage Dependency – Real Power Filter Time Constant.** This setting is used to apply the time constant to the low-pass filter for the real power output. A setting of 0 to 20 seconds may be entered in 0.1 second increments.

**Summing Point OEL**

The Summing Point OEL tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Summing Point Overexcitation Limiter settings. In the default logic schemes provided with the DECS-400, a contact input is used to select either the primary or secondary Summing Point OEL settings.

Summing Point OEL tab functions are shown in Figure 4-15 and described in the following paragraphs.

**Off-Line – High Level.** This setting configures the high-level current setpoint for the summing point off-line overexcitation limiter. A setting of 0 to 11,999 Adc may be entered in 0.01 Adc increments.

**Off-Line – High Time.** This setting establishes the time limit for high current limiting by the summing point off-line overexcitation limiter. A setting of 0 to 10 seconds may be entered in 1 second increments.

**Off-Line – Low Level.** This setting configures the low-level current setpoint for the summing point off-line overexcitation limiter. A setting of 0 to 11,999 Adc may be entered in 0.01 Adc increments.

**On-Line – High Level.** This setting configures the high-level current setpoint for the summing point on-line overexcitation limiter. A setting of 0 to 11,999 Adc may be entered in 0.01 Adc increments.

**On-Line – High Time.** This setting establishes the time limit for high current limiting by the summing point on-line overexcitation limiter. A setting of 0 to 60 seconds may be entered in 1 second increments.

**On-Line – Medium Level.** This setting configures the medium-level current setpoint for the summing point on-line overexcitation limiter. A setting of 0 to 11,999 Adc may be entered in 0.01 Adc increments.

**On-Line – Medium Time.** This setting establishes the time limit for medium current limiting by the summing point on-line overexcitation limiter. A setting of 0 to 120 seconds may be entered in 1 second increments.

**On-Line – Low Level.** This setting configures the low-level current setpoint for the summing point on-line overexcitation limiter. A setting of 0 to 11,999.00 Adc may be entered in 0.01 Adc increments.

**Takeover OEL**

The Takeover OEL tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Takeover Overexcitation Limiter settings. In the default
logic schemes provided with the DECS-400, a contact input is used to select either the primary or secondary Takeover OEL settings.

Takeover OEL functions are shown in Figure 4-16 and described in the following paragraphs.

*Figure 4-16. Limiters Screen, Takeover OEL Tab*

**Off-Line – Low Level.** This setting configures the low-level current setpoint for the takeover-style, off-line overexcitation limiter. A setting of 0 to 12.00 Adc may be entered in 0.01 Adc increments.

**Off-Line – High Level.** This setting configures the high-level current setpoint for the takeover-style, off-line overexcitation limiter. A setting of 0 to 11,999 Adc may be entered in 0.01 Adc increments.

**Off-Line – Time Dial.** This setting establishes the time delay for the takeover-style, off-line overexcitation limiter. A setting of 0.1 to 20.0 seconds may be entered in 0.1 second increments.

**On-Line – Low Level.** This setting configures the low-level current setpoint for the takeover-style, on-line overexcitation limiter. A setting of 0 to 12 Adc may be entered in 0.01 Adc increments.

**On-Line – High Level.** This setting configures the high-level current setpoint for the takeover-style, on-line overexcitation limiter. A setting of 0 to 11,999 Adc may be entered in 0.01 Adc increments.

**On-Line – Time Dial.** This setting establishes the time delay for the takeover-style, on-line overexcitation limiter. A setting of 0.1 to 20.0 seconds may be entered in 0.1 second increments.

**Offline and Online Curve Checkboxes.** Checking these boxes displays a plot of the takeover-style, off-line and on-line overexcitation limiter curves. Curve magnification is reset by the Reset Zoom button.

**UEL**

The UEL tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Underexcitation Limiter settings. In the default logic schemes provided with the DECS-400, a contact input is used to select either the primary or secondary UEL settings.

UEL functions are shown in Figure 4-17 and described in the following paragraphs.

**Curve Selection.** This setting selects either a custom or internal underexcitation limiter curve and is enabled in all DECS-400 operating modes except FCR. Selecting Custom enables the user to configure a customized, one-to-five point UEL curve that matches a specific generator’s characteristics. Selecting Internal creates a UEL curve based on the first point setting of the absorbed reactive power level.

**Real Power (kW).** These five setting fields establish the five real-power points of the underexcitation limiter curve. The Curve Selection setting must be “Custom” in order for these setting fields to be enabled.
Not all setting fields need be used. For example, entering kW values in three of the five setting fields produces a three-point UEL curve. The range for each setting field is based on the generator ratings entered on the Rated Data tab of the System Configuration screen.

Reactive Power (Leading kVAR). When the Curve Selection setting is “Custom”, these five setting fields establish the five reactive power points of the underexcitation limiter curve. Not all setting fields need be used. For example, entering kvar values in two of the five setting fields produces a two-point UEL curve. When the Curve Selection setting is “Internal”, only the first setting field is enabled and a UEL curve is internally generated based on the value entered in the field. The range for each setting field is based on the generator ratings entered on the Rated Data tab of the System Configuration screen.

SCL

The SCL tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Stator Current Limiter settings. In the default logic diagrams provided with the DECS-400, a contact input is used to select either the primary or secondary SCL settings.

SCL functions are shown in Figure 4-18 and described in the following paragraphs.

SCL – High SCL Level. This setting configures the high-level current setpoint for the stator current limiter. A setting of 0 to 66,000.0 Aac may be entered in 0.1 Aac increments.

SCL – High SCL Time. This setting establishes the time limit for high-level current limiting by the stator current limiter. A setting of 0 to 60.0 seconds may be entered in 0.1 second increments.

SCL – Low SCL Level. This setting configures the low-level current setpoint for the stator current limiter. A setting of 0 to 66,000.0 Aac may be entered in 0.1 Aac increments.
Scaling settings are shown in Figure 4-19 and described in the following paragraphs.

**Limiter Scaling.** The OEL Scale Enable setting can be enabled to adjust overexcitation limiting to compensate for the level of field current. The SCL Scale Enable setting can be enabled to adjust stator current limiting to compensate for the level of stator current.
**Summing Point OEL Scaling.** Scaling of summing-point overexcitation limiting is provided for three levels (or points) of field current. Each level, or point, has a Signal setting to adjust the scaling level and a Scale setting to establish the level of field current when the scaling occurs. Each of the three Signal settings has a setting range of −10 to 10 Vdc with increments of 0.01 Vdc. Each of the three Scale settings is expressed as a percentage of the rated field current and has a setting range of 0 to 200% with increments of 0.1%. These settings are enabled only when Summing Point overexcitation limiting is enabled on the Configuration tab of the Limiters screen.

**Takeover OEL Scaling.** Scaling of takeover-style overexcitation limiting is provided for three levels (or points) of field current. Each level, or point, has a Signal setting to adjust the scaling level and a Scale setting to establish the level of field current when the scaling occurs. Each of the three Signal settings has a setting range of −10 to 10 Vdc with increments of 0.01 Vdc. Each of the three Scale settings is expressed as a percentage of the rated field current and has a setting range of 0 to 200% with increments of 0.1%. These settings are enabled only when Takeover overexcitation limiting is enabled on the Configuration tab of the Limiters screen.

**SCL Scaling.** Scaling of stator current limiting is provided for three levels (or points) of field current. Each level, or point, has a Signal setting to adjust the scaling level and a Scale setting to establish the level of field current when the scaling occurs. Each of the three Signal settings has a setting range of −10 to 10 Vdc with increments of 0.01 Vdc. Each of the three Scale settings is expressed as a percentage of the rated field current and has a setting range of 0 to 200% with increments of 0.1%.

**Protection**

The Protection screen consists of five tabs: General Protection, Loss of Sensing, EDM, 24 Volts/Hertz, and Relay Setup. Click the **Protection** button on the tool bar, click **Window, 5 Protection** on the menu bar, or click **Protection** on the explorer bar to view the Protection screen.

**General Protection**

General Protection tab settings are shown in Figure 4-20 and described in the following paragraphs.

![Figure 4-20. Protection Screen, General Protection Tab](image)

The General Protection tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the protection settings used when the DECS-400 is functioning as the primary or secondary DECS-400 in a redundant system.

*Gen. Overvoltage – Enable/Disable.* The generator overvoltage pickup level and delay settings are enabled and disabled by this setting.
Field Overvoltage – Enable/Disable. The field overvoltage pickup level and delay settings are enabled and disabled by this setting.

Loss of FIT – Enable/Disable. Loss of field isolation transducer protection is enabled and disabled by this setting.

Gen. Undervoltage – Enable/Disable. The generator undervoltage pickup level and delay settings are enabled and disabled by this setting.

Field Overcurrent – Enable/Disable. The field overcurrent pickup level and dial settings are enabled and disabled by this setting.

Power Supply Low – Enable/Disable. Low power supply voltage protection is enabled and disabled by this setting. The low power supply voltage threshold is fixed and not user-adjustable.

Loss of Field – Enable/Disable. The loss of field pickup level and delay settings are enabled and disabled by this setting.

Field Overtemperature – Enable/Disable. The field overtemperature pickup level and delay settings are enabled and disabled by this setting.

Generator Overvoltage – Pickup Level. This setting configures the setpoint, in primary voltage, for generator overvoltage protection. A setting of 0 to 34,500 Vac may be entered in 1 Vac increments.

Generator Overvoltage – Delay. This setting establishes the time delay for the generator overvoltage protection function. A setting of 0.1 to 60.0 seconds may be entered in 0.1 second intervals.

Field Overvoltage – Pickup Level. This setting configures the setpoint for field overvoltage protection. A setting of 1 to 2,000 Vdc may be entered in 1 Vdc increments.

Field Overvoltage – Delay. This setting establishes the time delay for the field overvoltage protection function. A setting of 0.2 to 30.0 seconds may be entered in 0.1 second intervals.

Loss of Field Iso. Transducer – Delay. This setting establishes the time delay for loss of field isolation transducer protection. A setting of 0 to 9.9 seconds may be entered in 0.1 second increments.

Generator Undervoltage – Pickup Level. This setting configures the setpoint for generator undervoltage protection. A setting of 0 to 34,500 Vac may be entered in 1 Vac increments.

Generator Undervoltage – Delay. This setting establishes the time delay for the generator undervoltage protection function. A setting of 0.5 to 60.0 seconds may be entered in 0.1 second increments.

Field Overcurrent – Pickup Level. This setting configures the setpoint for field overcurrent protection. A setting of 0.1 to 9,999.0 Adc may be entered in 0.1 Adc increments.

Field Overcurrent – Dial. This setting establishes the time dial setting for the field overcurrent protection function. A setting of 0.1 to 20.0 seconds may be entered in 0.1 second increments.

Loss of Field – Pickup Level. This setting configures the setpoint for loss of field protection. A setting of 0 to 3,000,000 Vdc may be entered in 1 Vdc increments.

Loss of Field – Delay. This setting establishes the time delay for the loss of field protection function. A setting of 0 to 9.9 seconds may be entered in 0.1 second increments.

Field Overtemperature – Pickup Level. This setting configures the setpoint for field overtemperature protection. A setting of 0 to 572°C may be entered in 1°C increments.

Field Overtemperature – Delay. This setting establishes the time delay for field overtemperature protection. A setting of 0.1 to 60.0 seconds may be entered in 0.1 second increments.

**EDM**

EDM tab settings are shown in Figure 4-21 and described in the following paragraphs.

Pole Ratio. The ratio of the number of exciter field poles to the number of main field poles is entered in this setting field. A value of 0 to 10.00 may be entered in 0.01 increments.
The Calculator button, adjacent to the Pole Ratio field, can be clicked to access the Pole Ratio Calculator shown in Figure 4-22. Entering the number of exciter poles and the number of generator poles and clicking the Calculate button calculates the pole ratio. Clicking the Apply button or OK button enters the calculated result in the Pole Ratio field of the EDM tab.

Open Diode – Option. This setting enables and disables open exciter diode protection.

Open Diode – Pickup Level. This setting configures the percent of rated field current that indicates an open exciter diode. A setting of 0 to 100.0 percent may be entered in 0.1 percent increments.

Open Diode – Disable Level. This setting configures the percent of rated field current that disables both open- and shorted-diode protection. A setting of 0 to 100.0 percent may be entered in 0.1 percent increments.

Open Diode – Delay. This setting establishes the time delay between when an open exciter diode is detected and annunciated. A setting of 10 to 60.0 seconds may be entered in 0.1 second increments.

Shorted Diode – Option. This setting enables and disables shorted exciter diode protection.

Shorted Diode – Pickup Level. This setting configures the percent of rated field current that indicates a shorted exciter diode. A setting of 0 to 100.0 percent may be entered in 0.1 percent increments.

Shorted Diode – Delay. This setting establishes the time delay between when a shorted exciter diode is detected and annunciated. A setting of 5 to 30.0 seconds may be entered in 0.1 second increments.

Loss of Sensing
Loss of Sensing tab functions are shown in Figure 4-23 and described in the following paragraphs.

Loss of Sensing Voltage – Option. This setting enables and disables loss of sensing voltage protection.
Loss of Sensing Voltage – Balanced Level. When all three phases of sensing voltage decrease below this setting, the loss of sensing time delay begins timing out. A setting of 0 to 100 percent (of nominal) may be entered in 0.1 percent increments.

Loss of Sensing Voltage – Unbalanced Level. When any one of the three phases of sensing voltage decreases below this setting, the loss of sensing voltage time delay begins timing out. A setting of 0 to 100 percent (of nominal) may be entered in 0.1 percent increments.

Loss of Sensing Voltage – Delay. This setting determines the length of time between when a loss of sensing voltage condition is detected and annunciated. A setting of 0 to 30 seconds may be entered in 0.1 second increments.

Loss of Sensing Voltage – Transfer to FCR. This setting enables and disables the transfer to FCR mode when a loss of sensing voltage condition is detected.

24 Volts/Hz

24 Volts/Hz settings are shown in Figure 4-24 and described in the following paragraphs.

24 Volts/Hertz – Option. This setting enables and disables volts per hertz (overexcitation) protection.

24 Volts/Hertz – Inverse Time Curve Exponent. This setting is used to configure the inverse timing curve of the 24 protection function. An exponent of 0.5, 1, or 2 may be selected.

24 Volts/Hertz – Inverse Time Pickup Setpoint and Pickup Time Dial. These settings are used to establish an inverse square timing characteristic to approximate the heating characteristic of the field during overexcitation. A per-unit Pickup Setpoint of 0 to 6.0 may be entered in increments of 0.01. A Pickup Time Dial of 0 to 10 may be entered in increments of 1.

24 Volts/Hertz – Reset Time Dial. This setting establishes a linear reset characteristic that approximates the effects of field winding cooling. A Reset Time Dial setting of 0 to 10 may be entered in increments of 0.1.

24 Volts/Hertz – Definite Time Pickup #1, #2 and Definite Time Pickup #1, #2. Two sets of definite Volts/Hertz pickup settings can be used to establish two fixed-time overexcitation pickup settings. Definite Time Pickup #1 and #2 have a setting range of 0.5 to 6.0 with an increment of 0.01. Definite Time Delay #1 and #2 may be set over a range of 0.5 to 600 seconds in 0.05 second increments.
Relay Setup settings are shown in Figure 4-25 and described in the following paragraphs.

Relay #1, #2, #3, #4, #5, #6 – Contact Status. This setting configures the corresponding programmable output as having normally open or normally closed contacts.
Relay #1, #2, #3, #4, #5, #6 – Contact Type. This setting selects one of three contact types: Momentary, Maintained, or Latched. Selecting Momentary closes or opens the relay contacts for the duration determined by the Momentary Time setting. Selecting Maintained closes or opens the relay contacts for the duration of the condition triggering the relay’s change of state. Selecting Latched latches the relay contacts open or closed until the relay is reset by the user.

Relay #1, #2, #3, #4, #5, #6 – Momentary Time. When Momentary is selected as the contact type, this setting controls the duration that the contact is open/closed when the relay output is active. A time setting of 0.1 to 5 seconds may be entered in 0.05 second increments.

PSS
The PSS screen consists of three tabs: Control, Parameters, and Output Limiter. Click the PSS button on the tool bar, click Window, 6 PSS (Power System Stabilizer) on the menu bar, or click PSS (Power System Stabilizer) on the explorer bar to view the PSS screen.

Control
The General Protection tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Power System Stabilizer settings. In the default, PSS logic schemes provided with the DECS-400, a contact input is used to select between the primary and secondary PSS settings. (Primary/secondary gains are automatically selected when the PSS becomes active.)

Control tab settings are shown in Figure 4-26 and described in the following paragraphs.

PSS Control – Enable. This setting enables and disables the power system stabilization by the DECS-400. This setting is available only when the primary settings of the Control tab are displayed.

Supervisory Function – Power-On Threshold. This setting defines the power level required to enable power system stabilizer operation. The Power On Threshold is a per-unit setting that is based on the Generator Rated Data settings entered on the Rated Data tab of the BESTCOMS System Configuration screen. A setting of 0 to 1.00 may be entered in increments of 0.01.

Supervisory Function – Power Hysteresis. This setting provides a margin below the power-on threshold setting so that transient dips in power will not disable power system stabilizer operation. The per-unit Power Hysteresis setting is based on the Generator Rated Data settings entered on the Rated Data tab of the BESTCOMS System Configuration screen. A setting of 0 to 1.00 may be entered in increments of 0.01.

PSS Model Info. Clicking this link opens a window displaying the function blocks and software switches of the DECS-400 PSS function.
Software Switch Settings – SSW 0, Speed Low Pass Filter. This setting enables and disables the power system stabilizer speed input low-pass filter.

Software Switch Settings – SSW 1, Power Washout Filter #2. This setting enables and disables the washout filter of the power system stabilizer power input.

Software Switch Settings – SSW 2, PSS Signal. This setting selects either derived speed or frequency as the power system stabilizer signal.

Software Switch Settings – SSW 3, PSS Signal. This setting selects between derived speed or frequency (SSW 2) and power as the power system stabilizer signal.

Software Switch Settings – SSW 4, Torsional Filter 1. This setting enables and disables the first of two power system stabilizer torsional filters.

Software Switch Settings – SSW 5, Torsional Filter 2. This setting enables and disables the second of two power system stabilizer torsional filters.

Software Switch Settings – SSW 6, 3rd Lead/Lag Stage. This setting includes and excludes the third lead/lag stage of the power system stabilizer output.

Software Switch Settings – SSW 7, 4th Lead/Lag Stage. This setting includes and excludes the fourth lead/lag stage of the power system stabilizer output.

Software Switch Settings – SSW 8, Term. Voltage Limiter. This setting enables and disables the power system stabilizer terminal voltage limiter.

Software Switch Settings – SSW 9, Logic Limiter. This setting enables and disables the power system stabilizer logic limiter.

Software Switch Settings – SSW 10, PSS Output. This setting turns on and turns off the power system stabilizer output.

Parameters

The Parameters tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Power System Stabilizer settings. In the default, PSS logic schemes provided with the DECS-400, a contact input is used to select between the primary and secondary PSS settings. (Primary/secondary gains are automatically selected when the PSS becomes active.)

Parameters tab settings are shown in Figure 4-27 and described in the following paragraphs.
Figure 4-27. PSS Screen, Parameters Tab

**Low-Pass/Ramp Tracking – TI1, TI2, TI3-Time Const.** These setting fields configure the three low-pass filter time constants ($T_{I1}$, $T_{I2}$, and $T_{I3}$). Each time constant can be set over the range of 0 to 0.20 seconds in 0.01 second increments.

**Low-Pass/Ramp Tracking – Tr-Time Const.** This setting field configures the ramp tracking filter time constant. The time constant has a setting range of 0.05 to 1.00 with increments of 0.01.

**Low-Pass/Ramp Tracking – N-Num Exp.** This setting field establishes the mechanical power filter numerator exponent and can be set at a value of 0 or 1.

**Low-Pass/Ramp Tracking – M-Den Exp.** This setting field establishes the mechanical power filter denominator exponent. A denominator exponent of 0 to 5 may be entered in increments of 1.

**High-Pass Filtering/Integration – Tw1, Tw2, Tw3, Tw4-Time Const.** These setting fields configure the three high-pass filtering time constants ($T_{w1}$, $T_{w2}$, $T_{w3}$, and $T_{w4}$). Each time constant can be set over the range of 1 to 20.00 seconds in 0.01 second increments.

**High-Pass Filtering/Integration – H, Inertia.** This setting field adjusts rotor inertia (for integration of power signal) time constant $H$. The rotor inertia has a setting range of 1 to 25.00 MW-seconds/MVA with setting increments of 0.01 MW-seconds/MVA.

**Torsional Filters.** These setting fields are used to set the parameters for torsional filters 1 and 2.

- Zeta Num 1 and Zeta Num 2 are used to set the numerator damping ratio for torsional filters 1 and 2 respectively.
- Zeta Den 1 and Zeta Den 2 are used to set the denominator damping ratio for torsional filters 1 and 2 respectively. A setting of 0 to 1.00 may be entered in increments of 0.01.
- Wn 1 and Wn 2 are used to set the resonant frequency for torsional filters 1 and 2 respectively. A setting of 10 to 150.00 may be entered in increments of 0.05.

**Rotor Freq Calculation – Quadrature Xq.** This per-unit setting adjusts the level of quadrature axis compensation made by the PSS function. The quadrature reactance setting range is 0 to 5.000 with 0.0001 increments.

**Power Input – Kpe.** This setting field establishes the amplitude of the electrical power input used by the PSS function. A Kpe setting of 0 to 2.00 may be entered in 0.01 increments.

**Phase Comp.-Time Constants.** These eight settings adjust the first, second, third, and fourth phase compensation time constants (lead and lag). The phase compensation time constants may be set from 0.001 to 6 seconds in 0.001 second increments.
Output Limiter

The Output Limiter tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary Power System Stabilizer settings. In the default, PSS logic schemes provided with the DECS-400, a contact input is used to select between the primary and secondary PSS settings. (Primary/secondary gains are automatically selected when the PSS becomes active.)

Output Limiter tab settings are shown in Figure 4-28 and described in the following paragraphs.

**PSS Output Limiting – Upper Limit.** This per-unit setting adjusts the stabilizer output gain stage (Kg) maximum limit. A setting of 0 to 0.500 may be entered in 0.001 increments.

**PSS Output Limiting – Lower Limit.** This per unit setting adjusts the stabilizer output gain stage (Kg) minimum limit. A setting of –0.500 to 0 may be entered in 0.001 increments.

**Stabilizer Gain – Ks.** This setting adjusts the stabilizer gain time constant. The time constant has a setting range of 0 to 50 with increments of 0.01.

**Terminal Voltage Limiter – Time Constant.** This setting adjusts the time constant for the generator terminal voltage limiter. A time constant of 0.02 to 5 seconds may be entered in 0.01 second increments.

**Terminal Voltage Limiter – Setpoint.** This per-unit setting adjusts the setpoint for the generator terminal voltage limiter. A setpoint of 0 to 10 may be entered in increments of 0.01.

**Logic Limiter Washout Filter – Normal Time.** This setting adjusts the normal time constant of the washout filter. A normal time constant of 5 to 30 seconds may be entered in 0.1 second increments.

**Logic Limiter Washout Filter – Limit Time.** This setting adjusts the limit time constant of the washout filter. A limit time constant of 0 to 1 second may be entered in 0.01 second increments.

**Logic Output Limiter – Upper Limit.** This per-unit setting adjusts the high limit value for the logic output limiter. An upper limit of 0.01 to 0.04 may be entered in 0.001 increments.

**Logic Output Limiter – Lower Limit.** This per-unit setting adjusts the low limit value for the logic output limiter. A lower limit of –0.4 to –0.01 may be entered in 0.001 increments.

**Logic Output Limiter – Time Delay.** This setting adjusts the time delay of the logic output limiter. A time delay of 0 to 2 seconds may be entered in 0.01 second increments.
**Metering**

The Metering screen consists of four tabs: Operation, System Alarms, System Status, and I/O Status. Click the Meter button on the tool bar, click **Window, 8 Metering** on the menu bar, or click **Metering** on the explorer bar to view the Metering screen.

**Operation**

The Operation tab of the Metering screen is shown in Figure 4-29. (Not all Operation tab elements are visible in the illustration.) Operation tab parameters and controls are described in the following paragraphs.

*Generator.* Nine real-time metering values display the generator voltage, current and frequency.

*Field.* Four real-time metering values display the field voltage, current, temperature, and exciter diode ripple.

*Phase Angle.* These five real-time metering fields consist of two phase-angle fields for voltage and three phase-angle fields for current.

*Power.* Four real-time metering values display generator apparent power, real power, reactive power, and power factor.

*PSS (Power System Stabilizer).* Seven real-time values metered by the PSS function display positive sequence voltage and current, negative sequence voltage and current, terminal frequency deviation, compensated frequency deviation, and the per-unit PSS output level. The PSS function on/off status is also reported.

*Control.* These three real-time metering fields display the remote setpoint control signal level (volts or milliamperes) applied to the auxiliary input terminals and the excitation setpoint control signal level (volts or milliamperes) being supplied by the DECS-400.

*Tracking.* One real-time metering field indicates the setpoint tracking error. Two status fields indicate the on/off status for internal tracking and external tracking.

*Bus.* This real-time metering field displays the level of the bus voltage.

*Start/Stop Mode.* Two indicators show the start/stop mode status of the DECS-400. In Stop mode, the Stop indicator changes from gray to green. In Start mode, the Start indicator changes from gray to red. The Start/Stop button is clicked to toggle the DECS-400 start/stop mode status.

*AVR/FCR Mode.* AVR and FCR mode status is reported by two indicators. When the DECS-400 is operating in AVR mode, the AVR indicator changes from gray to red. When operating in FCR mode, the FCR indicator changes from gray to red. AVR mode or FCR mode is selected through the drop-down menu.
VAR/PF Mode. Three indicators report whether Var mode is active, Power Factor mode is active, or neither mode is active. When Var mode is active, the VAR indicator changes from gray to red. When Power Factor mode is active, the PF indicator changes from gray to red. When neither mode is active, the Off indicator changes from gray to green. Var and Power Factor modes are enabled and disabled through the drop-down menu.

Setpoint Pre-position. A control button and indicator is provided for the two setpoint pre-positions. Clicking the Set 1 button adjusts the excitation setpoint to the pre-position 1 value and changes the Pre-position 1 indicator from gray to red. Clicking the Set 2 button adjusts the excitation setpoint to the pre-position 2 value and changes the Pre-position 2 indicator from gray to red.

Setpoint Fine Adjust. Clicking the Raise button increases the active operating setpoint. Clicking the Lower button decreases the active operating setpoint. The raise and lower increment is a function of the setpoint range of adjustment and the active mode traverse rate. The increments are directly proportional to the adjustment range and inversely proportional to the traverse rate.

Setpoints. Four status fields indicate the setpoints for AVR mode, FCR mode, Var mode, and Power Factor mode.

System Alarms
System Alarms tab indicators are shown in Figure 4-30 and described in the following paragraphs.

System Alarms. When any of 25 alarm conditions (Figure 4-30) exist, the corresponding indicator changes from gray to red. Clicking the RESET button resets any system alarm annunciation that is no longer active.

NOTE
Two volts per hertz alarm indicators are provided on the System Alarms tab: Excessive V/Hz and Underfrequency V/Hz. The Excessive V/Hz indicator annunciates that V/Hz protection is active and the Underfrequency V/Hz indicator annunciates that the V/Hz limiter is active.
**System Status.** Various system operating modes (Figure 4-30) are listed alongside text labels that change according to the status of each operating mode.

![Figure 4-30. Metering Screen, System Alarms Tab](image)

**System Status**

System Status tab indicators are shown in Figure 4-31 and described in the following paragraphs.

**Front Panel LED Status.** These indicators mirror the front panel indicator LEDs on the DECS-400 front panel. An indicator changes from gray to red when the corresponding front panel LED lights.

**Active Setting Group Status.** Setting groups are listed (Figure 4-30) alongside text labels that change according to the status (primary or secondary) of each setting group.

**System Status.** Various system operating modes (Figure 4-31) are listed alongside text labels that change according to the status of each operating mode.
I/O Status tab indicators are shown in Figure 4-32 and described in the following paragraphs.

Switch Input Status. These indicators annunciate the status (open or closed) of each DECS-400 contact input. An open switch input is indicated by a gray indicator; a closed switch input is indicated by a green indicator.
**Relay Output Status.** These indicators annunciate the status of each DECS-400 contact output. A de-energized relay is indicated by a gray indicator; an energized relay is indicated by a red indicator.

**Set Programmable Labels.** Clicking this button opens the Programmable I/O Labels screen which enables user-defined labels to be assigned to the DECS-400 contact inputs and outputs. Each input/output can be assigned a label containing a maximum of 21 alphanumeric characters.

**System Status.** Various system operating modes (Figure 4-31) are listed alongside text labels that change according to the status of each operating mode.

**Data Log**
The Data Log screen consists of five tabs: Log Setup, Logic Triggers, Mode Triggers, Level Triggers/Log Selection, and Trending. Clock the Data Log button on the tool bar, click Window, Data Log on the menu bar, or click Data Log on the explorer bar to view the Data Log screen.

**Log Setup**
Log Setup tab parameters and controls are shown in Figure 4-33 and described in the following paragraphs.

**Data Log Setup – Data Logging Enabled.** This setting enables and disables data logging.

**Data Log Setup – Pre-Trigger Points.** This setting selects the number of data points that are recorded prior to a data log being triggered.

**Data Log Setup – Pre-Trigger Duration (sec).** This read-only field displays the length of time that pre-trigger data points are recorded. The value displayed is determined by the Pre-Trigger Points and Sample Interval settings.

**Data Log Setup – Post-Trigger Points.** This read-only field displays the number of data points that are recorded after a data log is triggered. The value displayed is determined by the Pre-Trigger Points and Sample Interval settings.

**Data Log Setup – Post-Trigger Duration (sec).** This read-only field displays the length of time that post-trigger data points are recorded. The value displayed is determined by the Pre-Trigger Points and Sample Interval settings.

**Data Log Setup – Sample Interval (ms).** This setting establishes the sample rate of the data points. When the Generator Frequency setting (Configure screen, Options tab) is 60 Hz, a sample interval of 4.166 to
10,415.000 milliseconds may be selected from the pull-down menu. When the Generator Frequency setting is 50 Hz, a sample interval of 5 to 12,500 milliseconds may be selected.

**Data Log Setup – Total Duration (sec).** This read-only field displays the total recording time for a data log and equals the sum of the Pre-Trigger Duration and the Post-Trigger Duration. The value displayed is determined by the Pre-Trigger Points and Sample Interval settings.

**View Sequence of Events.** Clicking this button displays the Sequence of Events Reporting screen (Figure 4-34). Sequence of Events Reporting screen displays and controls are described in the following paragraphs.

![Sequence Of Events Reporting](image)

**Report Summary.** This area of the Sequence of Events Reporting screen provides information such as the time and date, station, device and user identification information, and the number of new and total records.

**Event List.** This area of the Sequence of Events Reporting screen lists the available sequence of events records. The records displayed are determined by the event type selected from the Events To Display pull-down menu.

**Events To Display.** The event type displayed in the Event List is controlled by this pull-down menu. Available event-type selections are New, Most Recent, New Alarm, New I/O, and New Mode.

**Print.** Clicking this button displays a print preview window showing the Report Summary and the Event List. Clicking the printer icon sends the report to your printer.

**Save.** Clicking this button opens a Save As dialog box where the Report Summary and the Event List can be saved as a text file on your PC.

**Reset New Event List.** Clicking this button clears the new events from the Event List.

**View/Download Data Log.** Clicking this button displays the Data Log Viewer screen of Figure 4-35. Data Log Viewer screen displays and controls are described in the following paragraphs.

**Report Summary.** This area of the Data Log Viewer screen provides information such as the time and date, station, device and user identification information, and the number of new and total records.

**Record List.** This area of the Data Log Viewer screen displays the list of available data log records. Individual records can be selected from the list and printed, saved as a text file, or downloaded in the ASCII, ASCII COMTRADE, or binary COMTRADE formats.

**Selected Record Information.** This area of the Data Log View screen displays information relating to the data log record selected in the Record List. Displayed information includes the trigger source, number of pre-trigger points, number of post-trigger points, total points, the sample interval, and the number of parameters reported.
Trigger Record. This button is clicked to manually trigger data record acquisition. A data log cannot be manually triggered unless data logging is enabled on the Log Setup tab.

Stop Record. This button is clicked to end acquisition of a manually triggered data record.

Refresh Summary/List. Clicking this button updates the Report Summary data and Record List with the latest available information.

Reset New Record Counter. Clicking this button resets the number of new records reported in the Report Summary to zero.

Reset Total Record Counter. Clicking this button resets the number of total records reported in the Report Summary to zero.

Print Record. This button is clicked to print a selected data record in the Record List.

Print Report. This button is clicked to print a copy of the Report Summary.

Save Record. This button is clicked to save a selected record in a text file.

Save Report. This button is clicked to save the Report Summary in a text file.

Download Selected Record. Clicking this button displays the COMTRADE/Log File Download screen. This screen enables the fault record selected from the Record List to be downloaded in the ASCII, ASCII COMTRADE, or binary COMTRADE formats. Clicking the Download File button enables you to save the record in the desired format.

Download Trend Log. This button is clicked to display the Trending File Download screen, which enables you to save a trending file with a "log" file extension. Trend log duration and parameters are selected on the Trending tab of the Data Log screen.

Logic Triggers Tab

Logic Trigger tab settings are shown in Figure 4-36 and described in the following paragraphs.

Alarm States. This area of the Logic Triggers tab lists the available alarm conditions that can be selected to trigger a data log report. Any combination of alarm states may be selected.

Relay Outputs. This area of the Logic Triggers tab lists the available DECS-400 contact outputs that can be selected to trigger a data log report. Any combination of relay outputs may be selected.

Contact Inputs. This area of the Logic Triggers tab lists the available DECS-400 contact inputs that can be selected to trigger a data log report. Any combination of contact inputs may be selected.
Mode Triggers Tab

Mode Triggers tab settings are shown in Figure 4-37 and described in the following paragraphs.

Stop/Start Mode. This setting enables the Start or Stop mode to trigger a data log report. Selecting NO TRIGGER disables a Start or Stop mode trigger.

Soft Start Mode. This setting enables a data log report to be triggered when Soft Start mode is enabled (Soft Start Mode Active) or disabled (Off). Selecting NO TRIGGER disables a Soft Start mode trigger.
**Underfrequency Mode.** This setting enables a data log report to be triggered when Underfrequency mode is active or inactive. Selecting NO TRIGGER disables an Underfrequency mode trigger.

**Control Mode.** This setting enables a data log report to be triggered when either AVR mode or FCR mode is active. Selecting NO TRIGGER disables a control mode trigger.

**Operating Mode.** This setting enables a data log report to be triggered when Power Factor mode is active, Var mode is active, or neither mode is active. Selecting NO TRIGGER disables an Operating mode trigger.

**Limiter Mode.** This setting enables a data log report to be triggered when the underexcitation limiter, overexcitation limiter, or stator current limiter are active. Additionally, a data log report can be triggered when two of the limiters are active. The available limiter mode selections are listed below:

- UEL (underexcitation limiter active)
- OEL (overexcitation limiter active)
- UEL & OEL (underexcitation limiter and overexcitation limiter active)
- SCL (stator current limiter active)
- UEL & SCL (underexcitation limiter and stator current limiter active)
- OEL & SCL (overexcitation limiter and stator current limiter active)
- UEL, OEL & SCL (underexcitation limiter, overexcitation limiter, and stator current limiter active)
- Off (no limiters active)
- NO TRIGGER (disables a limiter mode trigger)

**Voltage Matching Mode.** This setting enables a data log report to be triggered when Voltage Matching mode is off or on. Selecting NO TRIGGER disables a Voltage Matching mode trigger.

**Secondary DECS Mode.** This setting enables a data log report to be triggered when the DECS-400 is functioning as the primary DECS-400 or secondary DECS-400 in a redundant DECS-400 system. Selecting NO TRIGGER disables a Secondary DECS Mode trigger.

**PSS Controller Mode.** This setting enables a data log report to be triggered when the PSS function is enabled or disabled. Selecting NO TRIGGER disables a PSS Controller mode trigger.

**Droop Mode.** This setting enables a data log report to be triggered when Droop mode is enabled or disabled. Selecting NO TRIGGER disables a Droop mode trigger.

**Line Drop Mode.** This setting enables a data log report to be triggered when Line Drop mode is enabled or disabled. Selecting NO TRIGGER disables a Line Drop mode trigger.

**Cross Current Comp. Mode.** This setting enables a data log report to be triggered when cross-current compensation (reactive differential) is enabled or disabled. Selecting NO TRIGGER disables a Cross-Current Compensation mode trigger.

**Test Mode.** This setting enables a data log report to be triggered when Test mode is enabled or disabled. Selecting NO TRIGGER disables a Test mode trigger.

### Level Triggers/Log Selection

The Level Triggers/Log Selection tab (Figure 4-38) consists of a list of parameters that can be selected to trigger a data log report. Up to six parameters can be selected as triggers. Each parameter has a Level Trigger Enable setting which configures a data log to be triggered when the parameter increases above the Upper Threshold setting, decreases below the Lower Threshold setting, or either increases above/decreases below the Upper Threshold/Lower Threshold setting. The list of parameters that can be selected from to trigger a data log report is provided in Table 4-2. The Lower Threshold and Upper Threshold setting range for each parameter is listed also.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit of Measure</th>
<th>Threshold Lower</th>
<th>Threshold Upper</th>
<th>Increment</th>
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</thead>
<tbody>
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<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
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<td>AVR PID Error Signal Input</td>
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<td>–2 to 2</td>
<td>–2 to 2</td>
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<td>Bus Frequency</td>
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<td>0.01</td>
</tr>
<tr>
<td>Bus Voltage</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Comp. Frequency Deviation</td>
<td>Hz</td>
<td>–60 to 60</td>
<td>–60 to 60</td>
<td>0.01</td>
</tr>
<tr>
<td>Control Output *</td>
<td>N/A</td>
<td>–32,767 to 32,767</td>
<td>–32,767 to 32,767</td>
<td>1</td>
</tr>
<tr>
<td>Parameter</td>
<td>Unit of Measure</td>
<td>Threshold</td>
<td>Increment</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------</td>
<td>--------------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>Cross Current Input</td>
<td>A</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Field Current</td>
<td>A</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Field Voltage</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Apparent Power</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Average Current</td>
<td>kVA</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Average Voltage</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Current Ia</td>
<td>A</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Current Ib</td>
<td>A</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Current Ic</td>
<td>A</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Frequency</td>
<td>Hz</td>
<td>0 to 180</td>
<td>0 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Power Factor</td>
<td>PF</td>
<td>–1 to 1</td>
<td>–1 to 1</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Reactive Power</td>
<td>kvar</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Real Power</td>
<td>kW</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Voltage Vab</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Voltage Vbc</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Generator Voltage Vca</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Negative Sequence Current</td>
<td>A</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Negative Sequence Voltage</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>OEL Controller Output</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PF Mode Output</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Phase Angle Ia – Vca</td>
<td>Degrees</td>
<td>–180 to 180</td>
<td>–180 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>Phase Angle Iaux – Vca</td>
<td>Degrees</td>
<td>–180 to 180</td>
<td>–180 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>Phase Angle Ib – Vca</td>
<td>Degrees</td>
<td>–180 to 180</td>
<td>–180 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>Phase Angle Ic – Vca</td>
<td>Degrees</td>
<td>–180 to 180</td>
<td>–180 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>Phase Angle Vab</td>
<td>Degrees</td>
<td>–180 to 180</td>
<td>–180 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>Phase Angle Vbc</td>
<td>Degrees</td>
<td>–180 to 180</td>
<td>–180 to 180</td>
<td>0.01</td>
</tr>
<tr>
<td>PID Integrator State</td>
<td>N/A</td>
<td>–32,767 to 32,767</td>
<td>–32,767 to 32,767</td>
<td>1</td>
</tr>
<tr>
<td>Positive Sequence Current</td>
<td>A</td>
<td>–4 to 4</td>
<td>–4 to 4</td>
<td>0.01</td>
</tr>
<tr>
<td>Positive Sequence Voltage</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Electrical Power</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Filtered Mech. Power</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Final Output</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Lead-Lag #1</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Lead-Lag #2</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Lead-Lag #3</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Lead-Lag #4</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Mechanical Power LP #1</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Mechanical Power LP #2</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Mechanical Power LP #3</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Mechanical Power LP #4</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Post-Limit Output</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Power HP #1</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Parameter</td>
<td>Unit of Measure</td>
<td>Threshold</td>
<td>Increment</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------</td>
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<td>-----------</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td>PSS Pre-Limit Output</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Speed HP #1</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Synthesized Speed</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Terminal Voltage</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Torsional Filter #1</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Torsional Filter #2</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>PSS Washed Out Power</td>
<td>PU</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>SCL Controller Output</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>Terminal Freq. Deviation</td>
<td>Hz</td>
<td>–60 to 60</td>
<td>–60 to 60</td>
<td>0.01</td>
</tr>
<tr>
<td>Time Response</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
<tr>
<td>UEL Controller Output</td>
<td>V</td>
<td>–2 to 2</td>
<td>–2 to 2</td>
<td>0.01</td>
</tr>
</tbody>
</table>

* The Control Output lower and upper threshold numbers correspond to a control output voltage with a range of –10 to 10 Vdc. The desired control voltage to trigger a data log can be converted to the equivalent threshold value by using the following equation:

\[
\text{Threshold Value} = \frac{\text{Control Voltage}}{10} \times 32767
\]

For example, to trigger a data log when the DECS-400 control voltage increases above 7 Vdc, an upper threshold value of 22,937 would be entered:

\[
22936.9 = \frac{7}{10} \times 32767
\]

![Figure 4-38. Data Log Screen, Level Triggers/Log Selection Tab](image-url)
**Trending**

Trending tab settings and controls are shown in Figure 4-39 and described in the following paragraphs.

![Figure 4-39. Data Log Screen, Trending Tab](image)

**Parameter.** A maximum of six system and DECS-400 parameters may be selected for monitoring in a trend log.

**Setup.** Trend log acquisition is enabled and disabled through this setting.

**Trend Duration.** Trend log duration is configured by three time settings: Day(s), Hour(s), and Minutes(s). The Day(s) setting has a range of 0 to 31 days with 1 day increments. The Hour(s) setting has a range of 0 to 23 hours with 1 hour increments. The Minute(s) setting has a range of 0 to 58 minutes with 1 minute increments. A read-only field below the Trend Duration settings displays the trend duration selected.

**Download Trend Log.** This button is clicked to display the Trending File Download screen, which enables you to save a trending file with a “log” file extension. Trend log duration and parameters are selected on the Trending tab of the Data Log screen.

**Analysis**

Click the **Analysis** button on the tool bar, click **Window, 9 Analysis** on the menu bar, or click **Analysis** on the explorer bar to view the Analysis screen.

The Analysis screen can be used to perform and monitor on-line PSS and AVR testing. Two plots of user-selected data can be generated and the logged data can be stored in a file for later examination. Analysis screen controls and indications are shown in Figure 4-40 and described in the following paragraphs.

**Save Button.** Graphs can be saved in a file by clicking this button.

**Open Button.** DECS-400 graphs saved with a .dg4 file extension can be retrieved with this button.

**Print Button.** Clicking this button displays a print preview screen that enables printing of graphs.

**Graph 1.** When this button is depressed, graph 1 is displayed on the Analysis screen. When this button is raised, only graph 2 is displayed.

**Graph 2.** When this button is depressed, graph 2 is displayed on the Analysis screen. When this button is raised, only graph 1 is displayed.

**Start/Stop.** This button starts and stops the acquisition of data points for the graphs. The button is labeled Start when graphing is stopped and Stop when graphing is active.

**Clear.** Clicking this button clears the data points displayed in the graphs.
**Time in Graph.** This setting selects the total time that data points are accumulated on the graph. When a different time setting is selected, the x-axis grid numbers automatically adjust to maintain 16.667 milliseconds between points. A time setting of 200 ms, 516 ms, 1.03 s, 2.08 s, 4.16 s, 8.33 s, 16.67 s, or 33.33 s may be selected.

**Scroll Graph.** Clicking this button displays the X Axis Start Point setting box which displays the permissible range for the x-axis start point and accepts a number representing a starting point for scrolling across the x-axis.

**Maximize/Restore.** This button expands the Analysis screen to a full-screen size and restores the Analysis screen to its normal, default size.

**Exit.** Clicking this button exits the Analysis screen and returns to the last-viewed screen.

**Graph Settings**

**Parameter.** This setting selects the parameter to be displayed on the graph. Any one of the following parameters may be selected:

- Aux voltage input (Vaux)
- Average line current (Iavg)
- Average line-to-line voltage (Vavg)
- AVR error signal (Errln)
- Bus frequency (BHz)
- Bus voltage (Vbus)
- Compensated frequency deviation (CompF)
- Control output (CntOp)
- Cross-current input (Iaux)
- Field current (Ifd)
- Field voltage (Vfd)
- Filtered mechanical power (MechP)
- Final PSS output (Pout)
- Freq response signal (Test)
- Generator frequency (GHz)
- Ia phase angle (PhA)
- Iaux phase angle (PhAux)
- Ib phase angle (PhB)
- Ic phase angle (PhC)
- Internal state (TrnOp)
- Lead-lag #1 (x15)
- Lead-lag #2 (x16)
- Lead-lag #3 (x17)
- Lead-lag #4 (x31)
- Mechanical power (x7)
- Mechanical power LP #1 (x8)
- Mechanical power LP #2 (x9)
- Mechanical power LP #3 (x10)
- Mechanical power LP #4 (x11)
- Negative sequence current (I2)
- Negative sequence voltage (V2)
- OEL controller output (OelOutput)
- PF mode output (VPfOp)
- Phase A current (Ia)
- Phase A to B, line-to-line voltage (Vab)
- Phase B current (Ib)
- Phase B to C, line-to-line voltage (Vbc)
- Phase C current (Ic)
- Phase C to A, line-to-line voltage (Vca)
- Positive sequence current (I1)
- Positive sequence voltage (V1)
- Post-limit output (Post)
- Power factor (PF)
- Power HP #1 (x5)
- Pre-limit output (Prelm)
- PSS electrical power (Pss/kW)
- PSS term voltage (Vtermag)
- Reactive power (kvar)
- Real power (kW)
- SCL controller output (SelOutput)
- Speed HP #1 (x2)
- Synthesized speed (Synth)
- Terminal frequency deviation (TermF)
- Time response signal (PTest)
- Torsional filter #1 (Tflt1)
- Torsional filter #2 (x29)
- Total power (kVA)
- UEL controller output (UelOutput)
- Vab phase angle (PhAB)
- Vbc phase angle (PhBC)
- Washed out power (WashP)
- Washed out speed (WashW)

**Y-Axis Max.** This setting selects the maximum value of the y axis.

**Y-Axis Min.** This setting selects the minimum value of the y axis.

**Filter (Hertz).** This setting selects the cutoff filter frequency for the parameter to be graphed.

**RTM Frequency Response**

Clicking the Frequency Response button on the Analysis screen displays the Real-Time-Metering Frequency Response screen shown in Figure 4-41. This screen’s settings and controls are described in the following paragraphs.

![RTM Frequency Response Screen](image)

**Mode.** Either Manual mode or Auto mode may be selected. In Manual mode, a single frequency can be specified to obtain the corresponding magnitude and phase responses. In Auto mode, BESTCOMS will sweep the range of frequencies (determined by the Frequency (Max) and Frequency (Min) settings) and obtain the corresponding magnitude and phase responses.

**Plot Frequency Response.** If selected, BESTCOMS will generate a Bode plot when requested to do so by clicking the Bode Plot button.

**Frequency Response – Magnitude (dB).** This read-only field displays the magnitude response that corresponds to the test signal previously applied.

**Frequency Response – Phase (Degrees).** This read-only field displays the phase response that corresponds to the test signal previously applied.

**Frequency Response – Test Frequency.** This read-only field displays the frequency of the test signal currently being applied.

**Bode Plot.** Clicking this button generates the magnitude and phase Bode plot. The Bode plot can be printed and saved. An image of the magnitude plot or phase plot can be saved as a GIF file. All graph data can also be saved as a comma-delimited format (CSV) file.
Exercise caution when performing frequency response testing on a generator connected to the grid. Frequencies that are close to the resonant frequency of the machine or neighboring machines are to be avoided. Frequencies above 3 Hz may correspond to the lowest shaft torsional frequencies of a genset. A torsional profile for the machine should be obtained from the manufacturer and consulted before conducting any frequency response tests.

**Automatic Options – Frequency (Max).** This setting selects the maximum frequency of the test signal that is applied to the DECS-400 in Auto mode. A setting of 0.1 to 10 Hz may be entered.

**Automatic Options – Frequency (Min).** This setting selects the minimum frequency of the test signal that is applied to the DECS-400 in Auto mode. A setting of 0.1 to 10 Hz may be entered.

**Automatic Options – Magnitude.** This setting selects the magnitude of the sinusoidal wave that is applied to the DECS-400 during the frequency response test. A setting of 0 to 10 seconds may be entered in 0.001 second increments.

**Manual Options – Frequency.** This setting selects the frequency of the test signal that is applied to the DECS-400 during the frequency response test. A setting of 0.1 to 10 hertz may be entered.

**Manual Options – Magnitude.** This setting selects the magnitude of the test signal that is applied to the DECS-400 during the frequency response test in Manual mode. A setting of 0 to 10 may be entered in 0.001 increments.

**Manual Options – Time Delay.** This setting selects the time after which the magnitude and phase response corresponding to the specified frequency is computed. This delay allows transients to settle before computations are made. A setting of 0 to 125 seconds may be entered in 0.1 second increments.

**Test Signal**

Clicking the Time Response button on the Analysis screen displays the Test Signal screen shown in Figure 4-42. This screen’s settings and controls are described in the following paragraphs.

**Time Delay.** This setting selects the length of time between when the Start button is clicked and testing begins. A setting of 0 to 125 seconds may be entered in 0.1 second increments.

**Start Button.** When clicked, this button initiates testing (after the Time Delay setting expires).

**Exit Button.** Clicking this button returns to the Analysis screen.

**Signal Input.** This setting selects the point in the PSS circuitry where the test signal is applied. Test points include AVR Summing, PSS Comp Frequency, PSS Electric Power, PSS Derived Speed, FCR Summing and Var/PF.

**Stabilizer Test Signal – Type.** This setting is used to disable the internal PSS test signal or select any one of four test signal types: Step, Sine, Swept Sine, or External.

**Stabilizer Test Signal – Magnitude (%).** This setting adjusts the magnitude (excludes gain for external signal) of the stabilizer test signal. When the test signal type is None, this setting is disabled (grayed out). The magnitude has a setting range of –10 to +10% with 0.1% increments.

**Stabilizer Test Signal – Offset (dc).** This setting adjusts the dc offset of the stabilizer test signal. When the test signal type is None or Step, this setting is disabled (grayed out). The offset can be adjusted over the range of –10 to +10 in 0.001 increments.

**Stabilizer Test Signal – Frequency (Hz).** This setting adjusts the frequency of the stabilizer test signal. When the test signal type is None, Swept Sine, or External, this setting is disabled (grayed out). The frequency can be adjusted over a range of 0 to 20 Hz in 0.001 Hz increments.
Stabilizer Test Signal – Duration (Sec). This setting adjusts the duration of the test signal. For sine and external test signals, this is the total test duration. For step test signals, this is the “on” period of the step signal. When the test signal type is None or Swept Sine, this setting is disabled (grayed out). The duration can be adjusted over a range of 0 to 49,999 seconds in 0.1 second increments.

Sweep Signal Frequency Settings – Sweep Type. This setting is enabled only when the test signal type is Swept Sine. A linear sweep type is selected by entering a 0. A logarithmic sweep type is selected by entering a 1.

Sweep Signal Frequency Settings – Start Frequency. This setting is enabled only when the test signal type is Swept Sine. The starting frequency for the swept sine test signal is selected with this setting. The Start Frequency has a setting range of 0 to 20 Hz with 0.001 Hz increments.

Sweep Signal Frequency – Frequency Step. This setting is enabled only when the test signal type is Swept Sine. The frequency step for the swept sine test signal is selected with this setting. For linear sweeps, the test signal frequency is incremented by “step” every half-cycle of the system frequency. For logarithmic sweeps, the test signal frequency is multiplied by 1.0 + step every half-cycle of the system frequency. The frequency step has a setting range of 0 to 1 with 0.001 increments.

Sweep Signal Frequency – Stop Frequency. This setting is enabled only when the test signal setting is Swept Sine. The end frequency for the swept sine test signal is selected with this setting. The stop frequency has a setting range of 0 to 20 Hz with 0.001 Hz increments.

RTM Step Response
Clicking the Step Response button on the Analysis screen displays the Real-Time Metering Step Response screen. This screen has four metering fields, an alarms window, an Exit button, a checkbox to trigger data logging on a step change, and four tabs.

The metering fields display the average generator output voltage, the level of field current, the reactive power level, and the power factor.

The alarms window displays any active alarms triggered by a step change.

Clicking the Exit button closes the RTM Step Response screen and returns to the Analysis screen.

Selecting the “Trigger Data Logging on Step Change” checkbox causes the DECS-400 to log a data record when a setpoint step change is performed.

NOTE
If logging is in progress, another log cannot be triggered.

Four RTM Step Response screen tabs, labeled AVR, FCR, VAR, and PF are described in the following paragraphs.

AVR Tab
AVR tab functions are shown in Figure 4-43 and described in the following paragraphs.

![Figure 4-43. RTM Step Response Screen, AVR Tab](image)

% increase of AVR Setpoint. This area of the AVR tab contains a step-change setting field, a read-only setpoint field, and a button to initiate a step change that increases the setpoint.
The step-change setting field establishes the percent change in the AVR setpoint that occurs when a step change is initiated to increase the AVR setpoint. A setting of 0 to 10% may be entered in 0.1% increments.

The read-only setpoint field indicates what the AVR setpoint will be when the step change occurs.

Clicking the button executes the step change. The button’s color changes from gray to red as an indication that the increased setpoint is active.

**Current Setpoint.** This area of the AVR tab contains a read-only setpoint field and a button to return the setpoint to the normal level.

The read-only setpoint field displays the AVR setpoint entered on the AVR/FCR tab of the BESTCOMS Settings screen.

Clicking the button returns the setpoint to the value of the read-only setpoint field. The button’s color changes from gray to red to indicate when the current setpoint level is active.

% decrease of AVR Setpoint. This area of the AVR tab contains a step-change setting field, a read-only setpoint field, and a button to initiate a step change that decreases the setpoint.

The step-change setting field establishes the percent change in the AVR setpoint that occurs when a step change is initiated to decrease the AVR setpoint. A setting of 0 to 10% may be entered in 0.1% increments.

The read-only setpoint field indicates what the AVR setpoint will be when the step change occurs.

Clicking the button executes the step change. The button’s color changes from gray to red to indicate that the decreased setpoint is active.

**FCR Tab**

FCR tab functions are shown in Figure 4-44 and described in the following paragraphs.

% increase of FCR Setpoint. This area of the FCR tab contains a step-change setting field, a read-only setpoint field, and a button to initiate a step change that increases the setpoint.

The step-change setting field establishes the percent change in the FCR setpoint that occurs when a step change is initiated to increase the FCR setpoint. A setting of 0 to 10% may be entered in 0.1% increments.

The read-only setpoint field indicates what the FCR setpoint will be when the step change occurs.

Clicking the button executes the step change. The button’s color changes from gray to red as an indication that the increased setpoint is active.

**Current Setpoint.** This area of the FCR tab contains a read-only setpoint field and a button to return the setpoint to the normal level.

The read-only setpoint field displays the FCR setpoint entered on the AVR/FCR tab of the BESTCOMS Setting Adjustment screen.

Clicking the button returns the setpoint to the value of the read-only setpoint field. The button’s color changes from gray to red to indicate when the current setpoint level is active.
% decrease of FCR Setpoint. This area of the FCR tab contains a step-change setting field, a read-only setpoint field, and a button to initiate a step change that decreases the setpoint.

The step-change setting field establishes the percent change in the FCR setpoint that occurs when a step change is initiated to decrease the FCR setpoint. A setting of 0 to 10% may be entered in 0.1% increments.

The read-only setpoint field indicates what the FCR setpoint will be when the step change occurs.

Clicking the button executes the step change. The button's color changes from gray to red to indicate that the decreased setpoint is active.

VAR Tab

VAR tab functions are shown in Figure 4-45 and described in the following paragraphs.

![Figure 4-45. RTM Step Response Screen, VAR Tab](image)

Maximum Setting (kvar). This read-only field displays the maximum allowable kvar setpoint and is based on the Reactive Power Control – Max (% of rated) setting of the Setting Adjustment screen VAR/PF tab.

Var Step Point 1 (kvar). This setting establishes the first of two available setpoints for a kvar setpoint step change. The limits of this setting are determined by the Maximum Setting and Minimum Setting fields. Clicking the associated button initiates a step change to the Var Step Point 1 value.

Current Setpoint (kvar). This read-only field displays the DECS-400 reactive power setpoint. This setpoint is accessed and adjusted on the VAR/PF tab of the Setting Adjustment screen. The button beside this field is clicked to force the kvar setpoint to the value of the field. The button’s color changes from gray to red to indicate when the current setpoint is active.

Var Step Point 2 (kvar). This setting establishes the second of two available setpoints for a kvar setpoint step change. The limits of this setting are determined by the Maximum Setting and Minimum Setting fields. Clicking the associated button initiates a step change to the Var Step Point 2 value.

Minimum Setting (kvar). This read-only field displays the minimum allowable kvar setpoint and is based on the Reactive Power Control – Min (% of rated) setting of the Setting Adjustment screen VAR/PF tab.

PF Tab

PF tab functions are shown in Figure 4-46 and described in the following paragraphs.

Maximum Setting. This read-only field displays the maximum allowable power factor setpoint and is based on the Power Factor Control – PF (Leading) setting of the Setting Adjustment screen VAR/PF tab.

Minimum Setting. This read-only field displays the minimum allowable power factor setpoint and is based on the Power Factor Control – PF (Lagging) setting of the Setting Adjustment screen VAR/PF tab.

Current Setpoint. This read-only field displays the DECS-400 power factor setpoint. This setpoint is accessed and adjusted on the VAR/PF tab of the Setting Adjustment screen. The button beside this field is clicked to force the PF setpoint to the value of the field. The button’s color changes from gray to red to indicate when the current setpoint is active.

PF Step Point 1. This setting establishes the first of two available setpoints for a PF setpoint step change. The limits of this setting are determined by the Maximum Setting and Minimum Setting fields. Clicking the associated button initiates a step change to the PF Step Point 1 value.
**Figure 4-46. RTM Step Response Screen, PF Tab**

**PF Step Point 2.** This setting establishes the second of two available setpoints for a PF setpoint step change. The limits of this setting are determined by the Maximum Setting and Minimum Setting fields. Clicking the associated button initiates a step change to the PF Step Point 2 value.

**Logic**

The Logic screen, accessed by clicking the **Logic** button on the tool bar, provides excitation system control and annunciation based on DECS-400 contact inputs, operating mode status, excitation system parameters, and predefined or user-defined programming. A full description of DECS-400 programmable logic is provided in Appendix A, *Programmable Logic*. 
## TABLE OF CONTENTS

### SECTION 5 • INSTALLATION

- [INTRODUCTION]........................................................................................................... 5-1
- [PRODUCT REGISTRATION]........................................................................................... 5-1
- [MOUNTING]................................................................................................................... 5-1
- **DECS-400** ................................................................................................................. 5-1
- [Field Isolation Module].................................................................................................. 5-1
- [CONNECTIONS]............................................................................................................. 5-5
- **DECS-400 Terminations** .............................................................................................. 5-5
  - Front Panel Terminations .............................................................................................. 5-5
  - Rear Panel Terminations .............................................................................................. 5-5
  - Field Isolation Module Terminations ........................................................................... 5-7
- **DECS-400 Terminal Functions and Assignments** ......................................................... 5-7
  - Operating Power ........................................................................................................... 5-7
  - Chassis Ground ............................................................................................................. 5-7
  - Generator and Bus Voltage Sensing ............................................................................ 5-7
  - Generator Current Sensing .......................................................................................... 5-7
  - Accessory Input ............................................................................................................ 5-8
  - Contact Inputs ............................................................................................................. 5-8
  - Field Voltage and Current ............................................................................................ 5-9
  - IRIG ................................................................................................................................. 5-9
  - Communication Ports ................................................................................................... 5-9
  - Control Outputs ........................................................................................................... 5-10
  - Metering Outputs ........................................................................................................ 5-10
  - Contact Outputs .......................................................................................................... 5-11
- **Field Isolation Module Terminal Functions and Assignments** .................................. 5-11
  - Chassis Ground ............................................................................................................. 5-11
  - Field Current Sensing .................................................................................................. 5-11
  - Field Voltage Sensing .................................................................................................. 5-12
  - Signal Port ..................................................................................................................... 5-12
  - Cross-Current Compensation ....................................................................................... 5-12
  - Typical Interconnections ............................................................................................. 5-12
  - Communication Connections ....................................................................................... 5-16
  - Com 0 ............................................................................................................................. 5-16
  - Com 1 and Com 2 ........................................................................................................... 5-16

### Figures

- Figure 5-1. DECS-400 with Escutcheon Plate, Overall Dimensions .................................. 5-2
- Figure 5-2. Panel Cutting and Drilling Dimensions ............................................................. 5-3
- Figure 5-3. Field Isolation Module Dimensions ................................................................ 5-4
- Figure 5-4. Isolation Transformer (BE31449001) Dimensions ........................................... 5-4
- Figure 5-5. Rear Panel Terminals ..................................................................................... 5-6
- Figure 5-6. Redundant Operating Power Connections ....................................................... 5-7
- Figure 5-7. Connections for Cross-Current (Reactive Differential) Compensation ............ 5-12
- Figure 5-8. Typical AC Connection Diagram .................................................................... 5-14
- Figure 5-9. Typical DC Connection Diagram .................................................................... 5-15
- Figure 5-10. Com 0 to PC Connections ............................................................................ 5-16
- Figure 5-11. Com 1 Connections for Redundant DECS-400 Operation ............................ 5-16
- Figure 5-12. DECS-400 to RS-485 DECS-B-37 Connections .............................................. 5-17

### Tables

- Table 5-1. Operating Power Terminals ........................................................................... 5-7
- Table 5-2. Generator and Bus Voltage Sensing Terminals ............................................... 5-8
- Table 5-3. Generator Current Sensing Terminals ............................................................. 5-8
- Table 5-4. Accessory Input Terminals ............................................................................. 5-8
- Table 5-5. Contact Input Terminals ................................................................................ 5-9
Table 5-6. IRIG Terminals ......................................................................................................................... 5-9
Table 5-7. Com 1 and Com 2 Terminals .................................................................................................. 5-10
Table 5-8. Control Output Terminals .................................................................................................... 5-10
Table 5-9. Metering Output Terminals .................................................................................................. 5-10
Table 5-10. Contact Output Terminals .................................................................................................. 5-11
Table 5-11. Field Current Sensing Terminals ....................................................................................... 5-11
Table 5-12. Com 0 Pin Functions .......................................................................................................... 5-16
SECTION 5 • INSTALLATION

INTRODUCTION

When not shipped as part of assembled equipment, DECS-400 Digital Excitation Control Systems are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a DECS-400, check the part number against the requisition and packing list for agreement. Inspect for damage and, if there is evidence of such, file a claim with the carrier and notify the Basler Electric regional sales office, your sales representative, or a sales representative at Basler Electric.

If the unit is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

PRODUCT REGISTRATION

Registering with Basler Electric enables you to receive important information updates on your product plus new product announcements. Register your product by directing your web browser to http://www.basler.com/Register.

MOUNTING

Because the DECS-400 and Field Isolation Module are of solid-state design, they can be mounted at any convenient angle in an environment where the temperature does not decrease below −40°C (−40°F) or exceed 60°C (140°F).

DECS-400

The DECS-400 is supplied with an escutcheon plate for panel (or cubicle door) mounting. The escutcheon plate allows the DECS-400 to be installed at one of two mounting depths. Overall dimensions for the DECS-400 and escutcheon plate are shown in Figure 5-1. Figure 5-2 shows the panel cutting and drilling dimensions for mounting a DECS-400 with the escutcheon plate.

Brackets are also available for mounting the DECS-400 in a 19-inch rack. Order part number 9365207030 (two brackets required).

An escutcheon plate is available for retrofitting a DECS-400 into an existing DECS-300 installation. Order part number 9369707009.

Field Isolation Module

The Field Isolation Module is intended for surface mounting and no panel cutout is required. Figure 5-3 shows the Field Isolation Module dimensions and hole drilling locations.

Isolation Power Transformer

In applications where redundant operating power is used (DECS-400 style XCXX only), ac operating power must be applied to the DECS-400 through an isolation transformer. Basler Electric part number BE31449001 is recommended. Figure 5-4 illustrates the dimensions and mounting hole locations of part number BE31449001.
Figure 5-1. DECS-400 with Escutcheon Plate, Overall Dimensions
Figure 5-2. Panel Cutting and Drilling Dimensions

Dimensions are in inches [millimeters].

Figure 5-2. Panel Cutting and Drilling Dimensions
Figure 5-3. Field Isolation Module Dimensions

Figure 5-4. Isolation Transformer (BE31449001) Dimensions
CONNECTIONS
DECS-400 connections are dependent on the application and excitation scheme used. Observe the following guidelines when making DECS-400 connections.

- All inputs or outputs may not be used in a given installation.
- Incorrect wiring may result in damage to the unit.
- Applying incorrect operating power or sensing current may result in damage to the unit. Compare the style number of your unit with the style chart before applying operating power.

NOTE
Be sure that the DECS-400 is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the ground terminal on the rear of the case. When the unit is configured in a system with other devices, it is recommended that each unit be grounded with a separate lead.

DECS-400 Terminations
DECS-400 terminations consist of screw terminals, D-type connectors, and an RJ-45 jack.

Front Panel Terminations
Front panel terminations consist of a nine-pin, female, D-type connector that is intended for short-term, RS-232 serial communication with a PC. The location of the front panel communication port is shown in Figure 2-1.

Rear Panel Terminations
Current sensing connections are made through #8 screw terminals at terminals A1 through A8. The Field Isolation Module connects to a 15-pin, female, D-type connector designated as P1. DECS-400 modem connections are provided by an RJ-11 jack. All other connections are made through #6 screw terminals. Rear panel terminations are illustrated in Figure 5-5.
Figure 5-5. Rear Panel Terminals
**Field Isolation Module Terminations**

Field Isolation Module terminations consist of screw terminals and a D-type connector. Input connections for field voltage and field current are made at #6 screw terminals. Field voltage and field current output signals are supplied at the 15-pin, female, D-type connector designated J1. Connector J1 connects to DECS-400 connector P1 through a cable supplied with the Field Isolation Module. Cable length is 15 feet (4.6 meters).

**DECS-400 Terminal Functions and Assignments**

In the following paragraphs, DECS-400 terminal functions are described and the terminal assignments for each function are listed.

**Operating Power**

DECS-400 units with style number XLXX accept 24 or 48 Vdc nominal operating power. Units with style number XCXX use two sets of operating power terminals and accept both 125 Vdc and 120 Vac nominal operating power. One source is sufficient for operation, but two sources can be used to provide redundancy.

The dc input has internal protection against reversed polarity. To prevent damage to the DECS-400 when using two sources, ac operating power must be applied to the DECS-400 through an isolation transformer. Basler Electric part number BE31449001 is recommended. Figure 5-6 illustrates the connections for redundant operating power.

![Figure 5-6. Redundant Operating Power Connections](image)

Operating power terminals are listed in Table 5-1.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2 (N)</td>
<td>Return or neutral side of ac input (style XCXX only)</td>
</tr>
<tr>
<td>C3 (L)</td>
<td>Line side of ac input (style XCXX only)</td>
</tr>
<tr>
<td>C4 (BATT–)</td>
<td>Negative side of dc input (style XCXX or XLXX)</td>
</tr>
<tr>
<td>C5 (BATT+)</td>
<td>Positive side of dc input (style XCXX or XLXX)</td>
</tr>
</tbody>
</table>

**Chassis Ground**

Terminal C1 (GND) serves as the chassis ground connection. Be sure that the DECS-400 is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to terminal C1.

**Generator and Bus Voltage Sensing**

DECS-400 units accommodate either single-phase or three-phase generator sensing voltage with two, automatically selected ranges: 120 Vac or 240 Vac.

A single bus sensing voltage input connects from phase A to phase C. A sensing range of 120 Vac or 240 Vac is automatically selected by the bus sensing voltage input.

Generator and bus voltage sensing terminals are listed in Table 5-2.
Table 5-2. Generator and Bus Voltage Sensing Terminals

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A9 (E1)</td>
<td>A-phase generator voltage sensing input</td>
</tr>
<tr>
<td>A10 (E2)</td>
<td>B-phase generator voltage sensing input</td>
</tr>
<tr>
<td>A11 (E3)</td>
<td>C-phase generator voltage sensing input</td>
</tr>
<tr>
<td>A13 (BUS1)</td>
<td>A-phase bus voltage sensing input</td>
</tr>
<tr>
<td>A14 (BUS3)</td>
<td>C-phase bus voltage sensing input</td>
</tr>
</tbody>
</table>

Generator Current Sensing

DECS-400 units have generator current sensing inputs for phases A, B, and C. An input is also provided for sensing the current in a cross-current (reactive differential) compensation loop. Units with style number XX1X connect to CTs with 1 Aac secondary windings. Units with style number XX5X connect to CTs with 5 Aac secondary windings. Generator current sensing terminals are listed in Table 5-3.

Table 5-3. Generator Current Sensing Terminals

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 (CTA)</td>
<td>A-phase generator current sensing input</td>
</tr>
<tr>
<td>A2 (CTA)</td>
<td></td>
</tr>
<tr>
<td>A3 (CTB)</td>
<td>B-phase generator current sensing input</td>
</tr>
<tr>
<td>A4 (CTB)</td>
<td></td>
</tr>
<tr>
<td>A5 (CTC)</td>
<td>C-phase generator current sensing input</td>
</tr>
<tr>
<td>A6 (CTC)</td>
<td></td>
</tr>
<tr>
<td>A7 (CCCT)</td>
<td>Cross-current compensation input</td>
</tr>
<tr>
<td>A8 (CCCT)</td>
<td></td>
</tr>
</tbody>
</table>

Accessory Input

DECS-400 units accept two types of accessory (analog) signals for remote control of the setpoint: voltage or current. Only one accessory input (either voltage or current) may be used at one time. The voltage input accepts a signal over the range of –10 Vdc to +10 Vdc. The current input accepts a signal over the range of 4 mAdc to 20 mAdc. If shielded cables are used, terminal A18 (GND) should be used for the shield connection. Table 5-4 lists the accessory input terminals.

Table 5-4. Accessory Input Terminals

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A16 (V+)</td>
<td>Positive side of voltage accessory input</td>
</tr>
<tr>
<td>A17 (V–)</td>
<td>Negative side of voltage accessory input</td>
</tr>
<tr>
<td>A18 (GND)</td>
<td>Shield connection for accessory inputs</td>
</tr>
<tr>
<td>A19 (I+)</td>
<td>Positive side of current accessory input</td>
</tr>
<tr>
<td>A20 (I–)</td>
<td>Negative side of current accessory input</td>
</tr>
</tbody>
</table>

Contact Inputs

Each contact input supplies an interrogation voltage of 12 Vdc and accepts dry switch/relay contacts or open collector PLC outputs. DECS-400 units have six fixed-function contact inputs and 10 programmable contact inputs. Information about assigning functions to the programmable contact inputs is provided in Section 3, Functional Description. Table 5-5 lists the contact input terminals.
Table 5-5. Contact Input Terminals

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 (START) *</td>
<td>Positive terminal of Start contact input</td>
</tr>
<tr>
<td>B2 (COM)</td>
<td>Common terminal of Start and Stop contact inputs</td>
</tr>
<tr>
<td>B3 (STOP) *</td>
<td>Positive terminal of Stop contact input</td>
</tr>
<tr>
<td>B4 (AVR) *</td>
<td>Positive terminal of AVR contact input</td>
</tr>
<tr>
<td>B5 (COM)</td>
<td>Common terminal of AVR and FCR contact inputs</td>
</tr>
<tr>
<td>B6 (FCR) *</td>
<td>Positive terminal of FCR contact input</td>
</tr>
<tr>
<td>B7 (RAISE) †</td>
<td>Positive terminal of Raise contact input</td>
</tr>
<tr>
<td>B8 (COM)</td>
<td>Common terminal of Raise and Lower contact inputs</td>
</tr>
<tr>
<td>B9 (LOWER) †</td>
<td>Positive terminal of Lower contact input</td>
</tr>
<tr>
<td>B10 (SW1)</td>
<td>Positive terminal of programmable contact input #1</td>
</tr>
<tr>
<td>B11 (COM)</td>
<td>Common terminal of programmable contact inputs #1 and #2</td>
</tr>
<tr>
<td>B12 (SW2)</td>
<td>Positive terminal of programmable contact input #2</td>
</tr>
<tr>
<td>C23 (SW3)</td>
<td>Positive terminal of programmable contact input #3</td>
</tr>
<tr>
<td>C24 (COM)</td>
<td>Common terminal of programmable contact inputs #3 and #4</td>
</tr>
<tr>
<td>C25 (SW4)</td>
<td>Positive terminal of programmable contact input #4</td>
</tr>
<tr>
<td>C26 (SW5)</td>
<td>Positive terminal of programmable contact input #5</td>
</tr>
<tr>
<td>C27 (COM)</td>
<td>Common terminal of programmable contact inputs #5 and #6</td>
</tr>
<tr>
<td>C28 (SW6)</td>
<td>Positive terminal of programmable contact input #6</td>
</tr>
<tr>
<td>C29 (SW7)</td>
<td>Positive terminal of programmable contact input #7</td>
</tr>
<tr>
<td>C30 (COM)</td>
<td>Common terminal of programmable contact inputs #7 and #8</td>
</tr>
<tr>
<td>C31 (SW8)</td>
<td>Positive terminal of programmable contact input #8</td>
</tr>
<tr>
<td>C32 (SW9)</td>
<td>Positive terminal of programmable contact input #9</td>
</tr>
<tr>
<td>C33 (COM)</td>
<td>Common terminal of programmable contact inputs #9 and #10</td>
</tr>
<tr>
<td>C34 (SW10)</td>
<td>Positive terminal of programmable contact input #10</td>
</tr>
</tbody>
</table>

* Functions are activated by a momentary input.
† Functions are active only when the corresponding contact input is active.

Field Voltage and Current

Field voltage and current signals are supplied to connector P1 of the DECS-400 by the Field Isolation Module. A cable, supplied with the Field Isolation Module, connects from Field Isolation Module connector J1 to DECS-400 connector P1.

IRIG

The clock function of the DECS-400 is synchronized with a time code source through the application of a standard IRIG-B signal to the IRIG terminals. Refer to Section 1, General Information for specifications pertaining to the IRIG input. Table 5-6 lists the IRIG terminals.

Table 5-6. IRIG Terminals

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1 (IRIG+)</td>
<td>Positive IRIG terminal</td>
</tr>
<tr>
<td>D2 (IRIG–)</td>
<td>Negative IRIG terminal</td>
</tr>
</tbody>
</table>

Communication Ports

DECS-400 units have four communication ports: Com 0, Com 1, Com 2, and J1.

Com 0, located on the front panel, is a female, DB-9, RS-232 connector that is intended for short-term, full-duplex, ASCII communication with a PC.
Com 1, located on the rear panel, is a half-duplex, RS-485 port. When redundant DECS-400 units are used, Com 1 is used to communicate (via ASCII protocol) with a second DECS-400. Com 1 connections are made through screw terminals. If shielded cable is used, terminal D3 can be used for the shield connection.

Com 2, located on the rear panel, is a half-duplex RS-485 port that communicates via Modbus protocol. Com 2 connections are made through screw terminals.

J1, located on the rear panel, is an RJ-45 jack that connects to an internal, FCC part 68 approved modem.

Terminal assignments for Com 1 and Com 2 are listed in Table 5-7. Interconnection diagrams for the communication ports are provided in Communication Connections.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3 (GND_)</td>
<td>Shield connection</td>
</tr>
<tr>
<td>D4 (A1)</td>
<td>Com 1 RS-485 Send/Receive A terminal (ASCII protocol)</td>
</tr>
<tr>
<td>D5 (B1)</td>
<td>Com 1 RS-485 Send/Receive B terminal (ASCII protocol)</td>
</tr>
<tr>
<td>D6 (C1)</td>
<td>Com 1 RS-485 Signal Ground terminal (ASCII protocol)</td>
</tr>
<tr>
<td>D9 (A2)</td>
<td>Com 2 RS-485 Send/Receive A terminal (Modbus™ protocol)</td>
</tr>
<tr>
<td>D10 (B2)</td>
<td>Com 2 RS-485 Send/Receive B terminal (Modbus™ protocol)</td>
</tr>
<tr>
<td>D11 (C2)</td>
<td>Com 2 RS-485 Signal Ground terminal (Modbus™ protocol)</td>
</tr>
</tbody>
</table>

Control Outputs

The DECS-400 can supply either an analog voltage or current excitation control output. The voltage output can be user-configured to supply a setpoint control signal over the range of 0 to +10 Vdc or –10 Vdc to +10 Vdc. The current output supplies a setpoint control signal over the range of 4 to 20 mA. If shielded cable is used, terminal D12 should be used for the shield connection. Table 5-8 lists the control output terminals.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D12 (GND)</td>
<td>Shield connection for control output</td>
</tr>
<tr>
<td>D13 (IC+)</td>
<td>Current control positive terminal</td>
</tr>
<tr>
<td>D14 (VC+)</td>
<td>Voltage control positive terminal</td>
</tr>
<tr>
<td>D15 (RTNC)</td>
<td>Common, return terminal for control output</td>
</tr>
</tbody>
</table>

Metering Outputs

The DECS-400 has two programmable, analog meter drivers. Either driver output can be user-programmed to meter a variety of generator and system parameters. Each meter driver supplies an output over the range of 4 to 20 mA. If shielded cable is used, terminal A23 should be used for the shield connection. Table 5-9 lists the terminals for the metering outputs.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A21 (M1+)</td>
<td>Meter driver #1 positive terminal</td>
</tr>
<tr>
<td>A22 (M1–)</td>
<td>Meter driver #1 negative terminal</td>
</tr>
<tr>
<td>A23 (GND)</td>
<td>Shield connection for meter driver #1 and #2</td>
</tr>
<tr>
<td>A24 (M2+)</td>
<td>Meter driver #2 positive terminal</td>
</tr>
<tr>
<td>A25 (M2–)</td>
<td>Meter driver #2 negative terminal</td>
</tr>
</tbody>
</table>
Contact Outputs

DECS-400 units have two dedicated contact outputs and six programmable contact outputs. The dedicated outputs consist of a Form B (SPDT) Watchdog output and a Form A (SPST) On/Off output. The six user-programmable outputs are all Form A outputs. Annunciation options for the programmable contact outputs are provided in Section 3, Functional Description. Contact output ratings are listed in Section 1, General Information, Specifications. Terminal assignments for the contact outputs are listed in Table 5-10.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6 (WTCH1)</td>
<td>Watchdog normally-open (NO) contact terminal</td>
</tr>
<tr>
<td>C7 (WTCH)</td>
<td>Watchdog common contact terminal</td>
</tr>
<tr>
<td>C8 (WTCH2)</td>
<td>Watchdog normally-closed (NC) contact terminal</td>
</tr>
<tr>
<td>C9 (ON/OF)</td>
<td>On/Off contact terminals</td>
</tr>
<tr>
<td>C10 (ON/OF)</td>
<td></td>
</tr>
<tr>
<td>C11 (RLY1)</td>
<td>Programmable relay #1 terminals</td>
</tr>
<tr>
<td>C12 (RLY1)</td>
<td></td>
</tr>
<tr>
<td>C13 (RLY2)</td>
<td>Programmable relay #2 terminals</td>
</tr>
<tr>
<td>C14 (RLY2)</td>
<td></td>
</tr>
<tr>
<td>C15 (RLY3)</td>
<td>Programmable relay #3 terminals</td>
</tr>
<tr>
<td>C16 (RLY3)</td>
<td></td>
</tr>
<tr>
<td>C17 (RLY4)</td>
<td>Programmable relay #4 terminals</td>
</tr>
<tr>
<td>C18 (RLY4)</td>
<td></td>
</tr>
<tr>
<td>C19 (RLY5)</td>
<td>Programmable relay #5 terminals</td>
</tr>
<tr>
<td>C20 (RLY5)</td>
<td></td>
</tr>
<tr>
<td>C21 (RLY6)</td>
<td>Programmable relay #6 terminals</td>
</tr>
<tr>
<td>C22 (RLY6)</td>
<td></td>
</tr>
</tbody>
</table>

Field Isolation Module Terminal Functions and Assignments

In the following paragraphs, Field Isolation Module terminal functions are described and the terminal assignments for each function are listed.

Chassis Ground

The GND terminal serves as the chassis ground connection. Be sure that the Field Isolation Module is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to terminal GND.

Field Current Sensing

A field current sensing signal is supplied to the Field Isolation Module from a user-supplied current shunt with an output rating of 50 mVdc or 100 mVdc. Field current sensing terminals are listed in Table 5-11.

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SH+</td>
<td>Connects to positive output terminal of current shunt</td>
</tr>
<tr>
<td>–50</td>
<td>Connects to negative output terminal of 50 mVdc current shunt (if used)</td>
</tr>
<tr>
<td>–100</td>
<td>Connects to negative output terminal of 100 mVdc current shunt (if used)</td>
</tr>
</tbody>
</table>
**Field Voltage Sensing**

The field voltage sensing input accepts field voltage at one of five nominal levels. Terminal sets are provided for a nominal field voltage of 63, 125, 250, 375, and 625 Vdc. Each voltage input has a positive and negative terminal.

**Signal Port**

Signal port connector J1 receives operating power from the DECS-400 and sends field current and field voltage signals to the DECS-400. J1 connects to DECS-400 connector P1 through a cable (Basler P/N 9322900006) supplied with the DECS-400.

**Cross-Current Compensation**

Cross-current compensation (reactive differential) mode allows two or more paralleled generators to share a common load. Figure 5-7 illustrates a typical cross-current compensation scheme for two paralleled generators. Each generator is controlled by a DECS-400 using the cross-current compensation input (CCCT) to sense generator current. The resistors shown in Figure 5-5 are used to set the burden. Their value may be adjusted to suit the application. Ensure that the power rating of the resistors is adequate for the installation.

Figure 5-7. Connections for Cross-Current (Reactive Differential) Compensation

**Typical Interconnections**

Figures 5-8 and 5-9 illustrate typical interconnections for a DECS-400 used in an excitation system with a Basler SSE-N (negative forcing) rectifier chassis. Figure 5-8 shows the ac connections and Figure 5-9 shows the dc connections. The following notes apply to Figures 5-8 and 5-9.

1. Switch is a momentary contact. Must be interlocked such that both contacts cannot close simultaneously.
2. Exciter must not be in Stop mode when generator is on bus. Exciter should not be in Start condition unless generator is up to speed and buildup can occur.
3. Interface Firing Module (IFM-150) is required for SSE-N systems. See IFM-150 instruction manual for specific interconnection details.
4. Single CT is required for voltage regulator applications. A minimum of two CTs are required for PSS applications.
5. For rectifier chassis interconnection, see instruction manual for the specific rectifier chassis used.
6. Dual dc power source is recommended. Station battery and separate 125 Vdc power supply shown.
7. Isolation power transformer is required.
8. DECS-400 output contacts RELAY #1 through #6 are customizable for specific system requirements.
9. DECS-400 switching inputs SW1 through SW10 are customizable for specific system requirements.
10. DECS-400 meter driver outputs are customizable for specific system requirements.
11. Accessory input can be configured to accept a current signal (4 – 20 mA) or voltage signal (differential ±10 V range).
Figure 5-8. Typical AC Connection Diagram
Figure 5-9. Typical DC Connection Diagram
Communication Connections

DECS-400 communication ports consist of a front-panel RS-232 port (Com 0), a rear-panel RS-485 port for DECS-400-to-DECS-400 communication (Com 1), a rear-panel RS-485 port for Modbus communication (Com 2), and an RJ-11 modem jack (J1). DECS-400 communication ports are described in the following paragraphs.

Com 0

Table 5-12 identifies the pin functions of this front-panel, female DB-9 connector. Figure 5-10 illustrates the connections between Com 0 and a PC.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Name</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shield</td>
<td>—</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Transmit Data</td>
<td>TXD</td>
<td>From DECS-400</td>
</tr>
<tr>
<td>3</td>
<td>Receive Data</td>
<td>RXD</td>
<td>Into DECS-400</td>
</tr>
<tr>
<td>4</td>
<td>No Connection</td>
<td>—</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>Signal Ground</td>
<td>GND</td>
<td>N/A</td>
</tr>
<tr>
<td>6</td>
<td>No Connection</td>
<td>—</td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>No Connection</td>
<td>—</td>
<td>N/A</td>
</tr>
<tr>
<td>8</td>
<td>No Connection</td>
<td>—</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 5-12. Com 0 Pin Functions

Com 1 and Com 2

Com 1 and Com 2 consist of rear-panel RS-485 ports. Com 1 is an ASCII port used for communication with another DECS-400 when operating in a redundant system configuration. Shielded, twisted-conductor cable is recommended for Com 1 connections. Com 2 is intended for polled communication over a Modbus network. Twisted-pair cable is recommended for Com 2 connections. Terminal functions for Com 1 and Com 2 are identified in Table 5-7. Figure 5-11 illustrates the Com 1 connections used for DECS-400-to-DECS-400 communication.

Figure 5-10. Com 0 to PC Connections

Figure 5-11. Com 1 Connections for Redundant DECS-400 Operation

⚠️ Connect cable shield to GND terminal of only one DECS-400 unit.

Twisted-conductor cable is recommended.
Figure 5-12 illustrates the Com 2 connections used for multiple DECS-400 units communicating over a Modbus network.

**Figure 5-12. DECS-400 to RS-485 DB-37 Connections**
SECTION 6 • COMMISSIONING

TABLE OF CONTENTS

SECTION 6 • COMMISSIONING .............................................................................................................. 6-1
INTRODUCTION ....................................................................................................................................... 6-1
PREPARATION ......................................................................................................................................... 6-1
Record System Parameters ................................................................................................................... 6-1
TESTING AND EVALUATION .............................................................................................................. 6-1
Off-Line Tests—Turbine Not Spinning ............................................................................................... 6-1
Start/Stop Tests .................................................................................................................................. 6-1
Control Gain Settings ....................................................................................................................... 6-2
PID Settings ........................................................................................................................................ 6-4
Off-Line Tests—Turbine Spinning ...................................................................................................... 6-4
FCR Mode ........................................................................................................................................... 6-4
Excitation Performance Evaluation ................................................................................................... 6-6
Off-Line Excitation Limiter Operation .............................................................................................. 6-6
Limit and Protection Check .............................................................................................................. 6-7
Parallel Operation, Generator On-Line ............................................................................................... 6-7
Recommended PSS Testing .............................................................................................................. 6-9
Closed-Loop Voltage Regulator Response Measurements ........................................................... 6-9
Input Signal Measurements .............................................................................................................. 6-9
Stabilizer Step Response Measurements ......................................................................................... 6-9
Large Disturbance Measurements ................................................................................................... 6-10
Disturbance Recording .................................................................................................................... 6-10

Figures
Figure 6-1. BESTCOMS Metering Screen, Operation Tab .................................................................... 6-2
Figure 6-2. BESTCOMS Gain Screen, AVR/FCR Gain Tab ................................................................. 6-3
Figure 6-3. BESTCOMS PID Screen .................................................................................................... 6-4
Figure 6-4. Field Voltage Output Waveform ....................................................................................... 6-5
Figure 6-5. Kg Gain Effect on Generator Performance ....................................................................... 6-6

Tables
Table 6-1. Recommended Settings for Exciter and Static Exciter Installations .................................... 6-3
Table 6-2. PPT Secondary Voltages .................................................................................................... 6-5
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SECTION 6 • COMMISSIONING

INTRODUCTION
This section provides generic procedures and information for testing the DECS-400 during excitation system commissioning. These procedures do not account for the specific operating parameters of every system; they are provided only as a guide.

PREPARATION
In these procedures, DECS-400 communication with a PC operating BESTCOMS is necessary to apply DECS-400 settings and retrieve DECS-400 and system status information. Refer to Section 4, BESTCOMS Software for information about installing BESTCOMS and establishing communication between BESTCOMS and the DECS-400.

Basler Electric Application Note #126 provides helpful information about paralleling circuits. This application note can be downloaded from the Basler Electric website at www.basler.com.

Record System Parameters
Record the pertinent information for your system in the following spaces.

<table>
<thead>
<tr>
<th>Generator Parameters</th>
<th></th>
<th>Main/Exciter Field Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vac</td>
<td>Hz</td>
<td>Vdc, full-load</td>
</tr>
<tr>
<td>MW</td>
<td>Mvar</td>
<td>Adc, full-load</td>
</tr>
<tr>
<td>rpm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TESTING AND EVALUATION
The following procedures may be performed during system commissioning to verify DECS-400 settings and performance.

Off-Line Tests—Turbine Not Spinning
For these tests, control of the machine is to be demonstrated via BESTCOMS, the DECS-400 front panel human-machine interface (HMI), and user-supplied, remote switches. These tests will ensure that the machine is not stressed because of incorrect wiring or faulty components. Recommended settings are only temporary, initial settings.

Start/Stop Tests
Check the operation of the following start and stop switches.

- Start/Stop from the Operation tab of the BESTCOMS Metering screen (see Figure 6-1 for illustration of Operation tab) ....................................................................................................................
- Start/Stop from the DECS-400 HMI ............................................................................................
- Start/Stop from remote, user-supplied switch ....................................................................

WARNING!
Field flashing current is used in the following steps. Even though the turbine is not moving, serious injury could result from high, stator-induced voltage. Verify that all personnel are clear of the machine before performing the following steps. To ensure safety, the field flashing fuses may be removed and only the unit start/stop capabilities checked.
Verify that field flashing and shutdown occurs with the start and stop functions.......................... 
If field flashing is used, verify alarms for failure to build voltage........................................... 
Verify alarm annunciation at front panel HMI, in BESTCOMS, and remote indicators........ 
With excitation off, check AVR/FCR transfer using the front panel HMI, remote switches, and BESTCOMS. 
Verify transfer indications from the front panel HMI, BESTCOMS, and any remote indicators. 
Check for proper raise/lower limits.......................................................... 
Verify raise/lower indications at the front panel HMI, through BESTCOMS, and from remote indicators.......................................................... 

NOTE

For station power systems, field flashing is not used. When the system is energized with the field connected, the field current will build to the value specified on the FCR setting screen. During the test, the suggested setting for the no-load field current is 20% and the FCR Kg gain is 1,000. Verify that the system is stable.

Control Gain Settings

Establish the gain settings for the active settings group.

Use the AVR/FCR tab of the BESTCOMS Setting Adjustment screen to set the generator no-load setpoint in FCR mode. The recommended setting is 20% of the rated exciter current. .......................................................... 

For the following steps, access the AVR/FCR Gain tab of the BESTCOMS Gain screen (Figure 6-2). Table 6-1 lists the recommended PID setting for exciter and static exciter installations.
Figure 6-2. BESTCOMS Gain Screen, AVR/FCR Gain Tab

Table 6-1. Recommended Settings for Exciter and Static Exciter Installations

<table>
<thead>
<tr>
<th>PID Setting</th>
<th>Static Exciter</th>
<th>Exciter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVR</td>
<td>FCR</td>
</tr>
<tr>
<td>Kp</td>
<td>80</td>
<td>—</td>
</tr>
<tr>
<td>Ki</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>Kd</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kg</td>
<td>15</td>
<td>1000</td>
</tr>
<tr>
<td>Td</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

- Set the Proportional Gain Kp setting.....................................................................................
- Set the Td filter setting. .........................................................................................................
- Set the FCR, Loop Gain Kg setting.......................................................................................

Recommended settings for OEL.
- Set Ki at 3............................................................................................................................
- Set Kg at 1 ............................................................................................................................

Recommended settings for UEL.
- Set Ki at 10..........................................................................................................................
- Set Kg at 1 ............................................................................................................................

Recommended settings for var/power factor.
- Set Ki at 10..........................................................................................................................
- Set Kg at 1 ............................................................................................................................

Recommended settings for SCL.
- Set Ki at 10..........................................................................................................................
- Set Kg at 1 ............................................................................................................................
**PID Settings**

While viewing the BESTCOMS Gain Setting screen, click the PID Calculator button to view the PID Calculator screen (Figure 6-3). Use the PID Calculator screen to select the proper PID values based upon the generator time constant, T'do, and exciter time constant Te. Refer to Section 4, BESTCOMS Software, Setting, Metering Values, and Data Records, Gain Settings for more information about PID settings.

- Verify transfer indications from the front panel HMI, BESTCOMS, and remote indicators.

<table>
<thead>
<tr>
<th>PID Calculator - Primary Settings Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Excitation Control Data</strong></td>
</tr>
<tr>
<td>Generator Information</td>
</tr>
<tr>
<td>Default</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>0.33</td>
</tr>
<tr>
<td>Use Default Exciter Time Constant</td>
</tr>
<tr>
<td>0.00</td>
</tr>
</tbody>
</table>

**Figure 6-3. BESTCOMS PID Screen**

**Off-Line Tests—Turbine Spinning**

For the off-line tests with the turbine spinning, the generator circuit breaker is open.

**WARNING!**

Field flashing current is used in the following steps. Even though the turbine is not moving, serious injury could result from high, stator-induced voltage. Verify that all personnel are clear of the machine before performing the following steps. To ensure safety, the field flashing fuses may be removed and only the unit start/stop capabilities checked.

**FCR Mode**

Initial testing should begin in the Manual (FCR) mode with minimum generated voltage.

- Place the DECS-400 in FCR mode.
- Place the Start/Stop switch in the Start position.
- The generator voltage should build to a percentage of the rated voltage. (The FCR setpoint was set to 20% of the rated exciter field current in a previous step.)
- Increase the exciter field current to 75% of rated.
- The generator voltage should build to a percentage of the rated voltage.
- Check the field voltage with an oscilloscope to verify proper output. (See the current balance firing circuit waveform of Figure 6-4.)
Figure 6-4. Field Voltage Output Waveform

- Meter for the correct voltages at the voltage sensing inputs (E1, E2, E3).
- Measure the PPT secondary voltages. (See Table 6-2 for the correct secondary voltages at the transformer output.)

<table>
<thead>
<tr>
<th>Rectifier DC Voltage</th>
<th>PPT AC Secondary Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>80</td>
</tr>
<tr>
<td>125</td>
<td>160</td>
</tr>
<tr>
<td>250</td>
<td>360</td>
</tr>
<tr>
<td>375</td>
<td>480</td>
</tr>
</tbody>
</table>

- Using the Raise/Lower control raise the terminal voltage incrementally to the rated voltage.
- Place the Start/Stop switch in the Stop position.
- Place the Start/Stop switch in the Start position to start the generator in FCR mode.
- Record the voltage buildup characteristic of the system as it reaches full-rated output.
- Perform a step response in FCR mode.
- Using the BESTCOMS Analysis screen, perform a 5% step change in FCR mode.
- Decrease the value first, then increase the value. (Observe stable performance using the recording capabilities of the Analysis screen.)
- Note the overshoot and settling time. (The FCR output should be very stable.)

During the following test, be prepared to transfer back to FCR mode if there is a problem. Use the BESTCOMS Metering screen to verify that tracking is stable before transferring. The Null Balance indicator on the front panel should be continuously lit. If pre-position is enabled, the setpoint will go to the assigned value first. Pre-position may need to be disabled for this test.

- Verify that the AVR setpoint follows (auto-tracks) the FCR setpoint, then transfer.

**NOTE**

During the following test, if pre-position is enabled, the setpoint will go to the assigned value first.

- Verify that the FCR setpoint follows (auto-tracks) the AVR setpoint, then transfer.
- Use the BESTCOMS Analysis screen to perform a step response in AVR mode.
- Review the PID numbers.
- On the Configuration tab of the BESTCOMS Limiter screen, turn all Limiters off.
- Perform a 2% voltage step response and record performance to verify stability.
• Adjust the PID parameters of the DECS-400 until desired performance is achieved. If performance appears stable, repeat with 5% step changes.

• Place the Start/Stop switch in the Stop position.

• Place the system in AVR mode.

• Monitor the generator voltage soft-start time.

• Place the Start/Stop switch in the Start position.

• Raise the terminal voltage to the setpoint.

---

**TUNING SUGGESTION**

Assuming that $T_d$ (main field) and $T_e$ (exciter field) is known (as applicable for main field static exciter or exciter field voltage regulator application), increasing $K_g$ will speed the response time of the generator. See Figure 6-5.

---

**Excitation Performance Evaluation**

In the following performance evaluation, temporary settings will enable you to test excitation performance without stressing the machine or exceeding ancillary protection devices. Procedures are provided that will allow you to set your final operating values. This evaluation is a continuation of the previous tests.

**Off-Line Excitation Limiter Operation**

In this test, with the generator set below the rated voltage output, you will set the AVR setpoint above the maximum setting and the system should alarm. If the system does not alarm, the OEL gain ($K_i$ and $K_g$) may be set too low. If the system does报警 and oscillates, $K_i$ and $K_g$ may be set too high.

• Enable the off-line OEL.

• Determine the field current required to reach 105% of the rated generator voltage.

• Set the off-line OEL for a value equal to the no-load field current.
• Lower the terminal voltage to 10% below rated.................................................................

To speed performance in the following test, you may increase the OEL gain (Ki and Kg).

• Using the AVR/FCR tab of the BESTCOMS Setting Adjustment screen, set the AVR
  setpoint to 110% of the rated output. (The AVR Max setting should remain at 105%). ...........

• If an output relay is programmed to alarm, the output, the front panel HMI,
  BESTCOMS, and any remote devices should annunciate the alarm.................................

• Return (set) the AVR setpoint to the rated output.............................................................

**Limit and Protection Check**

In this test, the generator overvoltage, generator undervoltage, field overvoltage, and field overcurrent
protection functions will be tested.

• Review the generator overvoltage protection settings on the General Protection tab of
  the BESTCOMS Protection screen.....................................................................................

• Lower the generator overvoltage setting to the operating setpoint....................................

• Verify that all alarms and annunciations function as programmed.....................................

• Reset the generator overvoltage setpoint to the final value..............................................

• Raise the generator undervoltage setting to the alarm threshold....................................

• Verify that all alarm and annunciations function as programmed.....................................

• Reset the generator undervoltage setpoint to the final value...........................................

• Lower the field overvoltage setting to the operating setpoint...........................................

• Verify that all alarms and annunciations function as programmed.....................................

• Reset the field overvoltage setpoint to the final value......................................................

• Lower the field overcurrent setting to the operating setpoint...........................................

• Verify that all alarms and annunciations function as programmed.....................................

• Reset the field overcurrent setting to the operating setpoint...........................................

**Parallel Operation, Generator On-Line**

In this test, the generator will be connected to the bus and the phase relationship between the current and
sensed voltage will be checked. If the CT polarity is incorrect, a shorting terminal block can be used to
reverse the polarity. If the sensed voltage has the wrong phasing, the generator breaker must be opened
and the generator must be shut down in order to reverse the voltage sensing polarity. After the phase
relationship is verified as correct, the overexcitation and underexcitation protection will be exercised. Also,
var and power factor performance evaluations will be conducted at values that will not stress the machine.

**Phase Relationship Test**

• Transfer to FCR mode.................................................................

• Parallel the generator with the bus.................................................................

• Set the machine kilowatts for approximately 25% of machine rating at zero vars................

• Check for a phase shift at the DECS-400 between the voltage sensing and current
  sensing B-phase inputs. The B-phase current should lag the sensed voltage between
  E1 and E3 by 90 degrees.................................................................

• If the phase relationship is correct, proceed with testing. If the phase relationship is
  incorrect, troubleshoot the system, resolve the problem, and retest as appropriate
  before transferring to AVR mode.................................................................

• Verify that AVR is nulled to FCR..............................................................................

• Verify that all null status indicators provide the null indication........................................

• Verify that AVR Pre-Position mode is disabled or the external pre-position contacts are
  open...........................................................................................................

In the following step, be prepared to transfer back to Manual mode if the excitation voltage increases
suddenly.
- Transfer to AVR.

OEL Test
- Disable the overexcitation limiter through the Configuration tab of the BESTCOMS Limiter screen.
- Set the On-Line, OEL three current limits at 15% above the no-load field current with a 5 second time delay.
- Using the Analysis screen capabilities of BESTCOMS, prepare to check the OEL response time. If the response time is too slow, increase OEL gain parameters Ki and Kg and repeat the test.
- Increase the field excitation until the field current reaches 125% of the no-load field current setting.
- Enable OEL through the Configuration tab of the BESTCOMS Limiter screen.
- Verify that the response time is within specified limits.
- Enter the final, operating OEL values.

UEL Test
- Disable the underexcitation limiter through the Configuration tab of the BESTCOMS Limiter screen.
- Set the UEL var limit for 5% vars into the generator.
- Adjust the vars into the generator for 15% at 25% load.
- Perform a step response into the UEL limit by enabling UEL in BESTCOMS.
- Verify stable performance and speed of response.
- If the response time is too slow, increase the UEL gain (Ki and Kg) and repeat the test.
- Verify stable UEL performance by testing the machine from 25% through 100% real power loading, underexcited.
- Increase the excitation above the UEL limit.
- Enter the final, operating UEL values.

SCL Test (If Applicable)
- Disable stator current limiting through the Configuration tab of the BESTCOMS Limiter screen.
- Operate the unit at approximately 30% load at 0.8 lagging power factor in Droop mode.
- Using BESTCOMS, set the SCL low limit to 5% greater than the metered current.
- Using BESTCOMS, set the SCL high limit to 50% greater than the metered current.
- Using BESTCOMS set the SCL high limit time delay at 5 seconds.
- Enable stator current limiting.
- Perform a step response into the SCL limit.
- Verify stable performance and speed of response.
- If the response time is too slow, increase the SCL gain (Ki and Kg) and repeat the test.
- Verify stable performance of the SCL by testing the machine from 25% through 100% real-power loading, underexcited.
- Increase the excitation above the UEL limit.
- Enter the final, operating UEL values.

Var Test (If Applicable)
- Verify that Var mode is nulled to AVR.
- Verify that all null status indicators indicate a null condition.
• Verify that the Var pre-position mode is disabled or the external pre-position contacts are open.

In the following step, be prepared to transfer back to AVR mode if the excitation voltage increases suddenly.

• Transfer to Var.

• Set kW for 25% output.

• Adjust vars to 30% of rated.

Monitor the field voltage to determine performance of the following step.

• Using BESTCOMS, perform a 5% step response stability test.

• If necessary, increase the var gain (Ki and Kg) to quicken the response and repeat the test.

Power Factor Test (If Applicable)

• Verify that PF mode is null to Var mode.

• Verify that all null status indicators indicate a null condition.

• Verify that the PF pre-position mode is disabled or the external pre-position contacts are open.

In the following step, be prepared to transfer back to PF mode if the excitation voltage increases suddenly.

• Transfer to PF.

• Adjust the power factor for 0.9 lagging.

• Perform a step response by changing the PF setpoint to 0.85 lagging to determine stability.

• If necessary, increase the PF gain (Ki and Kg) to quicken the response and repeat the test.

Recommended PSS Testing

The following paragraphs describe desired tests to evaluate and confirm stabilizer operation in your system. For specific testing and commissioning procedures, contact Basler Electric Technical Sales Support at +1 618-654-2341.

Closed-Loop Voltage Regulator Response Measurements

Proper operation of the automatic voltage regulator and exciter are critical to the performance of the PSS. Step response measurements of the voltage regulator should be performed to confirm the voltage regulator gain and other critical parameters. A transfer function measurement between terminal voltage reference and terminal voltage should be performed with the unit operating at very low load. This test provides an indirect measurement of the PSS phase requirement. As long as the unit is operating at very low load, the terminal voltage modulation does not produce significant speed and power changes.

Input Signal Measurements

Tests should be performed at various load levels to confirm that the input signals are calculated or measured correctly. Since the PSS uses compensated terminal frequency in place of speed, the derived mechanical power signal should be examined carefully to ensure that it does not contain any components at the electromechanical oscillation frequencies. If such components are present, it indicates that the frequency compensation is less than ideal, or that the unit inertia value is incorrect.

Stabilizer Step Response Measurements

A standard technique for verifying overall system response is through step response measurements. This involves exciting the local electromechanical oscillation modes through a fixed step change in the voltage regulator reference. Damping ratio and frequency of oscillation can be measured directly from recordings of generator speed and power for different operating conditions and settings. Normally this test is performed with variations of the following:

• Generator active and reactive power loading
• Stabilizer gain
- System configuration (e.g., lines out of service)
- Stabilizer parameters (e.g., phase lead, frequency compensation)

As the stabilizer gain is increased, the damping should increase continuously while the natural frequency of oscillation should remain relatively constant. Large changes in the frequency of oscillation, a lack of improvement in damping, or the emergence of new modes of oscillation are all indications of problems with the selected settings.

**Large Disturbance Measurements**

Depending on the location, tests may be performed to measure the response of the system to large disturbances. These disturbances can include line switching, load rejection, or generation runback. For example, on hydroelectric units, high mechanical power rates of change (in excess of 20% per second) may be possible. This requires an examination of the terminal voltage excursion that can be caused in dual-input stabilizers that band limit the mechanical power signal.

**Disturbance Recording**

The DECS-400 is equipped with a power data recorder that can capture several quantities. Some of these quantities include terminal voltage, field voltage, active power, reactive power, speed, generator current, and stabilizer output. The recorder can be set to trigger automatically for a system disturbance and save the captured data. This feature allows the user to obtain direct recordings of actual system disturbances for comparison with simulated responses. This can be very important since it may not be possible to configure the system to perform staged tests of worst-case configurations and contingencies.
# SECTION 7 • MAINTENANCE

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SECTION 7 • MAINTENANCE ..................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>PREVENTIVE MAINTENANCE ....................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>WARRANTY AND REPAIR SERVICE ................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>TROUBLESHOOTING ...............................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>DECS-400 Appear Inoperative ................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>Display Blank Or Frozen ....................................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>Generator Voltage Does Not Build ..................................................</td>
<td>7-1</td>
</tr>
<tr>
<td></td>
<td>Generator Voltage Builds But DECS-400 Fails To Flash .......................</td>
<td>7-2</td>
</tr>
<tr>
<td></td>
<td>Field Voltage or Current Reading on LCD Does Not Change ...................</td>
<td>7-2</td>
</tr>
<tr>
<td></td>
<td>Low Generator Voltage (In AVR Mode) ...............................................</td>
<td>7-2</td>
</tr>
<tr>
<td></td>
<td>High Generator Voltage (In AVR Mode) ............................................</td>
<td>7-2</td>
</tr>
<tr>
<td></td>
<td>Generator Voltage Unstable (Hunting) ..............................................</td>
<td>7-2</td>
</tr>
<tr>
<td></td>
<td>Poor Voltage Regulation ...................................................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>No Buildup in FCR Mode ....................................................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>No Control Signal at Firing Circuit Input .........................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>Limiters Do Not Limit at the Desired Level ......................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>Poor Reactive Control .......................................................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>Protection Or Limit Annunciation ....................................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>Metering Readings Incorrect ................................................................</td>
<td>7-3</td>
</tr>
<tr>
<td></td>
<td>No Communication .............................................................................</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
<td>Stored Data Lost After Loss of Control Power ....................................</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
<td>DECS-400 Reboots Frequently ................................................................</td>
<td>7-4</td>
</tr>
<tr>
<td></td>
<td>BACKUP BATTERY REPLACEMENT ................................................................</td>
<td>7-4</td>
</tr>
</tbody>
</table>

## Figures

- Figure 7-1. Typical Metering Readings ................................................. 7-3
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SECTION 7 • MAINTENANCE

PREVENTIVE MAINTENANCE
DECS-400 preventative maintenance consists of regular checks to ensure that the DECS-400 connections are clean and tight and periodic replacement of the backup battery. See Backup Battery Replacement for battery replacement guidelines.

WARRANTY AND REPAIR SERVICE
DECS-400 units are manufactured using state-of-the-art, surface mount technology. As such, Basler Electric recommends that no maintenance procedures be attempted by anyone other than Basler Electric personnel.

The DECS-400 is warranted against defective material and workmanship for 18 months from the date of shipment from our factory. Units submitted for warranty repair should be returned to the factory in Highland, Illinois, freight pre-paid, with a complete description of the installation and the reported problem. Pre-arrangement with either the nearest Basler Electric sales office or with the Technical Sales Support department at the factory will assure the fastest possible turn-around time.

TROUBLESHOOTING
These troubleshooting procedures assume that the excitation system components are selected correctly, fully operational, and connected correctly. If you do not get the results that you expect from the DECS-400, first check the programmable settings for the appropriate function.

DECS-400 Appear Inoperative
If the DECS-400 does not power up (no backlighting on front panel display), ensure that the operating power connections are correct and the voltage level is within the acceptable range. AC operating power connects to terminals C2 (N) and C3 (L) and must be within the range of 82 to 132 Vac. DC operating power connects to terminals C4 (BATT–) and C5 (BATT+). A DECS-400 with style number XCXX has an operating range of 90 to 150 Vdc. A DECS-400 with style number XLXX has an operating range of 16 to 60 Vdc.

Display Blank Or Frozen
If the front panel display (LCD) is blank or frozen (does not scroll), remove input power and then reapply input power after approximately 60 seconds. If the problem occurred during software uploading, repeat the upload procedures as described in the associated instructions. If the problem persists, return the unit to the factory as described in the preceding paragraphs.

Generator Voltage Does Not Build
Check the DECS-400 settings for the following system configurations.

a) Generator potential transformer (PT) primary voltage.
b) Generator PT secondary voltage.
c) Analog control output signal type.

Check the DECS-400 soft start settings.

d) Maximum field flash dropout time
e) Field flash dropout level.
f) Generator soft start bias.
g) Generator soft start time.

Check the external field flashing components.

h) Field flashing contactor
i) Field flashing power source fuses
j) Field flashing current limiting resistor values

If the generator voltage still does not build, increase the soft start setting values in paragraphs d through f, and decrease the setting for paragraph g.

Temporarily turn off the overexcitation limiter.
Generator Voltage Builds But DECS-400 Fails To Flash

Check the DECS-400 settings for the following system configurations.

a) Generator potential transformer (PT) primary voltage.

b) Generator PT secondary voltage.

c) Analog control output signal type.

Check the DECS-400 soft start settings.

d) Maximum field flash dropout time

e) Field flash dropout level.

f) Generator soft start bias.

g) Generator soft start time.

If the generator voltage still does not build, increase the soft start setting values in paragraphs d through f, and decrease the setting for paragraph g.

Temporarily turn off the overexcitation limiter.

Check the exciter power circuitry: rectifier bridge, firing circuit, and power input transformer.

If the problem persists, return the unit to the factory as described in the preceding paragraphs.

Field Voltage or Current Reading on LCD Does Not Change

Check the connections between the isolation module and the DECS-400.

Check the connections between the isolation module and shunt (field current sensing) and between the isolation module and the output of the exciter (field voltage sensing).

If the problem persists, apply a field current or voltage input signal to the DECS-400 at connector P1. (You are simulating the output from the isolation module.) The field current signal should be applied to P1, pin 4, and return to P1, pin 5. The field current signal should be 2.0 to 9.5 volts dc with 2.0 volts dc equal to zero field current. The field voltage signal should be applied to P1, pin 8, and return to P1, pin 7. The field voltage signal should be 0.9 to 9.1 volts dc with 5.0 volts dc equal to zero field voltage. If the LCD reading does not change, return the unit to the factory as described in the preceding paragraphs. If the reading does change, the isolation module is defective.

Low Generator Voltage (In AVR Mode)

Check the DECS-400 for the following settings.

a) AVR voltage setpoint

b) AVR Kg loop gain (too low)

c) Generator potential transformer (PT) primary voltage

d) Generator PT secondary voltage

e) OEL is not activated

f) Accessory inputs (should be zero)

g) Var/PF and droop should be disabled

h) Cut-in underfrequency setting is below the generator operating frequency

If the problem persists, contact Basler Electric Technical Sales Support for advice.

High Generator Voltage (In AVR Mode)

Check the DECS-400 for the following settings.

a) AVR voltage setpoint

b) AVR Kg loop gain (too high)

c) Generator potential transformer (PT) primary voltage

d) Generator PT secondary voltage

e) Accessory inputs (should be zero)

f) Var/PF and droop should be disabled

If the problem persists, contact Basler Electric Technical Sales Support for advice.

Generator Voltage Unstable (Hunting)

Verify that the exciter power converter is working correctly by substituting the appropriate battery voltage in place of the DECS-400 drive voltage. If the problem is caused by the DECS-400, check the gain settings for the specific mode of operation selected.
If the problem persists, contact Basler Electric Technical Sales Support for advice.

**Poor Voltage Regulation**
Poor voltage regulation may result from insufficient Kg loop gain. Increase the AVR loop gain accordingly.

**No Buildup in FCR Mode**
Low Kg loop gain may hinder buildup when operating in FCR mode. An FCR loop gain of 150 or greater may be necessary.

**No Control Signal at Firing Circuit Input**
Check the control signal setting and output of the DECS-400. Depending on the signal selected, the DECS-400 will produce a 0 to 10 Vdc, 4 to 20 mA, or –10 to +10 Vdc control signal.

**Limiters Do Not Limit at the Desired Level**
Insufficient Kg loop gain for the limiters may hinder limiter operation. Increase the limiter loop gain accordingly.

**Poor Reactive Control**
Poor reactive control may result if the AVR droop setting is too low. Adjust the AVR droop accordingly.

**Protection Or Limit Annunciation**
If a protection function or limiting function is annunciated, check the associated setting values. If the problem persists, contact Basler Electric Technical Sales Support for advice.

**Metering Readings Incorrect**
If your PF, var, or watt readings are significantly different from the expected readings for a known load, verify that the CT for phase B is actually placed on the phase B input to the DECS-400 and not on phase A or C. Figure 7-1 illustrates typical metering readings.

![Figure 7-1. Typical Metering Readings](image)
No Communication
If communication cannot be initialized, check the serial cables to the port connections, the transmission speed (baud rate), and supporting software.

Stored Data Lost After Loss of Control Power
A loss of real-time clock information, oscillography records, and sequence of events data indicates a depleted backup battery. See Backup Battery Replacement for the battery replacement procedure.

DECS-400 Reboots Frequently
If a single input power source is used and the input power is less than the minimum as specified or fluctuates below the minimum, the DECS-400 will reboot. Increase input power to meet or exceed the specified requirements.

BACKUP BATTERY REPLACEMENT
An internal battery maintains real-time clock information when DECS-400 operating power is removed or lost. The 3.6 volt, lithium, backup battery is secured in a holder located behind the front panel. The backup battery should be replaced every five years by using the following procedure.
1. Obtain a replacement battery (Tadiran TL-2150/S, Basler Electric 37819, or equivalent).
2. Remove the DECS-400 from service by observing all applicable safety and shutdown procedures.
3. Loosen the captive Phillips screw in both latches, release each latch, and withdraw the draw-out assembly from the case.
4. Locate the battery holder and cover on the circuit board attached to the front panel. When facing the back side of the front panel, the battery holder and cover are located near the upper, left-hand corner of the circuit board.
5. Unclip and remove the cover from the battery holder.
6. Remove the battery from the battery holder. Note the orientation (polarity) of the battery. The new battery must be installed with the same orientation.
7. Install the new battery in the holder. Ensure that the polarity of the installed battery is correct (+ to + and – to –).
8. Place the battery cover over the battery holder and snap it into place.
9. Insert the draw-out assembly into the case and secure it with the latches.
10. Place the DECS-400 back in service by observing all applicable safety and startup procedures.
APPENDIX A • PROGRAMMABLE LOGIC

TABLE OF CONTENTS
APPENDIX A • PROGRAMMABLE LOGIC .......................................................... A-1
INTRODUCTION .............................................................................................. A-1
LOGIC SCHEMES ......................................................................................... A-1
  Default Logic Scheme ................................................................................ A-1
  Predefined Logic Schemes ......................................................................... A-1
LOGIC SCHEME MODIFICATION ................................................................ A-15
  Open “Single DECS-400 Without PSS” Logic Scheme for Editing .............. A-16
  Delete Unneeded Logic Associations ......................................................... A-18
  Create New Logic Associations ................................................................ A-20
  Verify and Finalize Modified Logic Scheme ........................................... A-22

Figures
Figure A-1. Default Logic ............................................................................... A-2
Figure A-2. Single DECS-400 with PSS (Part 1 of 3) ...................................... A-3
Figure A-3. Single DECS-400 with PSS (Part 2 of 3) ...................................... A-4
Figure A-4. Single DECS-400 with PSS (Part 3 of 3) ...................................... A-5
Figure A-5. Single DECS-400 without PSS (Part 1 of 3) ............................... A-6
Figure A-6. Single DECS-400 without PSS (Part 2 of 3) ............................... A-7
Figure A-7. Single DECS-400 without PSS (Part 3 of 3) ............................... A-8
Figure A-8. Dual DECS-400 with PSS (Part 1 of 3) ....................................... A-9
Figure A-9. Dual DECS-400 with PSS (Part 2 of 3) ....................................... A-10
Figure A-10. Dual DECS-400 with PSS (Part 3 of 3) ..................................... A-11
Figure A-11. Dual DECS-400 without PSS (Part 1 of 3) ............................... A-12
Figure A-12. Dual DECS-400 without PSS (Part 2 of 3) ............................... A-13
Figure A-13. Dual DECS-400 without PSS (Part 3 of 3) ............................... A-14
Figure A-14. Logic Scheme Modification Illustration  ................................ A-15
Figure A-15. Open Default Logic Scheme Window ..................................... A-16
Figure A-16. Deletion of Layer1 InputBuffer.Volts per Hz Limit → Or1.Input4 A-18
Figure A-17. Deletion of Layer1 InputBuffer.Field Over Current → Or6.Input3 A-19
Figure A-18. Deletion of OutputBuffer – InputBuffer.Field Flashing → Relay Output5 A-19
Figure A-19. Addition of Layer3 InputBuffer.Volts per Hz Limit → Layer3.Or1.Input1 A-20
Figure A-20. Addition of Layer3 InputBuffer.Field Over Current → Layer3.Or1.Input2 A-21
Figure A-21. Addition of layer4 – Layer3.Or1.Output → Mux1.Input .............. A-21

Tables
Table A-1. Modified “Single DECS-400 Without PSS” Logic Scheme .............. A-16
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APPENDIX A • PROGRAMMABLE LOGIC

INTRODUCTION
The DECS-400 utilizes programmable logic functionality in the form of multiplexors, AND gates, OR gates, NOT gates, and timers. Inputs to the logic are in the form of discrete information including switching inputs, system status data, protection status data, limiter status data, alarm status data, and PSS status data. The outputs of the programmable logic module can be used to control the relay outputs as well as various other functions inside the DECS-400 such as control functions (start/stop, mode select, etc.), protection functions (field overvoltage enable, field overcurrent enable, etc.), limiter functions (OEL enable, UEL enable, etc.), and PSS functions.

The programmable logic capabilities of the DECS-400 are accessed through the Logic screen of BESTCOMS. Predefined logic schemes, saved as files, can be accessed and activated through BESTCOMS. If desired, a predefined logic scheme can be altered to accommodate the specific needs of an application.

LOGIC SCHEMES
Logic schemes provided with the DECS-400 include a default scheme that is part of the DECS-400 default settings and four predefined schemes supplied as files with the DECS-400.

Default Logic Scheme
A basic logic scheme is provided as part of the DECS-400 default settings. This scheme automatically selects either on-line or off-line overexcitation limiting and disables voltage matching during off-line operation. The default logic scheme is illustrated in Figure A-1.

Predefined Logic Schemes
The predefined schemes are supplied as files that are loaded on your PC when BESTCOMS is installed. A scheme can be accessed through the “Open Default Scheme…” command of the BESTCOMS File menu. If desired, a logic scheme may be opened and modified to accommodate the specific requirements of your application. If modification of a logic scheme is desired, contact the Basler Electric Technical Services Department for assistance.

Four predefined logic schemes are supplied with BESTCOMS for the DECS-400. These schemes include common control and annunciation provisions for the following applications:

- Single DECS-400 system with power system stabilization (PSS)
- Single DECS-400 system without PSS
- Dual DECS-400 system with PSS
- Dual DECS-400 system without PSS

The logic scheme for a single DECS-400 with PSS is illustrated in Figures A-2, A-3, and A-4. Figures A-5, A-6, and A-7 illustrate the logic scheme for a single DECS-400 without PSS. The logic scheme for a dual DECS-400 with PSS is illustrated in Figure A-8, A-9, and A-10. Figure A-11, A-12, and A-13 illustrate the logic scheme for a dual DECS-400 without PSS.
Figure A-1. Default Logic
Figure A-2. Single DECS-400 With PSS (Part 1 of 3)
Figure A-3. Single DECS-400 With PSS (Part 2 of 3)
Figure A-4. Single DECS-400 With PSS (Part 3 of 3)
Figure A-5. Single DECS-400 Without PSS (Part 1 of 3)
Figure A-6. Single DECS-400 Without PSS (Part 2 of 3)
Figure A-7. Single DECS-400 Without PSS (Part 3 of 3)
Figure A-8. Dual DECS-400 With PSS (Part 1 of 3)
**Figure A-9. Dual DECS-400 With PSS (Part 2 of 3)**
Figure A-10. Dual DECS-400 With PSS (Part 3 of 3)
Figure A-11. Dual DECS-400 Without PSS (Part 1 of 3)
Figure A-12. Dual DECS-400 Without PSS (Part 2 of 3)
Figure A-13. Dual DECS-400 Without PSS (Part 3 of 3)
LOGIC SCHEME MODIFICATION

If desired, a predefined logic scheme can be altered to accommodate the specific needs of an application. Logic scheme modification consists of the deletion and addition of logic components and connections to achieve the desired logic functionality. Logic scheme modification is illustrated here through an example where the “Single DECS-400 Without PSS” predefined logic scheme (illustrated in Figures A-5, A-6, and A-7) is altered as shown in Figure A-14. Figure A-14 illustrates the portion of the “Single DECS-400 Without PSS” logic scheme that will be modified. In Figure A-14, an “X” indicates the deletion of a logic connection. Bold lines indicate added components and connections. These changes are summarized as follows:

- Buildup Active input buffer is disconnected from Output Relay #5
- V/Hz Protection Active input buffer is disconnected from the Common Protection output (Relay Output #2)
- Field Overcurrent Active input buffer is disconnected from Relay Output #2
- The V/Hz Protection Active and Field Overcurrent Active input buffers are ORed together to operate Relay Output #5 and Relay Output #6

Figure A-14. Logic Scheme Modification Illustration
Open “Single DECS-400 Without PSS” Logic Scheme for Editing

1. Open the “Single DECS-400 Without PSS” logic scheme in BESTCOMS by clicking **File, Open Default Scheme**. When the Open Default Logic Scheme window opens, click the button labeled “Single DECS-400 Without PSS” (see Figure A-15). Click the **Yes** button in the warning dialog box to continue opening the logic scheme. Once the logic scheme has been opened, a second dialog box will appear. Click the **OK** button.

2. Access the DECS Logic window by clicking the **Logic** button on the BESTCOMS toolbar.

3. To view the active logic scheme (DECS Logic Viewer), click the View Logic button in the DECS Logic window.

Table A-1 lists the logic associations of the modified “Single DECS-400 Without PSS” scheme. Lined out entries in the list indicate logic associations that will be deleted. Bold entries in the list indicate logic associations that will be added later in this example.

<table>
<thead>
<tr>
<th>Table A-1. Modified “Single DECS-400 Without PSS” Logic Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>{ SOURCE ---&gt; DESTINATION }</td>
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<tr>
<td>======&gt; DESTINATION: Layer1</td>
</tr>
<tr>
<td>InputBuffer.Load Comp ---&gt; Mux1.Input</td>
</tr>
<tr>
<td>InputBuffer.Contact Switch 5 ---&gt; Mux2.Input</td>
</tr>
<tr>
<td>InputBuffer.Loss of Field Isolation Transducer ---&gt; Mux3.Input</td>
</tr>
<tr>
<td>InputBuffer.Loss of Sensing ---&gt; Mux4.Input</td>
</tr>
<tr>
<td>InputBuffer.Over Excitation Limit ---&gt; Or1.Input1</td>
</tr>
<tr>
<td>InputBuffer.Under Excitation Limit ---&gt; Or1.Input2</td>
</tr>
<tr>
<td>InputBuffer.Stator Current Limit ---&gt; Or1.Input3</td>
</tr>
<tr>
<td>InputBuffer.Under Freq Limit ---&gt; Or1.Input4</td>
</tr>
<tr>
<td>Layer1.Or1.Output ---&gt; Or2.Input1</td>
</tr>
<tr>
<td>Layer1.Or2.Output ---&gt; Or3.Input2</td>
</tr>
<tr>
<td>InputBuffer.Under Freq Limit ---&gt; Or3.Input4</td>
</tr>
<tr>
<td>Layer1.Mux3.Output2 ---&gt; Or4.Input1</td>
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<tr>
<td>InputBuffer.Failed To Build Up ---&gt; Or4.Input2</td>
</tr>
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<td>InputBuffer.EDM Open ---&gt; Or4.Input3</td>
</tr>
<tr>
<td>InputBuffer.EDM Short ---&gt; Or4.Input4</td>
</tr>
<tr>
<td>InputBuffer.Gen Over Voltage ---&gt; Or5.Input1</td>
</tr>
<tr>
<td>InputBuffer.Gen Under Voltage ---&gt; Or5.Input2</td>
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<tr>
<td>InputBuffer.Loss of Field ---&gt; Or5.Input3</td>
</tr>
<tr>
<td>InputBuffer.Volts per Hz ---&gt; Or5.Input4</td>
</tr>
<tr>
<td>InputBuffer.Field Over Temp ---&gt; Or6.Input1</td>
</tr>
<tr>
<td>InputBuffer.Field Over Voltage ---&gt; Or6.Input2</td>
</tr>
<tr>
<td>InputBuffer.Field Over Current ---&gt; Or6.Input3</td>
</tr>
<tr>
<td>Layer1.Mux4.Output1 ---&gt; Or6.Input4</td>
</tr>
<tr>
<td>InputBuffer.Contact Switch 10 ---&gt; Not2.Input</td>
</tr>
</tbody>
</table>
InputBuffer.Contact Switch 3 ---> Mux1.Input
Layer1.Not2.Output ---> Mux2.Input
Layer2.Mux3.Output2 ---> Or1.Input1
Layer2.Or1.Output ---> Or2.Input1
Layer1.Or4.Output ---> Or2.Input2
Layer1.Or5.Output ---> Or2.Input3
Layer1.Or6.Output ---> Or2.Input4
Layer2.Mux1.Output1 ---> Not1.Input

InputBuffer.Contact Switch 9 ---> And1.Input1
InputBuffer.Volts per Hz Limit ---> Or1.Input1
InputBuffer.Field Over Current ---> Or1.Input2

Layer2.Not2.Output ---> And1.Input1
InputBuffer.Contact Switch 2 ---> Pre Position 2
InputBuffer.AVR ---> AVR
InputBuffer.FCR ---> FCR
Layer2.Mux1.Output2 ---> Pre Position 1
InputBuffer.Raise ---> Raise
InputBuffer.Lower ---> Lower
Layer3.And1.Output ---> PF Var
InputBuffer.Contact Switch 8 ---> Dual PID Selection
InputBuffer.Contact Switch 1 ---> Alarm Reset
Layer1.Not3.Output ---> Voltage Matching
InputBuffer.Contact Switch 6 ---> Secondary Protect
Layer1.Not4.Output ---> Loss of Sensing Transfer to FCR
Layer1.Mux2.Output1 ---> Secondary OEL
Layer1.Mux2.Output2 ---> Secondary UEL
Layer1.Mux2.Output3 ---> Secondary SCL
Layer1.Mux1.Output1 ---> OEL Off-Line/On-Line Option
Layer2.Mux2.Output1 ---> Modbus Write
Layer2.Mux2.Output2 ---> Modem Write
InputBuffer.FCR Mode ---> Relay Output 1
Layer2.Or2.Output ---> Relay Output 2
Layer1.Mux4.Output2 ---> Relay Output 4
InputBuffer.Field Flashing ---> Relay Output 5
Delete Unneeded Logic Associations

All logic connections and components that will be affected by the modifications to be made must first be deleted before any new logic associations are created. As Figure A-14 and Table A-1 illustrate, three logic connections (associations) must be deleted. Perform the following steps to delete these associations.

**NOTE**

To preserve all logic changes, the modified logic scheme should be saved with a unique file name. A logic file is saved by clicking **File, Save** in the DECS Logic window. All DECS-400 logic is saved with a “.del” file extension.

1. Figure A-16 illustrates the DECS Logic window settings associated with this step. Disconnect the V/Hz Protection Active input buffer from input 4 of OR gate 5 on logic layer 1. In Table A-1, this association is identified by “DESTINATION: Layer1 – InputBuffer.Volts per Hz Limit → Or1.Input4”.

![Figure A-16. Deletion of Layer1 InputBuffer.Volts per Hz Limit --> Or1.Input4](image)

2. Figure A-17 illustrates the DECS Logic window settings associated with this step. Disconnect the Field Overcurrent Active input buffer from input 3 of OR gate 6 on logic layer 1. In Table A-1, this association is identified by “DESTINATION: Layer1 – InputBuffer.Field Over Current → Or6.Input3”.

![Figure A-17. Deletion of Layer1 InputBuffer.Field Over Current --> Or6.Input3](image)
3. Figure A-18 illustrates the DECS Logic window settings associated with this step. Disconnect the Buildup Active input buffer from the Output Relay #5 output buffer. In Table A-1, this association is identified by “DESTINATION: OutputBuffer – InputBuffer.Field Flashing → Relay Output 5”.

---

**Figure A-17. Deletion of Layer1 InputBuffer.Field Over Current ---> Or6.Input3**

**Figure A-18. Deletion of OutputBuffer - InputBuffer.Field Flashing ---> Relay Output 5**
Create New Logic Associations

After all unneeded logic associations are deleted, new logic associations can be made. Table A-2 lists the logic of the modified scheme after all deletions and additions have been made. Bold entries in the list indicate logic associations that will be added here.

1. Figure A-19 illustrates the DECS Logic window settings associated with this step. Connect the V/Hz Protection Active input buffer to input 1 of OR gate 1 on logic layer 3. In Table A-2, this association is identified by “DESTINATION: Layer3 – InputBuffer.Volts per Hz Limit → Or1.Input1”.

![Figure A-19. Addition of Layer3 InputBuffer.Volts per Hz Limit ---> Layer3.Or1.Input1](image)

2. Figure A-20 illustrates the DECS Logic window settings associated with this step. Connect the Field Overcurrent Active input buffer to input 2 of OR gate 1 on logic layer 3. In Table A-2, this association is identified by “DESTINATION: Layer3 – InputBuffer.Field Over Current → Or1.Input2”.

![Figure A-20. Addition of Layer3 Field Over Current ---> Layer3.Or1.Input2](image)
3. Figure A-21 illustrates the DECS Logic window settings associated with this step. Connect the output of OR gate 1 on layer 3 to the input of multiplexer 1 on layer 4. In Table A-2, this association is identified by “DESTINATION: Layer4 – Layer3.Or1.Output \( \rightarrow \) Mux1.Input”.

4. Figure A-22 illustrates the DECS Logic window settings associated with this step. Connect output1 of multiplexer 1 on layer 4 to the Output Relay #5 output buffer. In Table A-2, this association is identified by “DESTINATION: OutputBuffer – Layer4.Mux1.Output1 \( \rightarrow \) Relay Output5”.
5. Figure A-23 illustrates the DECS Logic window settings associated with this step. Connect output 2 of multiplexer 1 on layer 4 to the Output Relay #6 output buffer. In Table A-2, this association is identified by “DESTINATION: OutputBuffer – Layer4.Mux1.Output2 => Relay Output6”.

Verify and Finalize Modified Logic Scheme

Logic scheme modifications can be verified by reviewing the logic associations displayed in the DECS Logic Viewer.
If desired, the relay output labels (accessed through the I/O Status tab of the BESTCOMS Metering screen) can be edited to reflect their changed functionality. See Section 4, BESTCOMS Software for information about changing I/O label assignments.
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# APPENDIX B • MODBUS COMMUNICATION

## TABLE OF CONTENTS

APPENDIX B • MODBUS™ COMMUNICATION............................................................................................................B-1
INTRODUCTION..................................................................................................................................................B-1
DECS-400 MODBUS PROTOCOL..........................................................................................................................B-1
MESSAGE STRUCTURE......................................................................................................................................B-1
  Device Address Field..................................................................................................................................B-1
  Function Code Field..................................................................................................................................B-2
  Data Block Field..........................................................................................................................................B-2
  Error Check Field.......................................................................................................................................B-2
SERIAL TRANSMISSION DETAILS....................................................................................................................B-2
  Message Framing And Timing Considerations..........................................................................................B-3
  Error Handling And Exception Responses...............................................................................................B-3
COMMUNICATION HARDWARE REQUIREMENTS...............................................................................................B-3
DETAILED MESSAGE QUERY AND RESPONSE.................................................................................................B-3
  Read Holding Registers ...........................................................................................................................B-4
  Preset Multiple Registers ..........................................................................................................................B-4
  Preset Single Register (Write Single Holding Register)...........................................................................B-5
  Response....................................................................................................................................................B-5
  Loop Back Diagnostic Test (Fc=8) With Diagnostic Sub Function, Return Query Data .........................B-5
  Loop Back Diagnostic Test With Diagnostic Sub-Function, Restart Communications Option .............B-6
  Loop Back Diagnostic Test With Diagnostic Sub-Function, Force Slave To Listen-Only Mode ............B-6
DATA FORMATS.............................................................................................................................................B-6
  Generic Types Ui8 And I8 ............................................................................................................................B-7
  Generic Types Ui16 And I16 .........................................................................................................................B-7
  Generic Types Ui32 And I32 .........................................................................................................................B-7
  Floating Point (R23_32) Data Format ........................................................................................................B-7
CRC ERROR CHECK.......................................................................................................................................B-8
DECS-400 MODBUS REGISTER SPACE .............................................................................................................B-8
DECS-400 REGISTER TABLES..........................................................................................................................B-9
  Holding Registers For Version Data..........................................................................................................B-10
  Holding Registers For Metering, Group 1 .................................................................................................B-11
  Holding Registers For System Configuration ..........................................................................................B-12
  Holding Registers For Operating Mode Parameters ..............................................................................B-13
  Holding Registers For Setpoint Parameters............................................................................................B-14
  Holding Registers For Startup Parameters ..............................................................................................B-16
  Holding Registers For Limiter Parameters ...............................................................................................B-16
  Holding Registers For Gain Parameters ..................................................................................................B-18
  Holding Registers For Protection Function Parameters .........................................................................B-19
  Holding Registers For Exciter Diode Monitor Parameters ....................................................................B-19
  Holding Registers For Relay Parameters.................................................................................................B-20
  Holding Registers For General Ascii And Modbus Communication Parameters ....................................B-21
  Holding Registers For Metering Parameters, Group 2 ..........................................................................B-21
  Holding Registers For Power System Stabilizer Parameters...................................................................B-21
INTRODUCTION
This section describes the Modbus communication protocol employed by the DECS-400, and how to exchange information with the DECS-400 over a Modbus network. The DECS-400 communicates by emulating a subset of the Modicon 984 Programmable Controller.

DECS-400 MODBUS PROTOCOL
Modbus communication uses a master-slave technique in which only the master can initiate a transaction. This transaction is called a query. When appropriate, a slave (DECS-400) responds to the query. When a Modbus master communicates with a slave, information is provided or requested by the master.

Information residing in the DECS-400 is grouped characteristically in categories. The following information categories are maintained by the DECS-400:
- C1: Version data registers
- C2: Metering registers, group 1
- C3: System configuration registers
- C4: Operating mode parameter registers
- C5: Setpoint parameter registers
- C6: Startup parameter registers
- C7: Limiter parameter registers
- C8: Gain registers
- C9: Protection function parameter registers
- C10: Exciter diode monitor parameter registers
- C11: Relay parameter registers
- C12: ASCII and Modbus communication parameter registers
- C13: Metering registers, group 2
- C14: Power system stabilizer parameter registers

All supported data can be read or written as specified in the register table. Abbreviations are used in the register table to indicate the register access type. Register access types are read/write (RW) and read only (R).

All categories except metering (C2 and C13) and version data (C1) can generally be written via a Modbus message as well as read. Categories C11, C12, and C15 are strictly read-only.

When a slave receives a query, the slave responds by either supplying the requested data to the master or performing the requested action. A slave device never initiates communications on the Modbus™, and will always generate a response to the query unless certain error conditions occur. The DECS-300 is designed to communicate on the Modbus™ only as a slave device.

A master can only query slaves individually. If a query requests actions unable to be performed by the slave, the slave response message contains an exception response code defining the error detected.

MESSAGE STRUCTURE
Master initiated queries and DECS-300 (slave) responses share the same message structure. Each message is comprised of four message fields. They are:
- Device Address (1 byte)
- Function Code (1 byte)
- Data Block (n bytes)
- Error Check field (2 bytes)

Device Address Field
The device address field contains the unique Modbus address of the slave being queried. The addressed slave repeats the address in the device address field of the response message. This field is 1 byte.

Modbus protocol limits a device address from 1 to 247. The address is user-selectable at installation, and can be altered during real-time operation.
Function Code Field
The function code field in the query message defines the action to be taken by the addressed slave. This field is echoed in the response message, and is altered by setting the most significant bit (MSB) of the field to 1 if the response is an error response. This field is 1 byte.

The DECS-400 maps all registers into the Modicon 984 holding register address space (4XXXX) and supports the following function codes.
- **READ OUTPUT REGISTERS** (function code 3),
- **PRESET MULTIPLE REGISTERS** (function code 16), and
- **LOOPBACK DIAGNOSTIC TEST** (function code 8) with diagnostic sub-functions:
  - **Return Query Data** (diagnostic code 0),
  - **Restart Comm. option** (diagnostic code 1), and
  - **Force Slave To Listen Only Mode** (LOM, diagnostic code 4).

DECS-400 Modbus performs all of the above functions when a Modbus message has its unique address which is numbered from 1 to 247. The DECS-400 also recognizes a broadcast (group) address of 0. Only functions 16 and 8 are recognized as valid for broadcast. The DECS-400 does not send a response message for a broadcast query.

In listen-only mode (LOM), received data is monitored (but no responses are transmitted). The only query that will be recognized and processed while in LOM is a maintenance restart command (function code 8, diagnostic code 1).

Data Block Field
The query data block contains additional information needed by the slave to perform the requested function. The response data block contains data collected by the slave for the queried function. An error response will substitute an exception response code for the data block. The length of this field varies with each query. See the paragraphs on *Register Definitions* in this manual for interpretation of register data.

Error Check Field
The error check field provides a method for the slave to validate the integrity of the query message contents and allows the master to confirm the validity of response message contents. This field is 2 bytes.

**SERIAL TRANSMISSION DETAILS**
A standard Modbus network offers two transmission modes for communication: ASCII or remote terminal unit (RTU). The DECS-400 supports only the RTU mode via the rear RS-485 interface.

Communication settings for the DECS-400 rear RS-485 port are listed in Table B-1.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Programmable Y(Yes)/N(No)</th>
<th>Default Value</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baud rate</td>
<td>Y</td>
<td>9600</td>
<td>4800, 9600, or 19200</td>
</tr>
<tr>
<td>Data Size in bits</td>
<td>N</td>
<td>8</td>
<td>N/A</td>
</tr>
<tr>
<td>Parity</td>
<td>Y</td>
<td>None</td>
<td>’N’=None, ’O’=Odd, ’E’=Even</td>
</tr>
<tr>
<td>Stop Bits</td>
<td>Y</td>
<td>2</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Modbus Slave Address</td>
<td>Y</td>
<td>247</td>
<td>0 for broadcast, 1 to 247 for slave</td>
</tr>
<tr>
<td>Modbus Response Delay</td>
<td>Y</td>
<td>10 ms</td>
<td>From 0 to 200 ms in increments of 10 ms</td>
</tr>
</tbody>
</table>

Communication settings are user-selectable and can be set at installation and altered during real-time operation.
Message Framing and Timing Considerations
When receiving a message, the DECS-400 requires an inter-byte latency of 3.5 character times before considering the message complete.

Once a valid query is received, the DECS-400 waits an amount of time as specified in the Modbus Response Delay Time Register (48108) before responding. This register contains a value from 0 to 200 milliseconds. The default value is 10 milliseconds. The user may set the remote delay time parameter to 0 to minimize response latency.

Table B-2 provides the response message transmission time (in milliseconds) and 3.5 character times (in milliseconds) for the maximum response message length (225 characters), response to a read query for 125 points, and various baud rates.

<table>
<thead>
<tr>
<th>Baud Rate</th>
<th>1 character Time (ms)</th>
<th>3.5 characters Time (ms)</th>
<th>Max. Read Register Response Message (255 characters) Transmission Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4800</td>
<td>2.083</td>
<td>7.292</td>
<td>531.165</td>
</tr>
<tr>
<td>9600</td>
<td>1.0417</td>
<td>3.645</td>
<td>265.6335</td>
</tr>
<tr>
<td>19200</td>
<td>0.52083</td>
<td>1.823</td>
<td>132.812</td>
</tr>
</tbody>
</table>

Error Handling and Exception Responses
Any query received that contains a nonexistent device address, a framing error, or CRC error is ignored. No response is transmitted. Queries addressed to a DECS-400 with an unsupported function code, unsupported register references, or illegal values in the data block result in an error response message with an exception response code.

Each error response message consists of a slave (DECS-400) address, function code with the high-order bit set, error code, and error check (CRC) field.

The exception response error codes supported by the DECS-400 are provided in Table B-3.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Illegal Function</td>
<td>The query Function/Sub-function Code is unsupported; query read of more than 125 registers; query “preset multiple registers” of more than 100 registers</td>
</tr>
<tr>
<td>02</td>
<td>Illegal Data Address</td>
<td>A register referenced in the data block does not support queried read/write; For Function Codes 3 and 16 additionally: 1. Starting Register address is mapped to DECS-300 Modbus™ address space, but is not referenced to the highest order 16 bits of the assigned application data (see explanation in 2.7 Data Formats), and 2. The number of registers is too small to hold entire value of all data (variables) assigned to those registers (see explanation in 2.7 Data Formats).</td>
</tr>
<tr>
<td>03</td>
<td>Illegal Data Value</td>
<td>A preset register data block contains an incorrect number of bytes or one or more data values out of range.</td>
</tr>
</tbody>
</table>

COMMUNICATION HARDWARE REQUIREMENTS
The DECS-400 RS-485 physical interface consists of a three-position terminal strip with terminals for Send/Receive A (A), Send/Receive B (B), and Signal Ground (C).

DETAILED MESSAGE QUERY AND RESPONSE
A detailed description of DECS-400 supported message queries and responses are provided in the following paragraphs.
Read Holding Registers

Query
This query message requests a register or block of registers to be read. The data block contains the starting register address and the quantity of registers to be read. A register address of N will read holding register N+1.

<table>
<thead>
<tr>
<th>Device Address</th>
<th>Function Code = 03</th>
<th>Starting Address High</th>
<th>Starting Address Low</th>
<th>No. of Registers High</th>
<th>No. of Registers Low</th>
<th>CRC Low</th>
<th>CRC High</th>
</tr>
</thead>
</table>

The number of registers cannot exceed 125 without causing an error response with the exception code for an illegal function.

Response
The response message contains the data queried. The data block contains the block length in bytes followed by the data for each requested register. For each requested register, there is one Data Hi and one Data Lo. Attempting to read an unused register or a register which does not support a read returns a zero (0). If the query is a broadcast (device address = 0), no response message is returned.

Maximum response message length obtained for query of 125 registers is 5 + (125 x 2) = 255 bytes.

<table>
<thead>
<tr>
<th>Device Address</th>
<th>Function Code = 03</th>
<th>Byte Count</th>
<th>Data High</th>
<th>Data Low</th>
<th>For each requested register</th>
<th>Data High</th>
<th>Data Low</th>
<th>CRC Low</th>
<th>CRC High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>250 max.</td>
<td>First queried register High</td>
<td>First queried register Low</td>
<td>Data High and data Low</td>
<td>Last queried register High</td>
<td>Last queried register Low</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Preset Multiple Registers
A preset, multiple-registers query could address multiple registers in one slave or multiple slaves. If the query is broadcast (device address = 0), no response is required.

NOTE
Variables changed by this function will not be directly saved to non-volatile memory (EEPROM). If specific categories (one or more) of data have to be saved to EEPROM, then Holding Register 48161 (Data Id=13001, variable “SaveCommand”) has to be preset after a category has been changed. The exceptions to this rule are only those Holding Registers dealing with communication port RS-485. They will be changed and immediately saved to EEPROM with the function FC16.

Query
A Preset Multiple Registers query message requests a register or block of registers to be written. The data block contains the starting address and the quantity of registers to be written, followed by the Data Block byte count and data. The DECS-400 performs the write when the device address matches the DECS-400 remote address or when the device address is 0. A device address is 0 for a broadcast query.

A register address of N will write Holding Register N+1.

All Modbus Generic Data Formats can be loaded by this function (see Section 7.2.8, Data Format).

No data will be written if any of the following exceptions occur:
- Queries to write to Read Only or unsupported registers result in an error response with an exception code of Illegal Data Address.
- Queries attempting to write more than 100 registers cause an error response with an exception code of Illegal Function.
- An incorrect Byte Count results in an error response with an exception code of “Illegal Function”.
- A query to write an illegal value (out of range) to a register results in an error response with an exception code of Illegal Data Value.
- Query Starting Register address is mapped to DECS-400 Modbus address space, but is not referenced to the lower order 16 bits of the assigned application data. (See explanation in Section 7.2.8, Data Formats.)
- The number of query registers is too small to hold entire value of all data (variables) assigned to
those registers. (See explanation in section 7.2.8, Data Formats.)

Query message format is:
Device Address
Function Code = 10 (hex)
Starting Address High
Starting Address Low
Number of Registers High (total number of registers to be loaded)
Number of Registers Low
Byte Count (total number of registers to be loaded times 2)
Data High
Data Low
...
Data High
Data Low
CRC Error Check (Lo, Hi)

Note: Max. length of Preset Multiple Registers Query is 9 + (100 x 2) = 209 bytes.

Response
The response message echoes the starting address and the number of registers. There is no response message when the query is a broadcast (device address of 0).

<table>
<thead>
<tr>
<th>Device Address</th>
<th>Function Code = 10 (hex)</th>
<th>Starting Address High</th>
<th>Starting Address Low</th>
<th>Number of Registers High</th>
<th>Number of Registers Low</th>
<th>CRC Low</th>
<th>CRC High</th>
</tr>
</thead>
</table>

Preset Single Register (Write Single Holding Register)
A Preset Single Register query message requests a single register to be written. The DECS-400 will perform the write when the device address is the same as the DECS-400 remote address.

Query
Device Address
Function Code = 06 (hex)
Address Hi
Address Lo
Data Hi
Data Lo
CRC Hi error check
CRC Lo error check

Response
Normal Response
The response message echoes the Query message after the register has been altered.

Error Response
Data will cease to be written if any of the following exceptions occur.
- Queries to write to the Read Only registers result in an error response with Exception Code of “Illegal Data Address”.
- A query to write an illegal value (out of range) to a register results in an error response with Exception Code of “Illegal Data Value”.

There are several instances of registers that are grouped together to collectively represent a single numerical DECS-400 data value, e.g., floating point data and 32-bit integer data. A query to write a subset of such a register group will result in an error response with Exception Code “Illegal Data Address”.

Loop Back Diagnostic Test (FC=8) with Diagnostic Sub Function, Return Query Data
This query contains data to be returned (looped back) in the response. The response and query message should be identical. If the query is a broadcast (device address = 0), no response message is returned.
Loop Back Diagnostic Test with Diagnostic Sub-Function, Restart Communications Option

This query causes the DECS-400 remote communication function to restart, terminating an active listen-only mode of operation. Primary relay operations are not affected. Only the remote communication function is affected. If the query is a broadcast (device address of 0), no response message is returned.

If the DECS-400 receives this query while in the listen-only mode (LOM), no response message is generated. Otherwise, a response message identical to the query message is transmitted prior to the communication restart.

Loop Back Diagnostic Test with Diagnostic Sub-Function, Force Slave to Listen-Only Mode

This query forces the addressed DECS-400 to the listen-only mode for Modbus communication, isolating it from other devices on the network.

While in Listen mode (LOM), received data is monitored but no responses are transmitted. The only query that will be recognized and processed while in LOM is a maintenance restart command (Function Code 8, Diagnostic Code 1).

When the DECS-400 receives the restart communication query, the listen-only mode is removed.

DATA FORMATS

DECS-400 data does not need to be converted into any special format for transmission over a Modbus network.

Modbus registers hold original DECS-400 data of the generic (built-in) data types listed in Table B-4.

<table>
<thead>
<tr>
<th>Generic Data Types</th>
<th>Corresponding built-in data type (Storage Format)</th>
<th>Data Range</th>
<th>Data Size in bytes</th>
<th>Total number of Modbus Registers to hold data</th>
</tr>
</thead>
<tbody>
<tr>
<td>UI8</td>
<td>UCHAR: unsigned character</td>
<td>0 to 255</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>UI6</td>
<td>UINT16: unsigned short integer</td>
<td>0 to 65,535</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>UI32</td>
<td>UINT32: unsigned long integer</td>
<td>0 to 4,294,967,295</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>I8</td>
<td>CHAR: signed character</td>
<td>-128 to 127</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>I16</td>
<td>INT16: signed short integer</td>
<td>-32,768 to 32,767</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>I32</td>
<td>INT32: signed long integer</td>
<td>-2,147,483,648 to 2,147,483,647</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>R32_23</td>
<td>FLOAT: floating point number</td>
<td>Approximately 8.43 x 10^-37 to 3.38 x 10^38</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

It should be noted that an ASCII string is not a DECS-400 generic data type. An ASCII string will be considered as a sequence of “(string length + 1)” data of I8 type, and for its transmission via a Modbus network, “(string length + 1)” holding registers are needed.

DECS-400 data is copied to assigned Holding Register(s) [HR] by the rules presented in the following paragraphs.
Generic Types UI8 and I8
Data of type UI8 or I8 is copied to one holding register (HR). The high (first) HR byte always contains 0 and the second (low) HR byte contains the data.

Example:
Assume that value of UI8 type data is 0x56, and that the data is mapped to HR 44005. The content of HR 44005 will be as listed in Table B-5.

<table>
<thead>
<tr>
<th>Table B-5. HR 44005 Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR 44004</td>
</tr>
<tr>
<td>Low Byte</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

Generic Types UI16 and I16
Data of type UINT16 or INT16 is saved in one holding register. The high data byte is copied to the high HR byte and the low data byte is copied to the low HR byte.

Example:
Assume that DECS-400 UINT16 or INT16 type data which value is 0xF067 is mapped to HR 47003. Data is copied to HR 47003 as shown in Table B-6.

<table>
<thead>
<tr>
<th>Table B-6. HR 47003 Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR 47002</td>
</tr>
<tr>
<td>Low Byte</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

Generic Types UI32 and I32
Data of type UI32 or I32 is 4 bytes long. The Modbus 4-byte long data generic types use two consecutive registers to represent a data value. The lower numbered holding register contains the low order 16 bits, Lower Order word [LO w], and the higher numbered holding register contains the higher order 16 bits, Higher Order word [HO w].

Example:
UI32 data type, which value is 0xE0234567 is mapped to two Holding registers (such as 45003 and 45004) as shown in Table B-7.

<table>
<thead>
<tr>
<th>Table B-7. Typical Mapping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register</td>
</tr>
<tr>
<td>Hexadecimal</td>
</tr>
<tr>
<td>Binary</td>
</tr>
<tr>
<td>HR 45002</td>
</tr>
<tr>
<td>LO byte</td>
</tr>
<tr>
<td>...</td>
</tr>
</tbody>
</table>

Floating Point (R23_32) Data Format
The specific floating point format matches the floating point format used for the Modicon 984-8 family of programmable controllers.

Its representation in bit format is:

\[
\begin{array}{cccccccc}
S & E & E & E & E & E & E & E \\
& M & M & M & M & M & M & M \\
& M & M & M & M & M & M & M \\
\end{array}
\]

where the “S” is the sign bit for the floating point value (1) if negative, (0) if positive; the “E” field is the two’s complement exponent biased by 127 decimal; the “M” field is the 23-bit normalized mantissa. The most-significant bit of the mantissa is always assumed to be 1 and is not explicitly stored, yielding an effective precision of 24 bits.
The value of the floating-point number is obtained by multiplying the binary mantissa times two raised to the power of the unbiased exponent. The assumed bit of the binary mantissa has the value of 1.0, with the remaining 23 bits providing a fractional value.

Table B-8 shows the floating point format.

<table>
<thead>
<tr>
<th>Sign</th>
<th>2's Complement Of (Exponent + 127)</th>
<th>Mantissa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Bit</td>
<td>8 Bits</td>
<td>23 Bits</td>
</tr>
</tbody>
</table>

The floating point format allows a maximum value of $3.38 \times 10^{38}$.

Note that bytes 0 and 1 of the floating point value are stored in the lower numbered register, and bytes 2 and 3 are contained in the higher numbered register.

For example, number 123 in floating point format is mapped to two holding registers (such as 45005 and 45006) as shown in Table B-9.

<table>
<thead>
<tr>
<th>Register</th>
<th>45005</th>
<th>45006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hexadecimal</td>
<td>0000</td>
<td>42F6</td>
</tr>
<tr>
<td>Binary</td>
<td>0000 0000 0000 0000</td>
<td>0100 0010 1111 0110</td>
</tr>
</tbody>
</table>

**CAUTION**

For DECS-400 Modbus, two consecutive holding registers, which are mapped to any of the four-byte, generic data types, are considered to be linked together as an atomic, indivisible unit of information which can be read or written by a Modbus message only as one entity. (That is, one cannot be read or written without the other.)

---

**CRC ERROR CHECK**

This field contains a two-byte CRC value for transmission error detection. The master first calculates the CRC and appends it to the query message. The DECS-400 recalculates the CRC value for the received query and performs a comparison to the query CRC value to determine if a transmission error has occurred. If so, no response message is generated. If no transmission error has occurred, the slave calculates a new CRC value for the response message and appends it to the message for transmission.

The CRC calculation is performed using all bytes of the device address, function code and data block fields. A 16-bit CRC register is initialized to all 1's. Then, each eight-bit byte of the message is used in the following algorithm.

First, exclusive-OR the message byte with the low-order byte of the CRC register. The result, stored in the CRC register, will then be right-shifted eight times. The CRC register MSB is zero filled with each shift. After each shift, the CRC register LSB is examined. If the LSB is a 1, the CRC register is then exclusive-ORed with the fixed polynomial value A001 (hex) prior to the next shift. Once all bytes of the message have undergone the above algorithm, the CRC register will contain the message CRC value to be placed in the error check field.

**DECS-400 MODBUS REGISTER SPACE**

Modbus address space from 40000 to 49999 refers to function codes 3, 6, and 16. The DECS-400 uses address space from 40001 to 44999 (4,999 registers). This address space is divided into 14 areas, referred to as information categories. Table B-10 provides a statistical summary for each information category.
## Table B-10. Information Category Summary

<table>
<thead>
<tr>
<th>Information Category ID</th>
<th>Information Category</th>
<th>Total # of Reserved Holding Registers</th>
<th>Holding Register Address Space</th>
<th>Number of Used Registers</th>
<th>Access Privilege</th>
<th>Data Types Mapped to Registers (Total # of Variables)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Version Data</td>
<td>200</td>
<td>40001 to 40200</td>
<td>60</td>
<td>R</td>
<td>UINT8</td>
</tr>
<tr>
<td>C2</td>
<td>Metering, Group 1</td>
<td>199</td>
<td>40201 to 40399</td>
<td>61</td>
<td>R</td>
<td>UINT16: 11 FLOAT: 50</td>
</tr>
<tr>
<td>C3</td>
<td>System Configuration</td>
<td>199</td>
<td>40401 to 40599</td>
<td>40</td>
<td>RW: 39 R: 1</td>
<td>UINT16: 11 FLOAT: 29</td>
</tr>
<tr>
<td>C4</td>
<td>Operating Mode Parameters</td>
<td>97</td>
<td>40604 to 40700</td>
<td>45</td>
<td>RW: 23 R: 22</td>
<td>UINT: 45</td>
</tr>
<tr>
<td>C5</td>
<td>Setpoint Parameters</td>
<td>449</td>
<td>40701 to 41149</td>
<td>58</td>
<td>RW: 34 R: 24</td>
<td>UINT16: 8 FLOAT: 50</td>
</tr>
<tr>
<td>C6</td>
<td>Startup Parameters</td>
<td>199</td>
<td>41151 to 41349</td>
<td>17</td>
<td>RW: 16 R: 1</td>
<td>FLOAT: 16 UINT16: 1</td>
</tr>
<tr>
<td>C7</td>
<td>Limiter Parameters</td>
<td>1,124</td>
<td>41351 to 42474</td>
<td>68</td>
<td>RW: 65 R: 3</td>
<td>FLOAT: 62 UINT16: 6</td>
</tr>
<tr>
<td>C8</td>
<td>Gain Registers</td>
<td>524</td>
<td>42476 to 42999</td>
<td>33</td>
<td>RW: 32 R: 1</td>
<td>UINT16: 1 FLOAT: 32</td>
</tr>
<tr>
<td>C9</td>
<td>Protection Function Parameters</td>
<td>127</td>
<td>43001 to 43127</td>
<td>29</td>
<td>RW: 23 R: 6</td>
<td>UINT16: 13 FLOAT: 16</td>
</tr>
<tr>
<td>C10</td>
<td>Exciter Diode Monitor Parameters</td>
<td>149</td>
<td>43376 to 43492</td>
<td>26</td>
<td>RW</td>
<td>UINT16: 8 FLOAT: 18</td>
</tr>
<tr>
<td>C11</td>
<td>Relay Parameters</td>
<td>600</td>
<td>43526 to 44125</td>
<td>24</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>C12</td>
<td>ASCII and Modbus Communication Parameters</td>
<td>125</td>
<td>44126 to 44250</td>
<td>16</td>
<td>RW: 14 R: 2</td>
<td>UINT8: 2 UINT14: 6</td>
</tr>
<tr>
<td>C13</td>
<td>Metering, Group 2</td>
<td>50</td>
<td>44201 to 44250</td>
<td>3</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>C14</td>
<td>PSS Parameters</td>
<td>749</td>
<td>44251 to 44999</td>
<td>91</td>
<td>RW: 89 R: 2</td>
<td>UINT16: 23 FLOAT: 68</td>
</tr>
</tbody>
</table>

### DECS-400 REGISTER TABLES

Each data to be transmitted via Modbus is identified by its holding register(s). The following tables provide a complete list of holding register assignments and descriptions for the DECS-400. There is a separate table for each information category.
# Holding Registers for Version Data

## Table B-11. Information Category C1—Version Data

<table>
<thead>
<tr>
<th>Registers</th>
<th>Data Description</th>
<th>Access</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>40001</td>
<td>1st character of the model information</td>
<td>R</td>
<td>UINT8</td>
</tr>
<tr>
<td>40002</td>
<td>2nd character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40003</td>
<td>3rd character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40004</td>
<td>4th character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40005</td>
<td>5th character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40006</td>
<td>6th character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40007</td>
<td>7th character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40008</td>
<td>8th character of the model information</td>
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<td>UINT8</td>
</tr>
<tr>
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<td>Last character of the model information</td>
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</tr>
<tr>
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<td>1st character of the application program version</td>
<td>R</td>
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</tr>
<tr>
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</tr>
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<td>40013</td>
<td>4th character of the application program version</td>
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<tr>
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<tr>
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<td>UINT8</td>
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<tr>
<td>40017</td>
<td>Last character of the application program version</td>
<td>R</td>
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</tr>
<tr>
<td>40018</td>
<td>1st character of the date of the application program</td>
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<td>40019</td>
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</tr>
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<td>40020</td>
<td>3rd character of the date of the application program</td>
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<tr>
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<td>UINT8</td>
</tr>
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<td>40040</td>
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<td>R</td>
<td>UINT8</td>
</tr>
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<td>40041</td>
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</tr>
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<td>40042</td>
<td>8th character of the date of the DSP program</td>
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<td>UINT8</td>
</tr>
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</tr>
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<td>Last character of the boot program version</td>
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<td>40056</td>
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<tr>
<td>40057</td>
<td>6th character of the boot program date</td>
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<td>UINT8</td>
</tr>
<tr>
<td>40058</td>
<td>7th character of the boot program date</td>
<td>R</td>
<td>UINT8</td>
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</table>
### Holding Registers for Metering, Group 1

<table>
<thead>
<tr>
<th>Registers</th>
<th>Data Description</th>
<th>Access</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>40201</td>
<td>Leading/lagging load indicator 0 = leading load, 1 = lagging load</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40202</td>
<td>Motoring/generating indicator 0 = motoring, 1 = generating</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40203</td>
<td>Status of front panel LEDs (bit flags where 0 = off and 1 = on) b0 = null balance, b1 = PSS active, b2 = pre-position, b3 = upper limit, b4 = lower limit, b5 = edit, b6-b15 = unassigned</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40204</td>
<td>Contact input states b0 = 52JK, b1 = 52LM, b2 = auto transfer, b3 = external tracking enable</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40205</td>
<td>Voltage matching status indicator</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40206</td>
<td>Active operating setpoint</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40207</td>
<td>Annunciation status bit flags (0 = clear and 1 = annunciation is present) b0 = field overvoltage, b1 = field overcurrent, b2 = generator undervoltage, b3 = generator overvoltage, b4 = underfrequency, b5 = in OEL, b6 = in UEL, b7 = in FCR mode, b8 = no sensing, b9 = setpoint lower limit, b10 = setpoint upper limit, b11 = generator failed to build up, b12 = generator below 10 Hz, b13 = field overtemperature, b14 = EDM open diode, b15 = EDM shorted diode</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40208</td>
<td>Annunciation status bit flags (0 = clear and 1 = annunciation is present) b0 = loss of field, b1 = in SCL, b2 = V/Hz, b3 = loss of FIT, b4 = power low, b5 = PSS V unbalance, b6 = PSS I unbalance, b7 = PSS power below threshold, b8 = PSS speed failure, b9 = PSS voltage limit, b10 = clock reset, b11 = loss of IRIG, b12-b15 = unassigned</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40209</td>
<td>Protection status bit flags (0 = clear and 1 = status present) b0 = field overvoltage, b1 = field overcurrent, b2 = generator undervoltage, b3 = generator overvoltage, b4 = underfrequency, b5 = in OEL, b6 = in UEL, b7 = in FCR mode, b8 = no sensing, b9 = setpoint lower limit, b10 = setpoint upper limit, b11 = generator failed to build up, b12 = generator below 10 Hz, b13 = field overtemperature, b14 = EDM open diode, b15 = EDM shorted diode</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40210</td>
<td>Protection status bit flags (0 = clear and 1 = status present) b0 = loss of field, b1 = in SCL, b2 = V/Hz, b3 = loss of FIT, b4 = power low, b5 = PSS V unbalance, b6 = PSS I unbalance, b7 = PSS power below threshold, b8 = PSS speed failure, b9 = PSS voltage limit, b10 = clock reset, b11 = loss of IRIG, b12-b15 = unassigned</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40211</td>
<td>Relay output states b0 = watchdog, b1 = on/off, b2 = Relay 1, b3 = Relay 2, b4 = Relay 3, b5 = Relay 4, b6 = Relay 5, b7 = Relay 6, b8-b15 = unused</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>40212 to 40250</td>
<td>Not used</td>
<td>R</td>
<td>Not Supported</td>
</tr>
<tr>
<td>40251</td>
<td>Phase A to B rms generator voltage</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40253</td>
<td>Phase B to C rms generator voltage</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40255</td>
<td>Phase C to A rms generator voltage</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40257</td>
<td>RMS bus voltage</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40259</td>
<td>Generator phase A current rms</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40261</td>
<td>Generator phase B current rms</td>
<td>R</td>
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</tr>
<tr>
<td>40263</td>
<td>Generator phase C current rms</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40265</td>
<td>Average generator line-to-line rms voltage</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40267</td>
<td>Average generator phase current</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40269</td>
<td>DC field voltage</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40271</td>
<td>DC field current</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40273</td>
<td>Auxiliary input volts</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40275</td>
<td>Magnitude of A-B voltage fundamental phasor</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40277</td>
<td>Magnitude of B-C voltage fundamental phasor</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40279</td>
<td>Magnitude of C-A voltage fundamental phasor</td>
<td>R</td>
<td>FLOAT</td>
</tr>
</tbody>
</table>
### Registers | Data Description | Access | Data Format
---|---|---|---
40281 | Magnitude of line A current fundamental phasor | R | FLOAT
40283 | Magnitude of line B current fundamental phasor | R | FLOAT
40285 | Magnitude of line C current fundamental phasor | R | FLOAT
40287 | Current input for load compensation | R | FLOAT
40289 | Angle between Vab and Vca | R | FLOAT
40291 | Angle between Vbc and Vca | R | FLOAT
40293 | Angle between Ia and Vca | R | FLOAT
40295 | Angle between Ib and Vca | R | FLOAT
40297 | Angle between Ic and Vca | R | FLOAT
40299 | Angle between laux and Vca | R | FLOAT
40301 | Generator real power | R | FLOAT
40303 | Generator reactive power | R | FLOAT
40305 | Generator apparent power | R | FLOAT
40307 | Generator power factor | R | FLOAT
40309 | Generator positive sequence voltage | R | FLOAT
40311 | Generator negative sequence voltage | R | FLOAT
40313 | Generator positive sequence current | R | FLOAT
40315 | Generator negative sequence current | R | FLOAT
40317 | Generator frequency | R | FLOAT
40319 | Bus frequency | R | FLOAT
40321 | Null Balance or tracking error | R | FLOAT
40323 | Active controller output | R | FLOAT
40325 | Error signal to autotracking loop | R | FLOAT
40327 | Rotor temperature | R | FLOAT
40329 | Shorted diode harmonic current | R | FLOAT
40331 | Open diode harmonic current | R | FLOAT
40333 | VAR/PF controller output | R | FLOAT
40335 | PSS terminal frequency deviation | R | FLOAT
40337 | PSS compensated frequency deviation | R | FLOAT
40339 | PSS washed out speed deviation | R | FLOAT
40341 | PSS washed out power deviation | R | FLOAT
40343 | PSS mechanical power filter output | R | FLOAT
40345 | PSS signal before phase lead/lag blocks | R | FLOAT
40347 | PSS signal after phase lead/lag blocks | R | FLOAT
40349 | PSS signal after terminal voltage limiter | R | FLOAT
40351 | Final PSS output including test signal | R | FLOAT
40353 to 40399 | Reserved for future C2 use | R | Not Supported

### Holding Registers for System Configuration

#### Table B-13. Information Category C3—System Configuration

<table>
<thead>
<tr>
<th>Registers</th>
<th>Data Description</th>
<th>Access</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>40401</td>
<td>Sensing Configuration</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>40402</td>
<td>Auxiliary Input Summing Mode</td>
<td>RW</td>
<td>UINT16</td>
</tr>
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<td>40403</td>
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<td>Motor/Generator Mode</td>
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<td>Auxiliary Input Function</td>
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<td>Generator PT Secondary Voltage</td>
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<td>Generator CT Primary Current</td>
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<td>Field Current Shunt Rating</td>
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<td>Field Voltage Isolation Module Input</td>
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<td>Bus PT Primary Voltage</td>
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<td>Maximum Field Flash Time</td>
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<td>Field Flash Dropout Level</td>
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<td>Internal Tracking Traverse Rate</td>
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<td>Brush Voltage Drop</td>
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**Holding Registers for Operating Mode Parameters**

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<td>SysInput.Comports.LowerEnabled</td>
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<td>40609</td>
<td>SysOption.LimiterMode</td>
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<td>SysOption.VoltMatchMode</td>
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<td>SysOption.OperatingMode (0=off, 1=PF, 2=var)</td>
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<td>40612</td>
<td>SysOption.UnitMode (0=stop, 1=start, 2=shutdown)</td>
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<td>SysOption.ControlMode (1=FCR, 2=AVR)</td>
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<td>SysOption.Input.IntTrackEnabled</td>
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<td>SysOption.Input.AutoTransferEnabled</td>
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<td>40617</td>
<td>SysOption.LoadCompMode (0=off, 1=droop, 2=L droop, 4=CCC)</td>
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<td>40618</td>
<td>SysInput.Comports.AlarmResetEnabled</td>
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<td>40619</td>
<td>SysOption.LossOfSensingMode</td>
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<td>40620</td>
<td>SysOption.NoSenseToFcrMode</td>
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<td>40621</td>
<td>SysInput.Comports.ExtTrackEnabled</td>
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<td>40622</td>
<td>SysOption.UnderFregMode</td>
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<td>SysInput.Comports.OelOptionEnabled</td>
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### Registers Data Description Access Data Format

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### Holding Registers for Setpoint Parameters

**Table B-15. Information Category C5—Setpoint Parameters**

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<th>Registers</th>
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<tr>
<td>40701</td>
<td>FCR preposition mode 1: 0=maintained, 1=release</td>
<td>RW</td>
<td>UINT16</td>
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<td>40702</td>
<td>AVR preposition mode 1: 0=maintained, 1=release</td>
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<td>VAR preposition mode 1: 0=maintained, 1=release</td>
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<td>40704</td>
<td>PF preposition mode 1: 0=maintained, 1=release</td>
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<td>FCR preposition mode 2: 0=maintained, 1=release</td>
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<td>40706</td>
<td>AVR preposition mode 2: 0=maintained, 1=release</td>
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<td>PF preposition mode 2: 0=maintained, 1=release</td>
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<td>40751</td>
<td>FCR (Field Current Regulator) mode setpoint in amps; adjustment range is determined by registers (40761-62) and (40769-70)</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40752</td>
<td>AVR (Automatic Voltage Regulator) mode setpoint in volts; adjustment range is determined by registers(40763-64) and (40771-72)</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40755</td>
<td>VAR mode setpoint in kvars; adjustment range is determined by registers (40765-66) and (40773-74)</td>
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<td>40757</td>
<td>PF mode setpoint; adjustment range is determined by registers (40767-68) and (40775-76)</td>
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<td>FLOAT</td>
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<tr>
<td>40759</td>
<td>Reactive Droop setting in % of rated generator voltage; adjustable from -30 to +30% in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40761</td>
<td>FCR minimum setpoint (in amps) = % of nominal x rated field current:(regs. 40801-02) x (regs. 40479-80) / 100</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40763</td>
<td>AVR minimum setpoint (in volts) = % of nominal x rated generator voltage:(regs. 40803-04) x (regs. 40473-74) / 100</td>
<td>R</td>
<td>FLOAT</td>
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<td>40765</td>
<td>VAR minimum setpoint (in kvars) = % of nominal x rated generator VA:(regs. 40805-06) x rated VA / 100</td>
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<td>FLOAT</td>
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<td>40767</td>
<td>PF minimum setpoint = registers 40807-08</td>
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<td>40769</td>
<td>FCR maximum setpoint (in amps) = % of nominal x rated field current:(regs. 40809-10) x (regs. 40479-80) / 100</td>
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<td>40771</td>
<td>AVR maximum setpoint (in volts) = % of nominal x rated generator voltage:(regs. 40811-12) x (regs. 40473-74) / 100</td>
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<td>40773</td>
<td>VAR maximum setpoint (in kvars) = % of nominal x rated generator VA:(regs. 40813-14) x rated VA / 100</td>
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<td>40775</td>
<td>PF maximum setpoint = registers 40815-16</td>
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<td>40777</td>
<td>FCR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40779</td>
<td>AVR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments</td>
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<td>40781</td>
<td>VAR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments</td>
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<td>40783</td>
<td>PF mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments</td>
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<td>40785</td>
<td>FCR mode setpoint preposition 1; adjustment range is determined by registers (40761-62) and (40769-70)</td>
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<td>FLOAT</td>
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<td>40787</td>
<td>AVR mode setpoint preposition 1; adjustment range is determined by registers (40763-64) and (40771-72)</td>
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<td>40789</td>
<td>VAR mode setpoint preposition 1; adjustment range is determined by registers (40765-66) and (40773-74)</td>
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<td>40791</td>
<td>PF mode setpoint preposition 1; adjustment range is determined by registers (40767-68) and (40775-76)</td>
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<td>40793</td>
<td>FCR mode setpoint step size = setpoint range / (traverse rate x 10):([(regs. 40769-70) - (regs. 40761-62)] / [(regs. 40777-78) x 10])</td>
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<td>FLOAT</td>
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<tr>
<td>40795</td>
<td>AVR mode setpoint step size = setpoint range / (traverse rate x 10):([(regs. 40771-72) - (regs. 40763-64)] / [(regs. 40779-80) x 10])</td>
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<tr>
<td>40797</td>
<td>VAR mode setpoint step size = setpoint range / (traverse rate x 10):([(regs. 40773-74) - (regs. 40765-66)] / [(regs. 40781-82) x 10])</td>
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<tr>
<td>40799</td>
<td>PF mode setpoint step size = setpoint range / (traverse rate x 10):[(2 + (regs. 40775-76) - (regs. 40767-68)) / [(regs. 40783-84) x 10]]</td>
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<td>FLOAT</td>
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<td>40801</td>
<td>FCR mode setpoint's minimum (in % of rated field current), adjustable from 0 to 100%, in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<td>40803</td>
<td>AVR mode setpoint's minimum (in % of rated generator output voltage), adjustable from 70 to 100%, in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40805</td>
<td>VAR mode setpoint's minimum (in % of rated generator VA), adjustable from -100 to +100%, in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<td>40807</td>
<td>PF mode setpoint's minimum, adjustable from 0.5 to 1.0, in .005 increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40809</td>
<td>FCR mode setpoint's maximum (in % of rated field current), adjustable from 100 to 120%, in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40811</td>
<td>AVR mode setpoint's maximum (in % of rated generator output voltage), adjustable from 100 to 110%, in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40813</td>
<td>VAR mode setpoint's maximum (in % of rated generator VA), adjustable from -100 to +100%, in .1% increments</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>40815</td>
<td>PF mode setpoint's maximum, adjustable from -1.0 to -0.5, in .005 increments</td>
<td>RW</td>
<td>FLOAT</td>
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<td>40817</td>
<td>Minimum value for FCR mode setpoint's adjustable minimum (in % of rated field current) = 0%</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40819</td>
<td>Minimum value for AVR mode setpoint's adjustable minimum (in % of rated generator output voltage) = 70%</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40821</td>
<td>Minimum value for VAR mode setpoint's adjustable minimum (in % of rated generator VA) = -100%</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40823</td>
<td>Minimum value for PF mode setpoint's adjustable minimum</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40825</td>
<td>Maximum value for FCR mode setpoint's adjustable maximum (in % of rated field current) = 120%</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40827</td>
<td>Maximum value for AVR mode setpoint's adjustable maximum (in % of rated generator output voltage) = 110%</td>
<td>R</td>
<td>FLOAT</td>
</tr>
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<td>40829</td>
<td>Maximum value for VAR mode setpoint's adjustable maximum (in % of rated generator VA) = 100%</td>
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<td>FLOAT</td>
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<tr>
<td>40831</td>
<td>Maximum value for PF mode setpoint's adjustable maximum</td>
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<td>FLOAT</td>
</tr>
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<td>40833</td>
<td>Step size for FCR mode setpoint's adjustable maximum (in % of rated field current) = 0.1%</td>
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<td>FLOAT</td>
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<tr>
<td>40835</td>
<td>Step size for AVR mode setpoint's adjustable maximum (in % of rated generator output voltage) = 0.1%</td>
<td>R</td>
<td>FLOAT</td>
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<tr>
<td>40837</td>
<td>Step size for VAR mode setpoint's adjustable maximum (in % of rated generator VA) = 0.1%</td>
<td>R</td>
<td>FLOAT</td>
</tr>
<tr>
<td>40839</td>
<td>Step size for PF mode setpoint's adjustable maximum (in % of rated field current) = .005</td>
<td>R</td>
<td>FLOAT</td>
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<tr>
<td>40841</td>
<td>FCR mode setpoint preposition 2; adjustment range is determined by registers (40761-62) and (40769-70)</td>
<td>RW</td>
<td>FLOAT</td>
</tr>
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</table>
### Registers | Data Description | Access | Data Format
--- | --- | --- | ---
40843 | AVR mode setpoint preposition 2; adjustment range is determined by registers (40763-64) and (40771-72) | RW | FLOAT
40845 | VAR mode setpoint preposition 2; adjustment range is determined by registers (40765-66) and (40773-74) | RW | FLOAT
40847 | PF mode setpoint preposition 2; adjustment range is determined by registers (40767-68) and (40775-76) | RW | FLOAT
40849 | Line Drop Compensation Setpoint, adjustable from 0 to 30% in .1% increments | RW | FLOAT
40851 to 41149 | Reserved for future C5 use | R | Not Defined

### Holding Registers for Startup Parameters

**Table B-16. Information Category C6—Startup Parameters**

| Registers | Data Description | Access | Data Format |
--- | --- | --- | ---
41151 | Active Startup Setting Group | R | UINT16 |
41152 to 41170 | Not used | R | Not Defined |
41171 | Primary Generator Voltage Soft Start Bias | RW | FLOAT |
41173 | Primary Generator Voltage Soft Start Time | RW | FLOAT |
41175 | Underfrequency Setting (Corner Frequency) | RW | FLOAT |
41177 | V/Hz High Setting | RW | FLOAT |
41179 | V/Hz Low Setting | RW | FLOAT |
41181 | V/Hz Time Setting | RW | FLOAT |
41183 | Voltage Matching Band | RW | FLOAT |
41185 | Voltage Matching Level (Generator to Bus) | RW | FLOAT |
41187 | Fine Voltage Adjust Band | RW | FLOAT |
41189 | Loss of Sensing Time Delay | RW | FLOAT |
41191 | Loss of Sensing Balanced Level | RW | FLOAT |
41193 | Loss of Sensing Unbalanced Level | RW | FLOAT |
41195 | Reserved | RW | FLOAT |
41197 | Underfrequency Setting (Slope) | RW | FLOAT |
41199 to 41270 | Reserved for future C6 use | R | Not Defined |
41271 | Primary Generator Voltage Soft Start Bias | RW | FLOAT |
41273 | Primary Generator Voltage Soft Start Time | RW | FLOAT |
41275 to 41349 | Reserved for future C6 use | R | Not Defined |

### Holding Registers for Limiter Parameters

**Table B-17. Information Category C7—Limiter Parameters**

| Registers | Data Description | Access | Data Format |
--- | --- | --- | ---
41351 | Active OEL Limiter Setting Group | R | UINT16 |
41352 | OEL Low Value Gate Count | RW | UINT16 |
41353 | OEL Time Delay Count | RW | UINT16 |
41354 | OEL Override | RW | UINT16 |
41355 to 41360 | Not used | R | Not Defined |
41361 | Primary On-Line OEL Setting - High Current Level | RW | FLOAT |
41363 | Primary On-Line OEL Setting - High Current Time | RW | FLOAT |
41365 | Primary On-Line OEL Setting - Medium Current Level | RW | FLOAT |
41367 | Primary On-Line OEL Setting - Medium Current Time | RW | FLOAT |
41369 | Primary On-Line OEL Setting - Low Current Level | RW | FLOAT |
41371 | Primary Off-Line OEL Setting High Current Level | RW | FLOAT |
41373 | Primary Off-Line OEL Setting Low Current Level | RW | FLOAT |
41375 | Primary Off-Line OEL Setting High Current Time | RW | FLOAT |
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<th>Registers</th>
<th>Data Description</th>
<th>Access</th>
<th>Data Format</th>
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<td>41377</td>
<td>Primary Takeover Off-Line OEL High Current Level</td>
<td>RW</td>
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<td>Primary Takeover Off-Line OEL Low Current Level</td>
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### Holding Registers for Gain Parameters

**Table B-18. Information Category C8—Gain Parameters**

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<td>Primary AVR/FCR - Proportional Gain Kp</td>
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<td>42505</td>
<td>Primary AVR/FCR - Integral Gain Ki</td>
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<td>Primary AVR/FCR - Derivative Gain Kd</td>
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<td>PF - Integral Gain Ki</td>
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### Holding Registers for Protection Function Parameters

**Table B-19. Information Category C9—Protection Function Parameters**

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<td>Primary Generator Undervoltage</td>
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<td>Primary Loss of Field Isolation Transducer</td>
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<td>R</td>
<td>Not Defined</td>
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<td>43024</td>
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<td>43025</td>
<td>Active Protection Setting Group</td>
<td>R</td>
<td>UINT16</td>
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<td>43026</td>
<td>Primary Field Overvoltage Level</td>
<td>RW</td>
<td>FLOAT</td>
</tr>
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<td>43028</td>
<td>Primary Field Overcurrent Level</td>
<td>RW</td>
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</tr>
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<td>43030</td>
<td>Primary Generator Undervoltage Level</td>
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<tr>
<td>43032</td>
<td>Primary Generator Overvoltage Level</td>
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</tr>
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<td>43034</td>
<td>Primary Field Overvoltage Time Delay</td>
<td>RW</td>
<td>FLOAT</td>
</tr>
<tr>
<td>43036</td>
<td>Primary Field Overcurrent Time Delay</td>
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</tr>
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<td>43038</td>
<td>Primary Generator Undervoltage Time Delay</td>
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<td>43040</td>
<td>Primary Generator Overvoltage Time Delay</td>
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<td>43042</td>
<td>Primary Field Over Temperature Level</td>
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<td>43044</td>
<td>Primary Field Over Temperature Time Delay</td>
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<td>43046</td>
<td>Primary Loss of Field Level</td>
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<td>43048</td>
<td>Primary Loss of Field Time Delay</td>
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<td>43050</td>
<td>Primary Loss of Field Isolation Transducer Level</td>
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<td>43052</td>
<td>Primary Loss of Field Isolation Transducer Time Delay</td>
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<td>43054</td>
<td>Primary Power Low Level</td>
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<td>43056</td>
<td>Primary Power Low Time Delay</td>
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<tr>
<td>43058 to</td>
<td>Reserved for future C9 use</td>
<td>R</td>
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<tr>
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<tr>
<td>43126</td>
<td>Secondary Exciter Field Overvoltage</td>
<td>R</td>
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<td>Secondary Exciter Field Overcurrent</td>
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### Holding Registers for Exciter Diode Monitor Parameters

**Table B-20. Information Category C10—Exciter Diode Monitor Parameters**

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<td>Primary Number of Main Poles</td>
<td>RW</td>
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<td>Primary Number of Exciter Poles</td>
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<td>43378</td>
<td>Primary Open Diode Monitoring</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43379</td>
<td>Primary Shorted Diode Monitoring</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43380 to</td>
<td>Not used</td>
<td>R</td>
<td>Not Defined</td>
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<td>43400</td>
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<td>43401</td>
<td>Primary Open Diode Pickup Level</td>
<td>RW</td>
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<tr>
<td>43403</td>
<td>Primary Shorted Diode Pickup Level</td>
<td>RW</td>
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<tr>
<td>43405</td>
<td>Primary Disable Open Diode Level</td>
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<td>FLOAT</td>
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<tr>
<td>43407</td>
<td>Primary Open Diode Detection Time Delay</td>
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<tr>
<td>43409</td>
<td>Primary Shorted Diode Detection Time Delay</td>
<td>RW</td>
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<tr>
<td>43411</td>
<td>Primary Pole Ratio of Exciter Field to Main Field</td>
<td>RW</td>
<td>FLOAT</td>
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<tr>
<td>43413</td>
<td>Deadband - not used</td>
<td>RW</td>
<td>FLOAT</td>
</tr>
<tr>
<td>43415</td>
<td>Primary Open Diode Smoothing Filter Coefficient</td>
<td>RW</td>
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<tr>
<td>43417</td>
<td>Primary Shorted Diode Smoothing Filter Coefficient</td>
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### Registers and Data Description

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<td>43419 to 43449</td>
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<td>43451</td>
<td>Secondary Number of Main Poles</td>
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<td>43452</td>
<td>Secondary Number of Exciter Poles</td>
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<td>43453</td>
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<td>43454</td>
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<td>43455 to 43475</td>
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<td>Secondary Open Diode Pickup Level</td>
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<td>43478</td>
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<td>43482</td>
<td>Secondary Open Diode Detection Time Delay</td>
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<td>43484</td>
<td>Secondary Shorted Diode Detection Time Delay</td>
<td>RW</td>
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<tr>
<td>43486</td>
<td>Secondary Pole Ratio of Exciter Field to Main Field</td>
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<td>FLOAT</td>
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<td>43488</td>
<td>Deadband - not used</td>
<td>RW</td>
<td>FLOAT</td>
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<td>43490</td>
<td>Secondary Open Diode Smoothing Filter Coefficient</td>
<td>RW</td>
<td>FLOAT</td>
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<td>43492</td>
<td>Secondary Shorted Diode Smoothing Filter Coefficient</td>
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### Holding Registers for Relay Parameters

**Table B-21. Information Category C11—Relay Parameters**

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<td>43526</td>
<td>Relay 1 State</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43527</td>
<td>Relay 1 Contact Type</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43528</td>
<td>Relay 1 Contact Status</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43529</td>
<td>Relay 1 Momentary Time</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43530 to 43575</td>
<td>Reserved for future C11 use</td>
<td>R</td>
<td>Not Defined</td>
</tr>
<tr>
<td>43576</td>
<td>Relay 2 State</td>
<td>RW</td>
<td>UINT16</td>
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<td>43577</td>
<td>Relay 2 Contact Type</td>
<td>RW</td>
<td>UINT16</td>
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<tr>
<td>43578</td>
<td>Relay 2 Contact Status</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43579</td>
<td>Relay 2 Momentary Time</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43580 to 43625</td>
<td>Reserved for future C11 use</td>
<td>R</td>
<td>Not Defined</td>
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<tr>
<td>43626</td>
<td>Relay 3 State</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>43627</td>
<td>Relay 3 Contact Type</td>
<td>RW</td>
<td>UINT16</td>
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<td>Relay 3 Contact Status</td>
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<td>UINT16</td>
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<td>Relay 3 Momentary Time</td>
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<td>UINT16</td>
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<td>43630 to 43675</td>
<td>Reserved for future C11 use</td>
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<td>Not Defined</td>
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<td>43676</td>
<td>Relay 4 State</td>
<td>RW</td>
<td>UINT16</td>
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<td>43677</td>
<td>Relay 4 Contact Type</td>
<td>RW</td>
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<td>43678</td>
<td>Relay 4 Contact Status</td>
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<td>43679</td>
<td>Relay 4 Momentary Time</td>
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<td>UINT16</td>
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<td>43680 to 43725</td>
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<td>Relay 5 State</td>
<td>RW</td>
<td>UINT16</td>
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<td>43727</td>
<td>Relay 5 Contact Type</td>
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<td>UINT16</td>
</tr>
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<td>43728</td>
<td>Relay 5 Contact Status</td>
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<td>Relay 5 Momentary Time</td>
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<td>UINT16</td>
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<td>43730 to 43775</td>
<td>Reserved for future C11 use</td>
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<td>Not Defined</td>
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<td>Relay 6 State</td>
<td>RW</td>
<td>UINT16</td>
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<td>43777</td>
<td>Relay 6 Contact Type</td>
<td>RW</td>
<td>UINT16</td>
</tr>
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<td>43778</td>
<td>Relay 6 Contact Status</td>
<td>RW</td>
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<td>Relay 6 Momentary Time</td>
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</tr>
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<td>43780 to 44125</td>
<td>Reserved for future C11 use</td>
<td>R</td>
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### Holding Registers for General ASCII and Modbus Communication Parameters

**Table B-22. Information Category C12—General ASCII and Modbus Communication Parameters**

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<tr>
<th>Registers</th>
<th>Data Description</th>
<th>Access</th>
<th>Data Format</th>
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<tbody>
<tr>
<td>44126</td>
<td>Baud rate of Front communication port 0, RS-232, Data Range: 1200, 2400, 4800, 9600, 19200, Default 9600</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>44127</td>
<td>Baud rate of Rear communication port 1, RS-485, Data Range: 1200, 2400, 4800, 9600, 19200, Default 9600</td>
<td>R</td>
<td>UINT16</td>
</tr>
<tr>
<td>44128</td>
<td>Baud rate of Rear communication port 2, RS-485, Data Range: 4800, 9600, 19200, Default 9600</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44129</td>
<td>Modbus port Parity, valid only for Rear RS-485 port. ‘O’ = 79 = 0x4F for Odd Parity, ‘E’ = 69 = 0x45 or Even Parity, and ‘N’ = 78 = 0x4E for None</td>
<td>RW</td>
<td>UINT8</td>
</tr>
<tr>
<td>44130</td>
<td>Modbus port Stop Bits, 1 for 1 Stop Bit, 2 for 2 Stop bits, Default value: 2</td>
<td>RW</td>
<td>UINT8</td>
</tr>
<tr>
<td>44131</td>
<td>DECS400 Polling Address, valid only for Rear RS-485 port. 0 for Broadcast address, 1 to 247 for slave address, Default: 247</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44132</td>
<td>Modbus Response Delay Time Parameter in ms (Default value: 10ms) Data Range 0-200, step size 10</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44133</td>
<td>System Clock Month</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44134</td>
<td>System Clock Day</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44135</td>
<td>System Clock Year</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44136</td>
<td>System Clock Daylight Savings Time, 0 = Daylight Savings Time On, 1 = Daylight Savings Time Off</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44137</td>
<td>System Clock Hour</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44138</td>
<td>System Clock Minute</td>
<td>RW</td>
<td>UINT16</td>
</tr>
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<td>44139</td>
<td>System Clock Second</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44140</td>
<td>System Clock Time Format, 0 = 12 hour format, 1 = 24 hour format.</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44141</td>
<td>System Clock AM/PM. ‘A’ = 65 = 0x41 for AM, ‘P’ = 80 = 0x50 for PM, ‘X’ = 58 = 0x3A for none</td>
<td>RW</td>
<td>UINT16</td>
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<td>44142 to 44200</td>
<td>Reserved for future C12 use</td>
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### Holding Registers for Metering Parameters, Group 2

**Table B-23. Information Category C13—Metering, Group 2**

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<td>44201</td>
<td>1st Metering Display Field</td>
<td>RW</td>
<td>UINT16</td>
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<tr>
<td>44202</td>
<td>2nd Metering Display Field</td>
<td>RW</td>
<td>UINT16</td>
</tr>
<tr>
<td>44203</td>
<td>3rd Metering Display Field</td>
<td>RW</td>
<td>UINT16</td>
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<tr>
<td>44204 to 44250</td>
<td>Reserved for future C13 use</td>
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### Holding Registers for Power System Stabilizer Parameters

**Table B-24. Information Category C14—PSS Parameters**

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<td>44251</td>
<td>PSS Algorithm</td>
<td>RW</td>
<td>UINT16</td>
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<td>44252</td>
<td>Active PSS Setting Group</td>
<td>R</td>
<td>UINT16</td>
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<td>44253</td>
<td>PSS Testing Status</td>
<td>R</td>
<td>UINT16</td>
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<td>44254 to 44259</td>
<td>Not used</td>
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<td>Not Defined</td>
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<td>44260</td>
<td>Primary PSS Software Switch 0</td>
<td>RW</td>
<td>UINT16</td>
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<tr>
<td>44261</td>
<td>Primary PSS Software Switch 1</td>
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<td>44262</td>
<td>Primary PSS Software Switch 2</td>
<td>RW</td>
<td>UINT16</td>
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<td>44263</td>
<td>Primary PSS Software Switch 3</td>
<td>RW</td>
<td>UINT16</td>
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<td>44264</td>
<td>Primary PSS Software Switch 4</td>
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<td>UINT16</td>
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<td>44265</td>
<td>Primary PSS Software Switch 5</td>
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<td>44266</td>
<td>Primary PSS Software Switch 6</td>
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<td>Primary PSS Software Switch 7</td>
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<td>Primary PSS Software Switch 8</td>
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<td>Primary PSS Software Switch 9</td>
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<td>Primary PSS High Pass Filter Time Constant Tw1</td>
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<td>Primary PSS High Pass Filter Time Constant Tw2</td>
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<td>Primary PSS Unit Inertia</td>
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<td>Primary Low Pass Filter Time Constant T1</td>
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<td>Primary Phase Comp. First Phase Lead t1</td>
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<td>Primary Phase Comp. First Phase Lag t2</td>
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<td>Primary Phase Comp. Second Phase Lead t3</td>
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<td>Primary Phase Comp. Third Phase Lead t5</td>
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<td>Primary Phase Comp. Third Phase Lag t6</td>
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<td>Primary Phase Comp. Fourth Phase Lead t7</td>
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<td>Primary Phase Comp. Fourth Phase Lag t8</td>
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<td>Primary Terminal Voltage Limiter Time Constant</td>
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<td>Primary Terminal Voltage Limiter Set Point</td>
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<td>Primary Torsional Filter #1 Zeta Numerator</td>
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<td>Primary Torsional Filter #1 Zeta Denominator</td>
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