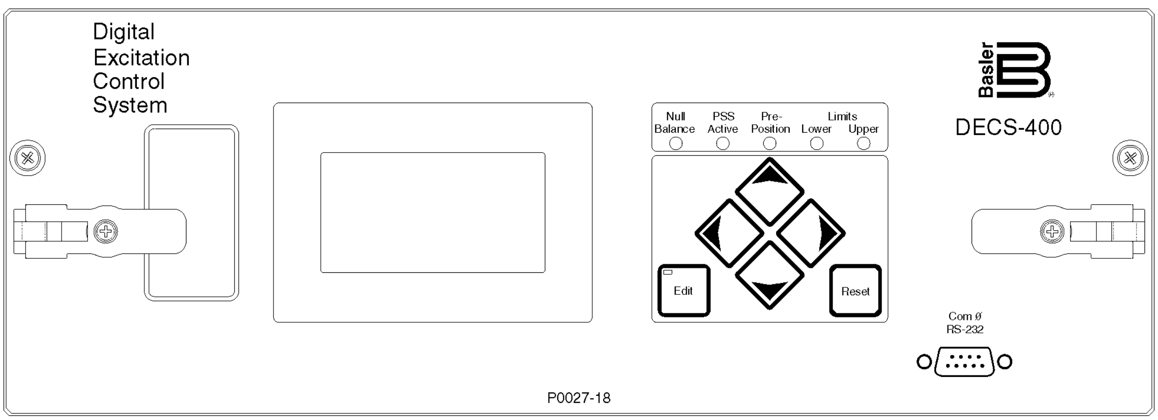
DECS-400

Digital Excitation Control System

Instruction Manual



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Preface

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

- General Information
- Controls and Indicators
- Functional Description
- BESTCOMS Software
- Installation
- Commissioning
- Maintenance and Troubleshooting
- Specifications
- Modbus® Protocol
- Math model

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Conventions Used in this Manual

Important safety and procedural information is emphasized and presented in this manual through warning, caution, and note boxes. Each type is illustrated and defined as follows.

Warning!
Warning boxes call attention to conditions or actions that may cause personal injury or death.

Caution
Caution boxes call attention to operating conditions that may lead to equipment or property damage.

Note
Note boxes emphasize important information pertaining to installation or operation.

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Warning!

READ THIS MANUAL. Read this manual before installing, operating, or maintaining the DECS-400. Note all warnings, cautions, and notes in this manual as well as on the product. Keep this manual with the product for reference. Only qualified personnel should install, operate, or service this system. Failure to follow warning and cautionary labels may result in personal injury or property damage. Exercise caution at all times.

Contents

1 • General Information

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/2B/2C, 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.

- Five excitation control modes:
    - Automatic Voltage Regulation (AVR)
    - Field Current Regulation (FCR)
    - Field Voltage Regulation (FVR)
    - Power Factor (PF)
    - Var
- Two pre-position setpoints (with adjustable traverse rate) 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
- Optional integrated power system stabilizer (IEEE Std 421.5 type PSS2A/2B/2C):
    - 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
- Five limiting functions:
    - Stator current
    - Overexcitation
    - Underexcitation
    - Underfrequency compensation
    - Reactive power
- 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:
  - Six fixed-function inputs: AVR, Manual, Lower, Raise, Start, and Stop
  - Ten user-programmable inputs
- Eight contact outputs:
  - Two fixed-function outputs: Watchdog, On/Off
  - Six user-programmable outputs, configurable for maintained, latched, or momentary operation
- Five communication ports:
  - Front RS-232 port for interface with PC running BESTCOMS software
  - Rear RS-485 port for dedicated communication with secondary, redundant DECS-400
  - Rear RS-485 port using Modbus® protocol for communication with remote terminal
  - Rear RJ-11 jack connects to onboard modem that provides dial-in and dial-out capability
  - Rear RJ-45 jack provides Ethernet network communication
- Data logging, sequence of events recording, and trending

Generator 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 provides 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 from 0 to 3 PU V/Hz in 0.1 hertz increments. The frequency roll-off knee-point 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 Manual 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. A Line Drop Compensation setting allows the DECS-400 to compensate for line drop between parallel generators.

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 mAdc or ±10 Vdc
- 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). An adjustable traverse rate setting can be used to control the rate at which the setpoint is driven toward the pre-position operating point. This feature allows the DECS-400 to be configured for multiple system and application needs.

Manual Operating Modes

The DECS-400 has two manual modes of operation: Field Current Regulation (FCR) and Field Voltage Regulation (FVR).

Field Current Regulation Mode

When operating in FCR mode, the DECS-400 regulates the dc output current of the power bridge. Because regulation of the field current is not dependent upon a generator voltage sensing input to the

DECS-400, FCR mode can provide backup excitation control when a loss of sensing is detected. In FCR mode, as the generator load varies, the operator must manually vary the field current to maintain nominal generator voltage.

Field Voltage Regulation Mode

When operating in FVR mode, the DECS-400 regulates the dc output voltage of the power bridge. FVR enables the user to perform generator modeling and validation testing in accordance with WECC testing requirements for bus-fed (shunt type) excitation systems. FVR mode can also be used to smooth the transfer from the active exciter to a backup exciter.

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.

Underexcitation Limiter

The underexcitation limiter (UEL) 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 and when the DECS-400 is off-line (52 J/K and 52 L/M contact inputs are closed). 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.

Reactive Power Limiter

The var limiter accommodates applications where the prime mover (turbine) has been uprated but the generator ratings are unchanged. In this case, the generator power factor is increased and the generator is var limited. The var limiter is available for these applications to limit reactive power flow out of the generator to a safe 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 are listed below. Functions marked with an asterisk (∗) have dual setting groups.

- 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

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 (OEL enable, UEL enable, etc.), and PSS functions. BESTCOMS provides a tool for customizing the system control logic for specific applications.

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. A file converter within BESTCOMS enables conversion of DECS-300 settings files for use with the DECS-400.

An RS-485 port on the rear panel supports Modbus® (floating point) communication protocol. Modbus® 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 Ethernet port on the rear panel enables communication with the DECS-400 over a TCP/IP network. Ethernet support in the DECS-400 enables remote access to DECS-400 settings and data through Modbus TCP or BESTCOMS. DECS-400 time synchronization with a network time server is also possible.

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.

Upgrading from DECS-300 to DECS-400

The upgrading process was designed to be easy, but some additional wiring may be necessary. An escutcheon plate for easy installation is recommended (see the *Installation* chapter). To make the upgrade process easier, BESTCOMS software for the DECS-400 provides a tool to convert a DECS-300 settings file to a DECS-400 settings file (see the *BESTCOMS Software* chapter).

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.

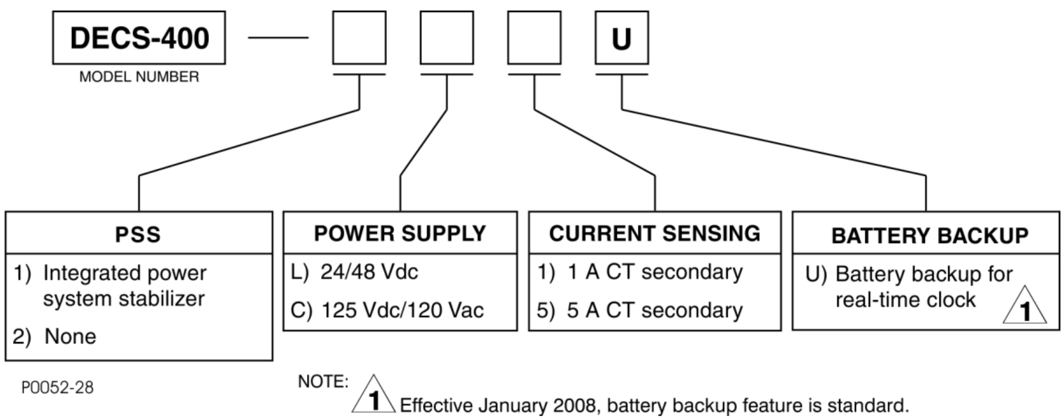


Figure 1-1. DECS-400 Style Chart

2 • Human-Machine Interface

This chapter 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.

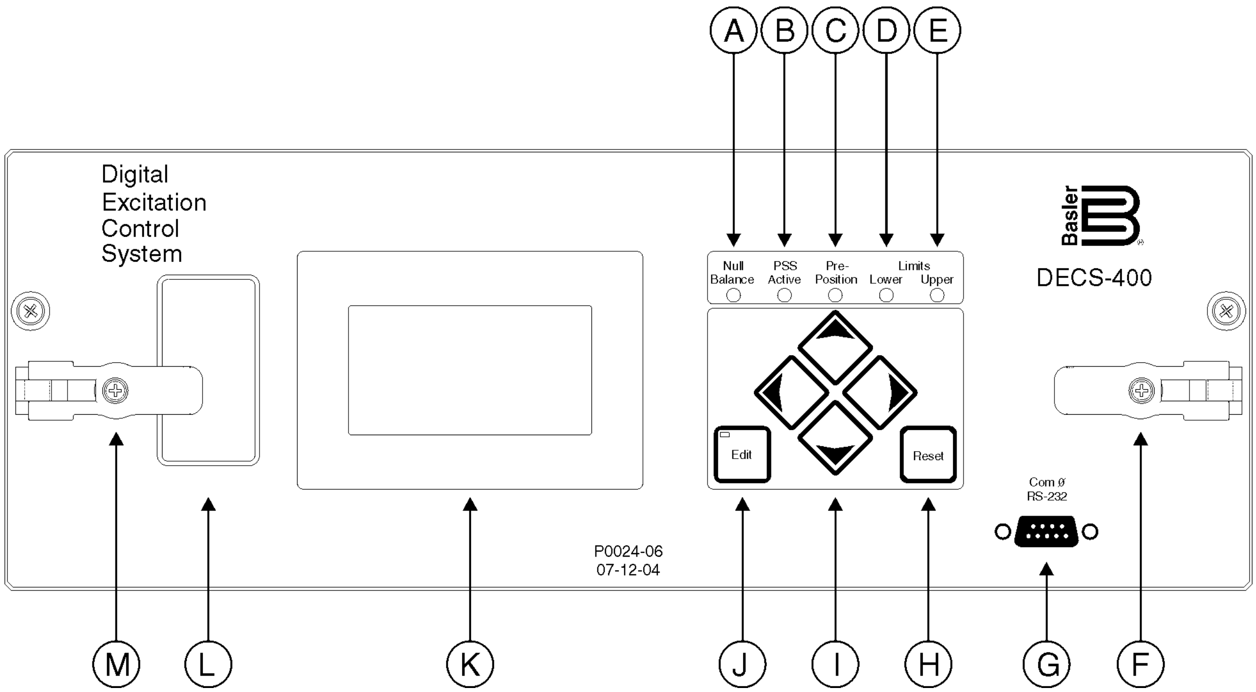


Figure 2-1. Controls and Indicators

Table 2-1. Control and Indicator Descriptions

Locator	Description
A	*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.
B	*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.
C	*Pre-Position Indicator.* This LED lights when the setpoint of the active operating mode is at either of the two pre-position setting levels.
D	*Lower Limit Indicator.* This LED lights when the setpoint of the active operating mode is decreased to the lower setpoint limit.
E	*Upper Limit Indicator.* This LED lights when the setpoint of the active operating mode is increased to the upper setpoint limit.
F	*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.

Locator	Description
G	*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).
H	*Reset Pushbutton.* This button is pressed to reset DECS-400 alarms or cancel a settings editing session.
I	*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.
J	*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.
K	*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.
L	*Identification Label.* The identification label contains information such as the model, style, and serial numbers and operating power and sensing current ratings.
M	*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 nine 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.* The power system stabilizer menu consists of four sub-menus which include Control, Parameters, Limiters, and Configuration.
8. *System Parameters*. The system parameters menu consists of nine sub-menus which include Generator Data, Field Data, Transformers, Configuration, Output Contacts, Traverse Rates, Pre-position Modes, Startup, and Tracking.
9. *General Settings.* The general settings menu consists of three sub-menus which include Communications, LCD Contrast, and Real-Time Clock.

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 push-buttons.

A detailed list of the menu system screens is provided below. The menu paths appear on the left and the settings appear on the right.

\D400\OPER	**OPERATING**
\OPERATE_1 START/STOP AVR/MANUAL PF OR VAR FCR OR FVR PREPOSN 1 PREPOSN 2	
\OPERATE_2 VOLT MATCH INT TRACK EXT TRACK CROSS CURNT LINE DROP DROOP	
\OPERATE_3 INNER LP	

\D400\SETPT	**SETPOINTS**
\MODE_SET1 AVR MODE FCR MODE DROOP VAR MODE PF MODE FVR MODE	
\MODE1\RANGE_1 FINE V BD AVR MIN AVR MAX FCR MIN FCR MAX KW LVL TRNS	
\MODE1\RANGE_2 MIN VAR OUT MAX VARA OUT MAX LAG PF MAX LEAD PF	

FVR MIN
FVR MAX

\MODE1\RANGE_3
V MATCH BD
V MATCH REF

\MODE_SET2
LINE DROP

\PREP_SET1
AVR MODE
FCR MODE
VAR MODE
PF MODE
FVR MODE

\PREP_SET2
AVR MODE
FCR MODE
VAR MODE
PF MODE
FVR MODE

\D400\GAIN **LOOP GAINS**

\P_AVR_GAINS
PRI STB RG
AVR Kp
AVR Ki
AVR Kd
AVR Td
AVR Kg

\AVRG1\S_AVR_GAINS
SEC STB RG
AVR Kp
AVR Ki
AVR Kd
AVR Td
AVR Kg

\P_FCR_GAINS
FCR Kp
FCR Ki
FCR Kd
FCR Td
FCR Kg

\P_FVR_GAINS
FVR Kp
FVR Ki
FVR Kd
FVR Td
FVR Kg

\LIM_GAINS
OEL Ki
OEL Kg
UEL Ki
UEL Kg
SCL Ki
SCL Kg

\LIMGN\\LIM_GAINS2
VARL Ki
VARL Kg

\CTL_GAINS
PF Ki
PF Kg
VAR Ki
VAR Kg
V MATCH Kg

\IN_LP_GAINS
INNER LP Ki
INNER LP Kg

\D400_METERING **METERING**

See *Metering Screen, Metering Values* for a list of the parameters available for display.

\D400_PROT **PROTECTION**

\V/HZ_PROT1
V/HZ ENABLE
V/HZ PCKUP
TIME DIAL
RESET DIAL
DLAY1 PKUP
DLAY1 TIME

\V/HZ_PROT2
DLAY2 PKUP
DLAY2 TIME
CURVE EXP

\PROT_ENAB1
FIELD OV
FIELD OC
STATOR OV
STATOR UV
NO SENSING
NO SNS->MAN

\ENAB1\S_PROT_ENE
FIELD OV
FIELD OC
STATOR OV
STATOR UV
FIELD OT
LOSS FIELD

\PROT_ENAB2
FIELD OT
LOSS FIELD
FIT FAILED
POWER LOW
EX DIOD OD
EX DIOD SD

\P_PROT_LVL1
FIELD OV
FIELD OC
STATOR OV
STATOR UV
FIELD OT
LOS BAL V

\P_PROT_LVL1
FIELD OV
FIELD OC
STATOR OV

STATOR UV
FIELD OT
LOSS FIELD

\P_PROT_LVL2
LOS IMBAL V
LOSS FIELD
EDM OD RPL
EDM SD RPL
EDM INH LVL

\P_PROT_TMR1
FIELD OV
FIELD OC TD
STATOR OV
STATOR UV
NO SENSING
FIELD OT

\P_TM1\S_PROT_TMR1
FIELD OV
FIELD OC TD
STATOR OV
STATOR UV
FIELD OT
LOSS FIELD

\P_PROT_TMR2
LOSS FIELD
FIT FAILED
EX DIOD OD
EX DIOD SD

\D400\LIMIT **LIMITERS**

\OPTION_1
OEL STYLE
OEL OPTION
UEL STYLE
OEL GROUP
UEL GROUP
SCL GROUP

\OPTION_2
UF OR V/HZ
OEL ENABLE
UEL ENABLE
SCL ENABLE
UEL FLTR TC
UEL VOL EXP

\P_ONLINE
INST LIMIT
INST TIME
MED LIMIT
MED TIME
CONT LIMIT

\P_ONL\S_ONLINE
INST LIMIT
INST TIME
MED LIMIT
MED TIME
CONT LIMIT

\P_OFFLINE

OEL HI LIM
HI LIM TIME
OEL LO LIM

\P_OFL\S_OFFLINE
- OEL HI LIM
- HI LIM TIME
- OEL LO LIM

\P_OFFTAKOVR
- OEL MAX CUR
- OEL MIN CUR
- OEL TD

\P_OFT\S_OFFTAKOVR
- OEL MAX CUR
- OEL MIN CUR
- OEL TD

\P_ONTAKOVR
- OEL MAX CUR
- OEL MIN CUR
- OEL TD

\P_ONT\S_ONTAKOVR
- OEL MAX CUR
- OEL MIN CUR
- OEL TD

\P_UEL_CRV_X
- PNT 1 WATTS
- PNT 2 WATTS
- PNT 3 WATTS
- PNT 4 WATTS
- PNT 5 WATTS

\P_UEX\S_UEL_CRV_X
- PNT 1 WATTS
- PNT 2 WATTS
- PNT 3 WATTS
- PNT 4 WATTS
- PNT 5 WATTS

\P_UEL_CRV_Y
- PNT 1 VARS
- PNT 2 VARS
- PNT 3 VARS
- PNT 4 VARS
- PNT 5 VARS

\S_UEL_CRV_Y
- PNT 1 VARS
- PNT 2 VARS
- PNT 3 VARS
- PNT 4 VARS
- PNT 5 VARS

\P_SCLIM
- SCL HI LIM
- HI LIM TIME
- SCL LO LIM
- INIT DELAY

\P_SCL\S_SCLIM
- SCL HI LIM
- HI LIM TIME
- SCL LO LIM
- INIT DELAY

\VARLM
- VARL ENABLE
- PRI SETPOINT
- PRI INITDLY
- SEC SETPNT
- SEC INITDLY
- VARL GROUP

\UF_V/HZ
- CORNER FREQ
- UF SLOPE
- V/HZ HI
- V/HZ LO
- V/HZ TIME

\D400\PSS **POWER SYSTEM STABILIZER**

\CONTROL
- PSS CONTROL

\P_BASIC_CTL
- SETTING GRP
- TM PWRN TLD
- TM PWR HYST

\P_CTL\S_BASIC_CTL
- SECONDARY
- TM PWRN TLD
- TM PWR HYST

\P_SOFT_SW1
- SSW 0
- SSW 1
- SSW 2
- SSW 3
- SSW 4
- SSW 5

\P_SS1\S_SOFT_SW2
- SSW 0
- SSW 1
- SSW 2
- SSW 3
- SSW 4
- SSW 5

\P_SOFT_SW2
- SSW 6
- SSW 7
- SSW 8
- SSW 9
- SSW 10

\P_SS2\S_SOFT_SW2
- SSW 6
- SSW 7
- SSW 8
- SSW 9
- SSW 10

\D400\PSS\PARAMETER
- PSS PARAMETERS

\P_FILTER1
- QUADTURE XQ
- SCALER KPE
- LP FLTR T11

LP FLTR T12
LP FLTR T13
RT FLTR TR

\P_FTR\S_FILTER
QUADTURE XQ
SCALER KPE
LP FLTR T11
LP FLTR T12
LP FLTR T13
RT FLTR TR

\P_FILTER2
HP FLTR H
HP FLTR TW1
HP FLTR TW2
HP FLTR TW3
HP FLTR TW4

\P_FTR\S_FILTER2
HP FLTR H
HP FLTR TW1
HP FLTR TW2
HP FLTR TW3
HP FLTR TW4

\P_FILTER3
NUM EXP N
NUM EXP M

\P_FTR\S_FILTER3
SECONDARY FILTER 3
NUM EXP N
NUM EXP M

\P_TRSN_FLTR
FILTER 1 ZN
FILTER 1 ZD
FILTER 1 WN
FILTER 2 ZN
FILTER 2 ZD
FILTER 2 WN

\P_TSN\S_TRSN_FLTR
FILTER 1 ZN
FILTER 1 ZD
FILTER 1 WN
FILTER 2 ZN
FILTER 2 ZD
FILTER 2 WN

\P_PHSE_COMP1
PHASE 1 TLD
PHASE 1 TLG
PHASE 2 TLD
PHASE 2 TLG

\S_PHSE_COMP1
PHASE 1 TLD
PHASE 1 TLG
PHASE 2 TLD
PHASE 2 TLG

\P_PHSE_COMP2
PHASE 3 TLD
PHASE 3 TLG
PHASE 4 TLD

PHASE 4 TLG

\S_PHSE_COMP2
PHASE 3 TLD
PHASE 3 TLG
PHASE 4 TLD
PHASE 4 TLG

\D400\PSS\LIMTERS
PSS LIMITERS

\P_OUTPUT_LMT
UPPER LIMIT
LOWER LIMIT
GAIN

\S_OUTPUT_LMT
UPPER LIMIT
LOWER LIMIT
GAIN

\P_VOLT_LIMIT
TIME CONST
SETPOINT

\P_VLT\S_VOLT_LMT
TIME CONST
SETPOINT

\P_LOGIC_LMT
FLTR NRM TM
FLTR LMT TM
OUT UPR LMT
OUT LWR LMT
OUT TM DLY

\P_LOG\S_LOGIC_LMT
FLTR NRM TM
FLTR LMT TM
OUT UPR LMT
OUT LWR LMT
OUT TM DLY

\D400\PSS\CONFIG
PSS CONFIGURATION

\CNFG SET GP
SETTING GROUP CONFIGURATION
PWR TLD ENA
SG PWR TLD
ST PWR HYST

\PSS_ROC
ROC ENABLE
ROC THRESH
ROC TM DLY
ROC BLKTIM
ROC LPF TC
ROC WF TC

\D400\SYSTEM **SYSTEM PARAMETERS**

\GENERATOR
GENERATOR DATA

\GEN\GEN_DATA
RATED VOLT
FREQUENCY
RATED KVA

\FIELD_DATA

FIELD DATA
\FIELD_DATA1 FIELD VOLT FIELD CURR SHUNT RATING ISOL BOX IN FIELD RES AMB TEMP
\FIELD_DATA_2 BRUSH DROP POLE RATIO
\TRNSFRMRS TRANSFORMERS
\XFMRS\XFMR_DATA GEN PT PRI GEN PT SEC BUS PT PRI BUS PT SEC GEN CT PRI GEN CT SEC
\CONFIGURE CONFIGURATION
\CONFG\CNFG_DATA_1 FIELD TYPE VLTAGE SNSE MOTOR MODE CURRNT SNSE CT SELECT
\CNFG\CNFG_DATA_2 CTRL SIGNAL AUX IN TYPE AUX IN FCTN CRSS I GAIN TEMP MODE
\AUX_GAINS AVR MODE FCR MODE VAR MODE PF MODE FVR MODE INNER/OUTER
\CONTACTS OUTPUT CONTACTS
\CNTCT\RELAY_1 OUTPT SENSE OUTPUT TYPE MOMENT TIME
\CNTCT\RELAY_2 OUTPT SENSE OUTPUT TYPE MOMENT TIME
\CNTCT\RELAY_3 OUTPT SENSE OUTPUT TYPE MOMENT TIME
\CNTCT\RELAY_4 OUTPT SENSE

OUTPT TYPE MOMENT TIME
\CNTCT\RELAY_5 OUTPT SENSE OUTPT TYPE MOMENT TIME
\CNTCT\RELAY_6 OUTPT SENSE OUTPT TYPE MOMENT TIME
\TRVRS_HEAD TRAVERSE RATES
\TRVRS\TRVRS_RATE AVR MODE FCR MODE VAR MODE PF MODE FVR MODE
\PMODE_HEAD PRE-POSITION MODES
\PMODE\PREP_MODE1 AVR MODE FCR MODE VAR MODE PF MODE FVR MODE
\PREP1_RATES1 AVR TRAVEL AVR RATE FCR TRAVEL FCR RATE VAR TRAVEL VAR RATE
\PREP1_RATES2 PF TRAVEL PF RATE FVR TRAVEL FVR RATE
\PMODE\PREP_MODE2 AVR MODE FCR MODE VAR MODE PF MODE FVR MODE
\PREP2_RATES1 AVR TRAVEL AVR RATE FCR TRAVEL FCR RATE VAR TRAVEL VAR RATE
\PREP2_RATES2 PF TRAVEL PF RATE FVR TRAVEL FVR RATE
\SU_HEAD

STARTUP

\START\P_STRTUP
SS LEVEL
SS TIME
FLASH TIME
FLASH LEVEL

\P_STP\S_STRTUP
SS LEVEL
SS TIME

\TRACK_HEAD
TRACKING

\TRACK_TRACK_DATA
INT RATE
INT DELAY
EXT RATE
EXT DELAY

\D400\SETUP **GENERAL SETTINGS**

\COMMS
COMMUNICATIONS

\COMMS\BAUD_RATE
COM0 RS232
COM1 RS485
COM2 RS485

\COMMS\MODBUS
COM2 ADDR
COM2 DELAY
PARITY
STOP BITS
MODBUS TCP

\COMMS\ETHERNET
IP
MAC
ST IP
NETM
GATEW
DHCP

\COMMS\NTP
NTP
TIME ZONE
UPDATE TIME
NTP STATUS

\COMMS\VERSION
VERSION
APP
DSP
BOOT
COMA
COMB
FLM

\CONTRAST
LCD CONTRAST

\CLOCK
CLOCK

\RTC\CLK_FORMAT
TIME FORMAT
DST FORMAT

DATE FORMAT

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

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

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.

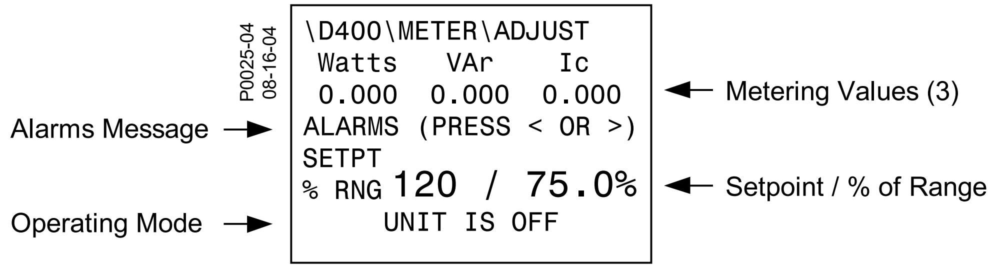


Figure 2-2. Metering Screen Information

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 2-3. Selectable Metering Parameters

Metering Label	Description
Bus Hz	Bus frequency
Bus V	Bus voltage
EDM OD	Exciter diode monitor open diode percent ripple
EDM SD	Exciter diode monitor shorted diode percent ripple
F Temp	Field temperature
Field V	Field voltage
Fld I	Field current
Gen Hz	Generator frequency
Hz/sec	Rate of frequency change
I Avg	Average of three generator line currents
Ia	A-phase generator line current
Ib	B-phase generator line current
Ic	C-phase generator line current

Metering Label	Description
NSeq I	Negative sequence current
NSeq V	Negative sequence voltage
PF	Power factor
PSeq I	Positive sequence current
PSeq V	Positive sequence voltage
V a-b	A-phase to B-phase generator rms voltage
V Aux	Accessory input voltage
V Avg	Average of three generator line-to-line voltages
V b-c	B-phase to C-phase generator rms voltage
V c-a	C-phase to A-phase generator rms voltage
VA	Generator load VA
VAr	Reactive power
Watts	Generator load watts

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 2-4. Setpoint Field Operating Mode Cross-Reference

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

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.

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

Annunciation Message	Duration of Message
CLOCK RESET	Maintained until reset
CURRENT UNBALANCE	Automatically reset
EXCESSIVE V/HZ	Maintained until reset
EXCITER DIODE OPEN	Maintained until reset
EXCITER DIODE SHORT	Maintained until reset
FAILED TO BUILD UP	Maintained until reset
FIELD OVER TEMP	Maintained until reset
FIELD OVERCURRENT	Maintained until reset
FIELD OVERVOLTAGE	Maintained until reset
GEN. OVERVOLTAGE	Maintained until reset
GEN. UNDERVOLTAGE	Maintained until reset
LOSS ISOLATION MODULE	Automatically reset
LOSS OF FIELD	Maintained until reset
LOSS OF IRIG	Automatically reset
LOST VOLTAGE SENSING	Maintained until reset
OVEREXCITATION LIMIT	Clears 2 s after end of event
POWER BELOW THRESHOLD	Automatically reset
POWER SUPPLY LOW	Automatically reset
PSS BLOCK	Automatically reset
SPEED FAILURE	Automatically reset
STATOR CURRENT LIMIT	Clears 2 s after end of event
SYSTEM BELOW 10 HZ	Clears 2 s after end of event
UNDEREXCITATION LIMIT	Clears 2 s after end of event
UNDERFREQUENCY	Clears 2 s after end of event
VAR LIMIT	Automatically reset
VOLTAGE LIMIT	Automatically reset
VOLTAGE UNBALANCE	Automatically reset

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.

3 • Functional Description

This chapter 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.*

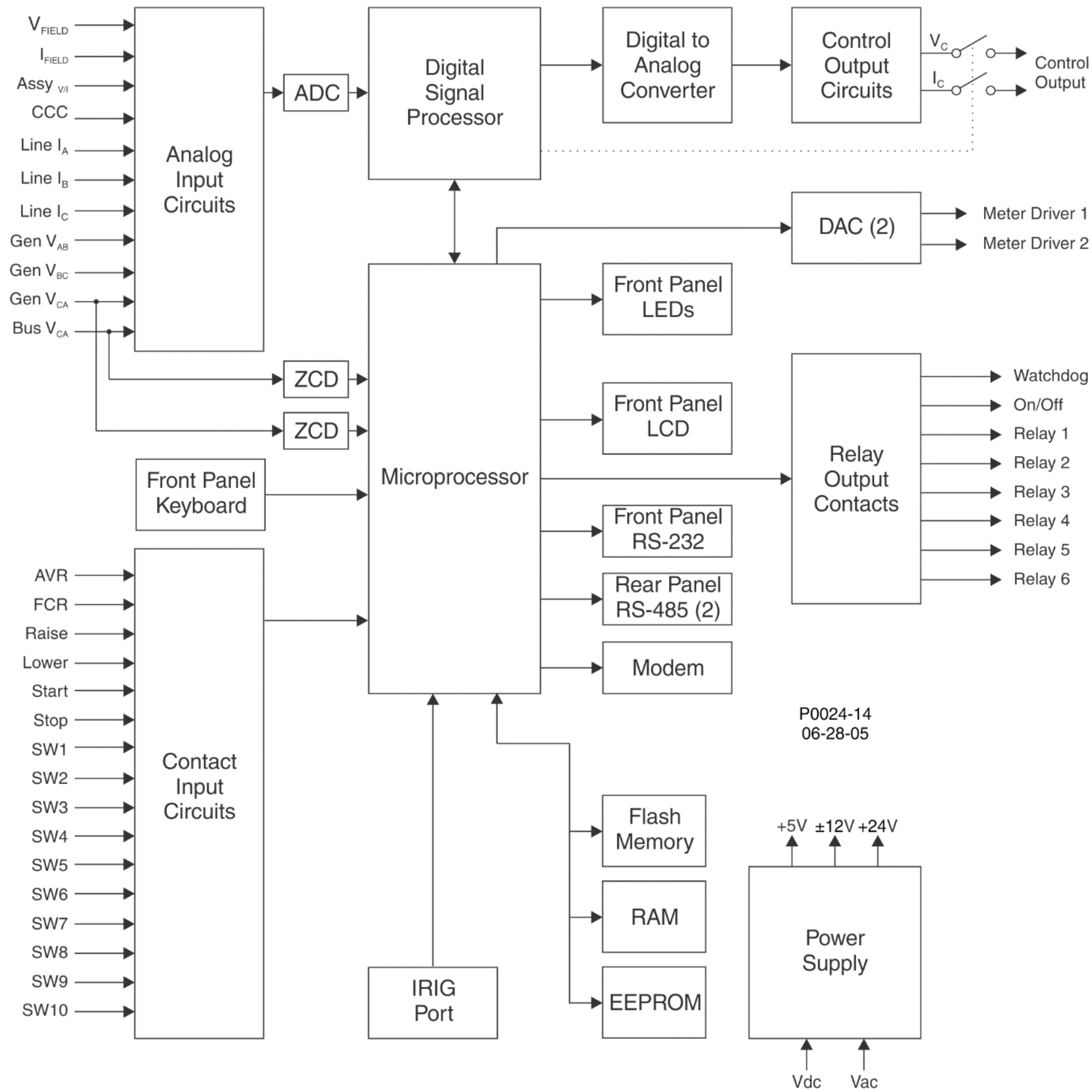


Figure 3-1. DECS-400 Function Blocks

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 (V_{AB}) voltage input, a B-phase to C-phase voltage input (V_{BC}), and a C-phase to A-phase voltage input (V_{CA}).

The V_{CA} 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 (I_A), a B-phase current input (I_B), and a C-phase current input (I_C).

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 I_B 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 chapter.) 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: Vaux = 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 ±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, Manual, 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).

Manual

This input accepts a momentary contact closure that places the DECS-400 in Manual mode. If the DECS-400 receives AVR and Manual contact inputs simultaneously, the Manual input has priority. When operating in Manual mode, the DECS-400 regulates (as configured in BESTCOMS™) either the level of field current (FCR) or the level of field voltage (FVR). Manual contact input connections are made at terminals B6 (MAN) 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 the *BESTCOMS Software* chapter.

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.

Caution
This product contains one or more *nonvolatile memory* devices. Nonvolatile memory is used to store information (such as settings) that needs to be preserved when the product is power-cycled or otherwise restarted. Established nonvolatile memory technologies have a physical limit on the number of times they can be erased and written. In this product, the limit is 1,000,000 erase/write cycles. During product application, consideration should be given to communications, logic, and other factors that may cause frequent/repeated writes of settings or other information that is retained by the product. Applications that result in such frequent/repeated writes may reduce the useable product life and result in loss of information and/or product inoperability.

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 mAdc 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
- Neg. Sequence Voltage
- Null Balance Level
- OEL Controller Output
- PF Mode Output
- Phase Angle Ia – Vca
- Phase Angle Iaux – Vca
- Phase Angle Ib – Vca
- Phase Angle Ic – Vca
- Phase Angle Vab
- Phase Angle Vbc
- 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 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
- Rate of Frequency Change
- SCL Controller Output
- Terminal Freq. Deviation
- Time Response
- UEL Controller Output
- Var Limiter 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 (NC), C7 (COM), and C8 (NO).

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.

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.

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. Two versions of the Modbus protocol are supported by the DECS-400. Depending upon the communication option selected, either Modbus RTU can be enabled or Modbus TCP can be enabled. Simultaneous use of Modbus RTU and Modbus TCP is not possible in the DECS-400. Com 2 connections are made at terminals D10 (A), D11 (B), and D12 (C).

Refer to the *General Information* chapter for the available range of communication settings for Com 1 and Com 2.

Ethernet Port

A rear-panel, RJ-45 connector, designated Com 3, enables communication with the DECS-400 over a 10BASE-T Ethernet network.

Modem

An internal telephone modem enables an off-site PC operating BESTCOMS software to dial into a DECS-400 and view 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 the *BESTCOMS Software* chapter.

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 the *Specifications* chapter 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.

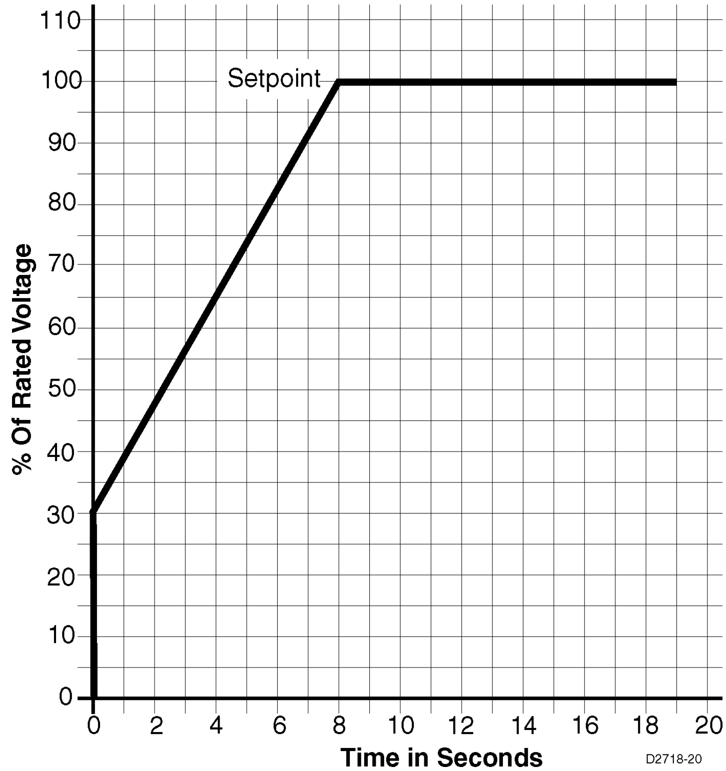


Figure 3-2. Soft Start Voltage Reference

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), Manual, 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.

Manual

Manual mode is selected by a momentary contact input applied to terminals B5 and B6. Manual mode can also be selected through BESTCOMS. If enabled, Manual mode can be selected automatically when a loss of sensing condition occurs. Manual mode can be configured through BESTCOMS to regulate either the field current (FCR) or the field voltage (FVR).

FCR

When operating in FCR (field current regulation) 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.

FVR

When operating in FVR (field voltage regulation) mode, the DECS-400 adjusts the control output to maintain the desired level of field voltage. The desired level of field voltage is entered through BESTCOMS or the front panel HMI as the FVR Setpoint setting. The setting range of the FVR Setpoint depends on the field type selected and other associated settings. Once established, the FVR setpoint is 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. FVR Min and FVR Max settings control the range of adjustment for the FVR setpoint. The FVR Min and FVR Max settings have a setting range of 0 to 150% of the rated field voltage. The length of time required to adjust the FVR setpoint from one limit to the other is controlled by the FVR Traverse Rate setting. The FVR 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 enable configuration of the DECS-400 for multiple system and application needs. Each pre-position setpoint can be assigned to a programmable contact input. When that 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 three settings: Setpoint, Mode, and Traverse Rate.

The Setpoint range of each pre-position setpoint 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 inputs from the Raise or Lower controls are applied immediately. 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.

When a setpoint is traveling toward a pre-position setting, the rules for Release and Maintain modes still apply. In Release mode or Maintain mode with the pre-position contact open, a Raise or Lower input will stop setpoint travel and the setpoint can be controlled normally. In Maintain mode, with the pre-position contact held closed, Raise and Lower inputs are ignored and travel to the pre-position setpoint is unhindered.

Note
In any pre-position mode, setpoint changes initiated through the HMI or BESTCOMS will always apply. The pre-position modes affect setpoint changes initiated only through the Raise and Lower inputs.

A Traverse Rate setting can be enabled to control the rate at which the control mode setpoint is driven toward the selected pre-position level. This setting is expressed in seconds and controls the length of time required for the setpoint to traverse the full setpoint range. Application of a pre-position input will typically result in a traverse time that is a fraction of the traverse rate setting. A Traverse Rate delay of 1 to 720 seconds is possible. When disabled, there is no intentional traverse delay.

Transient Boost

Note
Effective with firmware version 1.09, transient boost voltage settings are based on the voltage setpoint. In all previous firmware versions, transient boost voltage settings were based on the rated voltage.

The transient excitation boosting function improves response to successive faults by providing increased excitation support. When a simultaneous line current increase and line voltage decrease occurs, the DECS-400 compensates by elevating the voltage setpoint above the nominal setpoint. When the line voltage recovers, the voltage setpoint is restored to the nominal value.

Fault detection is controlled by a voltage threshold setting, a current threshold setting, and a duration setting. The fault voltage threshold is expressed as a percentage of the AVR setpoint and has an adjustment range of 0 to 100%. The fault current threshold is expressed as a percentage of the rated stator current and has an adjustment range of 0 to 400%. The duration setting determines how long a fault condition is tolerated before the setpoint is adjusted. A setting within the range of 0 to 1,000 milliseconds is possible.

Setpoint adjustment is controlled by a voltage setpoint boosting level, a clearing voltage threshold, and a clearing voltage delay. The setpoint boosting level is expressed as a percentage above the AVR setpoint and has an adjustment range of 0 to 100%. Transient boost is disabled once the line voltage recovers above the clearing voltage threshold. The clearing voltage threshold is expressed as a percentage above the AVR setpoint and has an adjustment range of 0 to 50%. The clearing voltage delay determines how long the line voltage must exceed the clearing voltage threshold before setpoint adjustment is terminated. A setting within the range of 0 to 1,000 milliseconds is possible.

Protection Functions

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

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

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 0.01 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.

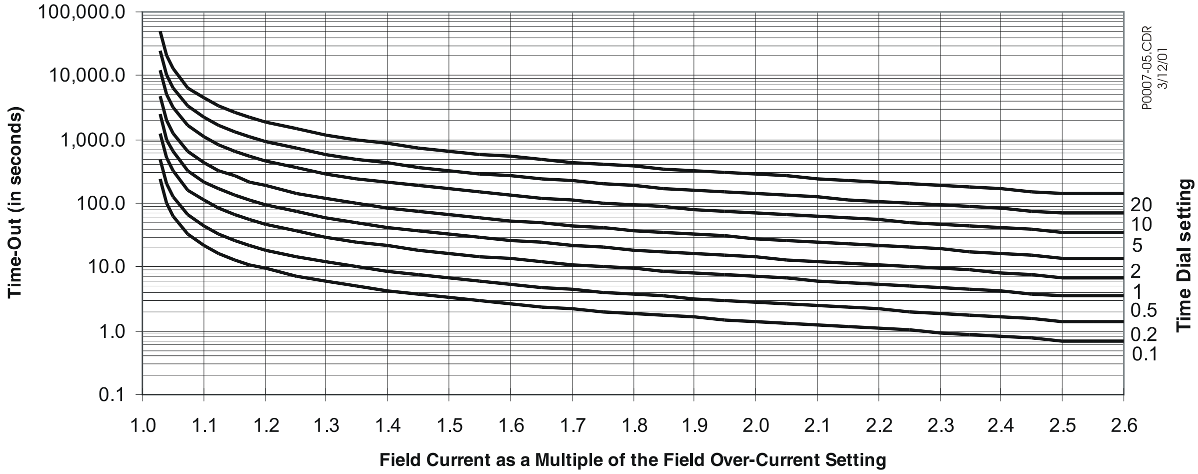


Figure 3-3. Field Overcurrent Timing Curves

The following equations are used to calculate the field overcurrent pickup and reset time delays. In each equation, MOP stands for multiple of pickup.

$$PU\ Time\ Delay = \frac{-95.908 \times Time\ Dial\ Setting}{-17.165 + \sqrt{490.864 - 191.816 \times MOP}}$$

$$Reset\ Time\ Delay = \frac{0.36 \times Time\ Dial\ Setting}{(MOP_{reset})^2 - 1}$$

The value returned from the Reset Time Delay equation is the time it would take to reset from a trip condition. The timer reset from a pickup that did not reach the trip condition will be shorter than this value.

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 75,000 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 575,000 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. Balanced Level settings are adjustable from 0 to 100% (of nominal generator voltage) in 0.1 percent increments. When the difference between nominal generator voltage and any one of the three phases of sensing voltage exceeds the Unbalanced Level setting, the Delay timer begins timing out. Unbalanced Level settings are adjustable from 0 to 100% (from nominal generator voltage) in 0.1 percent increments. The Delay timer setting is adjustable from 0 to 30 seconds 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 (V_{CA}), 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.

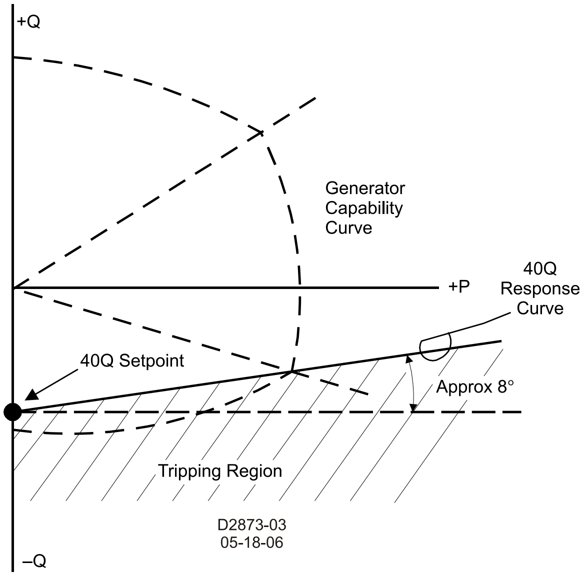


Figure 3-4. Generator Capability Curve Versus 40Q Response

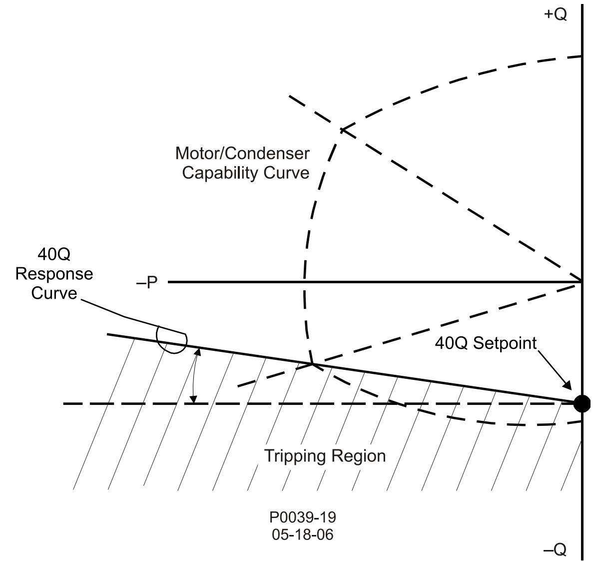


Figure 3-5. Motor Capability Curve Versus 40Q Response

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 or for rotary exciter applications where the field voltage and current is measured at the slip rings and main field current shunt on the brush-type rotary exciter.

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. Volts per hertz characteristic curves are illustrated in Figure 3-6 and Figure 3-7.

$$T_T = \frac{D_T}{\left(\frac{V/Hz_{MEASURED}}{V/Hz_{PICKUP}} - 1\right)^n} \qquad T_R = D_R \times \frac{E_T}{FST} \times 100$$

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.)

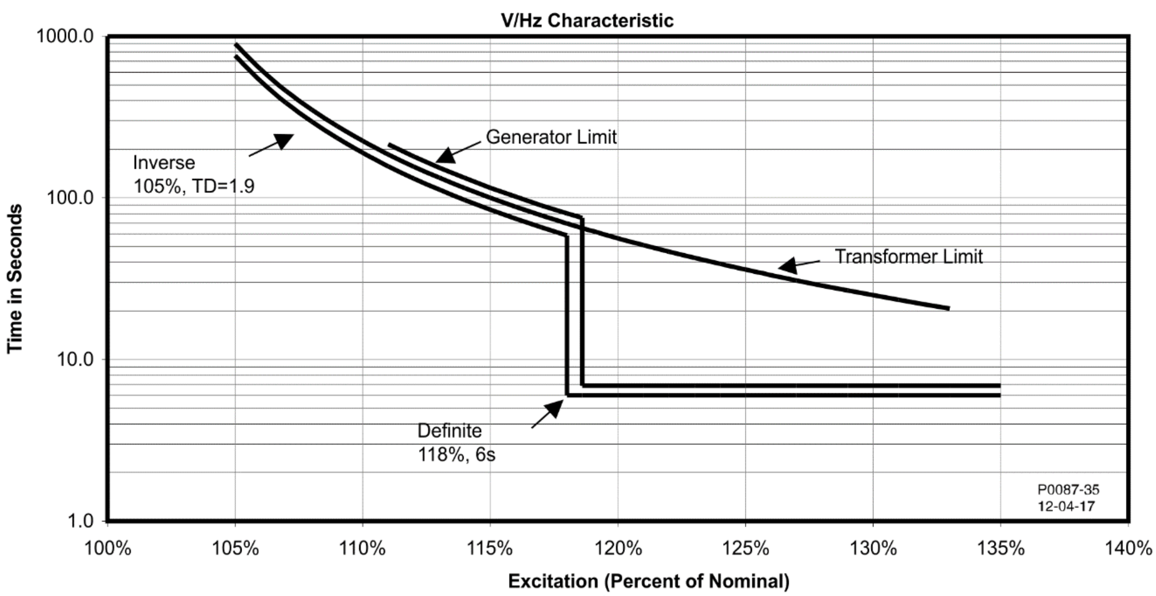


Figure 3-6. V/Hz Characteristic—Time Shown on Vertical Axis

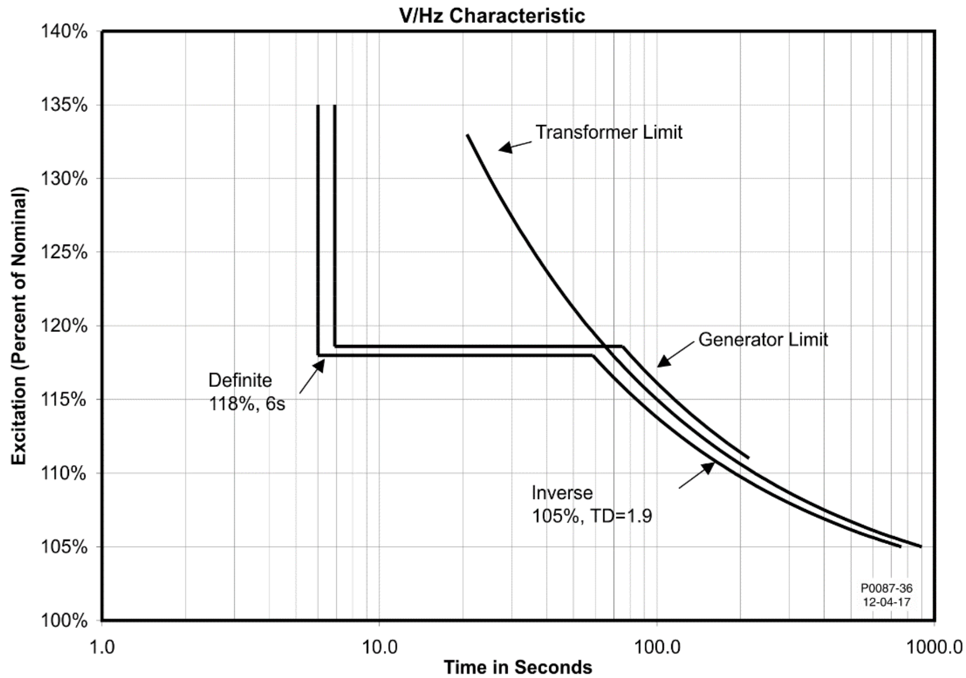


Figure 3-7. V/Hz Characteristic—Time Shown on Horizontal Axis

Exciter Diode Monitor (EDM)

The EDM function 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.

Exciter Diode Monitor Settings

It is especially difficult to detect open diode conditions when the number of generator and exciter poles is unknown. For this reason, the ratio of the number of poles for the brushless exciter armature to the generator rotor is entered to ensure proper operation for both open and shorted diode protection.

Setting the Pickup Level

To set the pickup level of the EDM OD value (open diode) ripple and EDM SD (shorted diode) ripple parameters, the maximum ripple current on the field must be known. This can be accomplished by running the generator unloaded and at rated speed. Vary the generator voltage from minimum to maximum voltage while monitoring the EDM OC (open circuit) and EDM SC (short circuit) % ripple on the DECS-400 HMI metering screen. Record the highest value for each. See the *Human-Machine Interface* chapter for more details on displaying metering quantities.

With Number of Generator Poles Known

Multiply the highest EDM OC (open circuit) value, obtained under *Setting the Pickup Level* by 3. The result is the Exciter Open Diode % Ripple Level (EDM OD % Ripple). The multiplier can be varied between 2 and 5 to increase or decrease the trip margin. However, reducing the multiplier could result in nuisance EDM OD indications. A time delay is also available and adjustable from 10 to 60 seconds.

Multiply the highest EDM SC (short circuit) value, obtained under *Setting the Pickup Level* by 50. The result is the Exciter Shorted Diode % Ripple Level (EDM SD % Ripple). The multiplier can be varied between 40 and 70 to increase or decrease the trip margin. However, reducing the multiplier could result in nuisance EDM SD indications. A time delay is also available and adjustable from 5 to 30 seconds.

The DECS-400 has fixed EDM inhibit levels to prevent nuisance EDM indications while the generator sensing voltage is less than 45 Hz, greater than 70 Hz, or when the field current is less than 1 Adc. Although the user can adjust the field current inhibit level from 0 to 100%, the fixed EDM inhibit levels take priority. Pole ratios must be in the range of 1 to 40 with 0 used if the ratio is unknown.

With Number of Generator Poles Unknown

The DECS-400 can detect shorted diode conditions when the number of generator poles is not known. To provide this protection, disable EDM OD protection and set the pole ratio to zero. Enable EDM SD protection. Multiply the maximum EDM SC (short circuit) % ripple value, obtained under *Setting the Pickup Level* by 30. The multiplier can be varied between 20 and 40 to increase or decrease the trip margin. Reducing the multiplier could result in nuisance EDM SD indication.

Test the EDM Settings

Start the generator from a dead stop condition and increase its speed and voltage to the rated value. Load the machine to its rating and confirm no EDM alarm indications occur. All of the EDM setup guidelines presented here assume the exciter diodes were not opened or shorted at the time of setup and testing.

Voltage / Current Unbalance Detection

If the voltage or current unbalance increases above 40% for 18 half-cycles, (about 150 milliseconds at 60 Hz), the power system stabilizer (PSS) is disabled. Voltage and current balance is determined by the ratio of negative-sequence quantities to positive-sequence quantities. When an unbalance condition decreases below the 40% threshold for 18 half-cycles, the stabilizer is enabled again. This feature is active only when the positive-sequence voltage magnitude is above 10% of the Rated Voltage setting (System Configuration screen, Rated Data tab). The PSS does not have to be enabled for this function to operate.

Loss of Speed

If the measured frequency is more than ±10% of rated frequency (<54 Hz or >66 Hz at 60 Hz rated) for 6 half-cycles (50 milliseconds at 60 Hz rated), the PSS is disabled. The PSS enables again when the measured frequency returns to within 10% of rated frequency.

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 3-8).

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 240 seconds with 0.1 second increments.

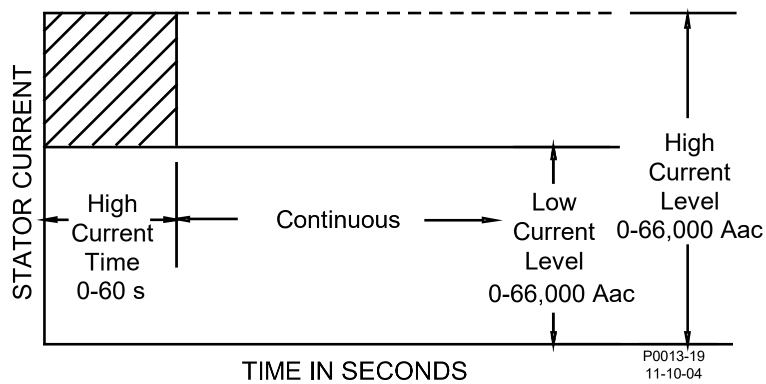


Figure 3-8. Stator Current Limiting

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.

The SCL will not respond until the SCL Initial Delay setting has expired.

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 3-9 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.

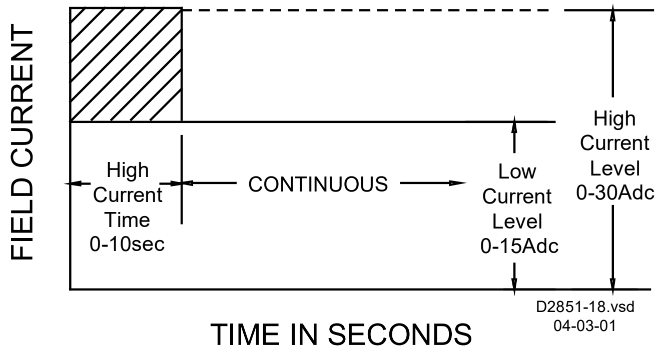


Figure 3-9. Summing Point, Off-Line Overexcitation Limiting

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 3-10 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.

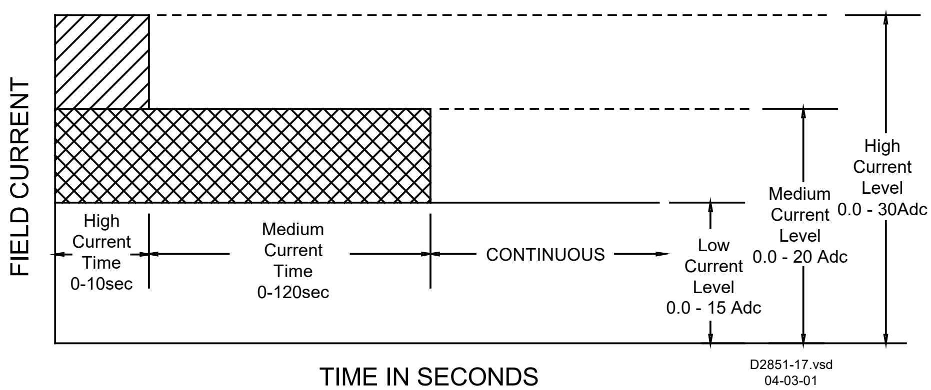


Figure 3-10. Summing Point, On-Line Overexcitation Limiting

On-line OEL operation can be tailored for fault proximity by OEL Voltage Dependency (dv/dt Enable and dv/dt Level) settings in BESTCOMS. If a fault is close to the generator, the OEL high-level setting is disabled (based upon the rate of change) and switches to the medium-level, summing-point OEL setting. If the fault is away from the machine, all three (high, medium, and low) settings are active.

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 3-11. 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.

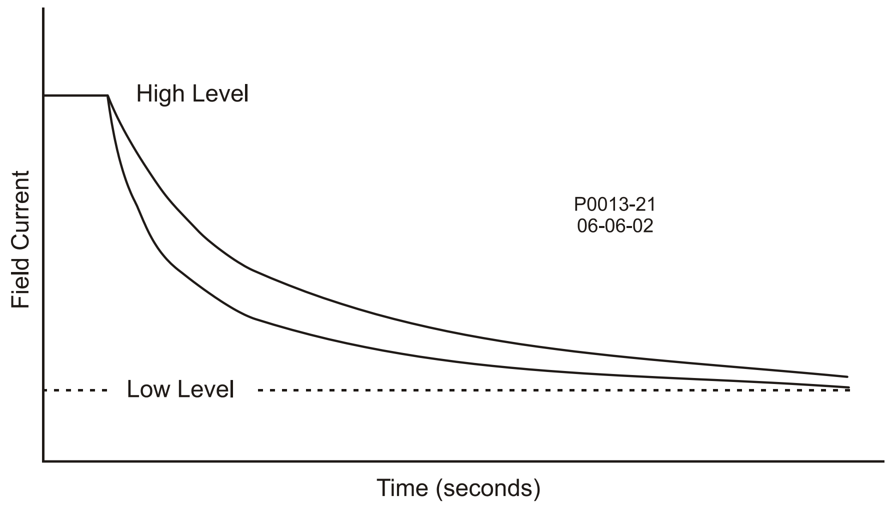


Figure 3-11. Inverse Time Characteristic for Takeover-Style OEL

The inverse time characteristic is defined by the following equation:

$$t_{pickup} = \frac{A \times TD}{B + \sqrt{C + D \times MOP}}$$

Where:

t_{pickup}	=	time to pickup in seconds
A	=	–95.908
B	=	–17.165
C	=	490.864
D	=	–191.816
TD	=	time dial setting <0.1, 20>
MOP	=	multiple of pickup <1.03, 2.5>

Once the field current decreases below the dropout level (95% of pickup), the function is reset based on the following curve equation:

$$Time_{reset} = \frac{0.36 \text{ x } TD}{(MOP_{reset})^2 - 1}$$

Each mode of operation (off-line and on-line) has a Low Level setting, a High Level setting, and a Time Dial setting. Each Low Level setting has a setting range of 0 to 11,999 Adc with 0.01 Adc increments. Each High Level setting has a setting range of 0 to 9,999 Adc with 0.01 Adc increments. Each Time Dial setting has a setting range of 0.1 to 20 seconds with 0.1 second increments.

The two current thresholds are defined by the Off-Line Low Level, Off-Line High Level, On-Line Low Level, and On-Line High Level settings. Each Low level setting has a setting range of 0 to 11,999 Adc with 0.01 Adc increments. Each High Level setting has a setting range of 0 to 9,999 Adc with 0.01 Adc increments. The Time Dial settings have a setting range of 0.1 to 20 seconds with 0.1 second increments.

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. 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. If the customized curve is selected and if a zero setting is entered for kW point 2 or kvar point 2, the UEL will use the internally-generated UEL curve. 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 following equation illustrates the internally-generated UEL curve:

$$(0.49 \text{ x } kW_{pu} \text{ x } kW_{pu} - 1.0) \text{ x } kvar\_level$$

Where:

kw_pu	=	metered kW level in per-unit
kvar_level	=	user setting for kvar in per-unit

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 3-12.

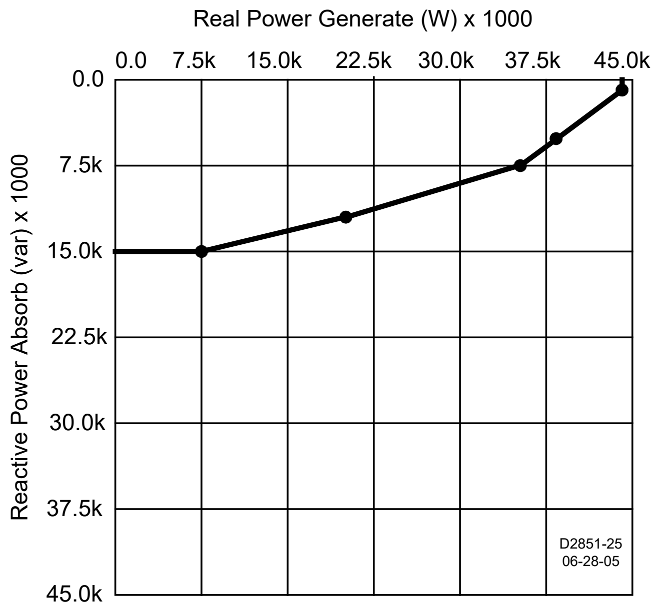


Figure 3-12. User-Defined UEL Curve

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 3-13), the DECS-400 adjusts the voltage setpoint so that the generator voltage follows the under-frequency 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.

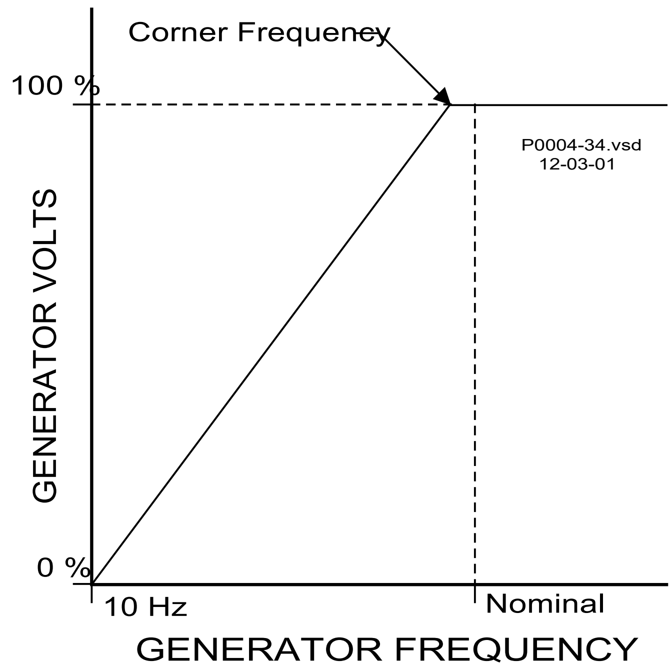


Figure 3-13. Typical Underfrequency Compensation Curve

Volts per Hertz Limiter

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

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 generator may operate continuously at setpoints below the low limit threshold. When the regulation setpoint is greater than the low limit threshold for the duration of the time delay, the setpoint is reduced to the low limit threshold and is prevented from exceeding the low limit threshold. The regulation setpoint is prevented from exceeding the value of the high limit threshold at all times.

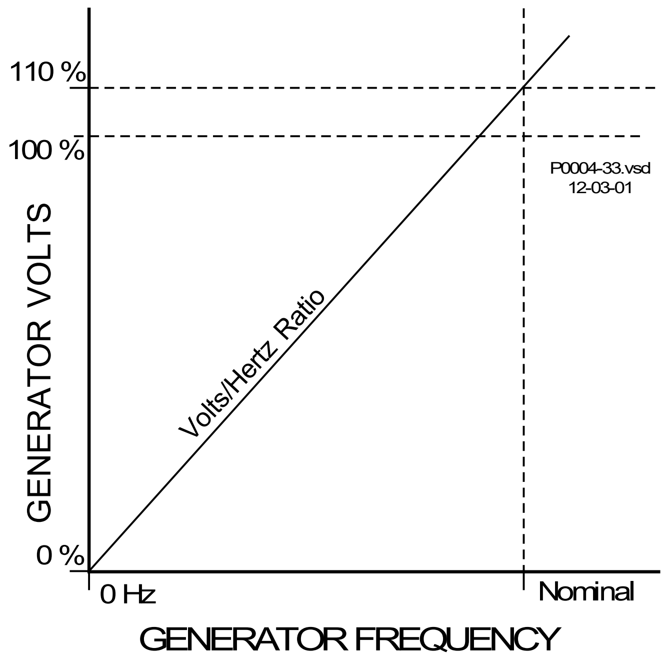


Figure 3-14. Typical 1.1 PU Volts/Hertz Limiter Curve

Var Limiter

The var limiter monitors and limits the level of reactive power exported from the generator. Var limiting is useful in an application where the turbine rating has been increased but the generator rating was not increased. In this case, the generator is considered to be var-limited since the generator power factor rating has increased. The var limiter functions as a summing-point limiter only.

Var limiting is configured with a setpoint and a time delay. The setpoint is expressed in kilovars and has a range determined by the rated kVA of the generator (entered on the Rated Data tab of the BESTCOMS System Configuration screen). When the level of exported vars exceeds the setpoint, the DECS-400 acts to limit the var flow after the time delay expires. The time delay has a setting range of 0 to 10 seconds with 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
- Generator Vab
- Generator Vbc
- Generator Vca
- Negative Sequence Current
- Negative Sequence Voltage
- Overexcitation Controller Output

- PF Mode Output
- Phase Angle Ia - Vca
- Phase Angle Iaux - 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

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.

A standard backup battery maintains real-time clock operation in the event that control power is lost. Refer to the *Maintenance* chapter for instructions on replacing the battery.

Trending

The trend log records the activity of 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 Iaux - 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

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/2B/2C, 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, generator and motor control modes, and rate of frequency change blocking.

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 3-15.

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 Tl1 setting which has a setting range of 0 to 0.2 seconds with 0.01 second increments. Tl1 is accessed on the Parameters tab of the BESTCOMS PSS screen.

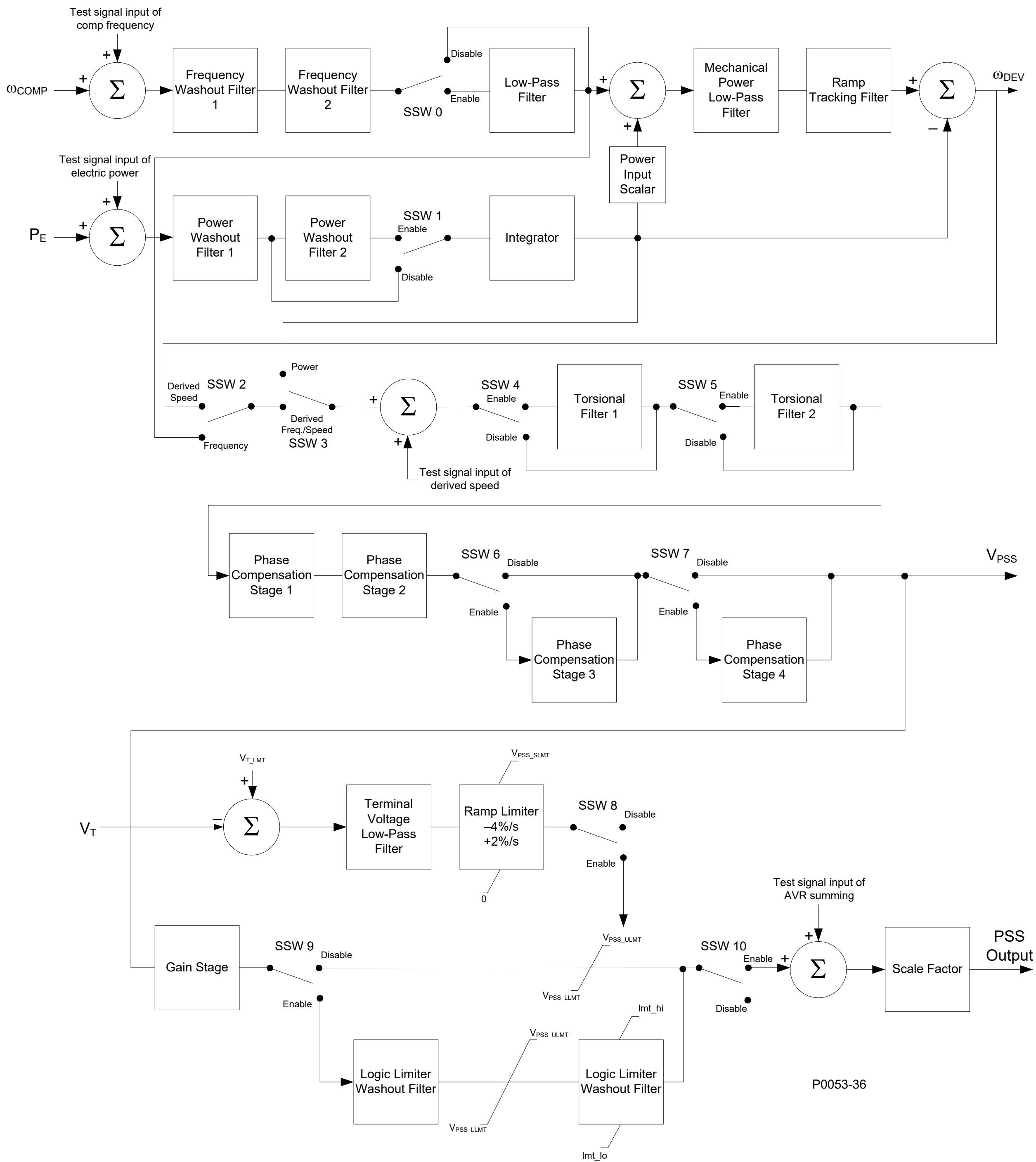


Figure 3-15. PSS Function Blocks and Software Switches

Figure 3-16 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.)

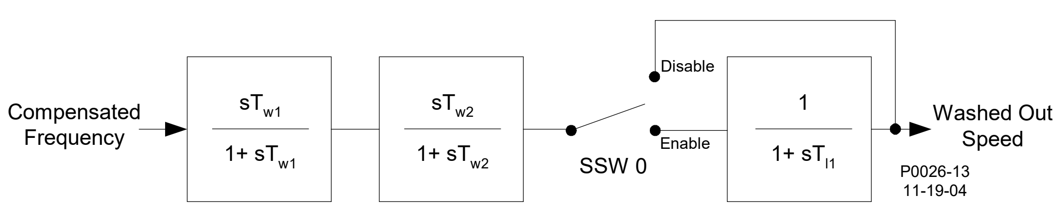


Figure 3-16. Speed Signal

Generator Electrical Power Signal

Figure 3-17 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 TI2. TI2 has a setting range of 1.00 to 0.01 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. TI2 and "H" are accessed on the Parameters tab of the BESTCOMS PSS screen.

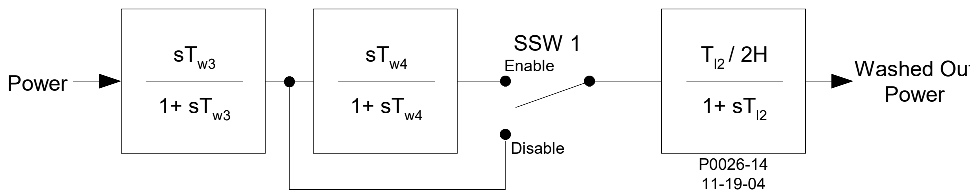


Figure 3-17. Generator Electrical Power Signal

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 0.2 to 20.0 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 0.01 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 3-18.

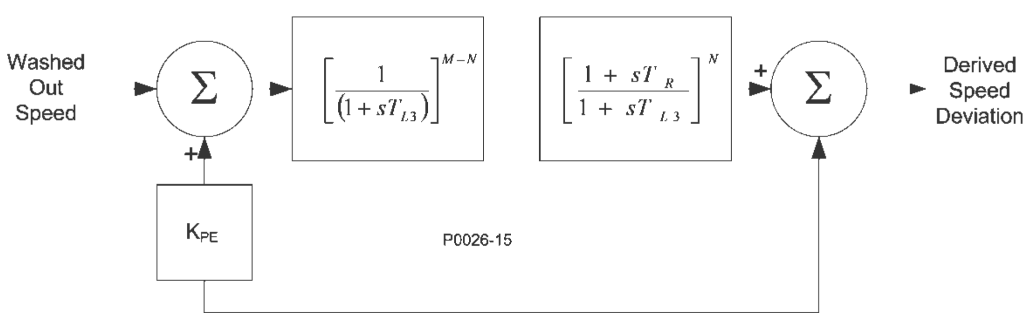


Figure 3-18. Derived Mechanical Power Signal

Stabilizing Signal Selection

Figure 3-19 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.

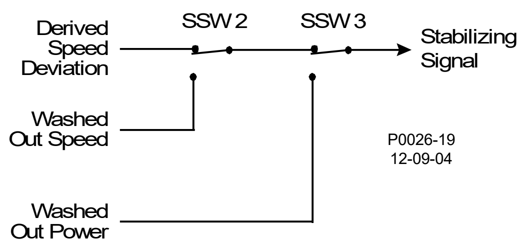


Figure 3-19. Stabilizing Signal Selection

Torsional Filters

Two torsional filters, shown in Figure 3-20, 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.

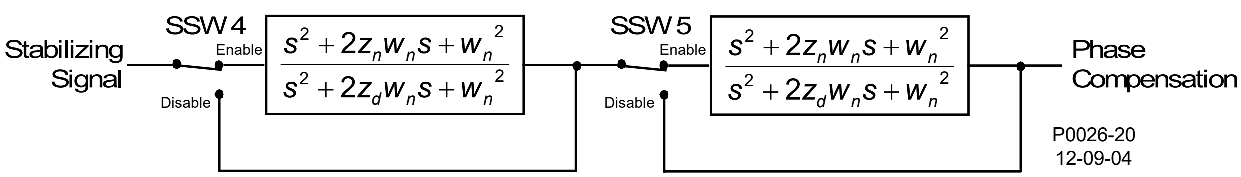


Figure 3-20. Torsional Filters

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. The 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 3-21 illustrates the phase compensation stages and associated software switches.

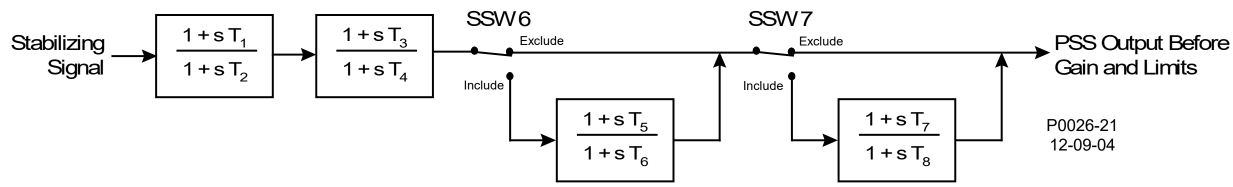


Figure 3-21. Phase Compensation Stages

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 3-22 illustrates the washout filter and logic limiter.

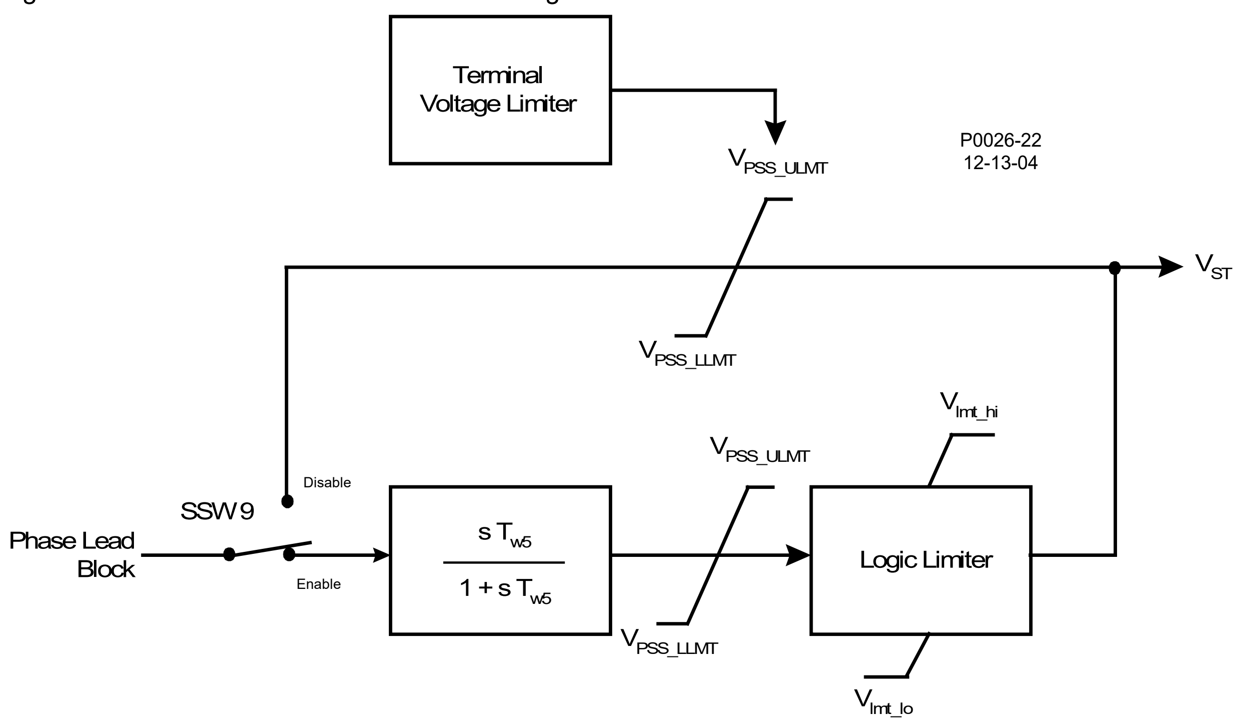


Figure 3-22. Washout Filter and Logic Limiter

Output Stage

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 3-23.

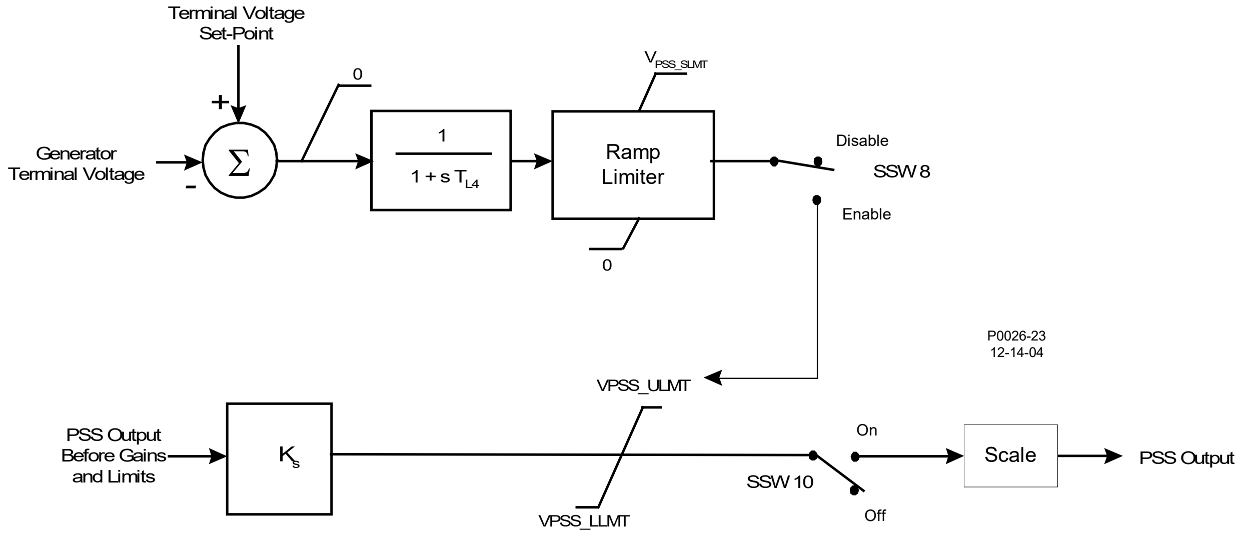


Figure 3-23. Output Stage

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 3-23) 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.

Rate of Frequency Change Blocking

The PSS rate-of-change function adjusts the PSS output to compensate for a generator rate-of-frequency change that exceeds the user-defined threshold. This threshold has an adjustment range of 0 to 10 hertz per second. When the generator frequency rate of change threshold setting is exceeded for the duration of a user-defined time delay, the PSS output is driven to zero and then ramped up to its previous, nominal value during the duration of a user-specified block timer. The delay time and block time are each adjustable from 0 to 20 seconds. The low-pass filter time constant and washout filter time constant settings are used to calculate the rate of change. These two settings have an adjustment range of 0 to 20 seconds.

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.

Field Isolation Modules are identified by two part numbers: 9372900100 and 9372900101. Part number 9372900100 identifies the Field Isolation Module assembly. Part number 9372900101 identifies the Field Isolation Module packaged for shipping and should be specified when requesting a replacement module.

4 • BESTCOMS™ Software

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 Windows® XP (32-bit), Windows® Vista (32-bit all editions), Windows® 7 (32/64-bit all editions), Windows® 8 and Windows® 10. 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 4-1. Hardware Requirements for BESTCOMS and the .NET Framework

Processor	Required RAM	Recommended RAM
Pentium-class 233 MHz	64 MB	128 MB or higher

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.

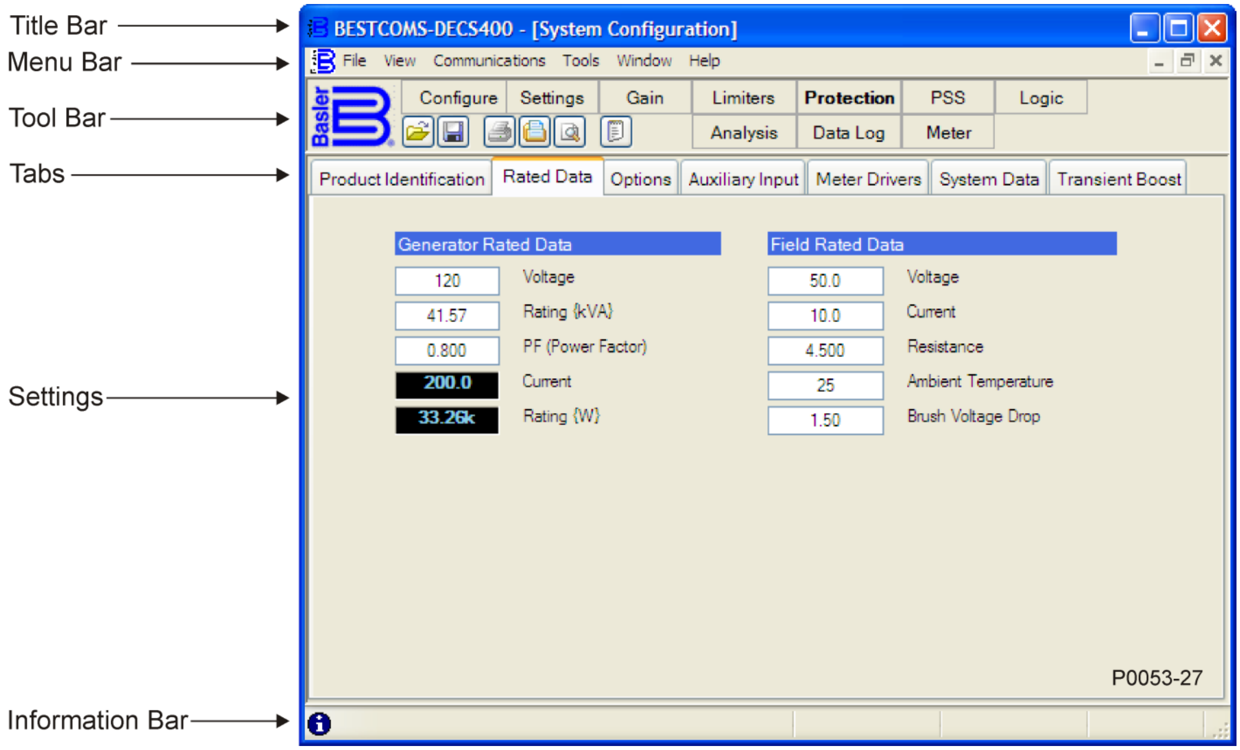


Figure 4-1. BESTCOMS Screen Components

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.)

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.

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. Maximized 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. Communication with BESTCOMS is possible through the DECS-400 RS-232 port (Com 0), Ethernet port (Com 3), or internal telephone modem (J1).

Caution
This product contains one or more *nonvolatile memory* devices. Nonvolatile memory is used to store information (such as settings) that needs to be preserved when the product is power-cycled or otherwise restarted. Established nonvolatile memory technologies have a physical limit on the number of times they can be erased and written. In this product, the limit is 1,000,000 erase/write cycles. During product application, consideration should be given to communications, logic, and other factors that may cause frequent/repeated writes of settings or other information that is retained by the product. Applications that result in such frequent/repeated writes may reduce the useable product life and result in loss of information and/or product inoperability.

IRIG time synchronization is interrupted during communication with BESTCOMS. The DECS-400 resumes IRIG synchronization shortly after BESTCOMS communication is terminated.

RS-232 Port Communication

Communication through Com 0 requires connection of a cable between the front-panel, RS-232 connector of the DECS-400 and the appropriate port of the PC.

Serial communication is established by selecting the PC communication port connected to the DECS-400 and entering the appropriate DECS-400 password. Click **Communications** on the menu bar, hover the mouse pointer over **Connect**, and then select **RS-232-COM0** from the menu. Select the appropriate PC communication port from the Communications Configuration window’s (Figure 28) drop-down menu and click the **Connect** button. When the Password window (Figure 29) appears, enter the appropriate password. (The DECS-400 is delivered with a password of decs4.) When the correct password is received, BESTCOMS automatically adjusts its communication settings (baud, parity, etc.) to match those of the DECS-400. BESTCOMS then reads and displays all DECS-400 settings.

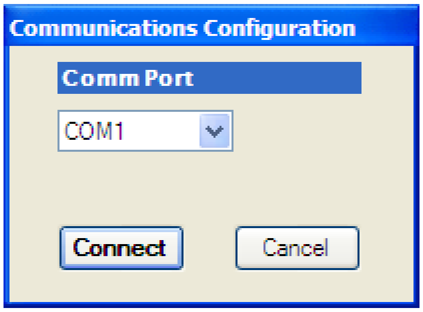


Figure 4-2. PC RS-232 Port Selection

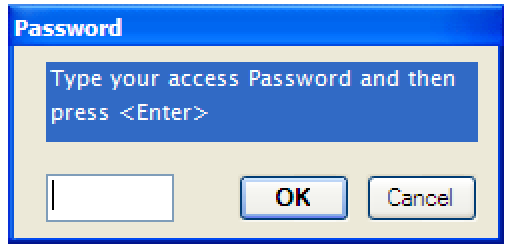


Figure 4-3. BESTCOMS Password Entry

Ethernet Port Communication

The rear-panel, RJ-45 jack (Com 3) of the DECS-400 enables it to communicate over a 10BASE-T Ethernet network with a PC equipped with an Ethernet adaptor and operating BESTCOMS. Com 3 uses the Transmission Control Protocol/Internet Protocol (TCP/IP) to encapsulate Modbus messages. A maximum of four simultaneous Modbus TCP/IP connections are possible with the DECS-400.

Connecting

BESTCOMS can connect to a networked DECS-400 by using one of two methods. If the static IP address for the DECS-400 is known, it can be entered directly. Or, the Device Discovery feature of BESTCOMS can be used to identify and connect to any DECS-400 networked through your PC's Ethernet adaptors. For either method, begin by clicking **Communications** on the menu bar, hovering the mouse pointer over **Connect**, and then selecting **Ethernet** from the menu. This will display the Ethernet Connection window shown in Figure 30. If the IP address of a networked DECS-400 is known, the four address fields can be completed and the Connect button clicked. After the appropriate DECS-400 password is entered in the Password window (Figure 4-3), communication is initiated. The BESTCOMS Device Discovery feature is initiated by clicking the **Ethernet** button. The Device Discovery feature scans the connected networks, identifies the found DECS-400 controllers, and lists each controller by its serial number, IP address, and device ID (Figure 31). The desired DECS-400 is selected and the Connect button is clicked. After the appropriate DECS-400 password is entered in the Password window (Figure 29), communication is initiated.

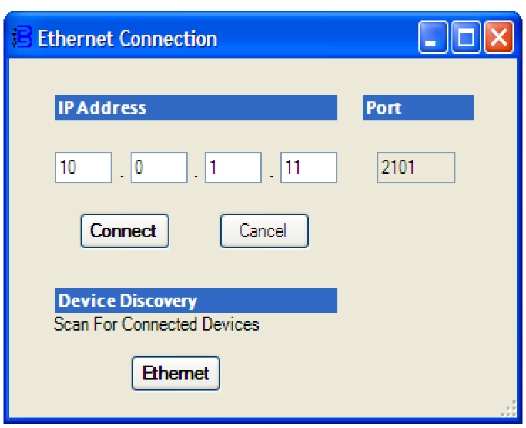


Figure 4-4. Ethernet Connection Window

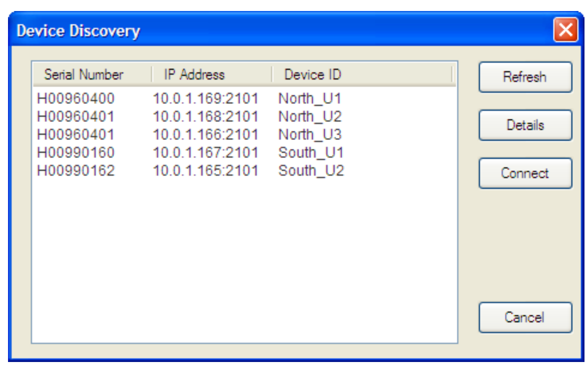


Figure 4-5. Device Discovery Results

After BESTCOMS reads all DECS-400 settings, "CONNECTED" is displayed on the right side of the BESTCOMS tool bar.

Static IP Address Configuration

The Ethernet settings of a connected DECS-400 can be read and altered through the BESTCOMS Configure Ethernet Port window. Access this window by clicking **Communications** on the menu bar and then clicking **Ethernet Configuration**. To configure a static IP address, uncheck the Enable DHCP box and set the IP Address, Subnet Mask, and Default Gateway settings to the desired values. Transmit the desired settings to the DECS-400 by clicking the **Send to Device** button. Note that these DECS-400 settings will not become active until after the DECS-400 is rebooted (control power is cycled). Of course, following a reboot, communication must be re-established since cycling control power terminates communication between the DECS-400 and BESTCOMS.

Network Time Protocol

The Network Time Protocol (NTP) can be used to assure accurate timekeeping by DECS-400 controllers connected to an Ethernet network. By synchronizing with a radio, atomic, or other clock located on the internet/intranet, each DECS-400 maintains accurate timekeeping that is coordinated with the time source.

NTP is enabled and configured in the NTP Settings window (Figure 32). This window is accessed by clicking **Communications** on the menu bar and selecting **NTP Settings**. (Communication with a DECS-400 must be established in order to make this menu selection.)

NTP coordination is enabled by checking the Enable NTP box.

The internet protocol address of the network time server is entered in the four, decimal-separated fields of the NTP Address setting.

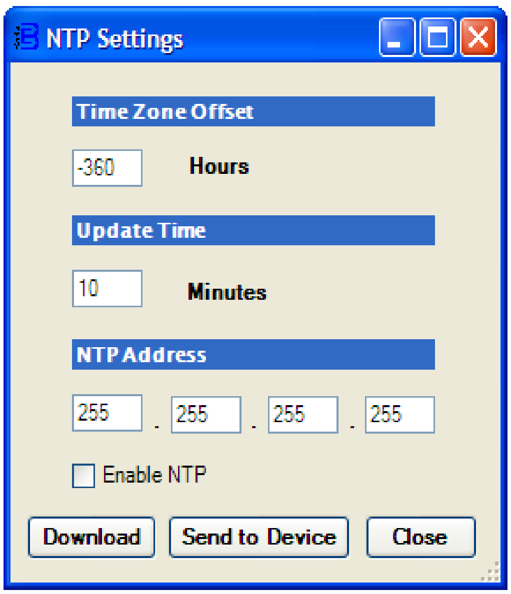


Figure 4-6. NTP Settings

The Update Time setting determines how frequently the DECS-400 accepts updates from the network time server. A setting of 1 to 1,440 minutes is possible.

The Time Zone Offset setting provides the necessary offset (in minutes) from the GMT (Greenwich Mean Time) standard. For example, CST (central standard time) is six hours behind GMT and would require a setting of –360. The Time Zone Offset range is –720 to 720.

Clicking the **Send to Device** button sends the Network Time Protocol settings to the DECS-400.

Modem Communication

The DECS-400's modem connects through the rear-panel, RJ-11 connector designated J1. The modem has a fixed baud rate of 9600. Modem access is read-only which prevents system control or the changing of DECS-400 settings. Password access is not required for modem communication.

Connecting

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.

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, Rated Data, Options, Auxiliary Input, Meter Drivers, System Data, Transient Boost. Click the **Configure** button on the tool bar to view the System Configuration screen.

Product Identification

Product Identification tab functions are shown in Figure 33 and described in the following paragraphs.

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

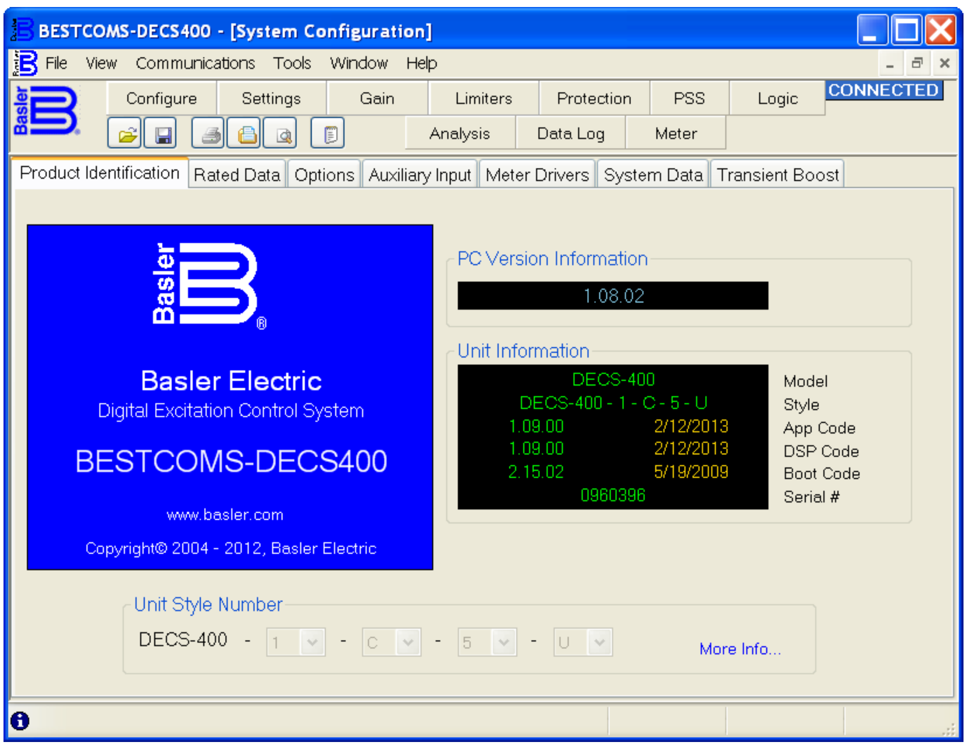


Figure 4-7. System Configuration Screen, Product Identification Tab

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.

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 34 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 1.40 to 2,000,000 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.

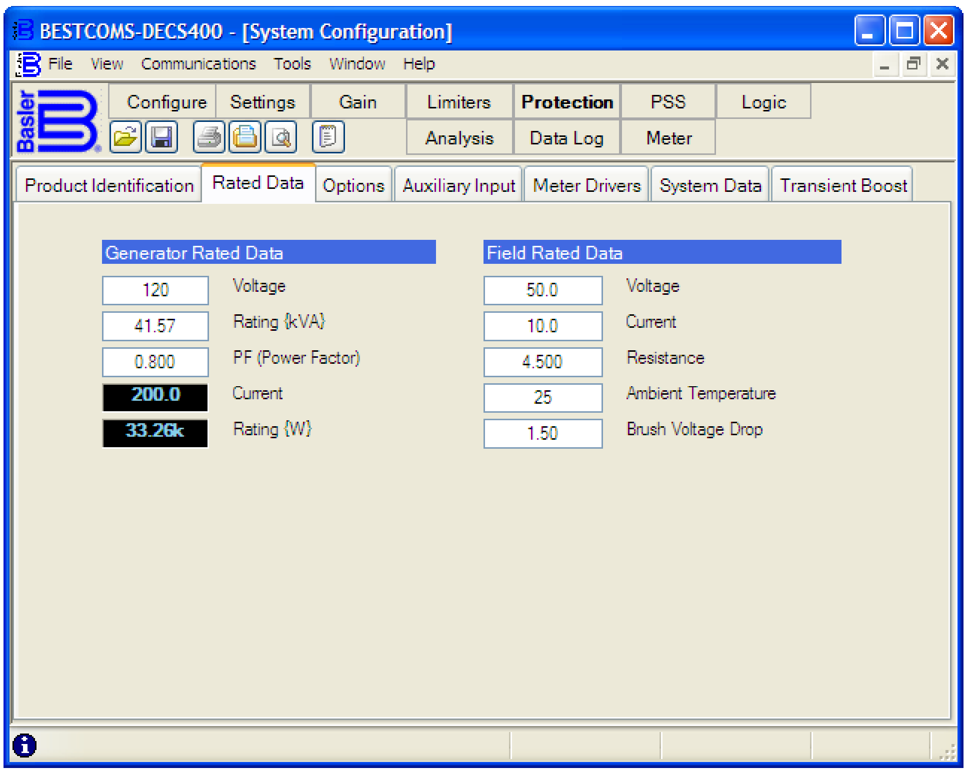


Figure 4-8. System Configuration Screen, Rated Data Tab

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°C may be entered in 1°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 20.00 V may be entered in 0.01 V increments. This setting field is enabled only for main field applications.

Options

Options tab functions are shown in Figure 35 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 mAdc.

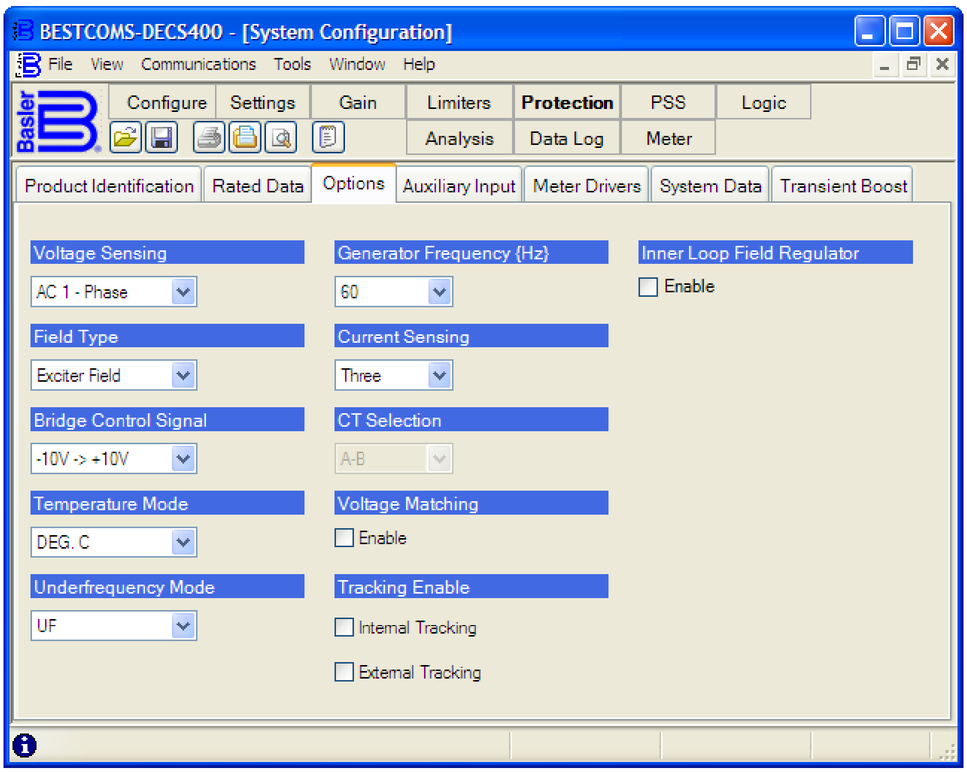


Figure 4-9. System Configuration Screen, Options Tab

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.

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.

Inner Loop Field Regulator. This setting enables the inner control loop of the field regulator for compensation of the exciter gains and time constants. When the inner control loop is enabled, the regulator response is dependent upon the inner loop gains selected on the Other Gain tab of the Gain Settings screen.

Auxiliary Input

Auxiliary Input tab functions are shown in Figure 36 and described in the following paragraphs.

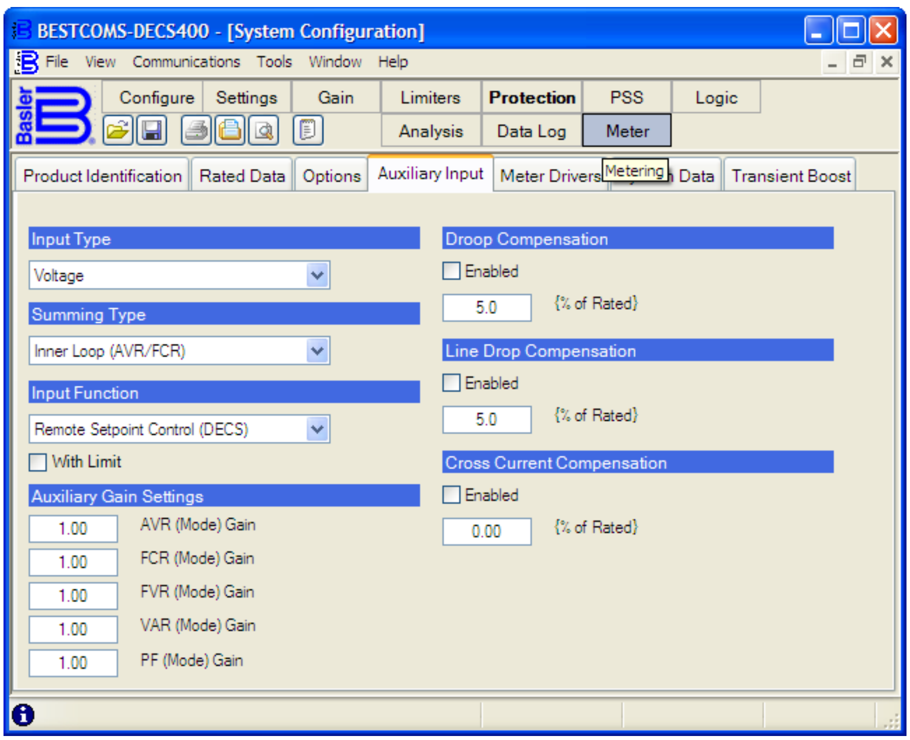


Figure 4-10. System Configuration Screen, Auxiliary Input Tab

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.

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.

Input Function. This drop-down menu configures the auxiliary input to control the excitation setpoint, the power system stabilizer (PSS), or limiter scaling. The auxiliary input is disabled by selecting “No Control”. Regardless of the selection made, the auxiliary input can always be used for functions such as metering and data logging.

Auxiliary Gain Settings. The five auxiliary gain setting fields, AVR, FCR, FVR, 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% (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% 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 37 and described in the following paragraphs.

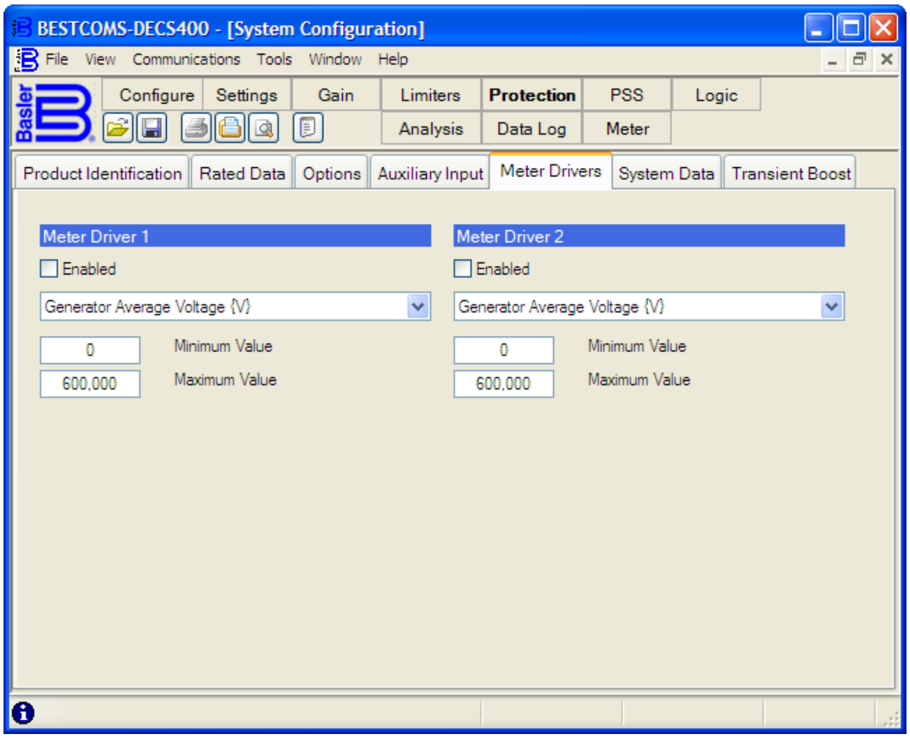


Figure 4-11. System Configuration Screen, Meter Drivers Tab

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:

- 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
- Neg. Sequence Voltage
- Null Balance Level
- OEL Controller Output
- PF Mode Output
- Phase Angle Ia – Vca

- Phase Angle Iaux – Vca
- Phase Angle Ib – Vca
- Phase Angle Ic – Vca
- Phase Angle Vab
- Phase Angle Vbc
- 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 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
- Rate of Frequency Change
- SCL Controller Output
- Terminal Freq. Deviation
- Time Response
- UEL Controller Output
- VARL Controller Output

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.

System Data

System Data tab functions are shown in Figure 38 and described in the following paragraphs.

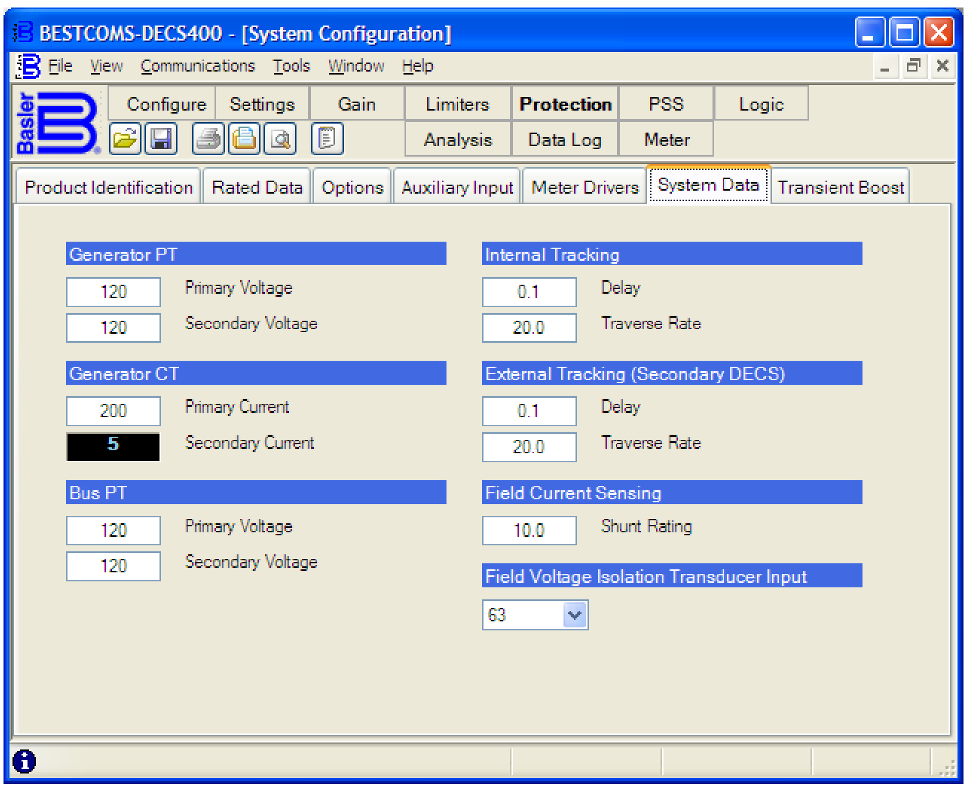


Figure 4-12. System Configuration Screen, System Data Tab

Generator PT – Primary Voltage. The primary voltage rating of the generator potential transformer is entered in this setting field. A setting of 1 to 500,000 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.

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 1.0 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.

<u>*Transient Boost*</u>

Note
Effective with firmware version 1.09, transient boost voltage settings are based on the voltage setpoint. In all previous firmware versions, transient boost voltage settings were based on the rated voltage.

This function improves response to successive faults by providing increased excitation support. When the DECS-400 detects a simultaneous increase in line current (Fault Current Threshold setting) and a decrease in line voltage (Fault Voltage Threshold setting) for a predetermined length of time (Minimum Fault Duration setting), the DECS-400 responds by elevating the AVR setpoint (Voltage Setpoint Boosting Level setting) above the nominal setpoint. If the line voltage recovers to the level defined by the Clearing Voltage Threshold setting for the duration specified by the Clearing Voltage Delay setting, the AVR setpoint is restored to the nominal value. All transient boost voltage settings are based on the DECS-400 voltage regulation setpoint.

Transient Boost tab functions are shown in Figure 39.

Discontinuous Transient Excitation Boosting. This setting enables the Discontinuous Transient Excitation Boosting function.

Fault Voltage Threshold. The threshold for fault voltage is entered in this field. A setting of 0 to 100 may be entered in 0.1% increments.

Fault Current Threshold. The threshold for fault current is entered in this field. A setting of 0 to 400 may be entered in 0.1% increments.

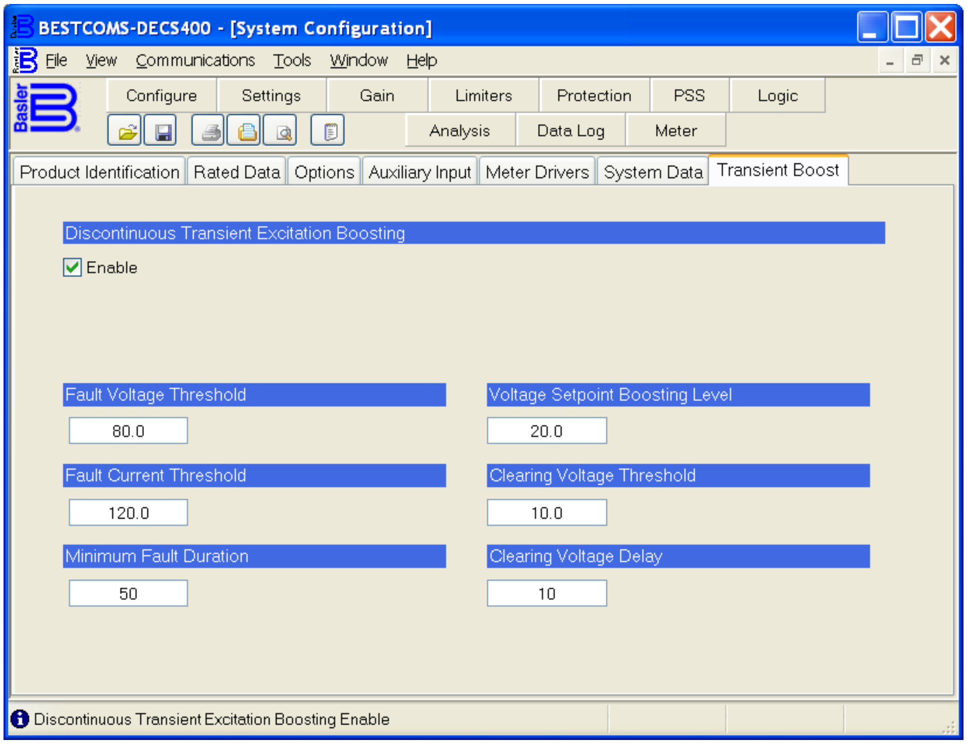


Figure 4-13. System Configuration Screen, Transient Boost

Minimum Fault Duration. The minimum fault duration is entered in this field. A setting of 0 to 1,000 may be entered in 1 ms increments.

Voltage Setpoint Boosting Level. The boosting level of the voltage setpoint is entered in this field. A setting of 0 to 100 may be entered in 0.1% increments.

Clearing Voltage Threshold. The threshold for clearing voltage is entered in this field. A setting of 0 to 50% may be entered in 0.1% increments.

Clearing Voltage Delay. The duration of the clearing voltage is entered in this field. A setting of 0 to 1,000 milliseconds may be entered in 1 millisecond increments.

Settings

The Settings screen consists of three tabs labeled AVR/FCR/FVR, VAR/PF, and Startup. Click the **Settings** button on the tool bar to view the Settings screen.

AVR/FCR/FVR

AVR/FCR/FVR tab functions are shown in Figure 40 and described in the following paragraphs.

Automatic Voltage Regulator (AVR) – DECS Setpoint. This read-only field displays the DECS-400 setpoint as entered in the AVR Setpoint field.

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 120 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 70 to 120 percent may be entered in 0.1 percent increments.

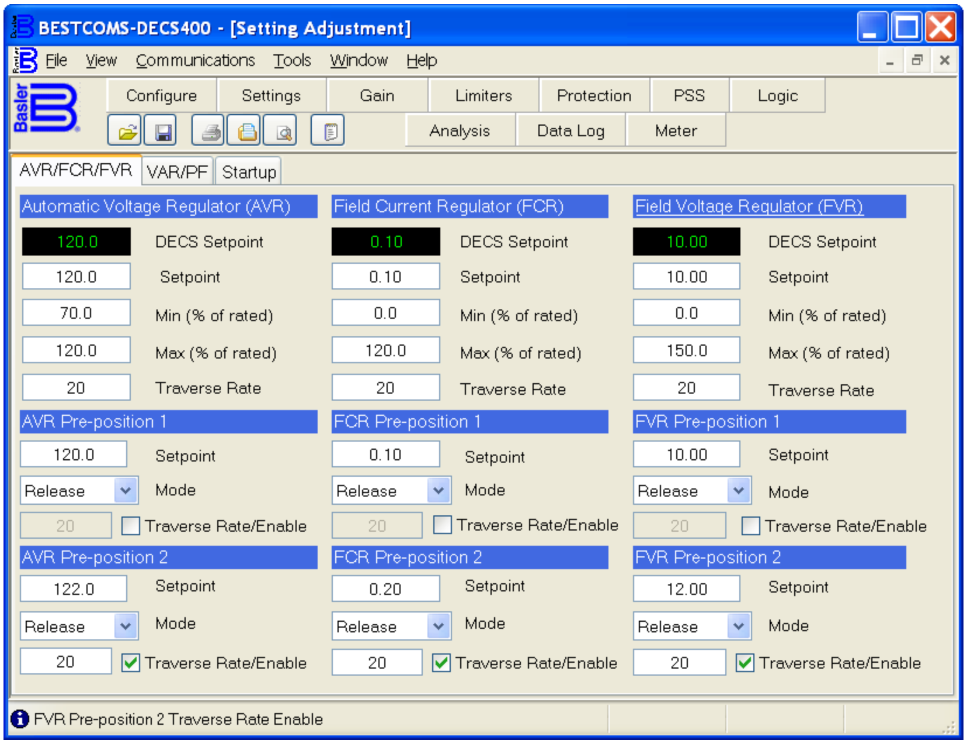


Figure 4-14. Setting Adjustment Screen, AVR/FCR/FVR Tab

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 1 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the AVR pre-position 1 setpoint. The rate setting establishes the length of time for the setpoint to travel the full setting range.

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.

AVR Pre-position 2 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the AVR pre-position 2 setpoint. The rate setting establishes the length of time for the setpoint to travel the full setting range.

Field Current Regulator (FCR) – DECS Setpoint. This read-only field displays the DECS-400 FCR setpoint as entered in the FCR Setpoint field.

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 120 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 1 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the FCR pre-position 1 setpoint. The rate setting establishes the length of time for the setpoint to travel the full setting range.

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.

FCR Pre-position 2 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the FCR pre-position 2 setpoint. The rate setting establishes the length of time for the setpoint to travel the full setting range.

Field Voltage Regulator (FVR) – DECS Setpoint. This read-only field displays the DECS FVR setpoint as entered in the FVR setpoint field.

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

Field Voltage Regulator (FVR) – Min (% of rated). This setting, expressed as a percentage of rated field voltage, establishes the minimum field voltage setpoint. A setting of 0 to 150 percent may be entered in 0.1 percent increments.

Field Voltage Regulator (FVR) – Max (% of rated). This setting, expressed as a percentage of rated field voltage, establishes the maximum field voltage setpoint. A setting of 0 to 150 percent may be entered in 0.1 percent increments.

Field Voltage Regulator (FVR) – Traverse Rate. This setting determines the time required for the FVR 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.

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

FVR 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 FVR setpoint.

FVR Pre-position 1 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the FVR pre-position 1 setpoint.

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

FVR 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. 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 FVR setpoint.

FVR Pre-position 2 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the FVR pre-position 2 setpoint.

VAR/PF

VAR/PF tab functions are shown in Figure 41 and described in the following paragraphs.

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.

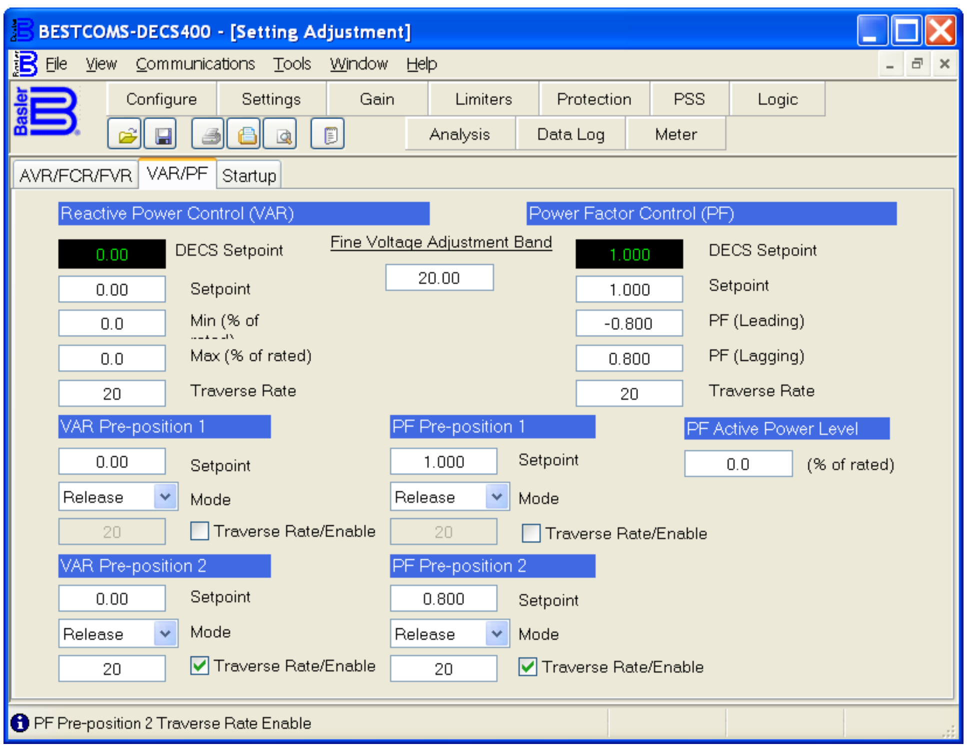


Figure 4-15. Setting Adjustment Screen, VAR/PF Tab

Reactive Power Control (VAR) – DECS Setpoint. This read-only field displays the DECS-400 setpoint as entered in the var setpoint field.

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 0% 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 0 to +100% 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 1 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the reactive power pre-position 1 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.

VAR Pre-position 2 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the reactive power pre-position 2 setpoint.

Power Factor Control (PF) – DECS Setpoint. This read-only field displays the DECS power factor setpoint as entered in the PF setpoint field.

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 1 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the power factor pre-position 1 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.

PF Pre-position 2 – Traverse Rate/Enable. When enabled, this setting controls the amount of time required to drive the operating setpoint to the power factor pre-position 2 setpoint.

PF Active Power Level – Level%. This setting establishes the level of generator output power (kW) where the DECS-400 switches to/from Droop Compensation/Power Factor mode. If the level of power decreases below the setting, the DECS-400 switches from Power Factor mode to Droop Compensation mode. Conversely, as the level of power increases above the setting, the DECS-400 switches from Droop Compensation mode to Power Factor mode. A setting of 0 to 30% may be entered in 0.1% increments.

Startup

Startup tab functions are shown in Figure 42 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.

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.

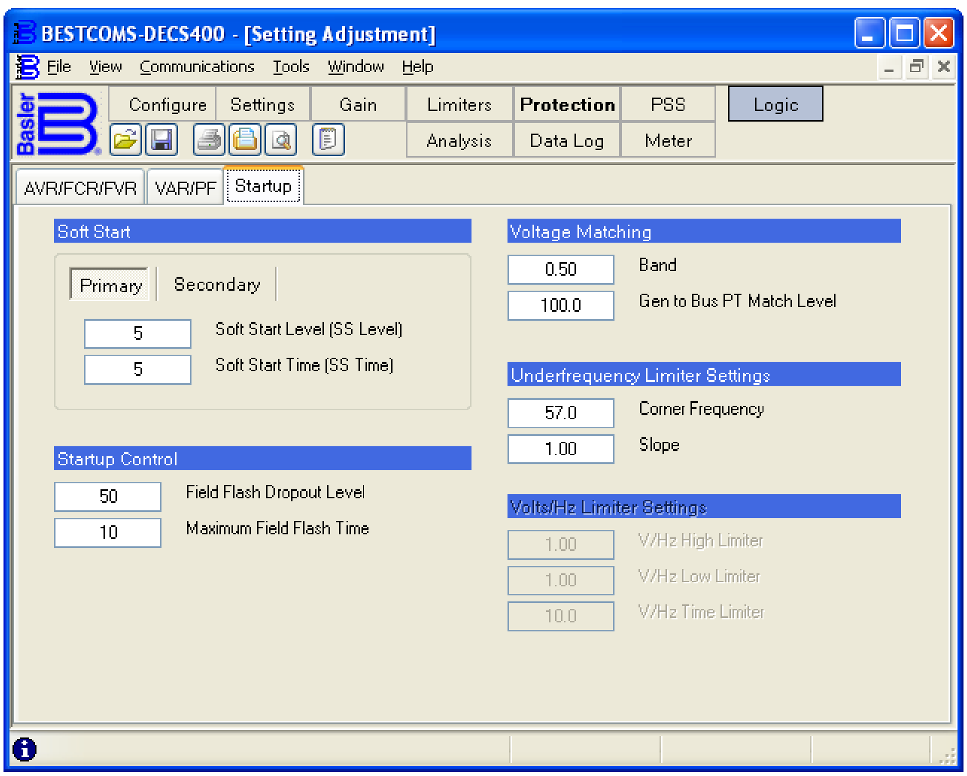


Figure 4-16. Setting Adjustment Screen, Startup Tab

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 parentage 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. The voltage matching band defines how close in magnitude the generator and bus voltage must be to each other for voltage matching to be active. The band level setting is a percentage of rated generator 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 0.01 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 0.01 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 0.01 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 four tabs labeled AVR Gain, FCR Gain, FVR Gain, and Other Gain. Click the **Gain** button on the tool bar to view the Gain Settings screen.

Note
Effective with firmware version 1.07, AVR and FCR modes have individual gain settings. This change is reflected in BESTCOMS version 1.04.00. If BESTCOMS detects a firmware version prior to 1.07, the *AVR Gain* and *FCR Gain* tabs will be combined into *AVR/FCR Gains*.

AVR Gain

The AVR Gain tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary AVR 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 Gain settings and PID settings.

AVR Gain tab functions are shown in Figure 43 and described in the following paragraphs.

AVR – 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.

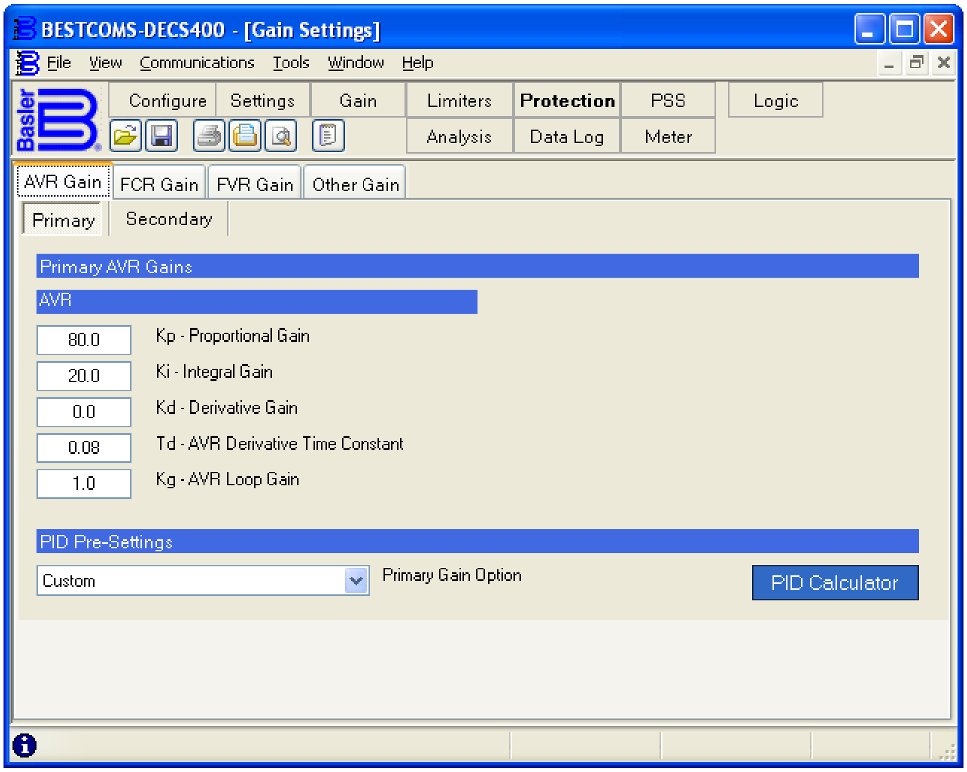


Figure 4-17. Gain Settings Screen, AVR Gain Tab

AVR – 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 Ki should be increased.

AVR – 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 – 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.

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 43. 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 Gain tab.

PID Calculator

PID Calculator functions are shown in Figure 44 and described in the following paragraphs.

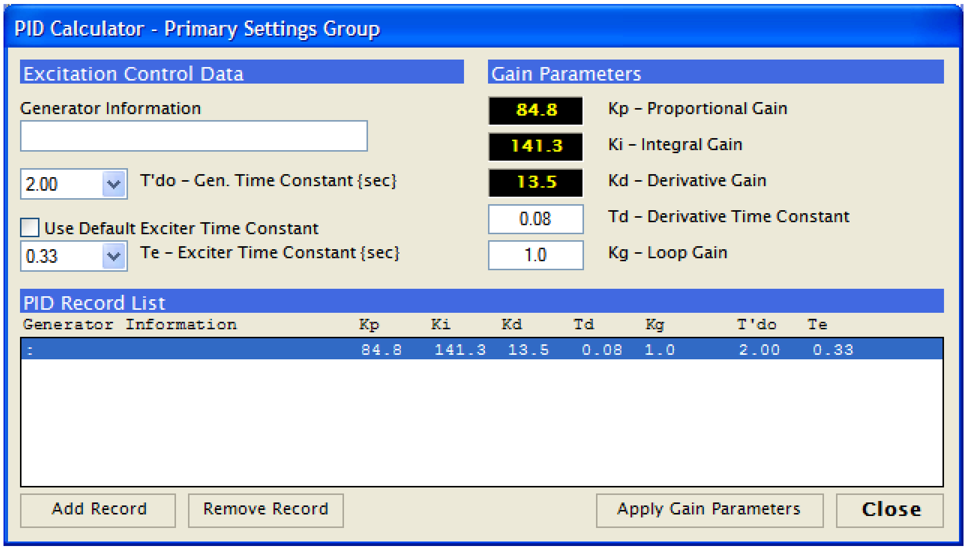


Figure 4-18. PID Calculator

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 Kp, Ki, and Kd. A setting of 1.00 to 15.00 may be selected from the pull-down menu.

Te – 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 Kp, Ki, and Kd. 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 – Kp-Proportional Gain. This read-only field displays the calculated value of Kp based on the generator time constant (T'do) and exciter time constant (Te).

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.

Caution

Calculated or user-defined PID values are to be implemented only after their suitability for the application has been verified by the user. Incorrect PID numbers can result in poor system performance or equipment damage.

FCR Gain and FVR Gain

FCR Gain tab functions are shown in Figure 45 and described in the following paragraphs. The FVR Gain tab has the same settings and is not illustrated here. The following FCR Gain tab setting descriptions also apply to the settings of the FVR Gain tab.

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 current setpoint and the actual field current. A setting of 0 to 1,000.0 may be entered in increments of 0.1.

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.

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 current setpoint and the actual field current. A setting of 0 to 1,000.0 may be entered in increments of 0.1.

If the time to reach steady-state is deemed too long, then Ki should be increased.

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 current setpoint and the actual field current. A setting of 0 to 1,000.0 may be entered in increments of 0.1.

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

FCR – Td-Derivative Time Constant. This setting is used to remove the noise effect on numerical differentiation. A setting of 0 to 1,000.00 may be entered in increments of 0.01.

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

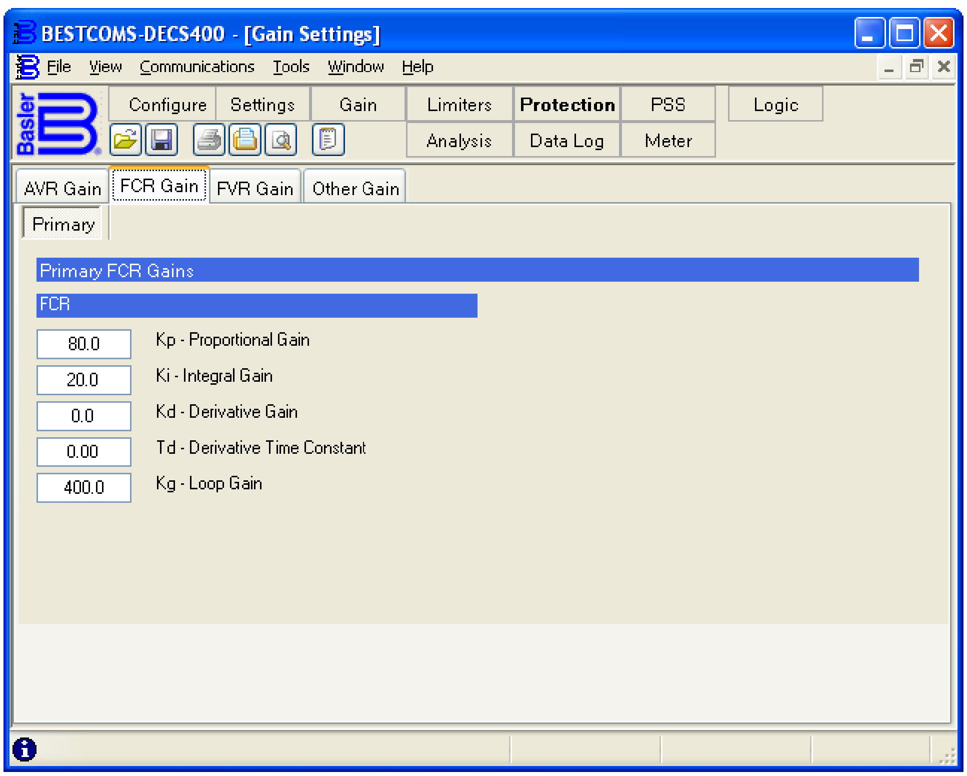


Figure 4-19. Gain Settings Screen, FCR Gain Tab

Other Gain

Other Gain tab functions are shown in Figure 46 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.

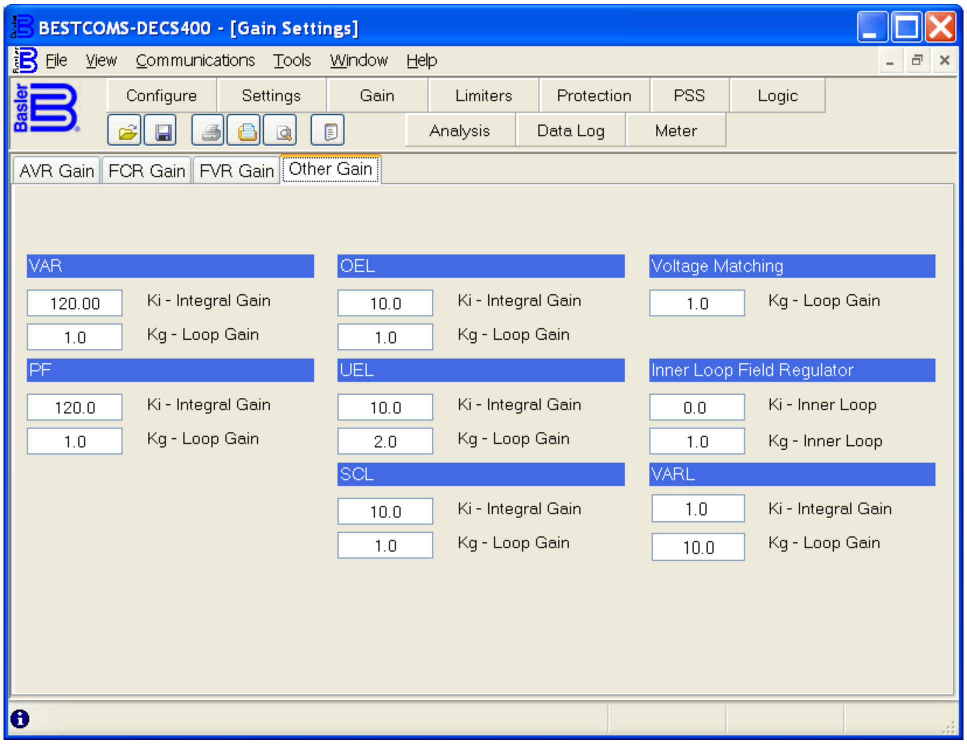


Figure 4-20. Gain Settings Screen, Other Gain Tab

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.

Inner Loop Field Regulator – Ki-Inner Loop. This setting adjusts the rate at which the DECS-400 responds to changes in the main field voltage. A setting of 0 to 1,000.0 may be entered in increments of 0.1.

Inner Loop Field Regulator – Kg Inner Loop. This setting adjusts the coarse loop-gain level of the PI algorithm for the inner loop field regulator. A setting of 0 to 1,000.0 may be entered in increments of 0.1.

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

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

Limiters

The Limiters screen consists of seven tabs labeled Configuration, Summing Point OEL, UEL, Takeover OEL, SCL, VARL, and Scaling. Click the **Limiters** button on the tool bar to view the Limiters screen.

Configuration

Configuration tab settings are shown in Figure 47 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).

OEL Mode – OEL. This setting selects either the summing point or takeover style of overexcitation limiting.

OEL Voltage Dependency – dv/dt Enable. Enabling this supervisory function affects the way the on-line overexcitation limiter operates. If this feature is enabled and the rate of reduction of terminal voltage exceeds the dv/dt Level setting, the High-, Medium-, and Low-Level On-Line OEL settings (Limiters screen, Summing Point OEL tab) are enabled. Otherwise, only the Medium- and Low-Levels are enabled.

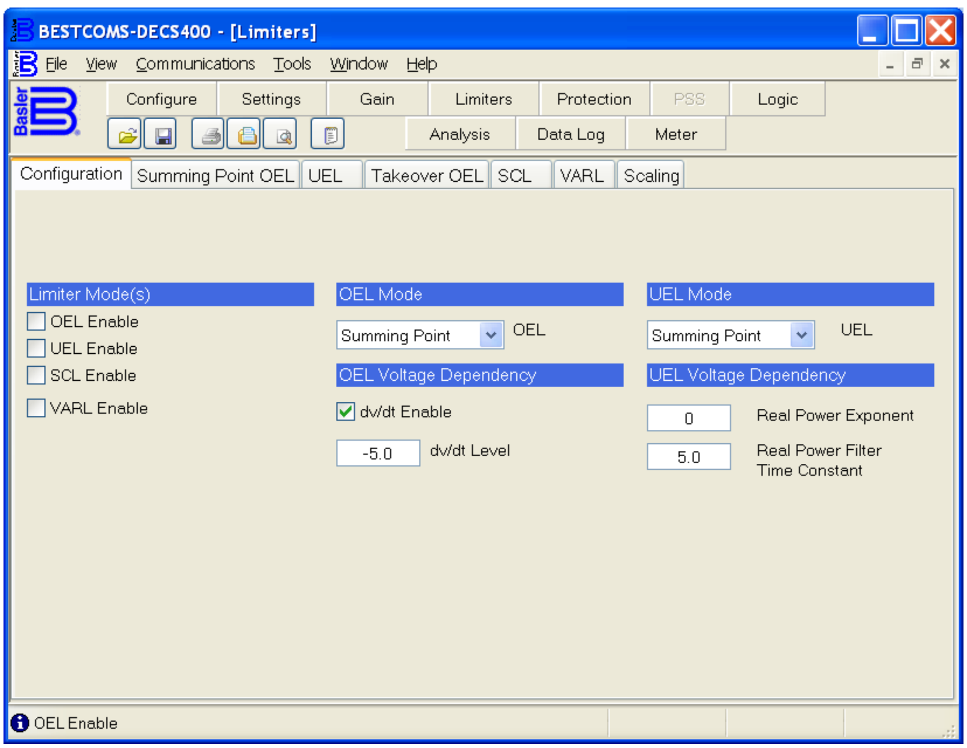


Figure 4-21. Limiters Screen, Configuration Tab

OEL Voltage Dependency – dv/dt Level. This setting controls the level of voltage that triggers the OEL Voltage Dependency function. If the Voltage Dependency function is enabled and the rate of reduction of terminal voltage exceeds this setting, the High-Level, On-Line OEL setting is enabled. Otherwise, the High-Level setting is disabled. This per-unit, per second setting has a range of –10.0 to 0. The setting increment is 0.1.

UEL Mode – UEL. This setting selects 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 48 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 240 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.

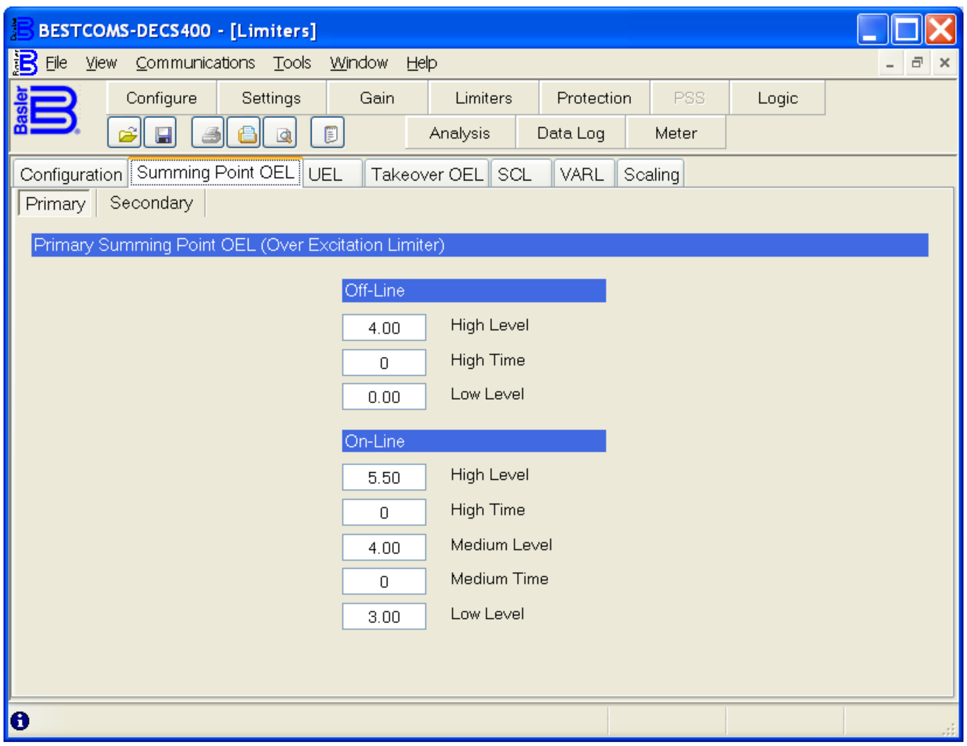


Figure 4-22. Limiters Screen, Summing Point OEL Tab

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 240 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 240 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.

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 49 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 setting fields establish the real-power points of the underexcitation limiter curves. Depending on whether a three-point or five-point curve is selected, either three or five setting fields are enabled to accept point values. The Curve Selection setting must be "Custom" in order for these setting fields to be enabled. The range for each setting field is based on the generator ratings entered on the Rated Data tab of the System Configuration screen.

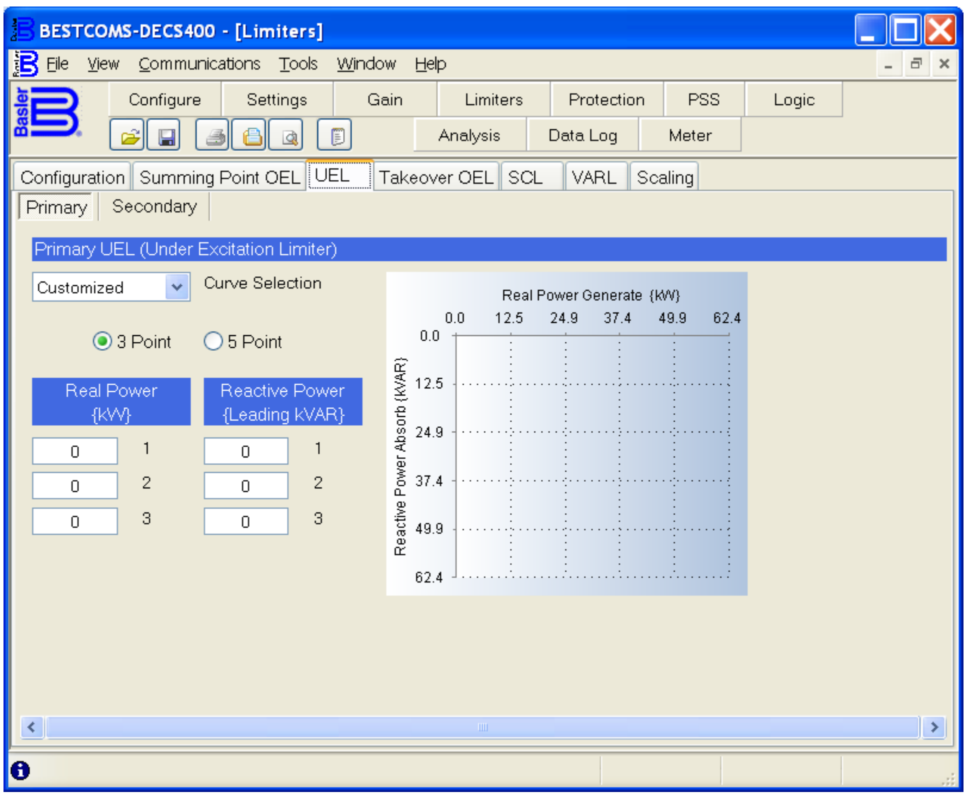


Figure 4-23. Limiters Window, UEL Tab

Reactive Power (Leading kVAR). When the Curve Selection setting is "Custom", these setting fields establish the reactive power points of the underexcitation limiter curve. Depending on whether a three-point or five-point curve is selected, either three or five setting fields are enabled to accept point values. 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.

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 50 and described in the following paragraphs.

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.

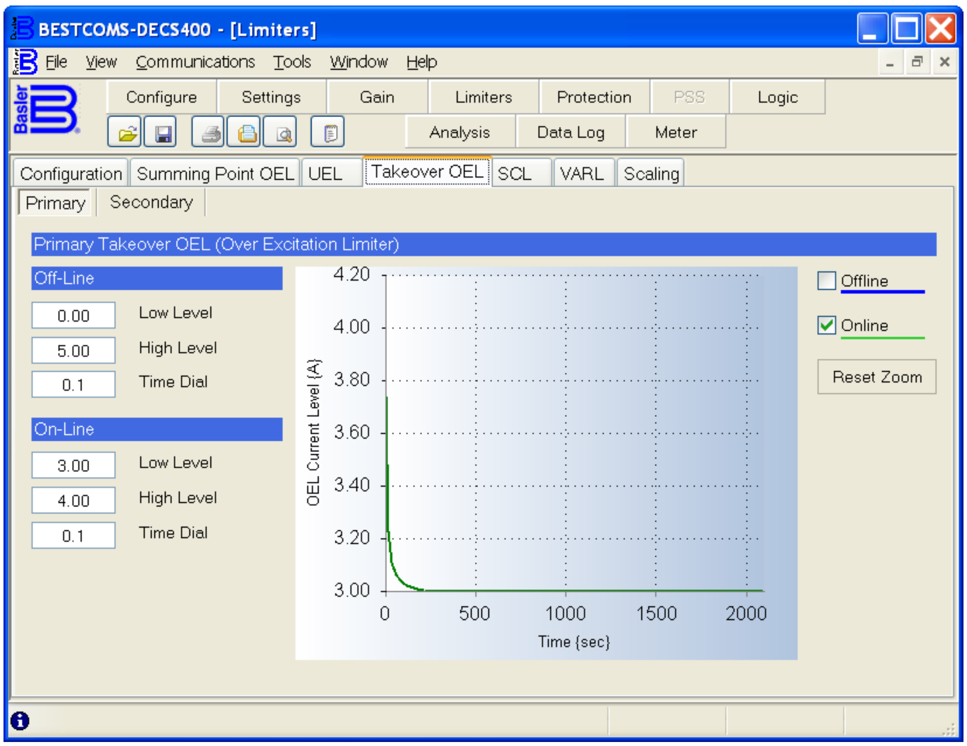


Figure 4-24. Limiters Screen, Takeover OEL Tab

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.

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 51 and described in the following paragraphs.

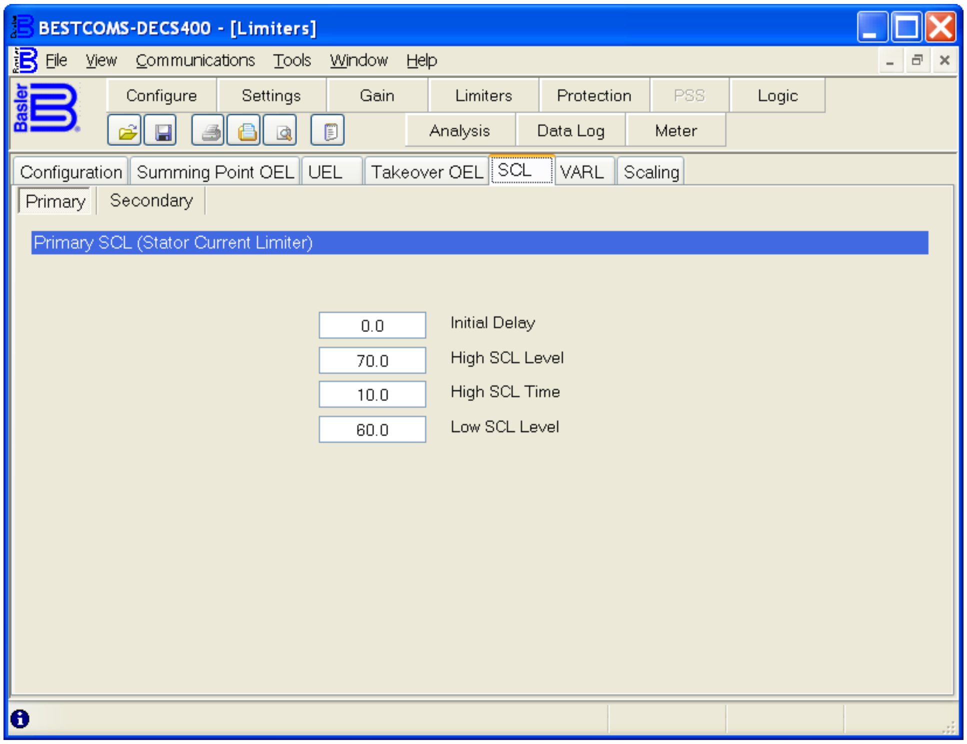


Figure 4-25. Limiters Screen, SCL Tab

SCL - Initial Delay. The SCL does not respond until the Initial Delay has expired. A setting of 0 to 10 may be entered in 0.1 second increments.

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 240.0 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.

VARL

The VARL tab has two setting groups: Primary and Secondary. The Primary and Secondary buttons select between the primary and secondary reactive power limiter settings.

VARL tab settings are shown in Figure 52 and described in the following paragraphs.

Setpoint. This setting configures the threshold where the level of exported reactive power is limited. The Setpoint setting range is dependent upon the level of generator apparent power entered on the Rated Data tab of the System Configuration screen. A setting is entered in kvar in 1 kvar increments.

Time Delay. This setting determines how quickly exported reactive power is limited once it exceeds the Setpoint threshold. A setting of 0 to 10 seconds may be entered in 0.1 second increments.

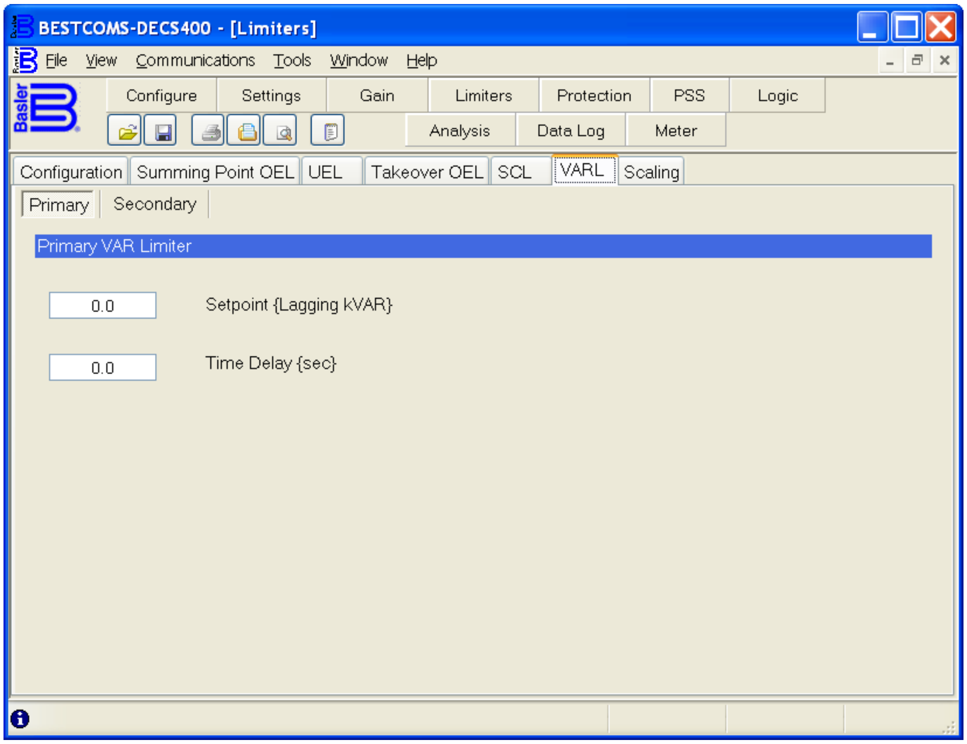


Figure 4-26. Limiters Screen, VARL Tab

Scaling

Scaling tab settings are shown in Figure 53 and described in the following paragraphs.

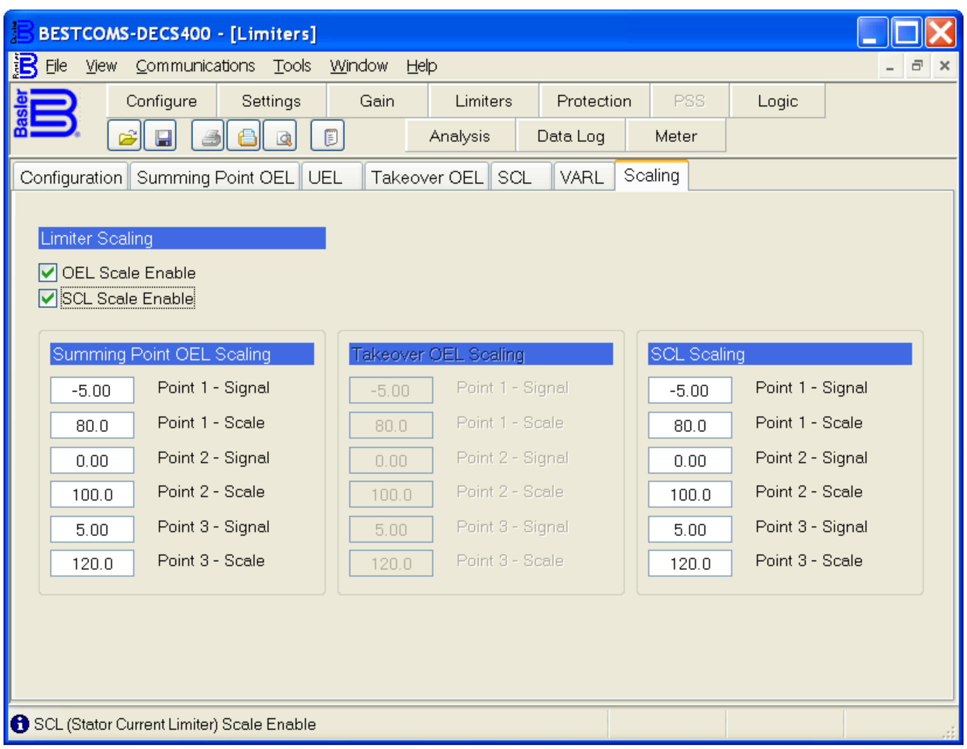


Figure 4-27. Limiters Screen, Scaling Tab

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 stator current. Each level, or point, has a Signal setting to adjust the scaling level and a Scale setting to establish the level of stator 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 stator 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, 24 Volts/Hertz, Loss of Sensing, EDM, and Relay Setup. Click the **Protection** button on the tool bar to view the Protection screen.

<u>General Protection</u>

General Protection tab settings are shown in Figure 54 and described in the following paragraphs.

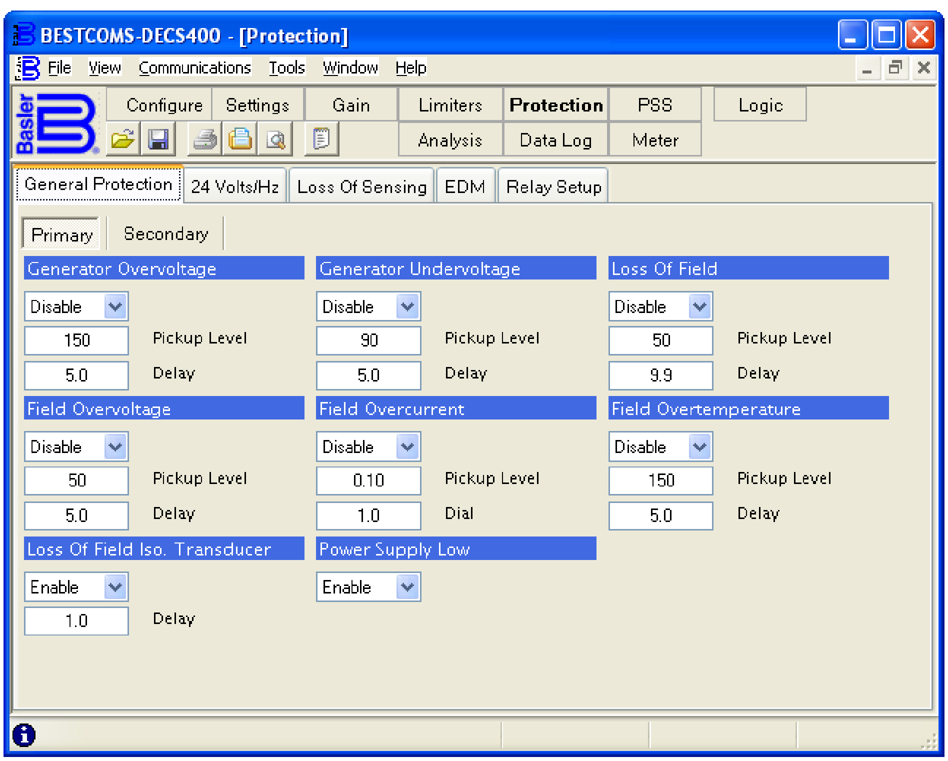


Figure 4-28. Protection Screen, General Protection Tab

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.

Generator Overvoltage – Enable/Disable. The generator overvoltage 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 575,000 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 – Enable/Disable. The field overvoltage pickup level and delay settings are enabled and disabled by this setting.

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

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

Generator Undervoltage – Pickup Level. This setting configures the setpoint for generator undervoltage protection. A setting of 0 to 575,000 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 – Enable/Disable. The field overcurrent pickup level and dial settings are enabled and disabled by this setting.

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 0.01 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.

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.

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

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.

24 Volts/Hz

24 Volts/Hz settings are shown in Figure 55 and described in the following paragraphs.

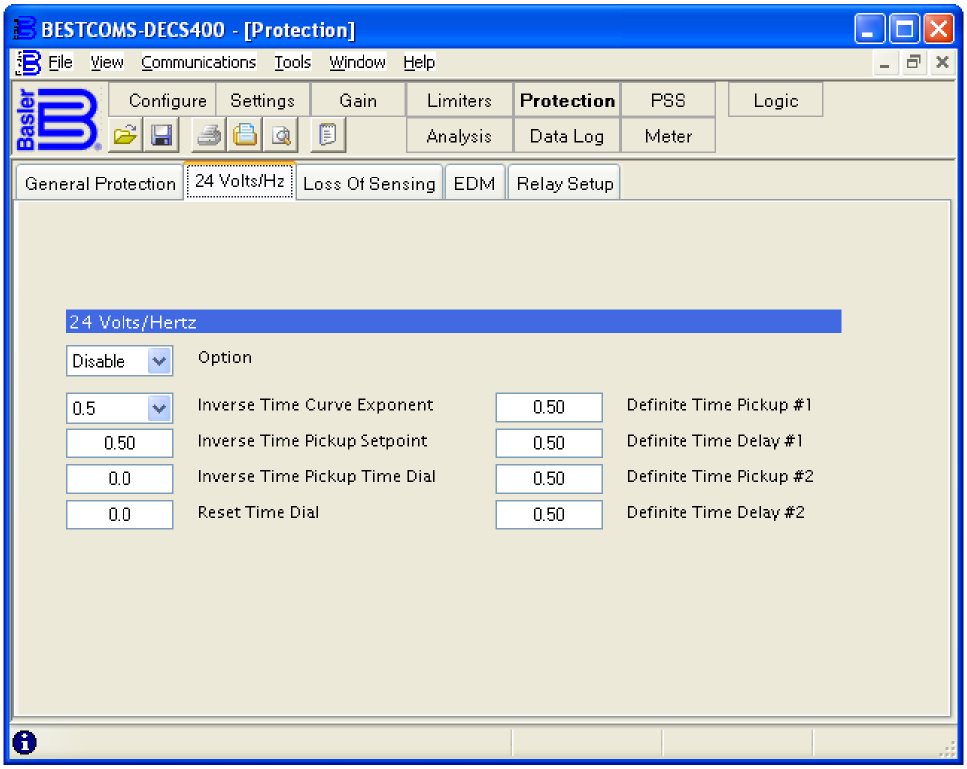


Figure 4-29. Protection Screen, 24 Volts/Hz Tab

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 generator end-iron heating characteristic during overexcitation. A per-unit Pickup Setpoint of 0.50 to 6.00 may be entered in increments of 0.01. A Pickup Time Dial of 0 to 9.9 may be entered in increments of 0.1.

24 Volts/Hertz – Reset Time Dial. This setting establishes a linear reset characteristic that approximates the effects of generator end-iron cooling. A Reset Time Dial setting of 0 to 9.9 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 6.00 with an increment of 0.01. Definite Time Delay #1 and #2 may be set over a range of 0.5 to 600.00 seconds in 0.05 second increments.

<u>*Loss of Sensing*</u>

Loss of Sensing tab functions are shown in Figure 56 and described in the following paragraphs.

Loss of Sensing Voltage – Option. This setting enables and disables loss of sensing voltage protection.

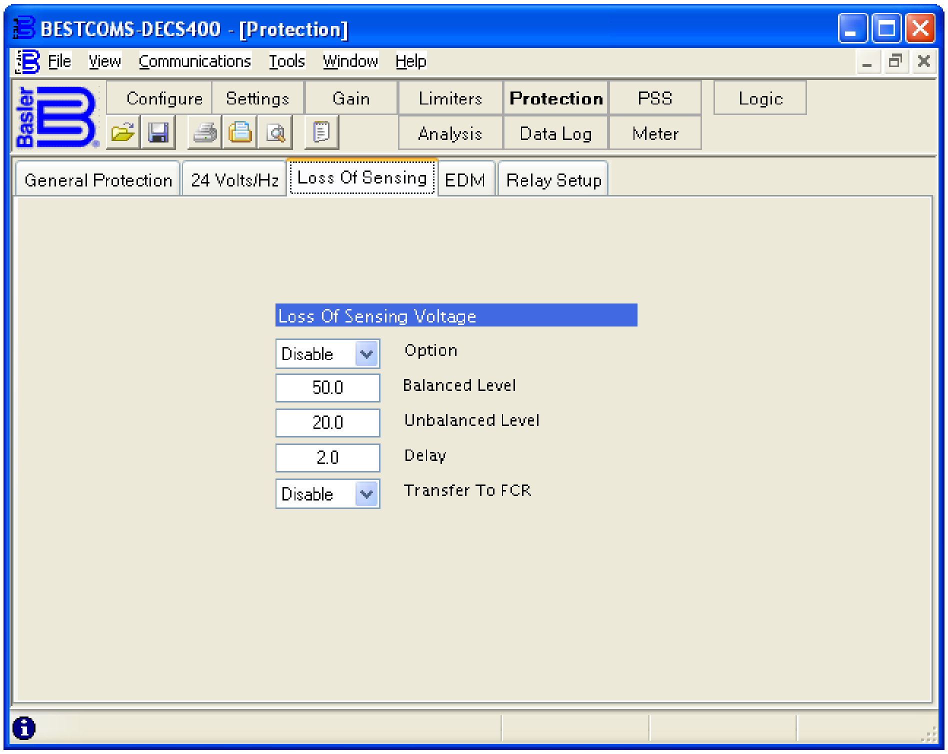


Figure 4-30. Protection Screen, Loss of Sensing Tab

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. Refer to the example in Figure 57.

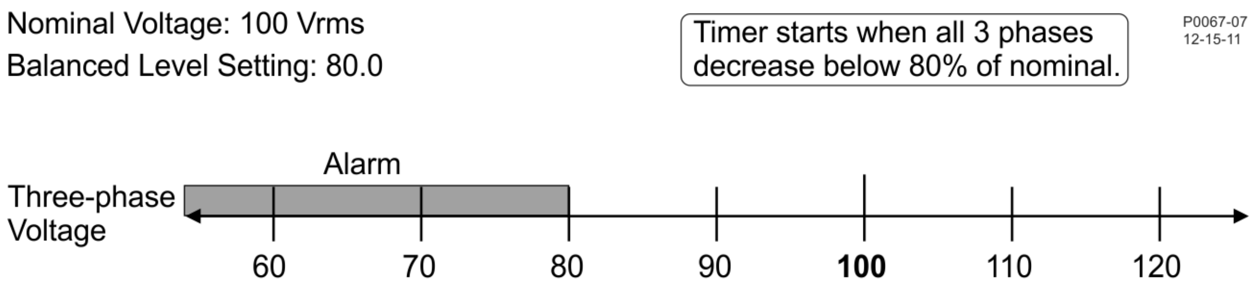


Figure 4-31. Example of Balanced Level Threshold

Loss of Sensing Voltage – Unbalanced Level. When the absolute difference between the average of all three phases and any one of the three phases of sensing voltage exceeds this setting, the loss of sensing voltage time delay begins timing out. A setting of 0 to 100 percent (from nominal) may be entered in 0.1 percent increments. Refer to the example in Figure 58.

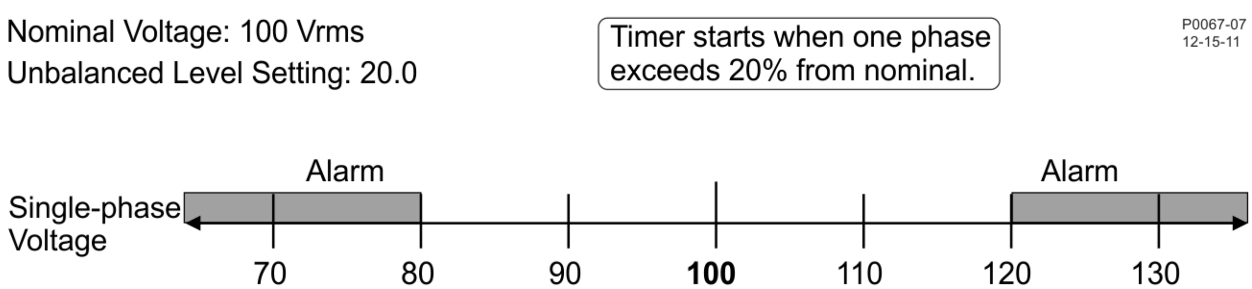


Figure 4-32. Example of Unbalanced Level Threshold

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.

EDM

EDM tab settings are shown in Figure 59 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 40.00 may be entered in 0.01 increments.

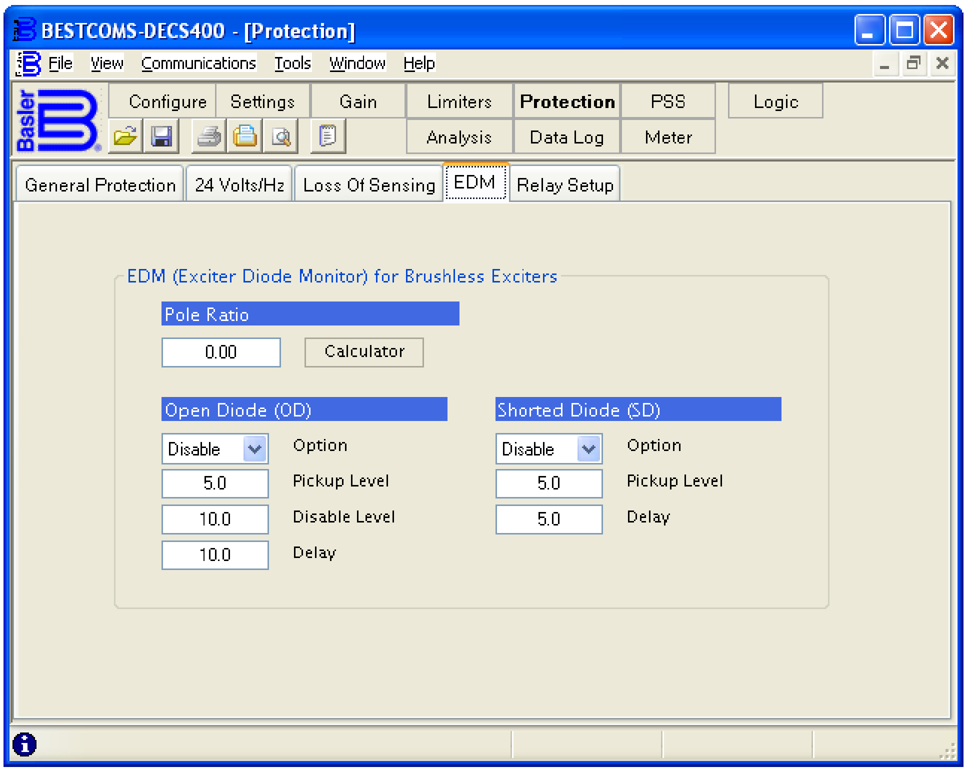


Figure 4-33. Protection Screen, EDM Tab

The Calculator button, adjacent to the Pole Ratio field, can be clicked to access the Pole Ratio Calculator shown in Figure 60. 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.

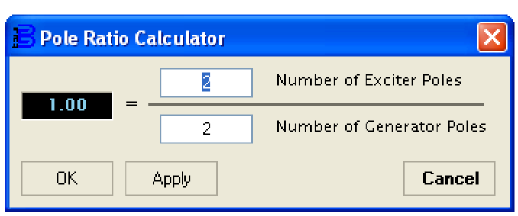


Figure 4-34. Pole Ratio Calculator

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.

Relay Setup

Relay Setup settings are shown in Figure 61 and described in the following paragraphs.

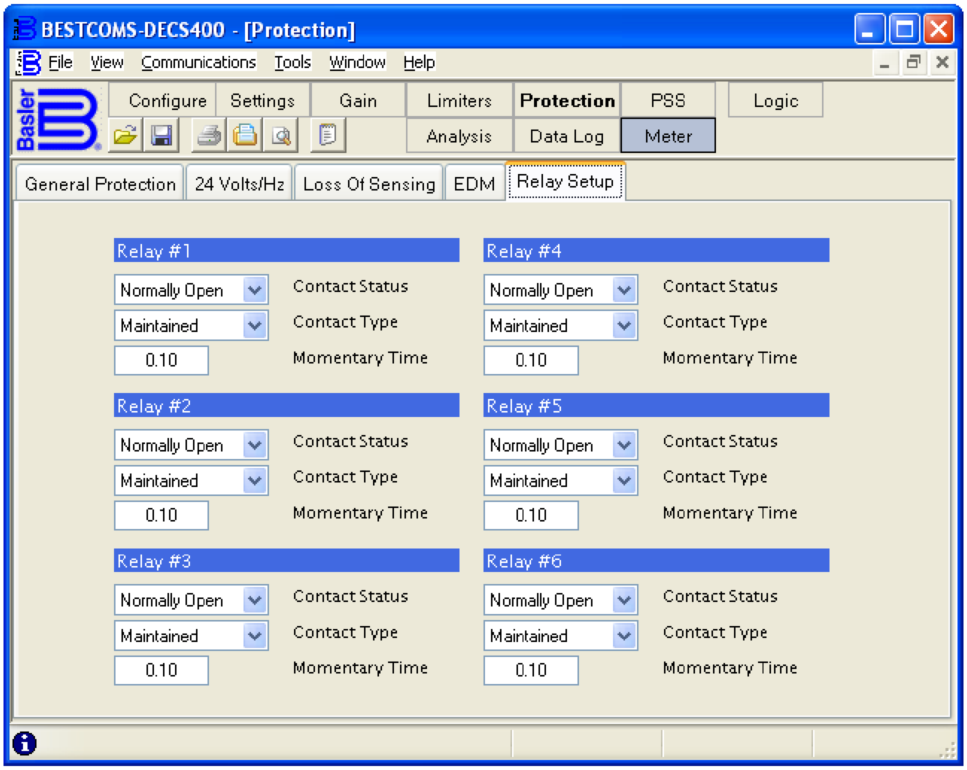


Figure 4-35. Protection Screen, Relay Setup Tab

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

Note
A minimum of two sensing CTs are required for PSS applications.

The PSS screen consists of five tabs: Configure, Control, Parameters, Output Limiter, and Rate of Change. Click the **PSS** button on the tool bar to view the PSS screen.

Configure

Configure tab settings consist of Setting Group Logic settings and Rate of Change settings. The Setting Group Logic settings are shown in Figure 62 and described in the following paragraphs.

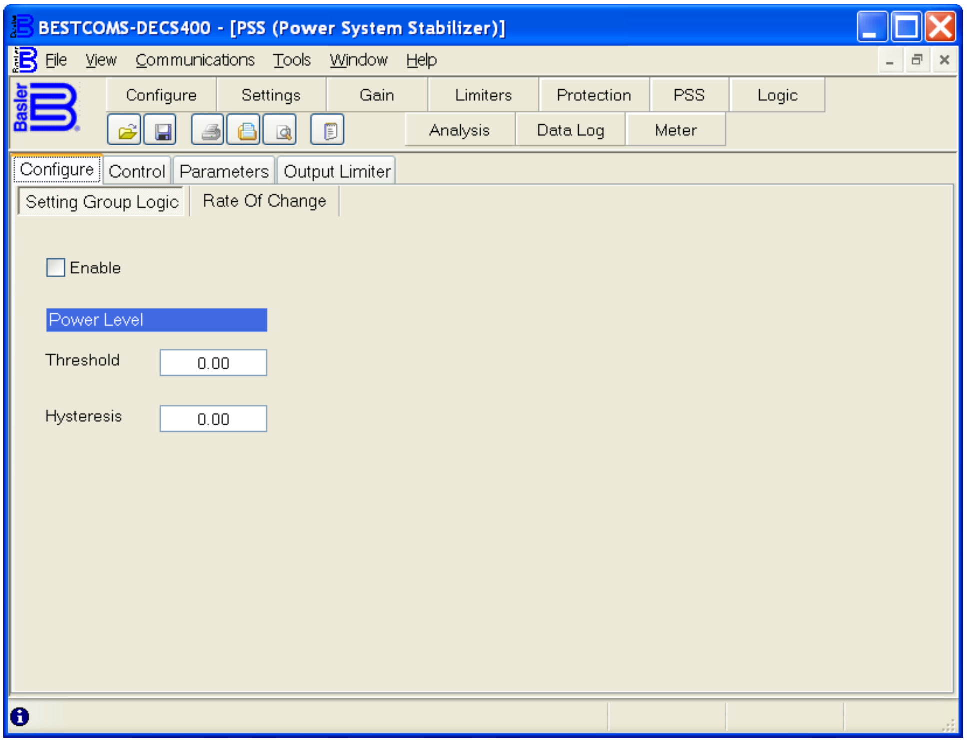


Figure 4-36. PSS Screen, Configure Tab

Power Level – Threshold. When the power level increases above this setting (and PSS Setting Group Logic is enabled), the PSS gain settings will switch from the primary group to the secondary group. A per-unit Threshold setting of 0 to 1.00 may be entered in increments of 0.01.

Power Level – Hysteresis. Following a transfer from the primary PSS gains settings to the secondary group, this setting determines the level of (decreasing) power where a transfer will occur from the secondary group to the primary group. A per-unit Hysteresis setting of 0 to 1.00 may be entered in increments of 0.01.

The Rate of Change settings are illustrated in Figure 63 and described in the following paragraphs.

Block Time. Once the PSS output is driven to zero during a rate of frequency-change event, it is ramped back up to its previous, nominal value over the time defined by the Block Time setting. A setting of 0 to 20 seconds may be entered in 0.1 second increments.

Low-Pass Filter Time Constant. This setting can be used to tailor the response of the PSS rate-of-change function to the application. A setting of 0 to 20 seconds may be entered in 0.01 second increments.

Washout Filter Time Constant. This setting can be used to tailor the response of the PSS rate-of-change function to the application. A setting of 0 to 20 seconds may be entered in 0.01 second increments.

Control

The Control tab has two setting groups: Primary and Secondary. These two groups are selected with the Primary and Secondary buttons. 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.)

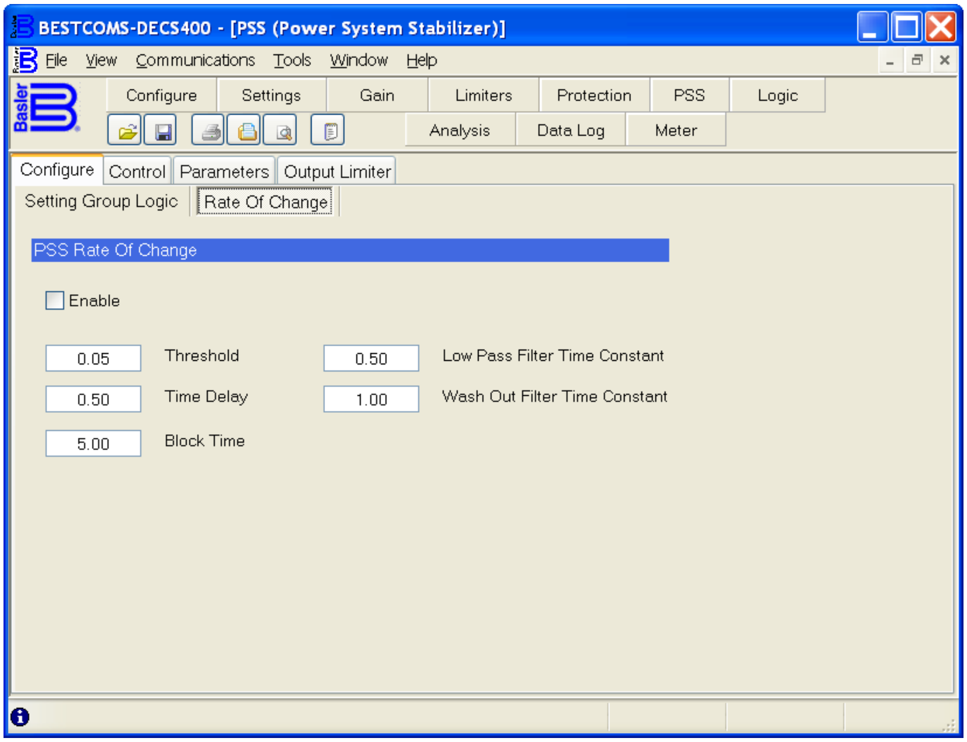


Figure 4-37. PSS Screen, Rate of Change Tab

Control tab settings are shown in Figure 64 and described in the following paragraphs.

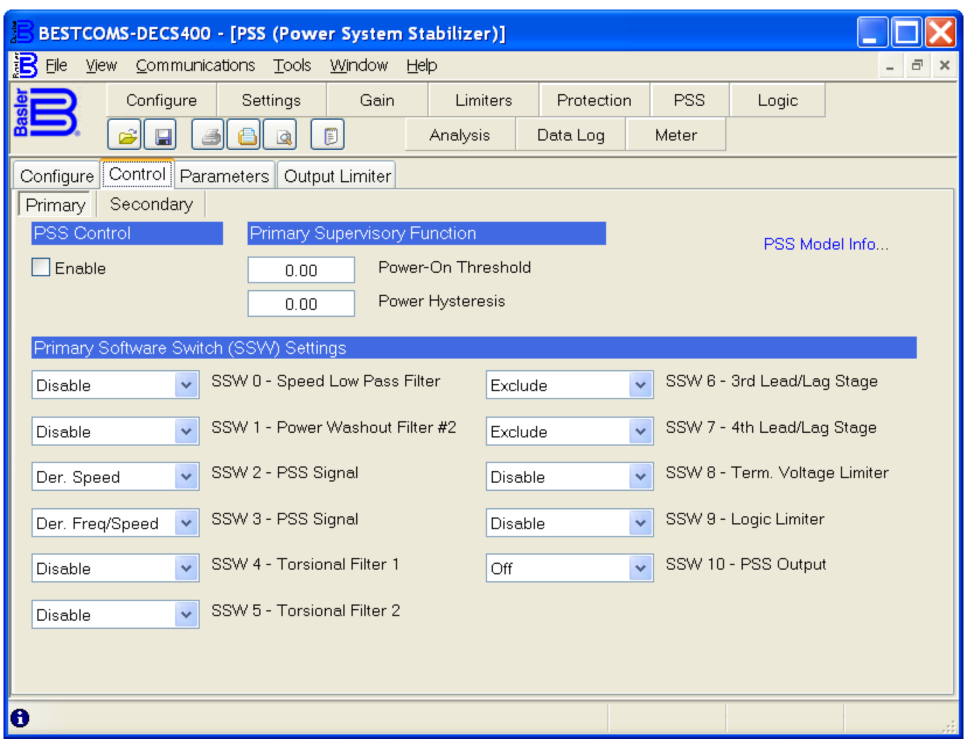


Figure 4-38. PSS Screen, Control Tab

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 (watts) 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 (watts) 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 65 and described in the following paragraphs.

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}). TI1 can be set over the range of 0 to 20 seconds in 0.01 second increments. TI2 can be set over the range of 0.01 to 20.00 seconds in 0.01 second increments. TI3 can be set over the range of 0.05 to 20.00 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 0.01 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.

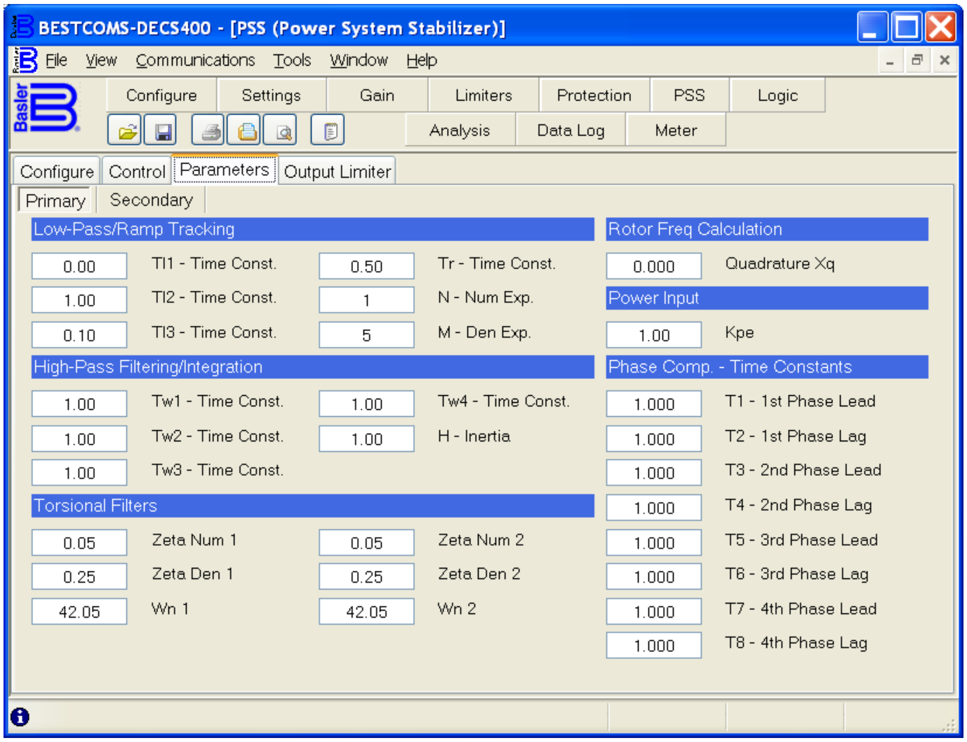


Figure 4-39. PSS Screen, Parameters Tab

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 66 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 –50 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.

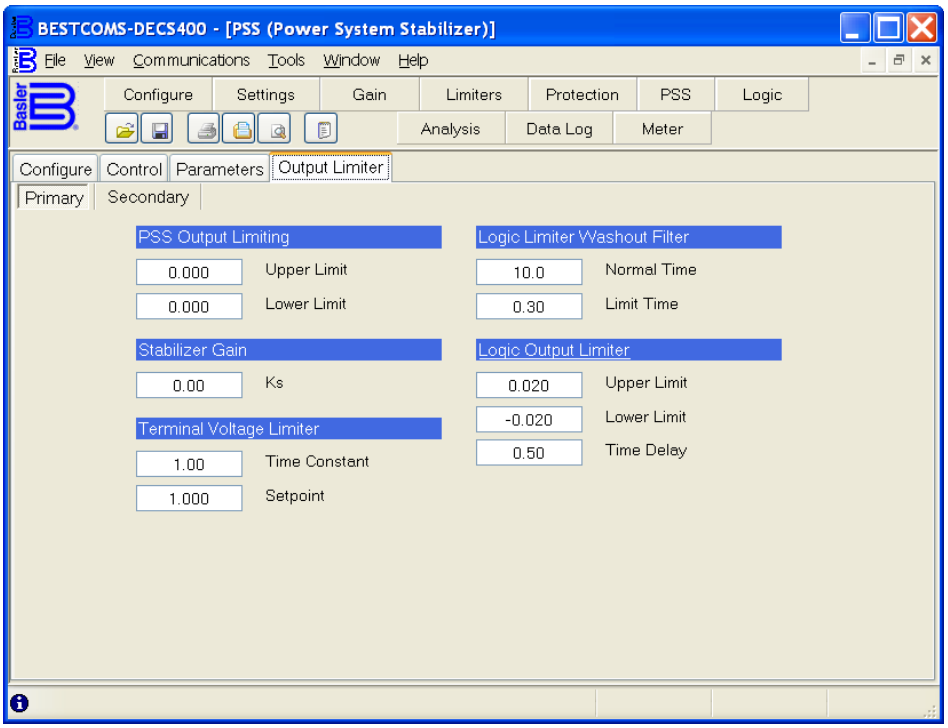


Figure 4-40. PSS Screen, Output Limiter Tab

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 to view the Metering screen.

Operation

The Operation tab of the Metering screen is shown in Figure 67. 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, percent terminal frequency deviation, percent compensated frequency deviation, the per-unit PSS output level, and PSS rate of change. 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.

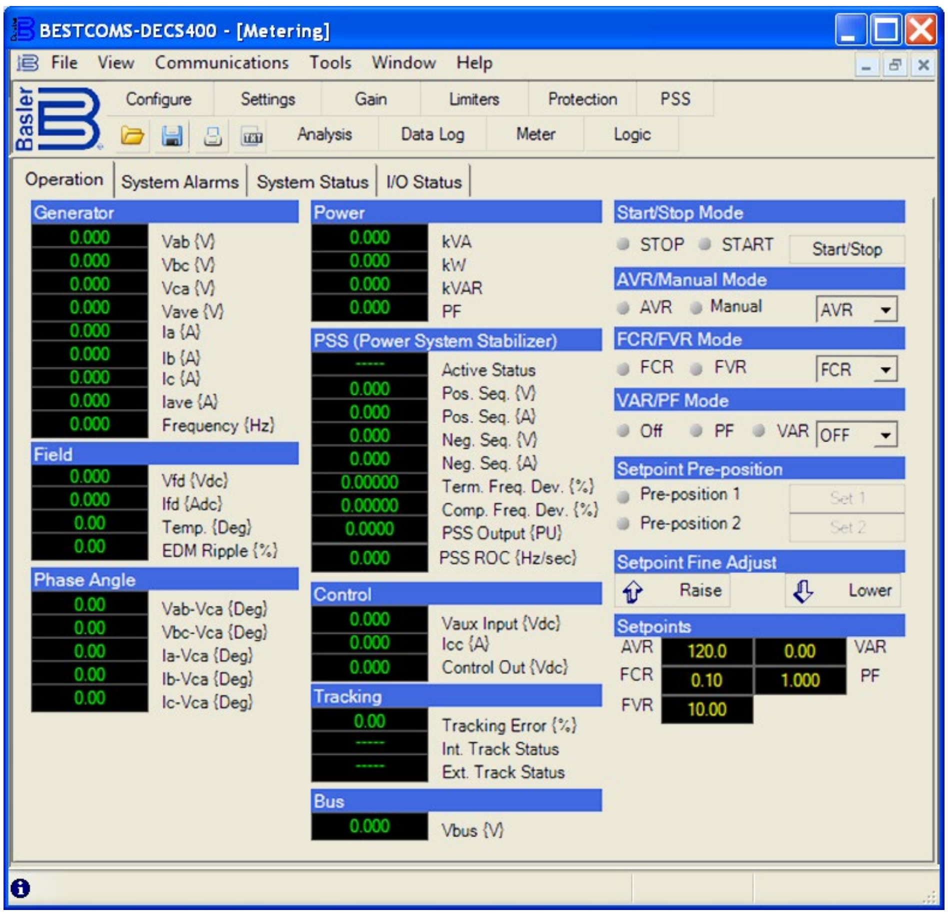


Figure 4-41. Metering Screen, Operation Tab

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/Manual Mode. AVR and Manual 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 Manual mode, the Manual indicator changes from gray to red. AVR mode or Manual mode is selected through the drop-down menu.

FCR/FVR Mode. FCR and FVR mode status is reported by two indicators. When the DECS-400 is operating in FCR mode, the FCR indicator changes from gray to red. When operating in FVR mode, the FVR indicator changes from gray to red. FCR mode or FVR 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. Five status fields indicate the setpoints for AVR mode, FCR mode, FVR mode, Var mode, and Power Factor mode.

System Alarms

System Alarms tab indicators are shown in Figure 68 and described in the following paragraphs.

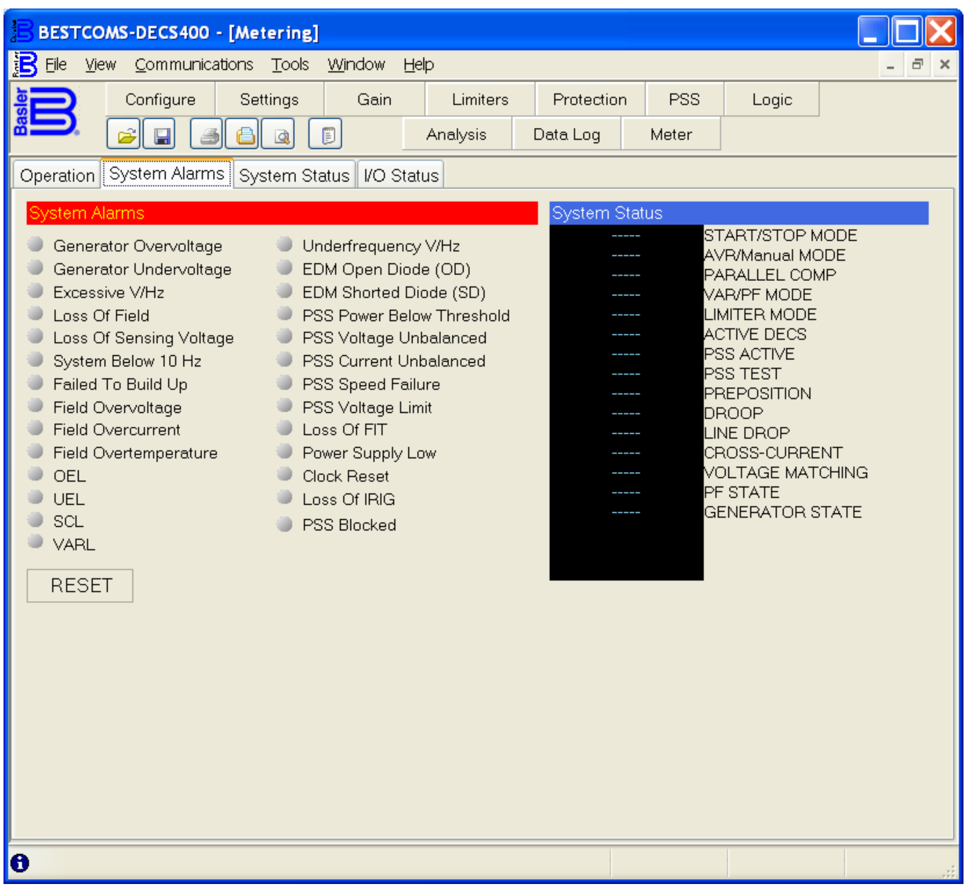


Figure 4-42. Metering Screen, System Alarms Tab

System Alarms. When any of 27 alarm conditions (Figure 68) 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 68) are listed alongside text labels that change according to the status of each operating mode.

System Status

System Status tab indicators are shown in Figure 69 and described in the following paragraphs.

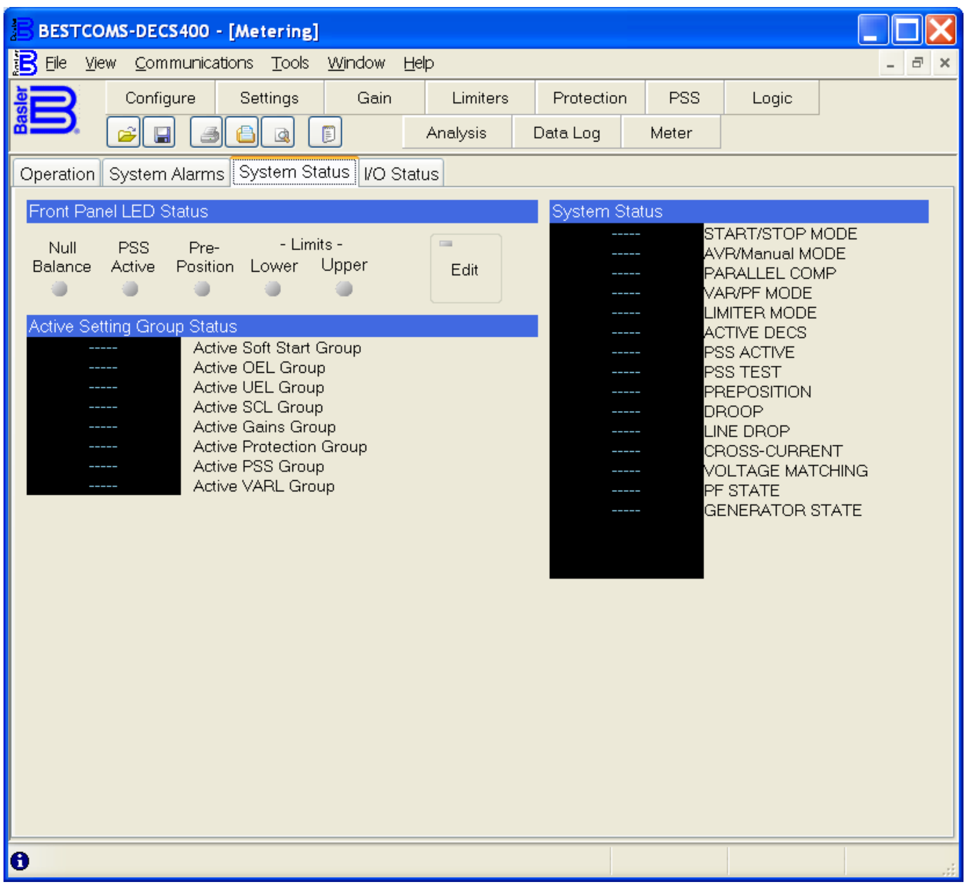


Figure 4-43. Metering Screen, System Status Tab

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 69) alongside text labels that change according to the status (primary or secondary) of each setting group.

System Status. Various system operating modes (Figure 69) are listed alongside text labels that change according to the status of each operating mode.

I/O Status

I/O Status tab indicators are shown in Figure 70 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 70) are listed alongside text labels that change according to the status of each operating mode.

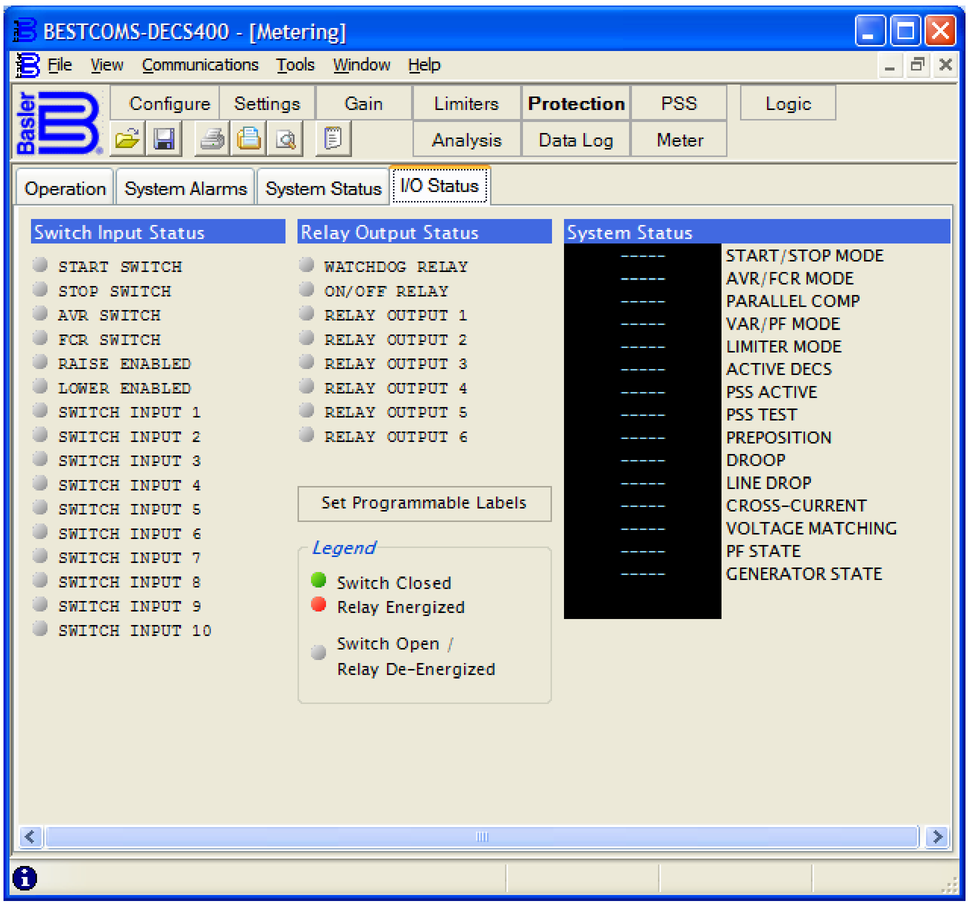


Figure 4-44. Metering Screen, I/O Status Tab

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 to view the Data Log screen.

Log Setup

Log Setup tab parameters and controls are shown in Figure 71 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. A value of 0 to 599 may be entered in increments of 1.

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.

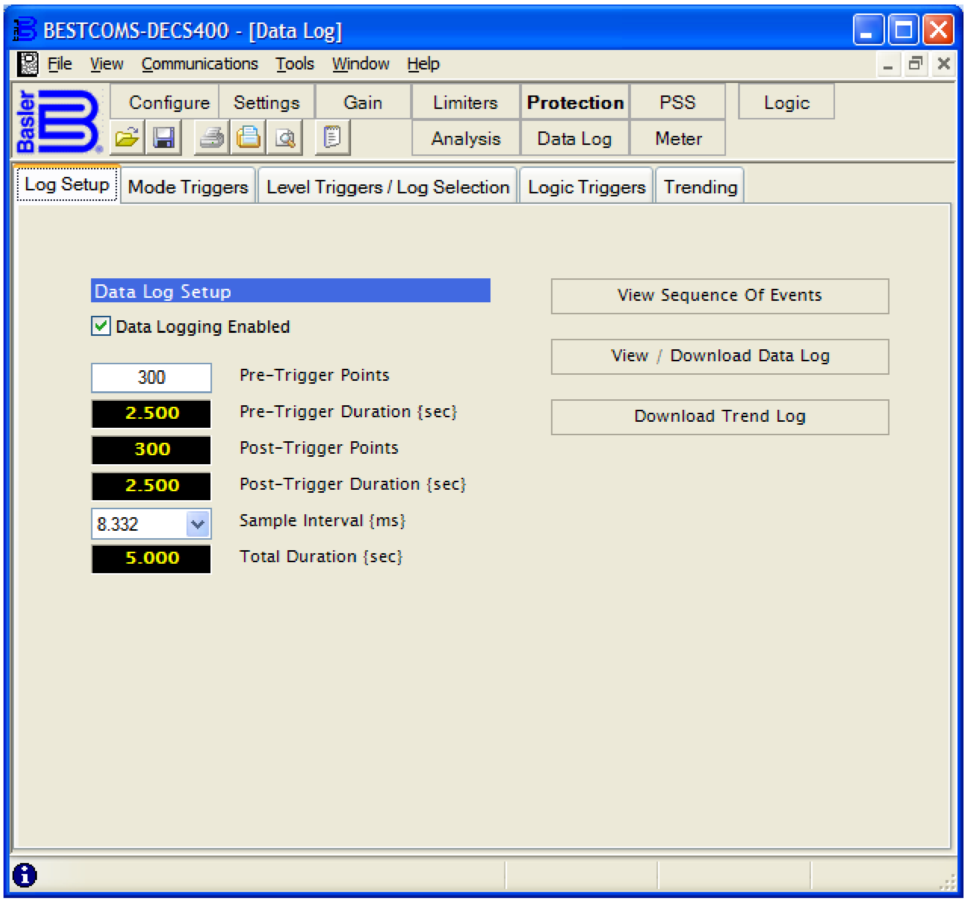


Figure 4-45. Data Log Screen, Log Setup Tab

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 72). Sequence of Events Reporting screen displays and controls are described in the following paragraphs.

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.

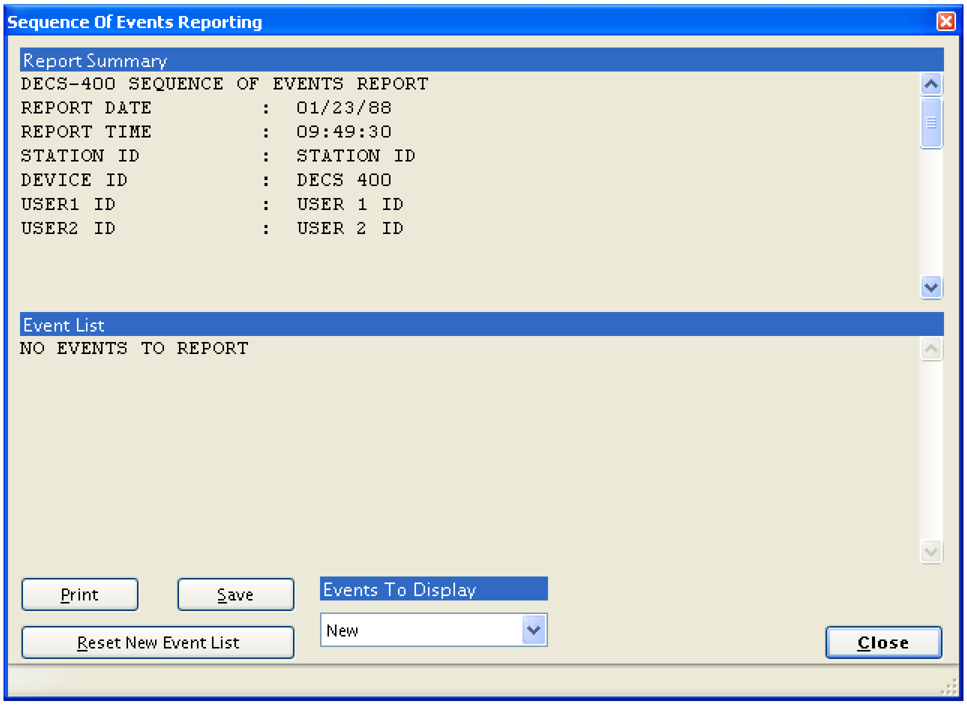


Figure 4-46. Sequence of Events Reporting Screen

View/Download Data Log. Clicking this button displays the Data Log Viewer screen of Figure 73. 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.

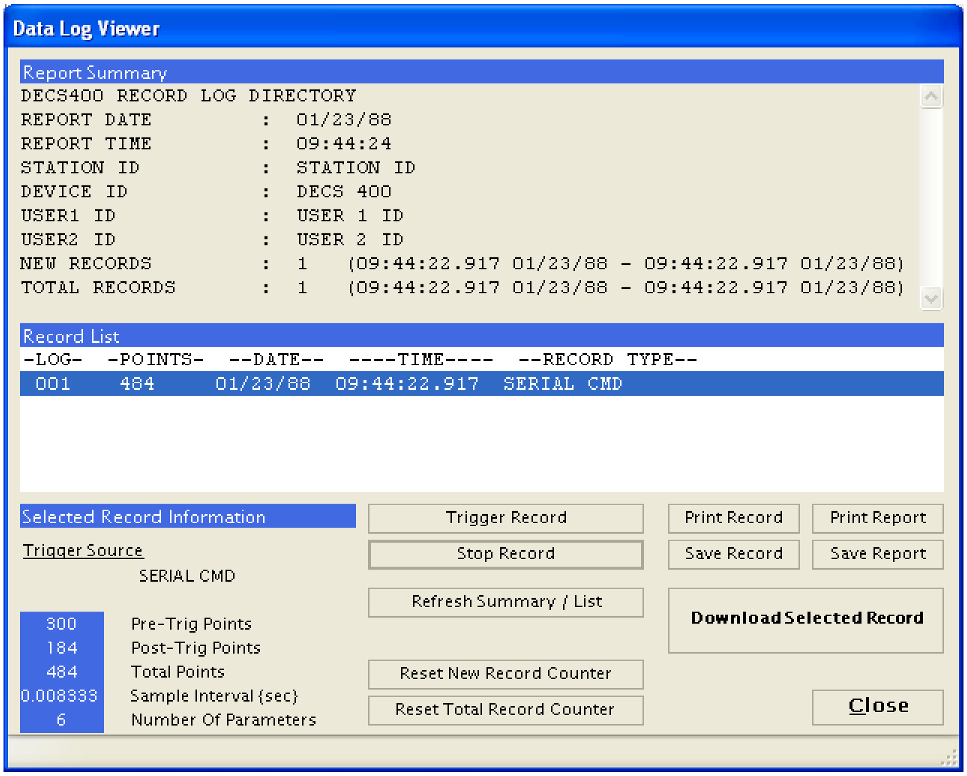


Figure 4-47. Data Log Viewer Screen

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.

Mode Triggers Tab

Mode Triggers tab settings are shown in Figure 74 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 Manual 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.

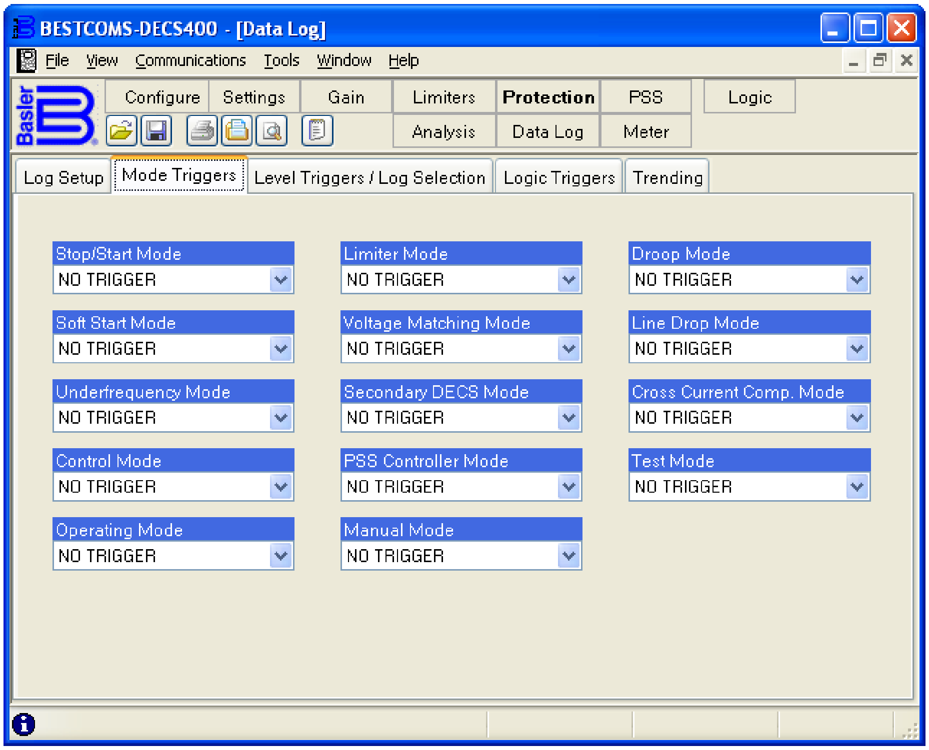


Figure 4-48. Data Log Screen, Mode Triggers Tab

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)
- OEL (overexcitation limiter)
- UEL & OEL
- SCL (stator current limiter)
- UEL & SCL
- OEL & SCL
- UEL, OEL & SCL
- VARL (reactive power limiter)
- VARL & UEL
- VARL & OEL
- VARL, OEL, & UEL
- VARL & SCL
- VARL, SCL, & UEL
- VARL, SCL, & OEL
- VARL, SCL, OEL, & UEL
- 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.

Manual Mode. This setting enables a data log report to be triggered when a transfer to Manual (either FCR or FVR) mode occurs.

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 75) 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 7.The Lower Threshold and Upper Threshold setting range for each parameter is listed also.

Table 4-2. Data Log Report Parameter Triggers

Parameter	Unit of Measure	Threshold		Increment
		Lower	Upper	
Auxiliary Voltage Input	V	–2 to 2	–2 to 2	0.01
AVR PID Error Signal Input	V	–2 to 2	–2 to 2	0.01
Bus Frequency	Hz	0 to 180	0 to 180	0.01
Bus Voltage	V	–2 to 2	–2 to 2	0.01
Comp. Frequency Deviation	Hz	–60 to 60	–60 to 60	0.01
Control Output ∗	N/A	–32,767 to 32,767	–32,767 to 32,767	1
Cross Current Input	A	–4 to 4	–4 to 4	0.01
Field Current	A	–2 to 2	–2 to 2	0.01
Field Temperature	PU	–2 to 2	–2 to 2	0.01
Field Voltage	V	–2 to 2	–2 to 2	0.01
Frequency Response	V	–2 to 2	–2 to 2	0.01
Generator Apparent Power	PU	–2 to 2	–2 to 2	0.01
Generator Average Current	kVA	–4 to 4	–4 to 4	0.01
Generator Average Voltage	V	–2 to 2	–2 to 2	0.01
Generator Current Ia	A	–4 to 4	–4 to 4	0.01
Generator Current Ib	A	–4 to 4	–4 to 4	0.01
Generator Current Ic	A	–4 to 4	–4 to 4	0.01
Generator Frequency	Hz	0 to 180	0 to 180	0.01
Generator Power Factor	PF	–1 to 1	–1 to 1	0.01
Generator Reactive Power	kvar	–2 to 2	–2 to 2	0.01
Generator Real Power	kW	–2 to 2	–2 to 2	0.01
Generator Voltage Vab	V	–2 to 2	–2 to 2	0.01
Generator Voltage Vbc	V	–2 to 2	–2 to 2	0.01
Generator Voltage Vca	V	–2 to 2	–2 to 2	0.01
Negative Sequence Current	A	–4 to 4	–4 to 4	0.01
Negative Sequence Voltage	V	–2 to 2	–2 to 2	0.01
Null Balance	PU	–2 to 2	–2 to 2	0.01
OEL Controller Output	V	–2 to 2	–2 to 2	0.01
PF Mode Output	V	–2 to 2	–2 to 2	0.01

Parameter	Unit of Measure	Threshold		Increment
		Lower	Upper	
Phase Angle Ia – Vca	Degrees	–180 to 180	–180 to 180	0.01
Phase Angle Iaux – Vca	Degrees	–180 to 180	–180 to 180	0.01
Phase Angle Ib – Vca	Degrees	–180 to 180	–180 to 180	0.01
Phase Angle Ic – Vca	Degrees	–180 to 180	–180 to 180	0.01
Phase Angle Vab	Degrees	–180 to 180	–180 to 180	0.01
Phase Angle Vbc	Degrees	–180 to 180	–180 to 180	0.01
PID Integrator State	N/A	–32,767 to 32,767	–32,767 to 32,767	1
Position Indication	PU	–2 to 2	–2 to 2	0.01
Positive Sequence Current	A	–4 to 4	–4 to 4	0.01
Positive Sequence Voltage	V	–2 to 2	–2 to 2	0.01
PSS Electrical Power	PU	–2 to 2	–2 to 2	0.01
PSS Filtered Mech. Power	PU	–2 to 2	–2 to 2	0.01
PSS Final Output	PU	–2 to 2	–2 to 2	0.01
PSS Lead-Lag #1	PU	–2 to 2	–2 to 2	0.01
PSS Lead-Lag #2	PU	–2 to 2	–2 to 2	0.01
PSS Lead-Lag #3	PU	–2 to 2	–2 to 2	0.01
PSS Lead-Lag #4	PU	–2 to 2	–2 to 2	0.01
PSS Mechanical Power LP #1	PU	–2 to 2	–2 to 2	0.01
PSS Mechanical Power LP #2	PU	–2 to 2	–2 to 2	0.01
PSS Mechanical Power LP #3	PU	–2 to 2	–2 to 2	0.01
PSS Mechanical Power LP #4	PU	–2 to 2	–2 to 2	0.01
PSS Mechanical Power	PU	–2 to 2	–2 to 2	0.01
PSS Post-Limit Output	PU	–2 to 2	–2 to 2	0.01
PSS Power HP #1	PU	–2 to 2	–2 to 2	0.01
PSS Pre-Limit Output	PU	–2 to 2	–2 to 2	0.01
PSS Speed HP #1	PU	–2 to 2	–2 to 2	0.01
PSS Synthesized Speed	PU	–2 to 2	–2 to 2	0.01
PSS Terminal Voltage	PU	–2 to 2	–2 to 2	0.01
PSS Torsional Filter #1	PU	–2 to 2	–2 to 2	0.01
PSS Torsional Filter #2	PU	–2 to 2	–2 to 2	0.01
PSS Washed Out Power	PU	–2 to 2	–2 to 2	0.01
PSS Washed Out Speed	PU	–2 to 2	–2 to 2	0.01
Rate of Frequency Change	PU	–2 to 2	–2 to 2	0.01
SCL Controller Output	V	–2 to 2	–2 to 2	0.01
Terminal Freq. Deviation	Hz	–60 to 60	–60 to 60	0.01
Time Response	V	–2 to 2	–2 to 2	0.01
UEL Controller Output	V	–2 to 2	–2 to 2	0.01
VARL Controller Output	PU	–2 to 2	–2 to 2	0.01

∗ 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:

$$Threshold\ Value = \frac{Control\ Voltage}{10} \times 32767$$

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:

$$22936.9 = \frac{7}{10} \times 32767$$

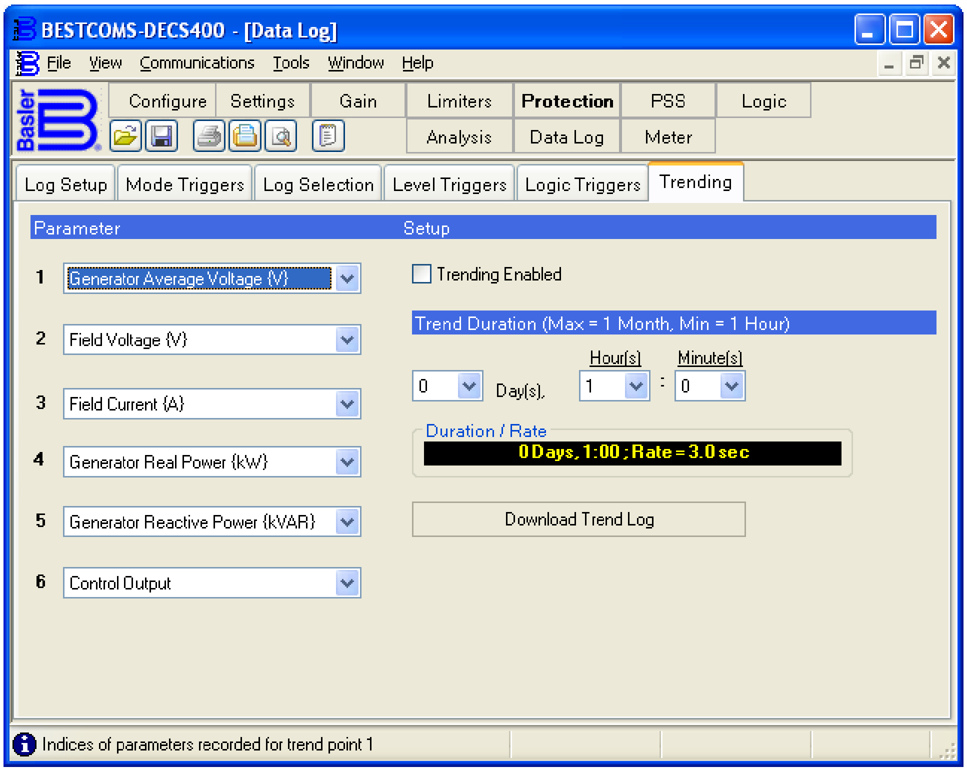


Figure 4-49. Data Log Screen, Level Triggers/Log Selection Tab

Logic Triggers Tab

Logic Trigger tab settings are shown in Figure 76 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.

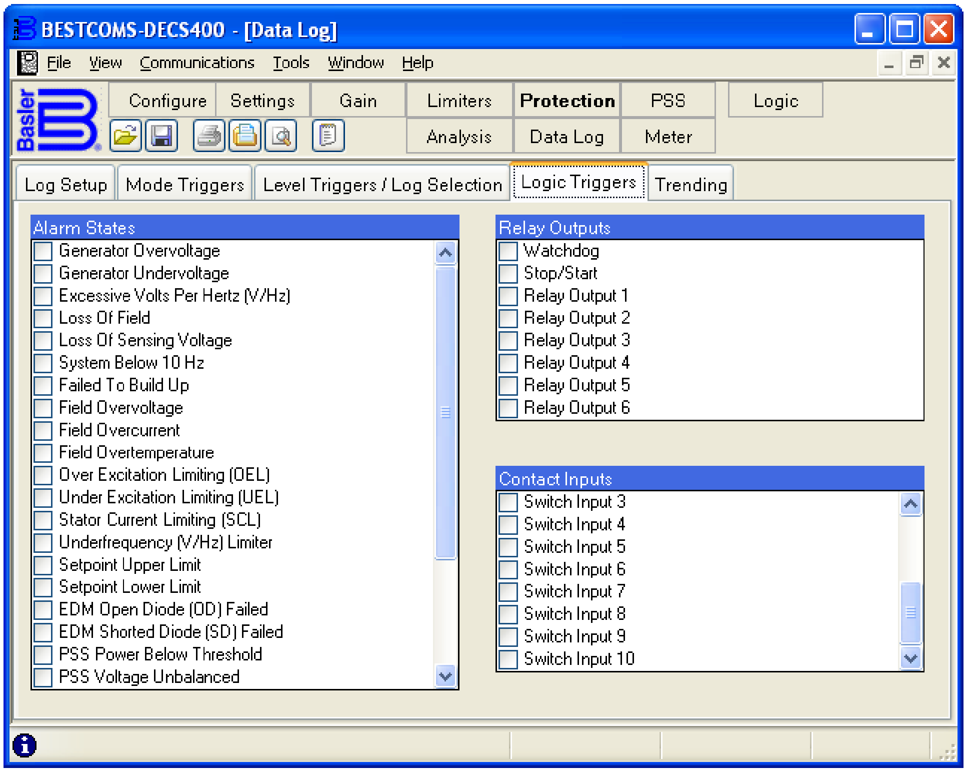


Figure 4-50. Data Log Screen, Logic Triggers Tab

Trending

Trending tab settings and controls are shown in Figure 77 and described in the following paragraphs.

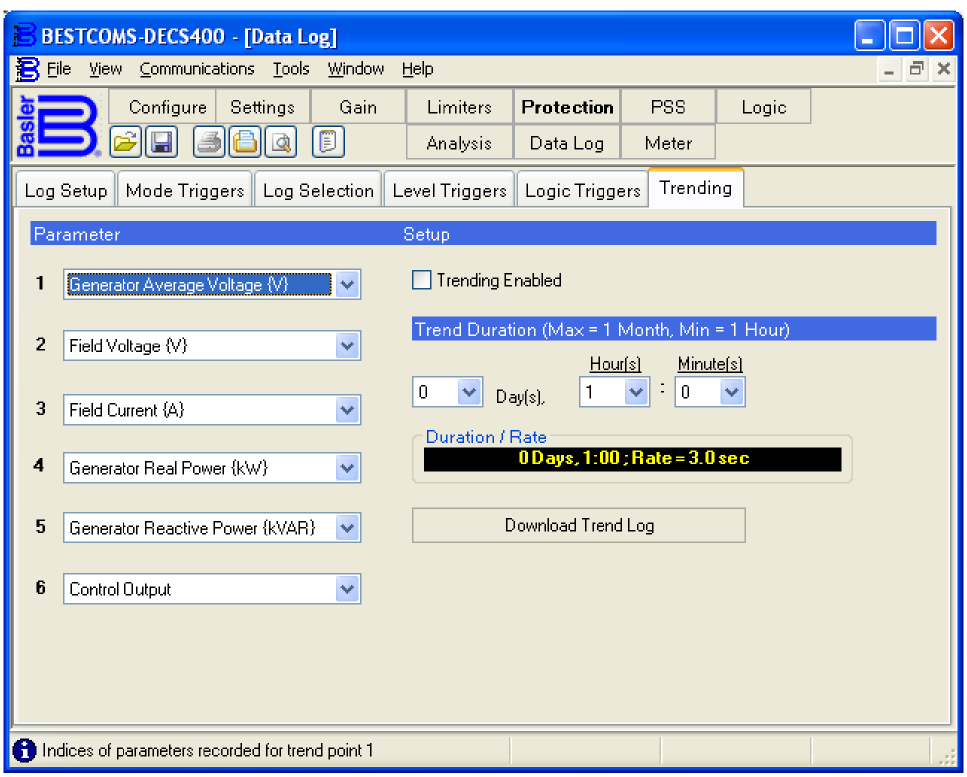


Figure 4-51. Data Log Screen, Trending Tab

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 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 78 and described in the following paragraphs.

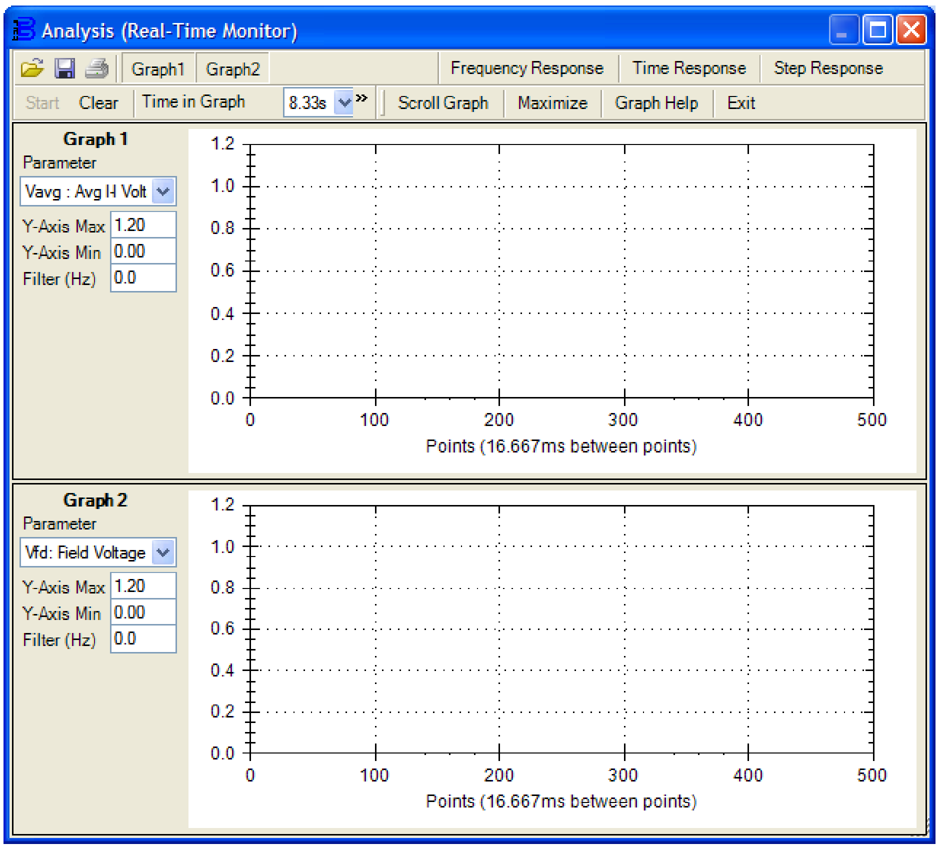


Figure 4-52. Analysis Screen

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 (ErrIn)
- Bus frequency (BHz)
- Bus voltage (Vbus)
- Compensated frequency deviation (CompF)
- Control output (CntOp)
- Cross-current input (Iaux)
- Field current (Ifd)
- Field voltage (Vfd)
- Field temperature
- 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)
- Null balance (%)
- 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)
- Position indication (%)
- 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 (Vtmag)
- Rate of frequency change
- 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)
- VARL controller output (PU)
- 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 79. This screen's settings and controls are described in the following paragraphs.

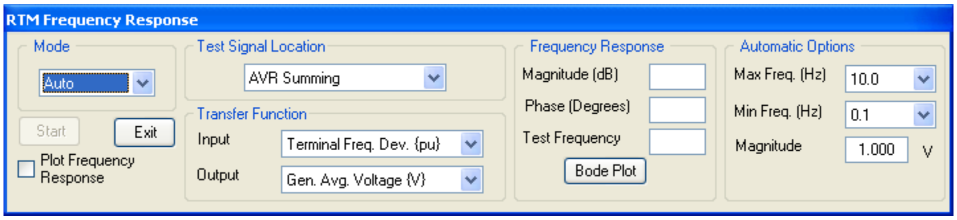


Figure 4-53. RTM Frequency Response Screen

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. Phase compensation time constants T1-T8 can also be plotted and adjusted on the Bode Plot screen.

Test Signal Location. This pull-down menu allows selection of the point in the DECS-400 logic circuitry where a signal is injected for analysis of magnitude and phase responses on the Analysis screen plot. Signal points include AVR summing, PSS Comp Frequency, PSS Electric Power, AVR PID Input, and Manual PID Input.

Transfer Function – Input and Output. These two pull-down menus select the type of signal to be applied and output. The available signal types are:

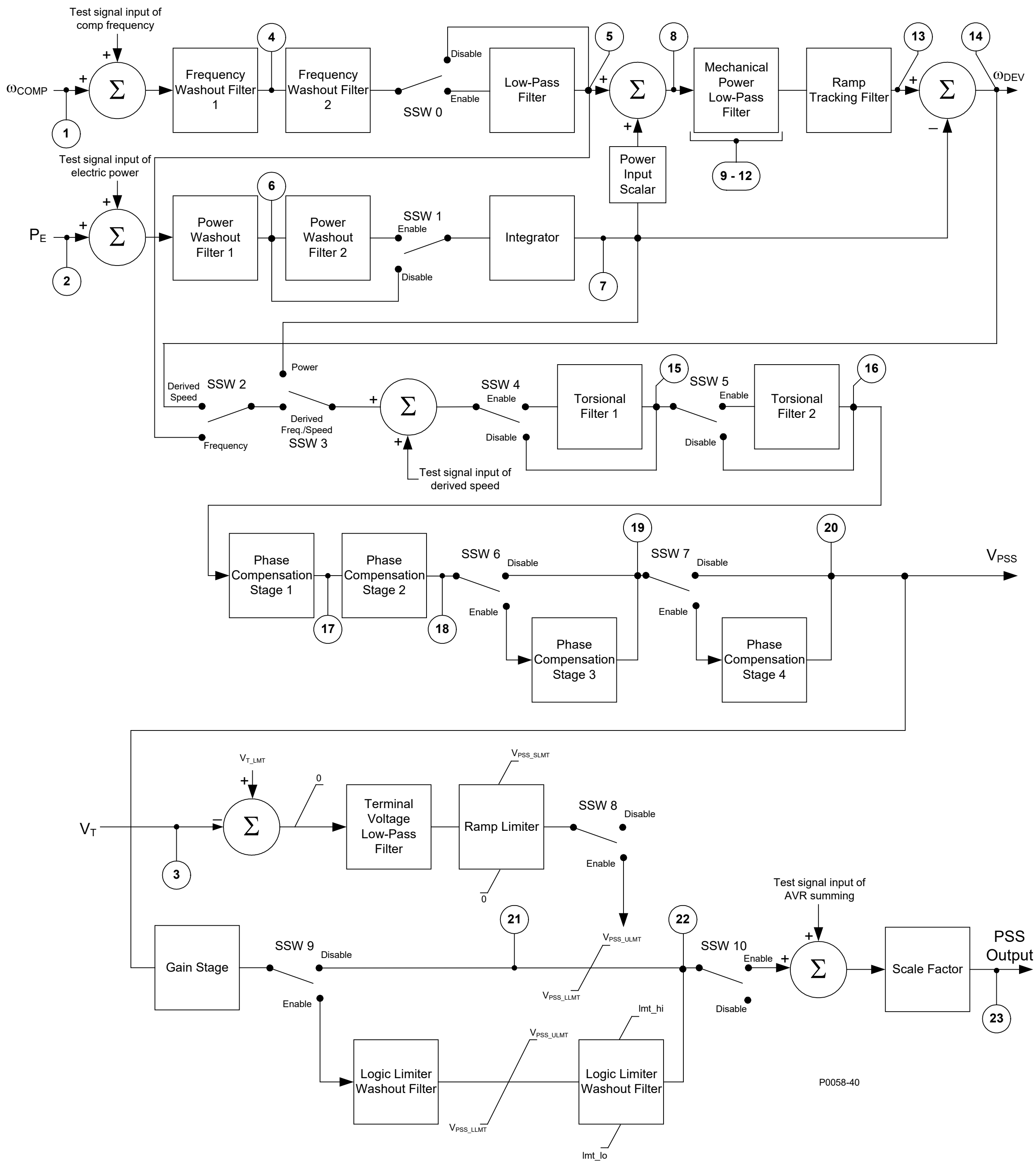
- Auxiliary Voltage Input (V)
- AVR PID Error Signal Input (V)
- Comp. Frequency Deviation (%)
- Control Output
- Field Current (A)
- Field Voltage (V)
- Generator Average Voltage (V)
- Generator Frequency (Hz)
- Generator Reactive Power (kvar)
- Generator Real Power (kW)
- PSS Electrical Power (PU)
- PSS Filtered Mech. Power (PU)
- PSS Final Output (PU)
- PSS Lead/Lag #1 (PU)
- PSS Lead/Lag #2 (PU)
- PSS Lead/Lag #3 (PU)
- PSS Lead/Lag #4 (PU)
- PSS Mech. Power LP #1 (PU)
- PSS Mech. Power LP #2 (PU)
- PSS Mech. Power LP #3 (PU)
- PSS Mech. Power LP #4 (PU)
- PSS Mechanical Power (PU)
- PSS Post-Limit Output (PU)
- PSS Power HP #1 (PU)
- PSS Pre-Limit Output (PU)
- PSS Speed HP #1 (PU)
- PSS Synthesized Speed (PU)
- PSS Terminal Voltage (PU)
- PSS Torsional Filter #1 (PU)
- PSS Torsional Filter #2 (PU)
- PSS Washed Out Power (PU)
- PSS Washed Out Speed (PU)
- Terminal Frequency Deviation (%)
- Test Signal (V)

Transfer function input/output locations are illustrated in Figure 80.

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.



LEGEND

1. Comp. Freq. Dev. (PU)
2. PSS Electrical Power (PU)
3. PSS Terminal Voltage (PU)
4. PSS Speed HP #1 (PU)
5. PSS Washed Out Speed (PU)
6. PSS Power HP #1 (PU)
7. PSS Washed Out Power (PU)
8. PSS Mechanical Power (PU)
9. PSS Mechanical Power LP #1 (PU)
10. PSS Mechanical Power LP #2 (PU)
11. PSS Mechanical Power LP #3 (PU)
12. PSS Mechanical Power LP #4 (PU)
13. PSS Filt. Mech. Power (PU)
14. PSS Synthesized Speed (PU)
15. PSS Torsional Filter #1 (PU)
16. PSS Torsional Filter #2 (PU)
17. PSS Lead/Lag #1 (PU)
18. PSS lead/Lag #2 (PU)
19. PSS Lead/Lag #3 (PU)
20. PSS Lead/Lag #4 (PU)
21. PSS Pre-Limit Output (PU)
22. PSS Post-Limit Output (PU)
23. PSS Final Output (PU)

Figure 4-54. PSS Block Diagram: Transfer Function Input/Output Locations

Caution

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 volts may be entered in 0.001 volt 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.

<u>*Test Signal*</u>

Clicking the Time Response button on the Analysis screen displays the Test Signal screen shown in Figure 81. This screen's settings and controls are described in the following paragraphs.

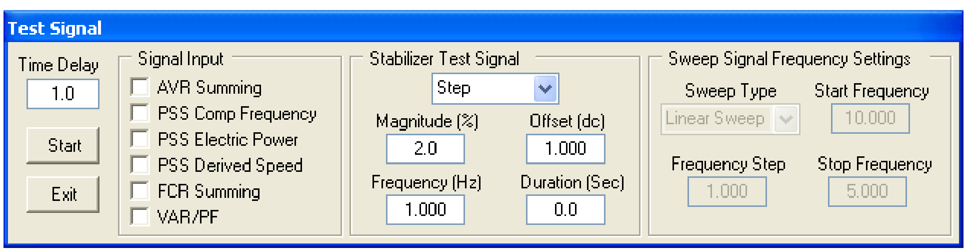


Figure 4-55. Test Signal Screen

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.

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 82 and described in the following paragraphs.

The AVR tab of the RTM Step Response screen enables step changes to be applied to the AVR setpoint. Step changes that increase or decrease the AVR setpoint can be applied by clicking the increment (up arrow) or decrement (down arrow) button. Step-change setting fields (one for increase and one for decrease) establish the percent change in the AVR setpoint that occurs when the increment or decrement button is clicked. A setting of 0 to 10% may be entered in 0.1% increments. A read-only setpoint field indicates the current setpoint and what the setpoint will be when a step change occurs. A button is provided to return the AVR setpoint to its original value before any step changes were invoked. This original value is the AVR setpoint entered on the AVR/FCR/FVR tab of the BESTCOMS Settings screen and is displayed in the read-only field adjacent to the button.

Notes

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

Response characteristics displayed on the RTM Step Response screen are not automatically updated when the DECS-400 operating mode is switched externally. The RTM Step Response screen must be manually updated by exiting and then reopening the screen.

A checkbox enables the triggering of a data log when a step change is initiated.

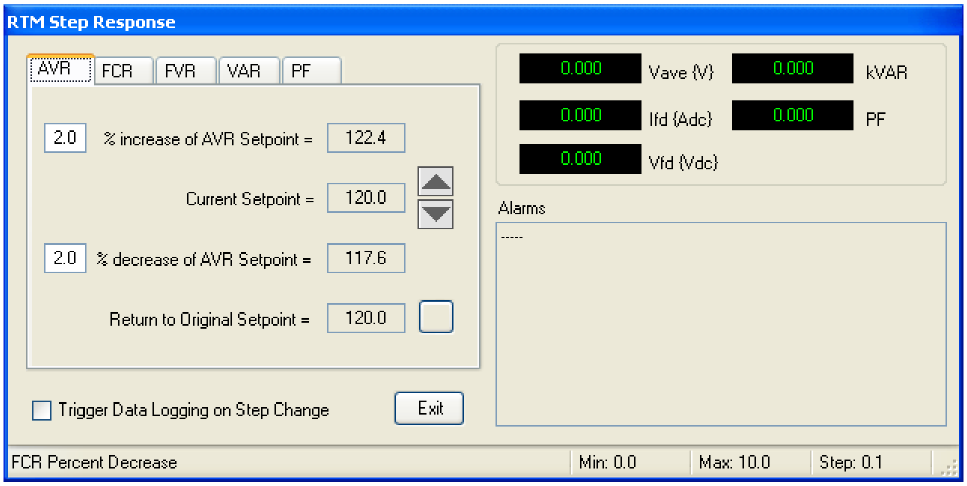


Figure 4-56. RTM Step Response Screen, AVR Tab

FCR Tab

FCR tab functions are shown in Figure 83 and described in the following paragraphs.

The FCR tab of the RTM Step Response screen enables step changes to be applied to the FCR setpoint. Step changes that increase or decrease the FCR setpoint can be applied by clicking the increment (up arrow) or decrement (down arrow) button. Step-change setting fields (one for increase and one for decrease) establish the percent change in the FCR setpoint that occurs when the increment or decrement button is clicked. A setting of 0 to 10% may be entered in 0.1% increments. Read-only setpoint field indicate the current setpoint and what the setpoint will be when a step change occurs. A button is provided to return the FCR setpoint to its original value before any step changes were invoked. This original value is the FCR setpoint entered on the AVR/FCR/FVR tab of the BESTCOMS Settings screen and is displayed in the read-only field adjacent to the button.

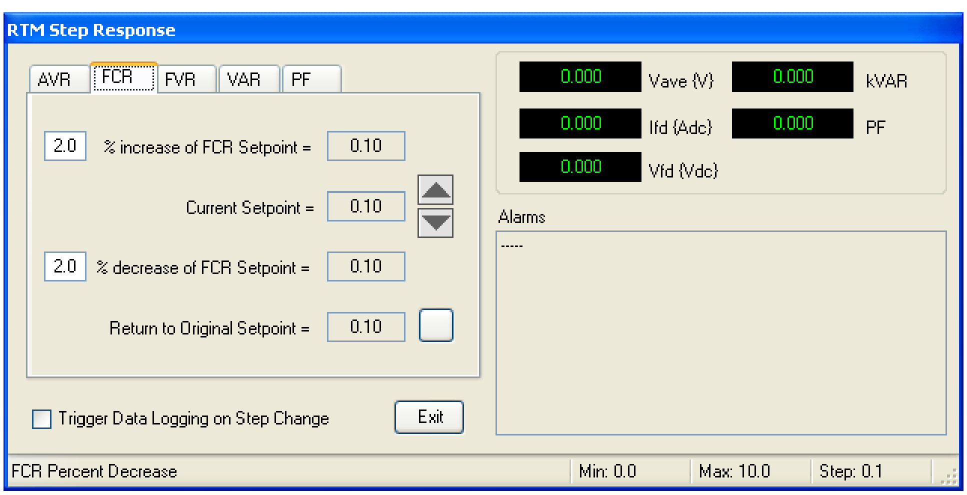


Figure 4-57. RTM Step Response Screen, FCR Tab

A checkbox enables the triggering of a data log when a step change is initiated.

FVR Tab

FVR tab functions are shown in Figure 84 and described in the following paragraphs.

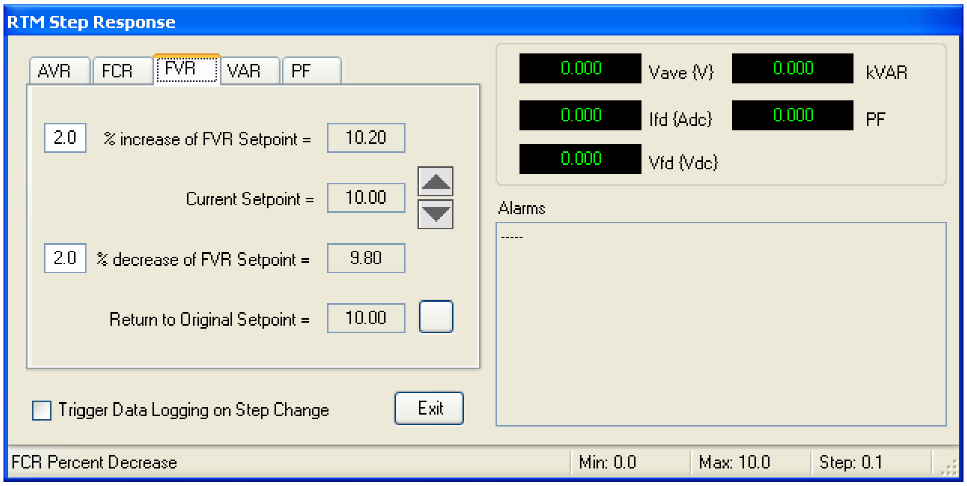


Figure 4-58. RTM Step Response Screen, FVR Tab

The FVR tab of the RTM Step Response screen enables step changes to be applied to the FVR setpoint. Step changes that increase or decrease the FVR setpoint can be applied by clicking the increment (up arrow) or decrement (down arrow) button. Step-change setting fields (one for increase and one for decrease) establish the percent change in the FVR setpoint that occurs when the increment or decrement button is clicked. A setting of 0 to 10% may be entered in 0.1% increments. Read-only setpoint fields indicate the current setpoint and what the setpoint will be when a step change occurs. A button is provided to return the FVR setpoint to its original value before any step changes were invoked. This original value is the FVR setpoint entered on the AVR/FCR/FVR tab of the BESTCOMS Settings screen and is displayed in the read-only field adjacent to the button.

A checkbox enables the triggering of a data log when a step change is initiated.

VAR Tab

VAR tab functions are shown in Figure 85 and described in the following paragraphs.

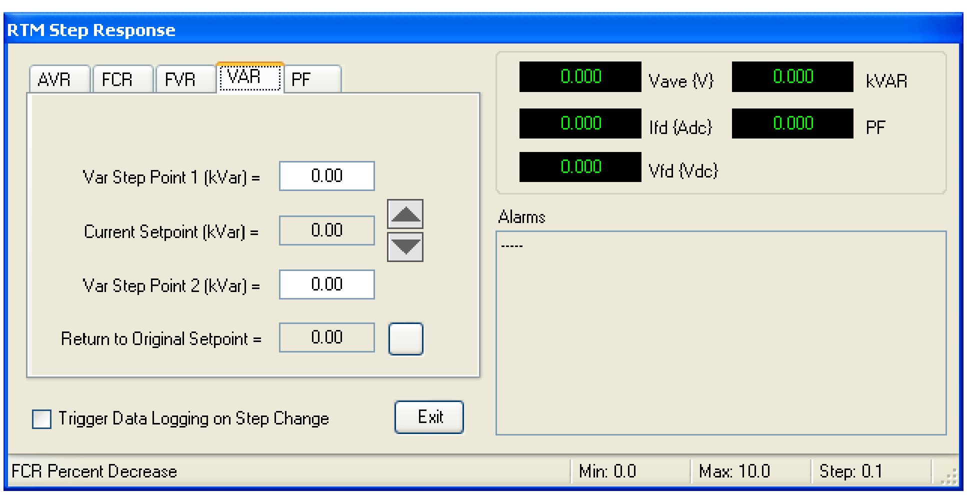


Figure 4-59. RTM Step Response Screen, VAR Tab

The VAR tab of the RTM Step Response screen enables step changes to be applied to the kvar setpoint. Two user-adjustable step changes are available for the kvar setpoint: Var Step Point 1 and Var Step Point 2. The Var Step Point 1 value is selected by clicking the increment (up arrow) button and the Var Step Point 2 value is selected by clicking the decrement (down arrow) button. The acceptable setting range for each step point is determined by the var minimum and maximum settings entered on the VAR/PF tab of the BESTCOMS Settings screen. A read-only field displays the current reactive power setpoint. A button is provided to return the var setpoint to its original value before any step changes were invoked. This original value is the var setpoint entered on the VAR/PF tab of the BESTCOMS Settings screen and is displayed in the read-only field adjacent to the button.

A checkbox enables the triggering of a data log when a step change is initiated.

PF Tab

PF tab functions are shown in Figure 86 and described in the following paragraphs.

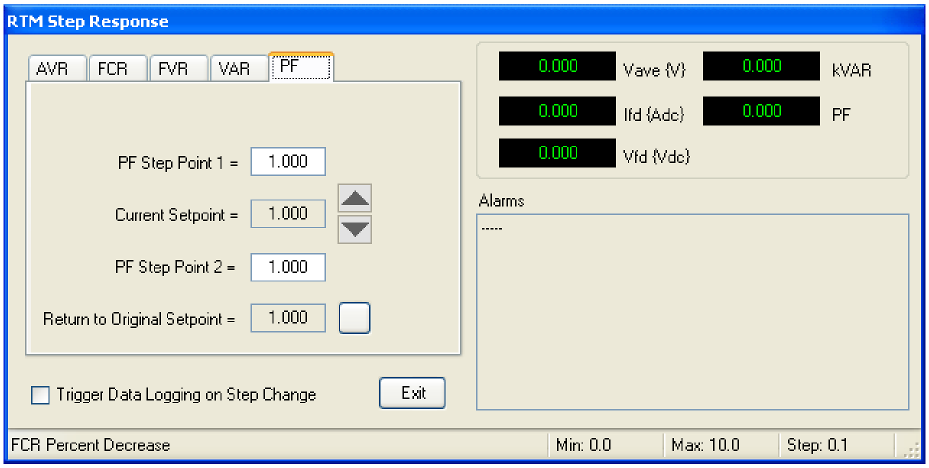


Figure 4-60. RTM Step Response Screen, PF Tab

The PF tab of the RTM Step Response screen enables step changes to be applied to the power factor setpoint. Two user-adjustable step changes are available for the power factor setpoint: PF Step Point 1 and PF Step Point 2. The PF Step Point 1 value is selected by clicking the increment (up arrow) button and the PF Step Point 2 value is selected by clicking the decrement (down arrow) button. The acceptable setting range for each step point is determined by the PF leading and lagging settings entered on the VAR/PF tab of the BESTCOMS Settings screen. A read-only field displays the current power factor setpoint. A button is provided to return the power factor setpoint to its original value before any step changes were invoked. This original value is the power factor setpoint entered on the VAR/PF tab of the BESTCOMS Settings screen and is displayed in the read-only field adjacent to the button.

A checkbox enables the triggering of a data log when a step change is initiated.

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 the *Programmable Logic* chapter.

DECS-300 Settings File Converter

Transitioning generator excitation control from a DECS-300 to DECS-400 is simplified through the BESTCOMS DECS-300 settings file converter. The converter opens your application-specific DECS-300 settings file (with a *de3* file extension) and automatically converts all settings for compatibility with the DECS-400. Once converted, you are prompted to save the settings file and the file converter gives the file a DECS-400 settings file extension (*de4*).

Use the following procedure to convert a DECS-300 settings file for use with a DECS-400.

1. Open BESTCOMS-DECS-400 and click *Tools* on the menu bar.
2. Select *DECS-300 File Converter* from the drop-down menu list.
3. On the DECS-300 Settings Converter window, click the *Open File* button, navigate to the desired DECS-300 settings file on your PC, select it, and click the *Open* button. This places the file name and path in the source file field of the DECS-300 Settings Converter window.

4. Click the *Convert* button to initiate file conversion. A successful file conversion is reported in a popup window. Click the *OK* button to close the window.
5. You are then prompted to save the converted file. Navigate to the desired location, assign a file name, and click the *Save* button to save the file. Successful saving of the file is reported in a popup window. Click the *OK* button to close the window and the settings converter.

5 • Installation

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.

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.

Escutcheon plate part number 9577100001 provides a shallower mounting depth for the DECS-400 than is possible with the standard escutcheon. When attached to the rearmost mounting position, this escutcheon provides a mounting depth of 6.8 inches (173 millimeters) behind the mounting panel. Figure 5-3 shows the top view of the DECS-400 with the escutcheon attached at the rearmost position.

Draw-Out Assembly Extraction and Installation

Mounting may be simplified by separating the draw-out assembly from the case. The draw-out assembly is held in the case by two lever-style latches located on the front panel. Each latch has a captive Phillips screw that is rotated clockwise to lock the latch in the closed position. Locking the latches in the closed position precludes the latches from opening in the presence of excessive vibration or shock.

A latch is opened by rotating the locking screw counterclockwise to unlock the latch. Then, the latch lever is pulled outward.

Once the case is mounted, the draw-out assembly can be returned to its case. Seat the draw-out assembly fully in its case and close both latches by pressing each latch lever into the closed position. Each latch should then be locked with its locking screw. Using a No. 1 Phillips screwdriver, press in on the screw and rotate it clockwise one-quarter turn.

Field Isolation Module

The Field Isolation Module is intended for surface mounting and no panel cutout is required. Figure 5-4 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 5-5 illustrates the dimensions and mounting hole locations of part number BE31449001.

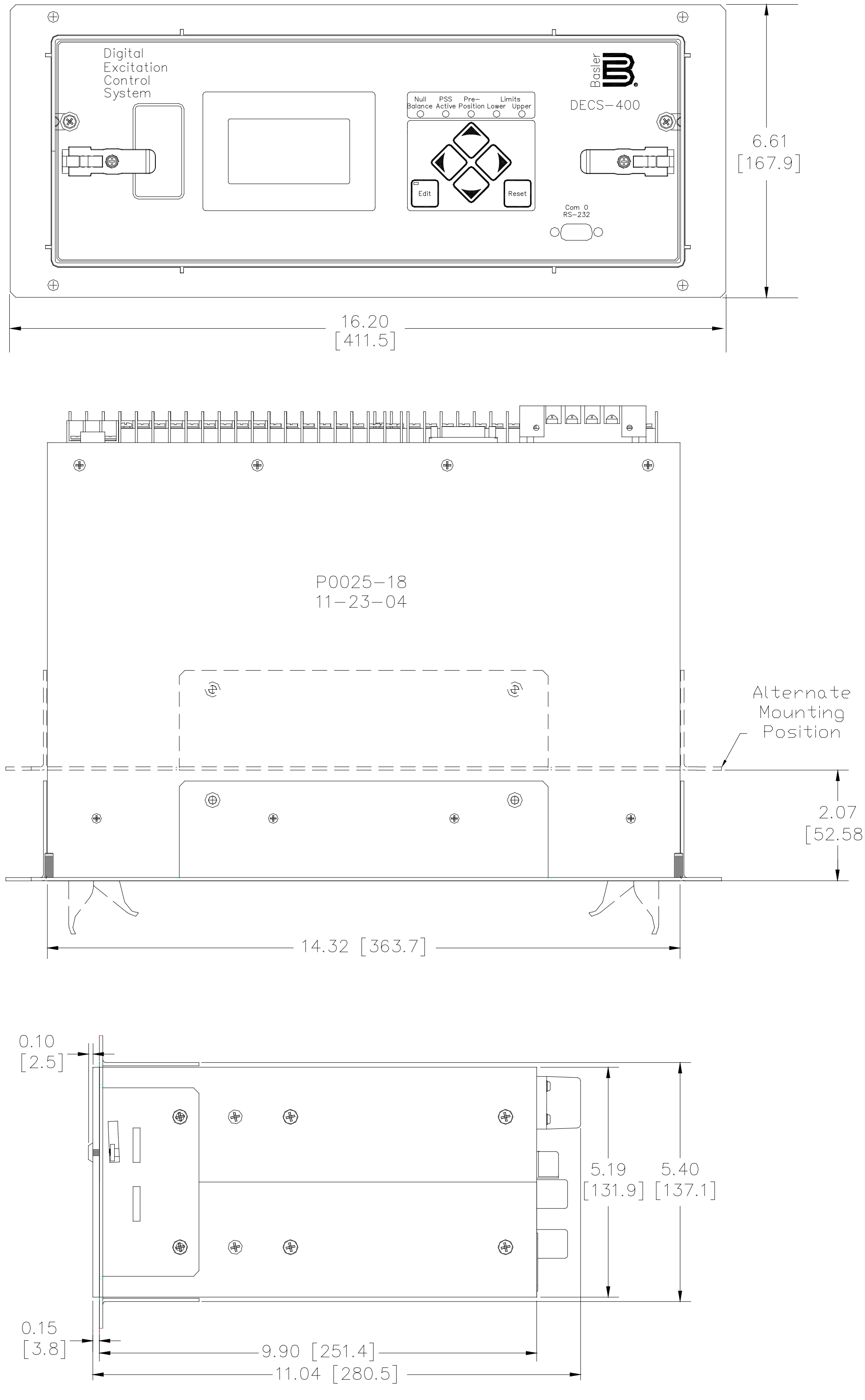
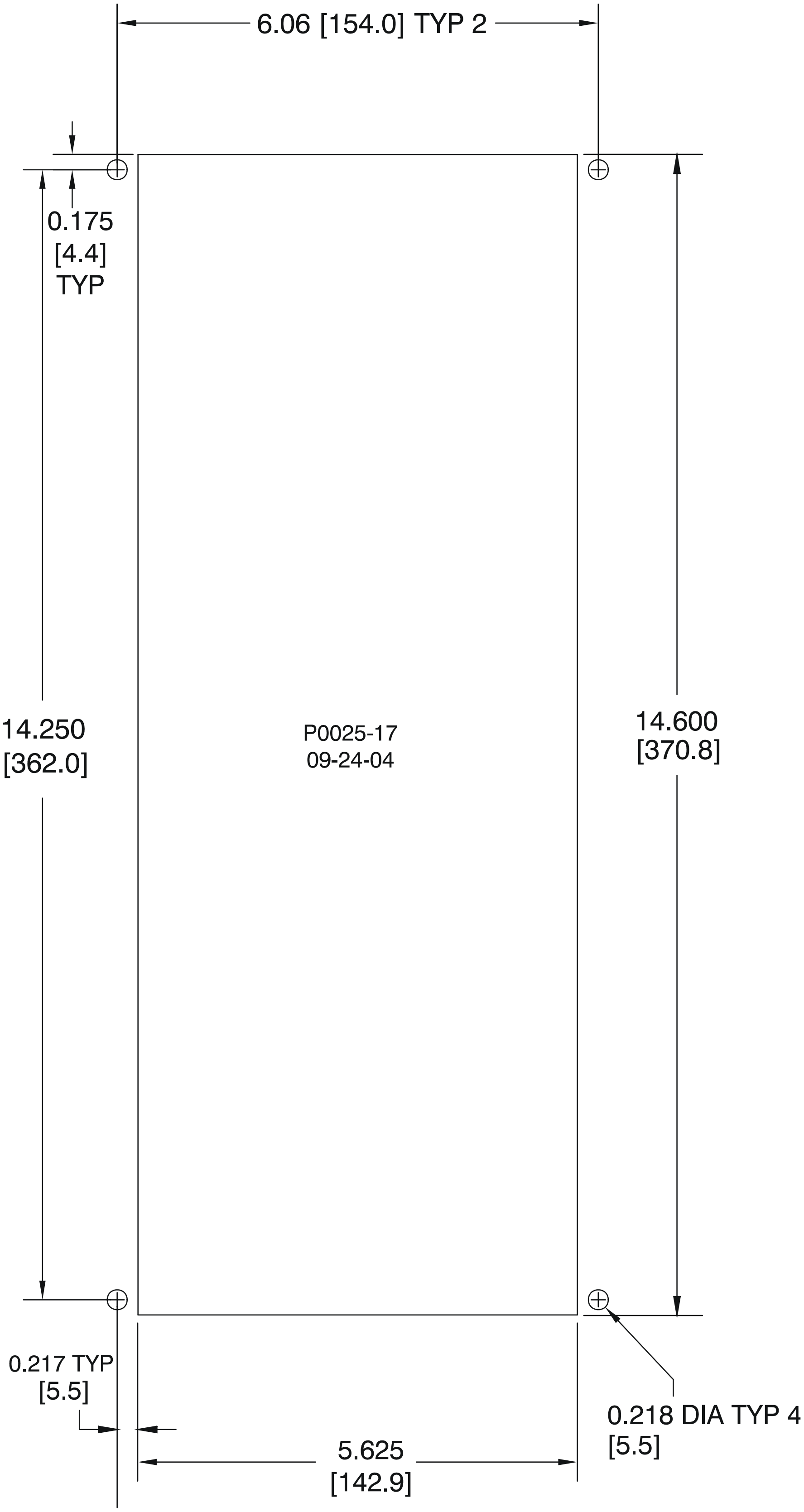


Figure 5-1. DECS-400 with Escutcheon Plate, Overall Dimensions



Dimensions are in inches [millimeters].

Figure 5-2. Panel Cutting and Drilling Dimensions

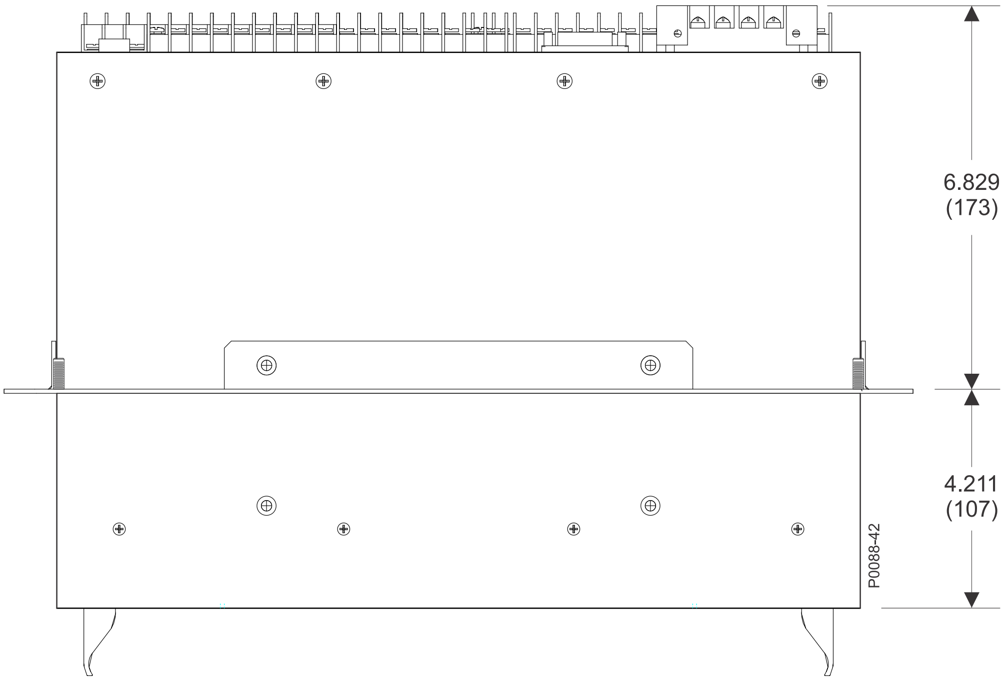


Figure 5-3. Top View of DECS-400 with Escutcheon Plate Installed

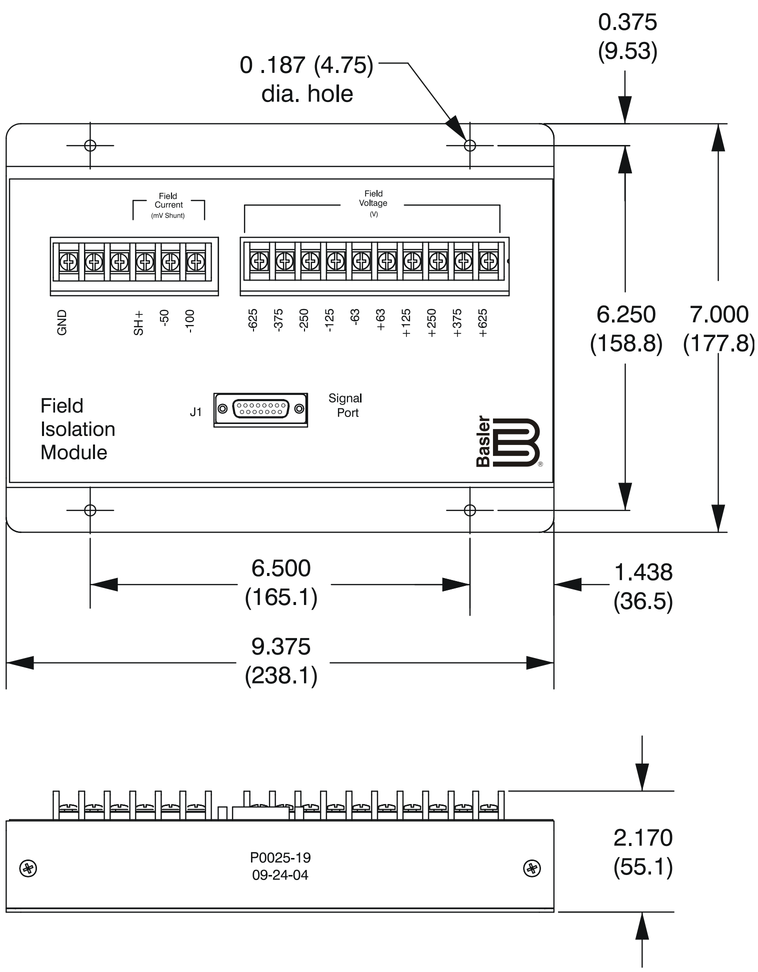


Figure 5-4. Field Isolation Module Dimensions

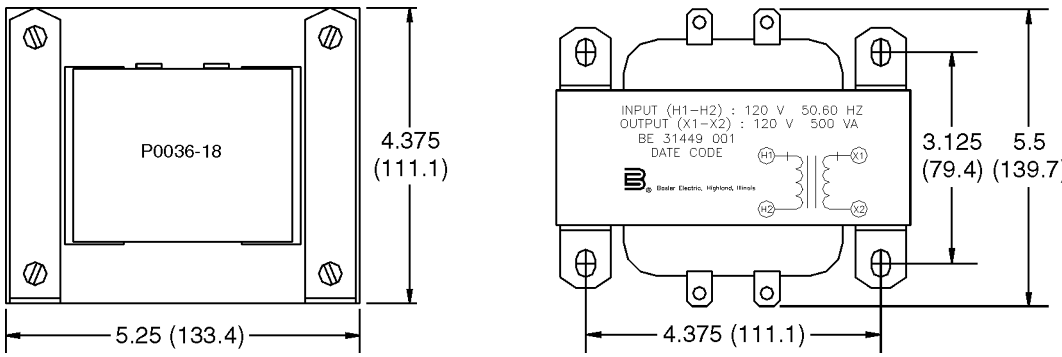


Figure 5-5. Isolation Transformer (BE31449001) Dimensions

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.

In a system where the DECS-400 is mounted remotely, ensure that the chassis ground potential of the DECS-400 is equal to the chassis ground potential of the rest of the excitation system. Poor system grounding can cause equipment malfunction, damage, and failure.

DECS-400 Terminations

DECS-400 terminations consist of screw terminals, D-type connectors, an RJ-11 jack, 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 the *Human-Machine Interface* chapter.

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 (J1). Connections for Ethernet communication are made through an RJ-45 jack (Com 3). All other connections are made through #6 screw terminals. Rear panel terminations are illustrated in Figure 5-6.

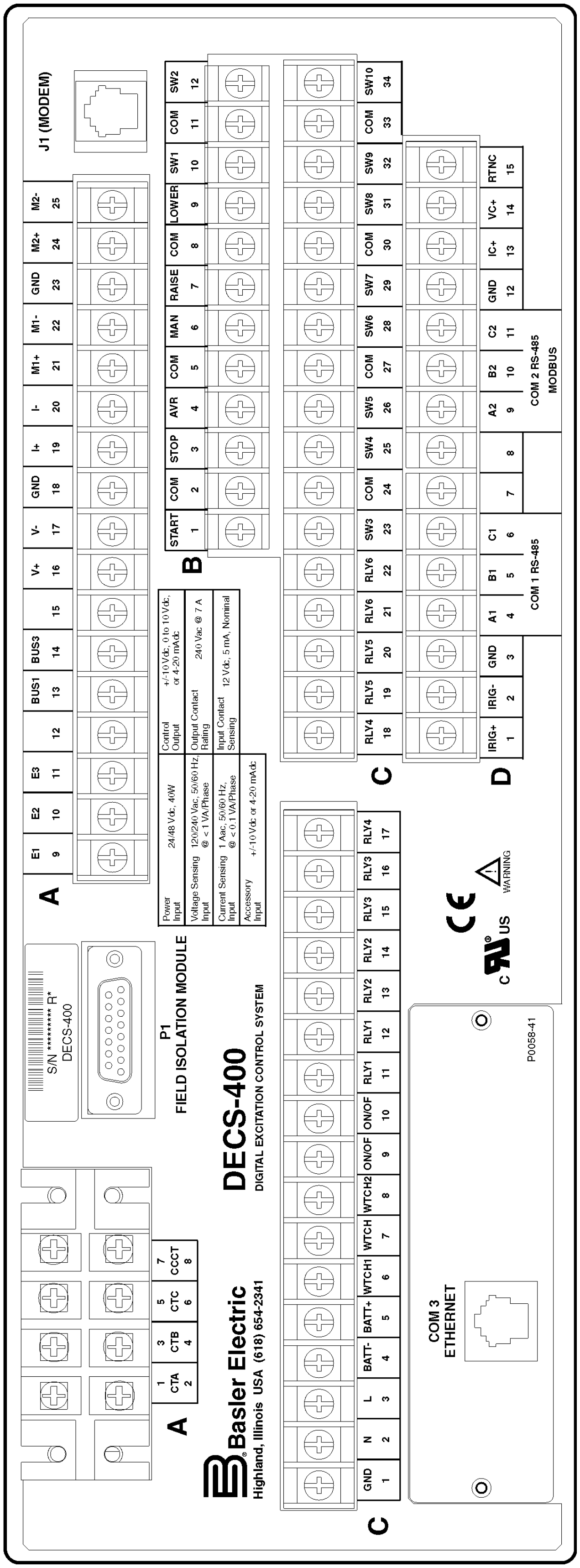


Figure 5-6. Rear Panel Terminals

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 5-7 illustrates the connections for redundant operating power.

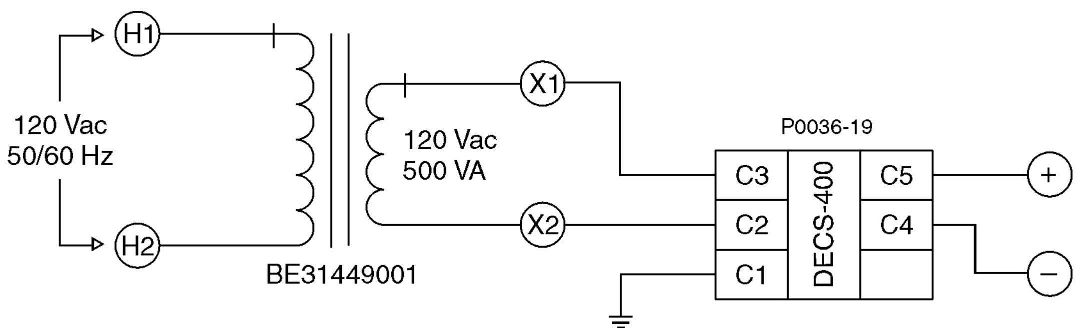


Figure 5-7. Redundant Operating Power Connections

Operating power terminals are listed in Table 5-1.

Table 5-1. Operating Power Terminals

Terminal	Description
C2 (N)	Return or neutral side of ac input (style XCXX only)
C3 (L)	Line side of ac input (style XCXX only)
C4 (BATT–)	Negative side of dc input (style XCXX or XLXX)
C5 (BATT+)	Positive side of dc input (style XCXX or XLXX)

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.

In a system where the DECS-400 is mounted remotely, ensure that the chassis ground potential of the DECS-400 is equal to the chassis ground potential of the rest of the excitation system. Poor system grounding can cause equipment malfunction, damage, and failure.

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

Terminal	Description
A9 (E1)	A-phase generator voltage sensing input
A10 (E2)	B-phase generator voltage sensing input
A11 (E3)	C-phase generator voltage sensing input
A13 (BUS1)	A-phase bus voltage sensing input
A14 (BUS3)	C-phase bus voltage sensing input

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

Terminal	Description
A1 (CTA)	A-phase generator current sensing input
A2 (CTA)	
A3 (CTB)	B-phase generator current sensing input
A4 (CTB)	
A5 (CTC)	C-phase generator current sensing input
A6 (CTC)	
A7 (CCCT)	Cross-current compensation input
A8 (CCCT)	

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

Terminal	Description
A16 (V+)	Positive side of voltage accessory input
A17 (V–)	Negative side of voltage accessory input
A18 (GND)	Shield connection for accessory inputs
A19 (I+)	Positive side of current accessory input
A20 (I–)	Negative side of current accessory input

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 the *Functional Description* chapter.

Table 5-5 lists the contact input terminals.

Table 5-5. Contact Input Terminals

Terminal	Description
B1 (START) ∗	Positive terminal of Start contact input
B2 (COM)	Common terminal of Start and Stop contact inputs
B3 (STOP) ∗	Positive terminal of Stop contact input
B4 (AVR) ∗	Positive terminal of AVR contact input
B5 (COM)	Common terminal of AVR and FCR contact inputs
B6 (MAN) ∗	Positive terminal of Manual contact input
B7 (RAISE) †	Positive terminal of Raise contact input
B8 (COM)	Common terminal of Raise and Lower contact inputs
B9 (LOWER) †	Positive terminal of Lower contact input
B10 (SW1)	Positive terminal of programmable contact input #1
B11 (COM)	Common terminal of programmable contact inputs #1 and #2
B12 (SW2)	Positive terminal of programmable contact input #2
C23 (SW3)	Positive terminal of programmable contact input #3
C24 (COM)	Common terminal of programmable contact inputs #3 and #4
C25 (SW4)	Positive terminal of programmable contact input #4
C26 (SW5)	Positive terminal of programmable contact input #5
C27 (COM)	Common terminal of programmable contact inputs #5 and #6
C28 (SW6)	Positive terminal of programmable contact input #6
C29 (SW7)	Positive terminal of programmable contact input #7
C30 (COM)	Common terminal of programmable contact inputs #7 and #8
C31 (SW8)	Positive terminal of programmable contact input #8
C32 (SW9)	Positive terminal of programmable contact input #9
C33 (COM)	Common terminal of programmable contact inputs #9 and #10
C34 (SW10)	Positive terminal of programmable contact input #10

∗ 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 the *Specifications* chapter for specifications pertaining to the IRIG input. Table 5-6 lists the IRIG terminals.

Table 5-6. IRIG Terminals

Terminal	Description
D1 (IRIG+)	Positive IRIG terminal
D2 (IRIG–)	Negative IRIG terminal

Communication Ports

DECS-400 units have five communication ports: Com 0, Com 1, Com 2, Com 3, 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-11 ~~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 5-7. Com 1 and Com 2 Terminals

Terminal	Description
D3 (GND)	Shield connection
D4 (A1)	Com 1 RS-485 Send/Receive A terminal (ASCII protocol)
D5 (B1)	Com 1 RS-485 Send/Receive B terminal (ASCII protocol)
D6 (C1)	Com 1 RS-485 Signal Ground terminal (ASCII protocol)
D9 (A2)	Com 2 RS-485 Send/Receive A terminal (Modbus® protocol)
D10 (B2)	Com 2 RS-485 Send/Receive B terminal (Modbus® protocol)
D11 (C2)	Com 2 RS-485 Signal Ground terminal (Modbus® protocol)

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 mAdc. If shielded cable is used, terminal D12 should be used for the shield connection. Table 5-8 lists the control output terminals.

Table 5-8. Control Output Terminals

Terminal	Description
D12 (GND)	Shield connection for control output
D13 (IC+)	Current control positive terminal
D14 (VC+)	Voltage control positive terminal
D15 (RTNC)	Common, return terminal for control output

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 mAdc. 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 5-9. Metering Output Terminals

Terminal	Description
A21 (M1+)	Meter driver #1 positive terminal
A22 (M1–)	Meter driver #1 negative terminal

Terminal	Description
A23 (GND)	Shield connection for meter driver #1 and #2
A24 (M2+)	Meter driver #2 positive terminal
A25 (M2–)	Meter driver #2 negative terminal

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 the *Functional Description* chapter. Contact output ratings are listed in the *Specifications* chapter. Terminal assignments for the contact outputs are listed in Table 5-10.

Table 5-10. Contact Output Terminals

Terminal	Description
C6 (WTCH1)	Watchdog normally-closed (NC) contact terminal
C7 (WTCH)	Watchdog common contact terminal
C8 (WTCH2)	Watchdog normally-open (NO) contact terminal
C9 (ON/OF)	On/Off contact terminals
C10 (ON/OF)	
C11 (RLY1)	Programmable relay #1 terminals
C12 (RLY1)	
C13 (RLY2)	Programmable relay #2 terminals
C14 (RLY2)	
C15 (RLY3)	Programmable relay #3 terminals
C16 (RLY3)	
C17 (RLY4)	Programmable relay #4 terminals
C18 (RLY4)	
C19 (RLY5)	Programmable relay #5 terminals
C20 (RLY5)	
C21 (RLY6)	Programmable relay #6 terminals
C22 (RLY6)	

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 5-11. Field Current Sensing Terminals

Terminal	Description
SH+	Connects to positive output terminal of current shunt
–50	Connects to negative output terminal of 50 mVdc current shunt (if used)
–100	Connects to negative output terminal of 100 mVdc current shunt (if used)

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 5-8 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

Table 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.

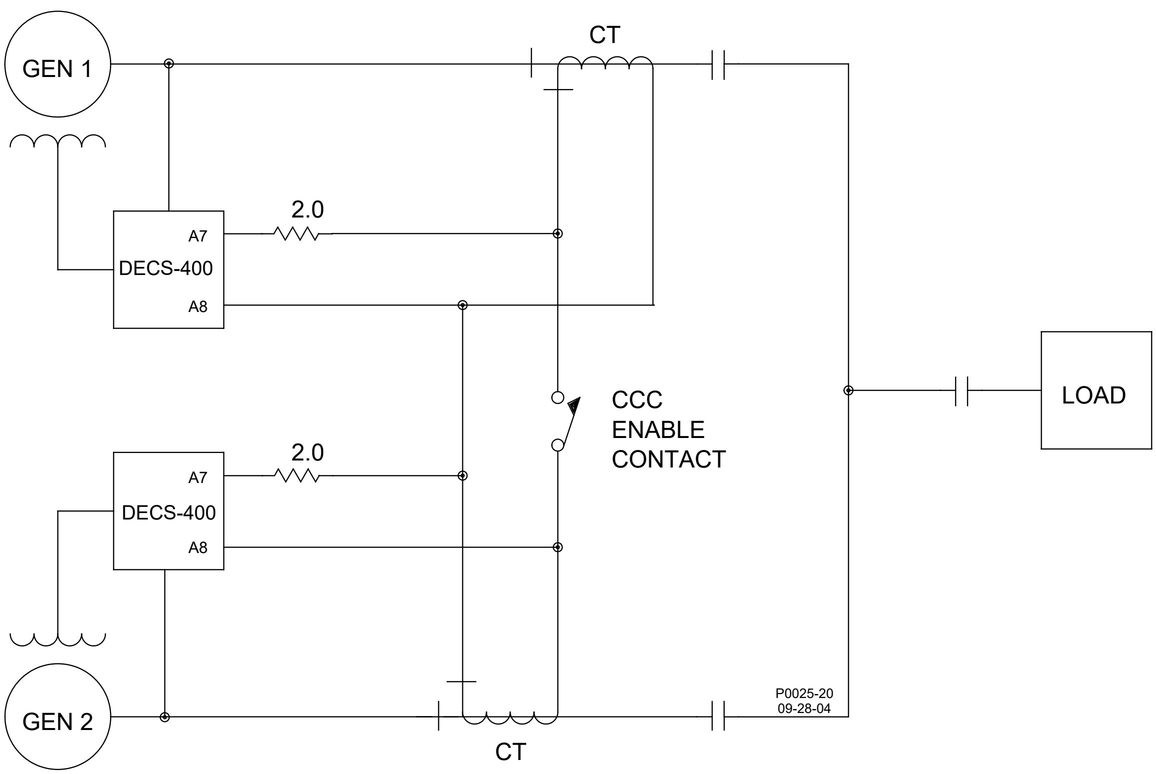


Figure 5-8. Connections for Cross-Current (Reactive Differential) Compensation

Connections for CE-Compliant Systems

For CE compliance, a line filter must be applied to the bridge operating power input of a DECS-400 system rated for less than 75 kVA input. A DECS-400 system with a rated input greater than 75 kVA does not require the application of a line filter for CE compliance.

Table 5-12 lists the available line filters based on the rated system kVA of the DECS-400 system. For additional information see Basler publication 9504000994.

Table 5-12. DECS-400 Line Filters

Line Filter Part Number	DECS-400 Rated System kVA	Rated Current RMS
9504012100	22.72 kVA	82 Aac
9504012100	45.45 kVA	82 Aac
9504012101	45.45 kVA	164 Aac
9504012102	61 kVA	220 Aac

For DECS-400 systems less than 75 kVA not listed in Table 5-12,contact Basler Electric for proper line filter selection.

Typical Interconnections

Figure 5-9 and Figure 5-10 illustrate typical interconnections for a DECS-400 used in an excitation system with a Basler SSE-N (negative forcing) rectifier chassis. Figure 5-9 shows the ac connections and Figure 5-10 shows the dc connections. The following notes apply to those figures.

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).

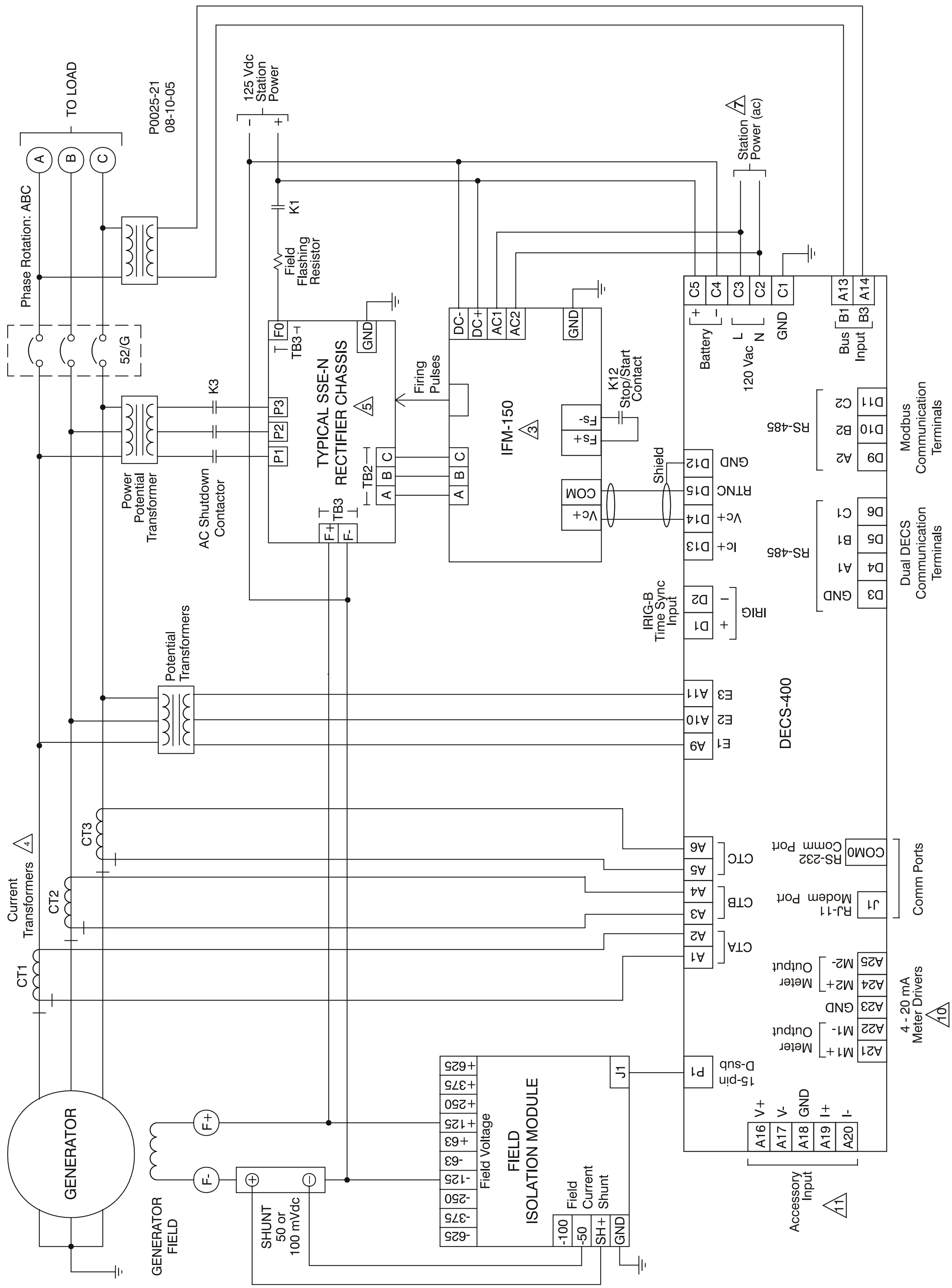


Figure 5-9. Typical AC Connection Diagram

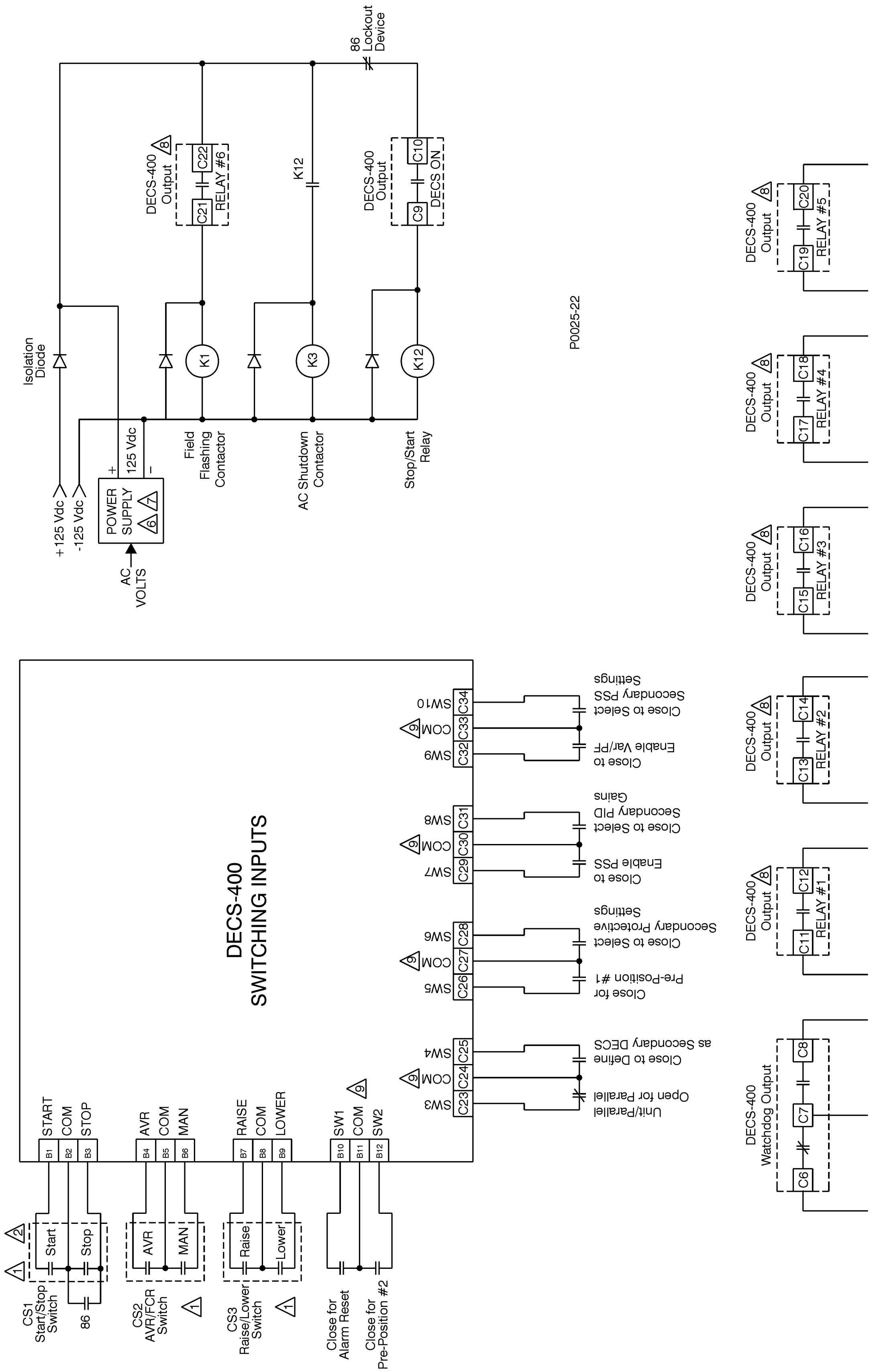


Figure 5-10. Typical DC Connection Diagram

Communication Connections

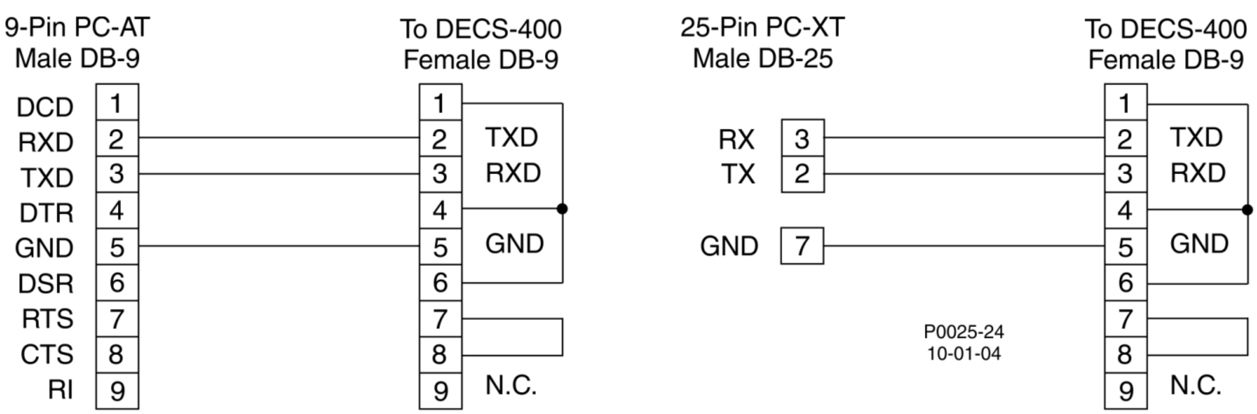
DECS-400 communication ports consist of a front-panel RS-232 port (Com 0), a rear-panel RS-485 port for DECS-400-to-DECS-400 communication (Com 1), a rear-panel RS-485 port for Modbus communication (Com 2), and an RJ-11 modem jack (J1). DECS-400 communication ports are described in the following paragraphs.

Com 0

Table 5-13 identifies the pin functions of this front-panel, female DB-9 connector. Figure 5-11 illustrates the connections between Com 0 and a PC.

Table 5-13. Com 0 Pin Functions

Pin	Function	Name	Direction
1	Shield	—	N/A
2	Transmit Data	TXD	From DECS-400
3	Receive Data	RXD	Into DECS-400
4	No Connection	—	N/A
5	Signal Ground	GND	N/A
6	No Connection	—	N/A
7	No Connection	—	N/A
8	No Connection	—	N/A



9-Pin PC-AT Male DB-9 to DECS-400 Female DB-9

25-Pin PC-XT Male DB-25 to DECS-400 Female DB-9

Figure 5-11. Com 0 to PC Connections

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 5-12 illustrates the Com 1 connections used for DECS-400-to-DECS-400 communication.

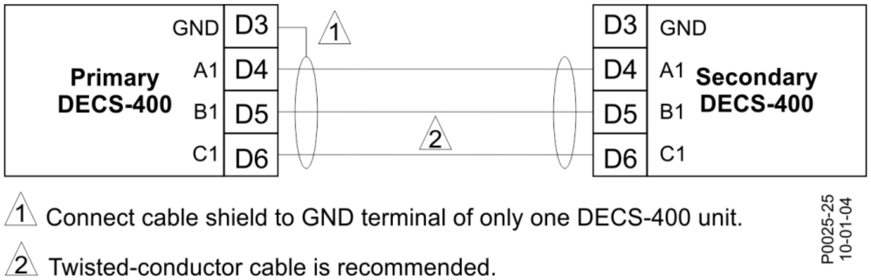


Figure 5-12. Com 1 Connections for Redundant DECS-400 Operation

Figure 5-13 illustrates the Com 2 connections used for multiple DECS-400 units communicating over a Modbus network.

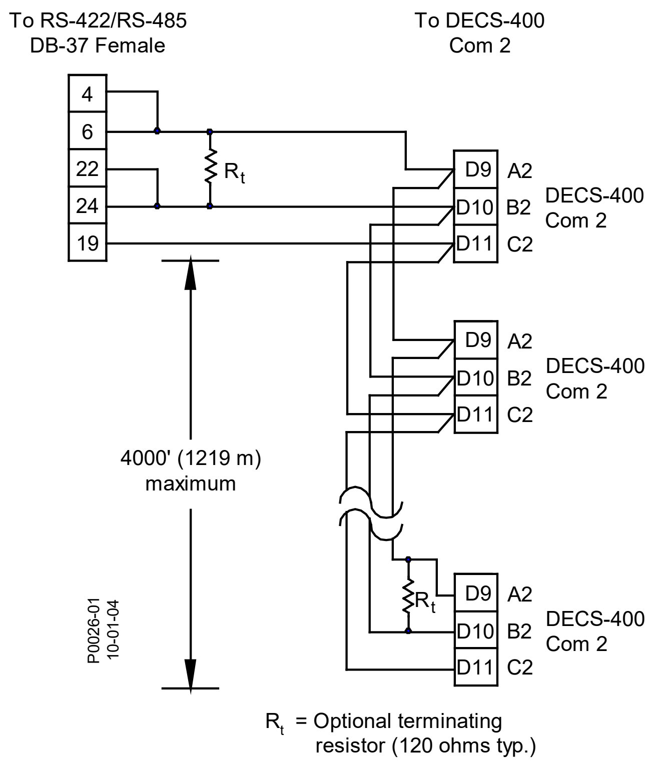


Figure 5-13. DECS-400 to RS-485 DB-37 Connections

Com 3

Com 3 is used for 10BASE-T Ethernet network communication. The Com 3 jack accepts an eight pin, RJ-45 plug connected to unshielded, twisted-pair, Category 5 copper conductors. Conductor length, per segment, can be no longer than 100 meters or 328 feet. Com 3 has a maximum data transfer rate of 10 megabits per second. Pin assignments/definitions for the Com 3 connector are listed in Table 5-14 and illustrated in Figure 5-14.

Table 5-14. Com 3 Connector Pin Definitions

Pin	Signal	Function	Direction
1	TD+	Transmit data +	From DECS-400
2	TD–	Transmit data –	From DECS-400
3	RD+	Receive data +	To DECS-400
4		Not used	
5		Not used	

Pin	Signal	Function	Direction
6	RD–	Receive data -	To DECS-400
7		Not used	
8		Not used	

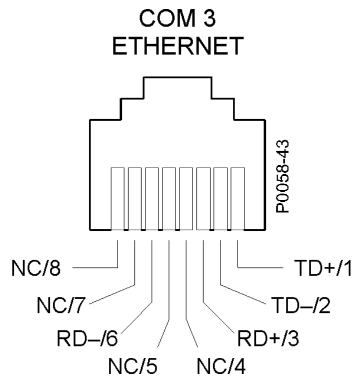


Figure 5-14. Com 3 Pin Assignments

J1

J1 is an RJ-11 jack that serves as the connection to the DECS-400's internal, FCC part 68 approved modem. J1 has a fixed communication baud rate of 9600 and provides read-only access. Information about initiating modem communication is provided in the *BESTCOMS Software* chapter.

6 • Commissioning

This chapter 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 the *BESTCOMS Software* chapter for information about installing BESTCOMS and establishing communication between BESTCOMS and the DECS-400.

Record System Parameters

Record the pertinent information for your system in the following spaces.

Generator Parameters

_______________ Vac

_______________ Hz

_______________ MW

_______________ Mvar

_______________ rpm

Main/Exciter Field Parameters

__________________ Vdc, full-load

__________________ Adc, full-load

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.

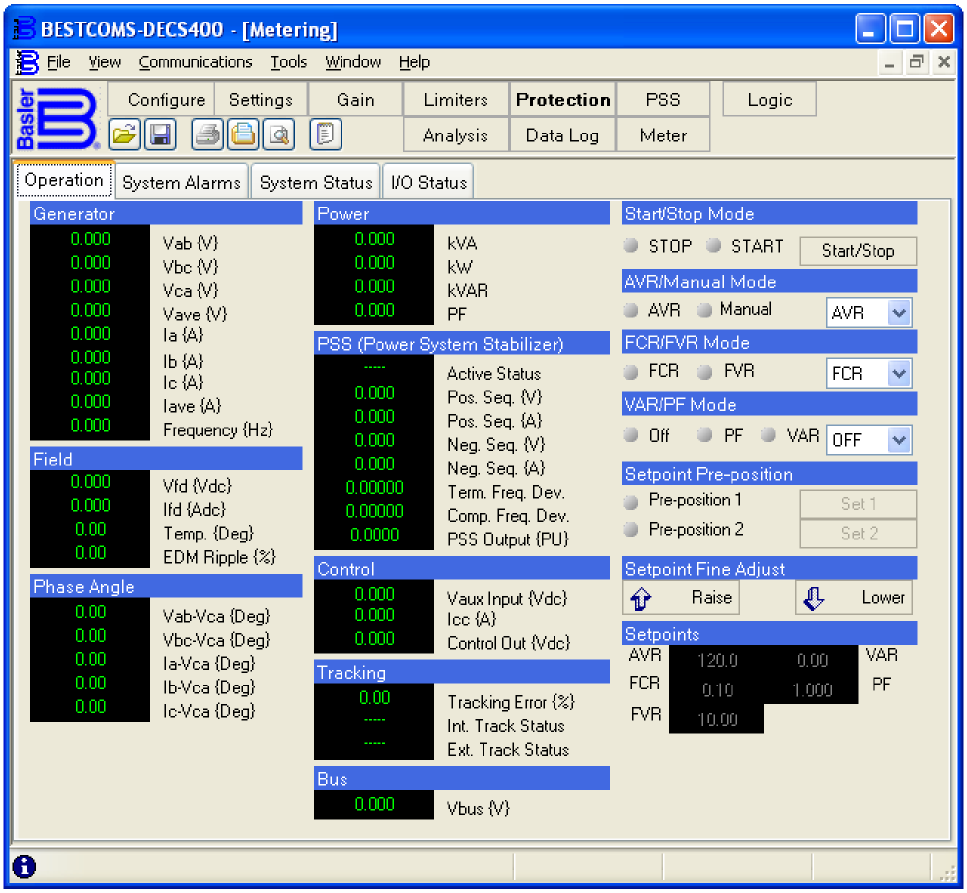


Figure 6-1. BESTCOMS Metering Screen, Operation Tab

- 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. .... _________

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.

- Check for proper raise/lower limits. .... _________
- Verify raise/lower indications at the front panel HMI, through BESTCOMS, and from remote indicators. .... _________

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 Gain tab of the BESTCOMS Gain screen (Figure 6-2). Table 6-1 lists the recommended PID setting for exciter and static exciter installations.

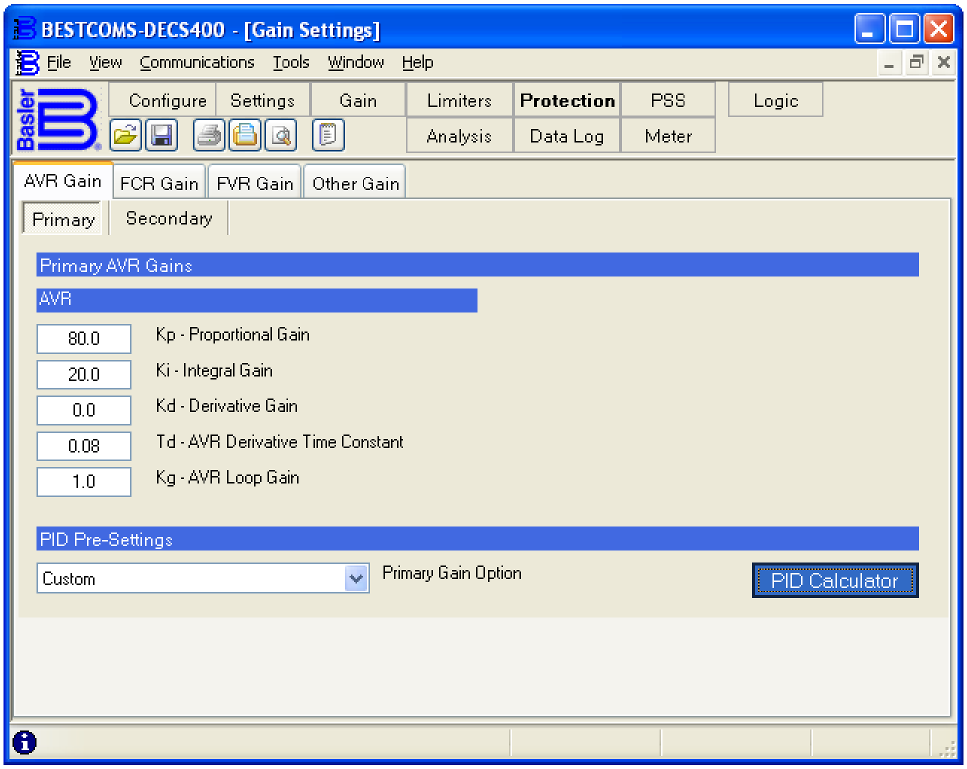


Figure 6-2. BESTCOMS Gain Screen, AVR Gain Tab

Table 6-1. Recommended Settings for Exciter and Static Exciter Installations

PID Setting	Static Exciter		Exciter	
	AVR	**FCR**	**AVR**	**FCR**
Kp	80	—	80	—
Ki	20	—	15	—
Kd	—	—	40	—
Kg	15	1000	15	1000
Td	0.01	0.01	0.01	0.01

- 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 the *BESTCOMS Software* chapter for more information about PID settings.

- Verify transfer indications from the front panel HMI, BESTCOMS, and remote indicators. ....

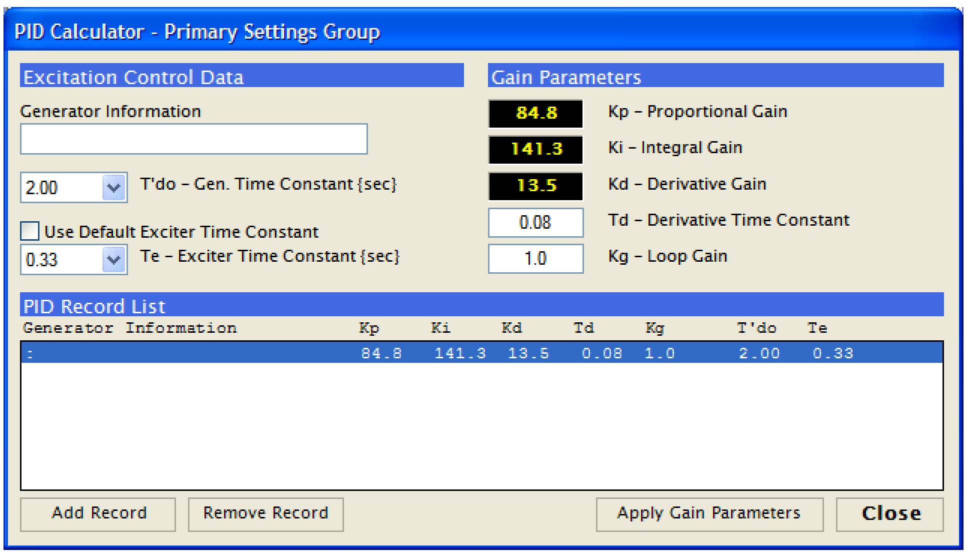


Figure 6-3. BESTCOMS PID Screen

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.) .... _________

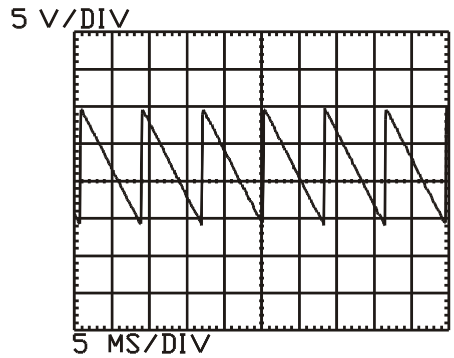


Figure 6-4. Field Voltage Output Waveform

- 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 6-2. PPT Secondary Voltages

Rectifier DC Voltage	PPT AC Secondary Voltage
63	80
125	160
250	360
375	480

- 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, and 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'do (main field) and Te (exciter field) is known (as applicable for main field static exciter or exciter field voltage regulator application), increasing Kg will speed the response time of the generator. See Figure 6-5.

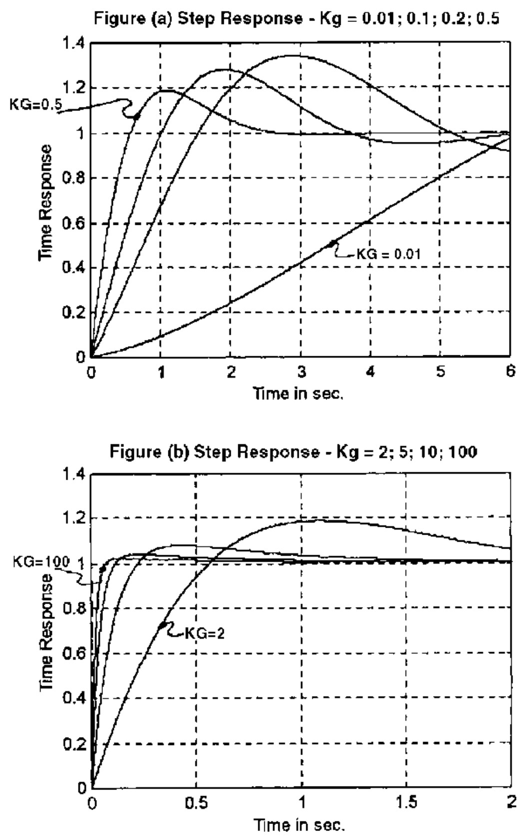


Figure 6-5. Kg Gain Effect on Generator Performance

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 (Ki and Kg) may be set too low. If the system doe alarm and oscillates, Ki and Kg 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. .... _________
- Repeat with unit supplying 30% load at 0.8 leading PF in Droop mode. .... _________

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 nulled 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.

7 • 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.

Storage

Stored units should be kept in the original shipping package in a moisture- and dust-free environment.

This device contains long-life aluminum electrolytic capacitors. For devices that are not in service (spares in storage), the life of these capacitors can be maximized by energizing the device for 30 minutes once per year.

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.

The DECS-400 Appears 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 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 K_g loop gain. Increase the AVR loop gain accordingly.

No Buildup in FCR Mode

Low K_g 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 mAdc, or –10 to +10 Vdc control signal.

Limiters Do Not Limit at the Desired Level

Insufficient K_g 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 or phase A or C.

No Communication

If communication cannot be initialized, check the serial cables to the port connections, the transmission speed (baud rate), and supporting software.

Real-Time Clock Information Lost After Loss of Control Power

A loss of real-time clock information indicates a depleted backup battery. See *Backup Battery Replacement* for the battery replacement procedure.

The 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. In applications where the battery is not desired, refer to the following instructions to remove the battery.

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.

Caution
Observe all applicable electrostatic discharge (ESD) precautions when handling the draw-out assembly.

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.

Warning!
Do not short-circuit the battery, reverse the battery polarity, or attempt to recharge the battery.

Note
The battery should be disposed of properly. Consult your local health, solid waste disposal, or recycling agency for battery disposal guidelines.

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.

Upgrading DECS-400 Nonvolatile Memory

This product contains one or more nonvolatile memory devices. Nonvolatile memory is used to store information (such as settings) that needs to be preserved when the product is power-cycled or otherwise restarted. Established nonvolatile memory technologies have a physical limit on the number of times they can be erased and written. In this product, the limit is 1,000,000 erase/write cycles. During product application, consideration should be given to communications, logic, and other factors that may cause frequent/repeated writes of settings or other information that is retained by the product. Applications that result in such frequent/repeated writes may reduce the useable product life and result in loss of information and/or product inoperability.

It is recommended that DECS-400 units loaded with firmware versions prior to 1.10.00 are upgraded using BESTCOMS to prevent information loss and product inoperability due to nonvolatile memory failure.

This tool copies the settings and other information stored in nonvolatile memory and saves it on the connected PC. A firmware upgrade is performed, then the settings are loaded back into the DECS-400.

Caution

- A failed nonvolatile memory chip continues to operate normally as long as power remains present. However, after power is cycled, the DECS-400 becomes inoperable.
- Some firmware upgrades require the reassignment and re-landing of some wire terminations due to features that may be added, changed or removed. Contact Basler Electric and ask about any hardware or system changes that will need to be performed before installing new firmware. Serious damage to the DECS or your system could result if these changes are not completed first.
- DECS-400 units with hardware version AB and later support only firmware versions 1.10.00 and later.

Note

In the course of upgrading firmware, the DECS-400 will reboot several times. This may cause the DECS to give a Watchdog Failure alarm and, depending on your fault tripping scheme, may trip your generator's lockout relay. It is recommended that firmware upgrades be done while the prime mover is stopped for maintenance.

Nonvolatile Memory Upgrade Procedure

The following conventions are used in this procedure:

- *Italic text* marks the menu commands and submenu commands that are to be clicked
- **Bold text** marks the buttons that are to be clicked

Before upgrading DECS-400 nonvolatile memory and firmware, read the entire procedure and ensure that you have the DECS-400 serial number, latest BESTCOMS software, latest firmware package, and all files required to install the firmware.

- Obtain the serial number of the DECS-400 to be upgraded and record for later use. The serial number is found on the DECS-400 front panel ratings label.
- Obtain the latest DECS-400 firmware package by contacting Basler Electric Technical Support. Firmware files may be supplied as an email message file attachment, a file downloaded from the Basler Electric website, or on a firmware update CD-ROM. Retain the firmware package for later use.

- Install the latest version of BESTCOMS-DECS400. Refer to the *BESTCOMS™ Software* chapter for installation instructions. Visit www.basler.com/Downloads/ to download the latest version of BESTCOMS-DECS400 or contact Technical Support.

If you have difficulty upgrading the nonvolatile memory, contact Basler Electric Technical Support for assistance.

1. Start BESTCOMS and connect to the DECS unit.
   a. *Communications*
   b. *Connect*
   c. *RS232-COM0*
   d. Select the communications port of the host PC.
   e. Click **Connect**
   f. Type the password for your unit (default: DECS4) and press **Enter** or click **OK**.
   g. Wait for the currently installed settings to load from the DECS into BESTCOMS.

2. Take note of the DECS serial port speed.
   a. *Communications*
   b. *Configure*
   c. Make note of the baud rate listed under “Com0 RS-232”.
   d. Click **OK** when finished.

3. Start the nonvolatile memory upgrade
   a. *Communications*
   b. *NVRAM Upgrade* (This option is disabled if the DECS-400 is loaded with firmware version 1.10.00 or higher.)
   c. An NVRAM dialog appears.
   d. Click **Upgrade**.
   e. An NVRAM Upgrade Notice dialog appears. When the DECS-400 serial number and latest firmware package have been obtained, proceed to the next step.
   f. Click **Yes**.
   g. Wait while all settings are copied from nonvolatile memory.
   h. When complete, a Save All Settings dialog appears.

4. Save the nonvolatile memory settings file.
   a. Click **OK**.
   b. Select a location that you can find again later (e.g., c:\Windows\desktop).
   c. Select an appropriate file name.
   d. Click **Save**
   e. A Continue Upgrade dialog appears.

5. Upgrade firmware
   a. Click **OK**.
   b. BESTCOMS disconnects from the DECS-400.
   c. BESTload™ is launched automatically.

6. Check the BESTload port speed.
   a. *Communications*
   b. *Configure*
   c. Serial port should be comm1 or the current port you are using on your computer.
   d. Adjust the baud rate to the same value noted in Step 2, if necessary.
   e. Click **OK**.

7. Click **Get Relay Info**.
   BESTload begins communicating with the DECS and displays the current, installed firmware in the left-hand box.
8. Click **Start Transfer**.
9. You are asked for the location of the firmware file.
   a. Navigate to the location where you have saved the firmware file.
   b. Select the "gdDECS400_hxxyy.hex" file and click **Open**.
10. Enter the password for your DECS and press **Enter**.
    The BESTload program loads the new firmware file. The DECS front panel display indicates "Reprogramming In Progress" and the front panel LEDs flash. The DECS should reboot when the file is completely loaded.
11. A dialog box should appear explaining if there was an error or if the firmware will have to be reloaded when the download is complete. Click **OK**.
12. The new firmware version that you have just loaded should now appear in the right hand box.
    The DECS HMI should now be on the main screen.
13. Close BESTload.
14. Load Settings.
    a. Once BESTload is closed, BESTCOMS attempts to reconnect to the DECS-400.
    b. You are asked for the location of the nonvolatile memory settings file.
       i. Navigate to the location where you have saved the nonvolatile memory settings file.
       ii. Select the ".de4x" file and click **Open**.
    c. If the correct firmware is installed, a Firmware Upload Successful dialog appears.
    d. Enter the serial number of the DECS-400 in the provided field.
    e. Click **Submit**.
    f. If the serial number is correct, the nonvolatile memory settings will be uploaded to the DECS.
    g. If the serial number is incorrect, a Serial Number Mismatch dialog appears.
       i. Click **Yes** to re-enter the serial number. Click **No** to cancel.
       ii. If cancelled, an Upgrade Cancelled dialog appears. Click **OK**.
       iii. You may resume the upgrade by clicking *File, Upload .de4x file*.
       iv. Go to Step 14c above.
15. When complete, an Upgrade Complete dialog appears.
16. Click **OK**. BESTCOMS closes the upgrade tool and communications with the DECS.

Upgrading DECS-400 Firmware

Future enhancements to DECS-400 functionality may make a firmware upgrade desirable. Before upgrading DECS-400 firmware, read the entire procedure and ensure that you have all files required to install the firmware. Firmware files may be supplied as an email message file attachment, a file downloaded from the Basler Electric website, or on a firmware update CD-ROM.

Firmware Installation Procedure

The following conventions are used in this procedure:

- *Italic text* marks the menu commands and submenu commands that are to be clicked
- **Bold text** marks the buttons that are to be clicked

If you have difficulty installing the firmware, contact Basler Electric for assistance.

Caution

- Some firmware upgrades require the reassignment and re-landing of some wire terminations due to features that may be added, changed or removed. Contact Basler Electric and ask about any hardware or system changes that will need to be performed before installing new firmware. Serious damage to the DECS or your system could result if these changes are not completed first.
- DECS-400 units with hardware version AB and later support only firmware versions 1.10.00 and later.

Note

In the course of upgrading firmware, the DECS-400 will reboot several times. This may cause the DECS to give a Watchdog Failure alarm and, depending on your fault tripping scheme, may trip your generator's lockout relay. It is recommended that firmware upgrades be done while the prime mover is stopped for maintenance.

1. Start BESTCOMS and connect to the DECS unit.
   a. *Communications*
   b. *Connect*
   c. *RS232-COM0*
   d. Select the communications port of the host PC.
   e. Click **Connect**
   f. Type the password for your unit and press **Enter** or click **OK**.
   g. Wait for the currently installed settings to load from the DECS into BESTCOMS.

2. Take note of the DECS serial port speed.
   a. *Communications*
   b. *Configure*
   c. Make note of the baud rate listed under "Com0 RS-232".
   d. Click **OK** when finished.

3. Save the settings to your hard drive.
   a. Click the disk icon (□).
   b. Select a location that you can find again later (e.g., c:\Windows\desktop).
   c. Select an appropriate file name.
   d. Click **Save**

4. Print the settings to a text file.
   a. *File*
   b. *Printing*
   c. *Print To File*
   d. You will be asked to supply some information on the unit, like a serial number.
      i. This information will help you identify the file later.
      ii. You can enter any information desired or also leave the three boxes blank.
   e. Click **OK**
   f. Choose a location that you can locate later (e.g., c:\Windows\desktop).
   g. Select an appropriate file name.
   h. Click **Save**

5. Close BESTCOMS.
   a. *Communications*
   b. *Close*

   Settings are saved to the EEPROM of the DECS.

6. Start BESTload™.

7. Check the BESTload port speed.
   a. *Communications*
   b. *Configure*
   c. Serial port should be comm1 or the current port you are using on your computer.
   d. Baud rate should be set to the same speed as you noted above for BESTCOMS, if not, change it to appropriate speed.
   e. Click **OK**.

8. Click **Get Relay Info**.

   BESTload will begin communicating with the DECS and display the current, installed firmware in the left-hand box.

9. Click **Start Transfer**.

10. You will be asked for the location of the firmware file.
    a. Navigate to the location where you have saved the firmware file.
    b. Select the "gdDECS400_hxxyy.hex" file and click **Open**.

11. Enter the password for your DECS and press **Enter**.

    The BESTload program should start loading the new firmware file. The DECS front panel display should indicate "Reprogramming In Progress" and the front panel LEDs should flash. The DECS should reboot when the file is completely loaded.

12. A dialog box should appear explaining if there was an error or if the firmware will have to be reloaded when the download is complete. Click **OK**.

13. The new firmware version that you have just loaded should now appear somewhere in the right hand box.

    The DECS HMI should now be on the main screen.

14. Close BESTload.

15. If you have not already done so, install the BESTCOMS program that's on the firmware update CD.

16. Start BESTCOMS in order to re-install the operating settings into the DECS.
    a. *Communications*
    b. *Connect*
    c. *RS232-COM0*
    d. Select the communications port of the host PC.
    e. Click **Connect**
    f. Type the password for your unit and press **Enter** or click **OK**.
    g. Wait for the currently installed settings to load from the DECS into BESTCOMS.

17. Open the settings files you saved in step 5.
    a. Click the "open file" icon (□).
    b. Navigate to the location where the settings file was saved.

c. Select the file that you saved.
d. Click **Open**. The settings file will be uploaded to the DECS.

18. While you are still connected to the DECS, open the text file that you saved earlier and compare these settings to what is now in the DECS.
    a. Check all entries to verify that the settings have not changed. Keep in mind that some settings, like the active mode setpoint, change as a natural course of the DECS functioning. Differences in these settings, unless they seem out of the ordinary, do not necessarily indicate a problem.
    b. You may find that some new features were added. Default values will be entered into the new features.
        i. If your current version of BESTCOMS no longer communicates with the DECS unit containing the new firmware, contact Basler Electric for a version of BESTCOMS that is compatible with your firmware.

19. Save the new settings to your PC hard drive.
    a. Click the disk icon ()
    b. Select a location that you can find again later (e.g., c:\Windows\desktop).
    c. Select an appropriate file name for the new settings.
    d. Click **Save**.

20. Save a new copy of your settings text file.
    a. *File*
    b. *Printing*
    c. *Print To File*
    d. You will be asked to supply some information on the unit, like a serial number.
        i. This information will help you identify the file later.
        ii. You can enter any information desired or also leave the three boxes blank.
    e. Click **OK**
    f. Choose a location that you can locate later (e.g., c:\Windows\desktop).
    g. Select an appropriate file name.
    h. Click **Save**

21. Close BESTCOMS.
    a. *Communications*
    b. *Close*

    Settings are saved to the EEPROM of the DECS.

8 • 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 .... 1-, 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: 63 Vdc, 125 Vdc, 250 Vdc, 375 Vdc, and 625 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 the *Installation* chapter 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 ∗
- Manual ∗
- 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)
Manual.. B6 (Man), 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
Burden... 1 kΩ maximum
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 (NC)), C7 (WTCH (COM)), C8 (WTCH2 (NO))
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 Type .... 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 Type .... Rear-panel screw terminals
Terminals....................................... D9 (A), D10 (B), D11 (C)
Protocol .... Either Modbus® RTU or Modbus TCP/IP
Data Transmission .... Half duplex
Baud .... 4800 to 19200
Data Bits.. 8
Parity .... None
Stop Bits 2

Com 3

Interface .... 10BASE-T Ethernet per IEEE 802.3
Connection Type .... Rear-panel RJ-45
Data Transfer
Medium .... Category 5 twisted-pairs, copper conductors, 100 m (328 ft) maximum
Rate .... 10 Mb/s
Connections
Modbus TCP/IP .... 4, maximum
BESTCOMS .... 1, maximum

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 kΩ at 3.5 Vdc, 3 kΩ 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 and FVR Mode

Field Current/Voltage 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%
Aux. Voltage & Current Input .... ±1.0%

Power System Stabilizer (PSS)

Model:... IEEE Std 421.5 type PSS2A/2B/2C
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.

Traverse Rates

Setpoint

Setting Range .... 10 to 200 s
Setting Increment .... 1 s

Pre-Position Setpoint

Setting Range .... 1 to 720 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 or 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.

Setpoint Range
High, Low .... 100 to 300% of nominal generator output current
Definite Time Delay
High .... 0 to 60 s, 1 s increments

Reactive Power

The reactive power limiter ensures that the level of var flow out of the generator does not exceed its capability.

Setting Range (Lagging kvar)...... Determined by rated kVA specified for the controlled machine: from 0 to current value of generator rating in 1 kvar increments.
Time Delay .... 0 to 10 s

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

Exciter to Stator Poles Ratio .... 1 to 10 (0 if unknown)
Ripple Threshold, Open/Shorted .. 0 to 100%, in 0.1% increments
Time Delay Open .... 10 to 60 s, in 0.1 increments
Time Delay Shorted .... 5 to 30 s, in 0.1 increments
Open/Shorted Inhibit Levels.......... 0 to 100%, in 0.1% increments
Generator Frequency Range .... 40 to 70 Hz

Type Tests

Shock .... IEC 60255-21-2
Vibration .... IEC 60255-21-1
Humidity .... IEC 68-1, IEC 68-2-28
Dielectric Strength......................... IEEE 421.3
Transients...................................... IEEE C37.90.1-1989
Surge Withstand Capability........... IEEE C37.90.1-1989
Impulse.. IEC 60255-5
Electrostatic Discharge .... IEEE C37.90.3 Draft 2.3
Radio Frequency Interference ...... IEEE C37.90.2

Agency Certifications

UL

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

CE

In its intended use, this equipment conforms with the relevant EU harmonization legislation:
Low Voltage Directive (LVD)................... 2014/35/EU
Electromagnetic Compatibility (EMC) 2014/30/EU

NIIPT

NIIPT, JSC Russian certification.

Real-Time Clock Battery

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

Note

For applications where battery backup is not desired, refer to the *Maintenance* chapter, for instructions on removing the battery. Operating the DECS-400 without the backup battery installed may result in loss of real-time clock information if control power to the DECS-400 is lost.

Environment

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

Physical

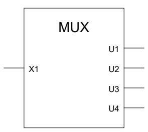
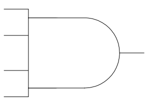
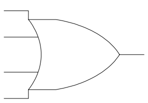
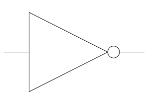
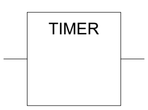
Weight .... 6.01 kg (13.25 lb)
Size .... Refer to the *Installation* chapter for DECS-400 dimensions.

9 • Programmable Logic

The DECS-400 utilizes programmable logic functionality in the form of multiplexors, AND gates, OR gates, NOT gates, and timers. Refer to Table 9-1. 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.

Table 9-1. Programmable Logic Functionality

Symbol	Description
	*Multiplexor* - The input line is connected to all output lines.
	*AND Gate* - Produces an output of 1 when all inputs are 1, otherwise the output is 0.
	*OR Gate* - If any or all of the inputs are 1, the resulting output value is a 1. The output is 0 only when all inputs are 0.
	*NOT Gate* - Changes the input to its opposite.
	*Timer* - Places a time delay between two points in the logic.

Logic Timer Configuration

The logic timer element has four available logic modes: pickup/dropout, one-shot retriggerable, one-shot non-retriggerable, and oscillator. The four timer modes are illustrated in Figure 9-1.

For each timer mode, a logic 1 at the Block Inhibit input inhibits timer operation.

Timer delay settings (T1 and T2) are expressed in milliseconds. T1 is the logic 1 time delay while T2 is the logic 0 time delay.

The one-shot retriggerable and non-retriggerable timers are initiated by a positive edge trigger at the timer input.

The input of the oscillator timer is always ignored and has no effect on oscillator timer operation.

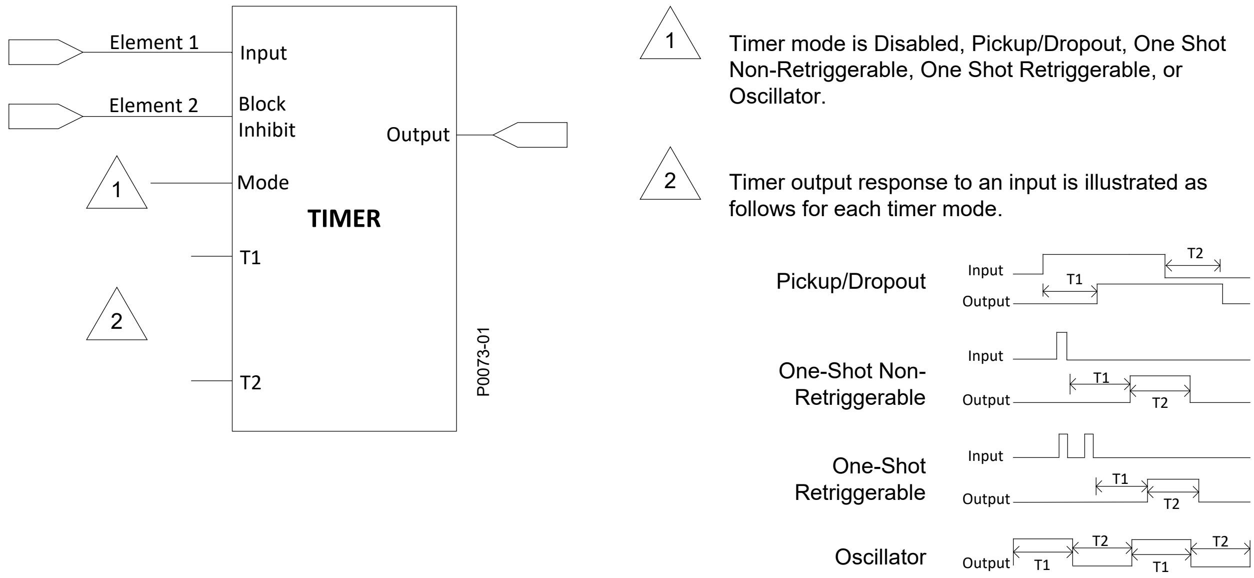


Figure 9-1. Logic Timer Configuration

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 9-2.

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 12, 13, and 14. Figures 15, 16, and 17 illustrate the logic scheme for a single DECS-400 without PSS. The logic scheme for a dual DECS-400 with PSS is illustrated in Figures 18, 19, and 20. Figures 21, 22, and 23 illustrate the logic scheme for a dual DECS-400 without PSS.

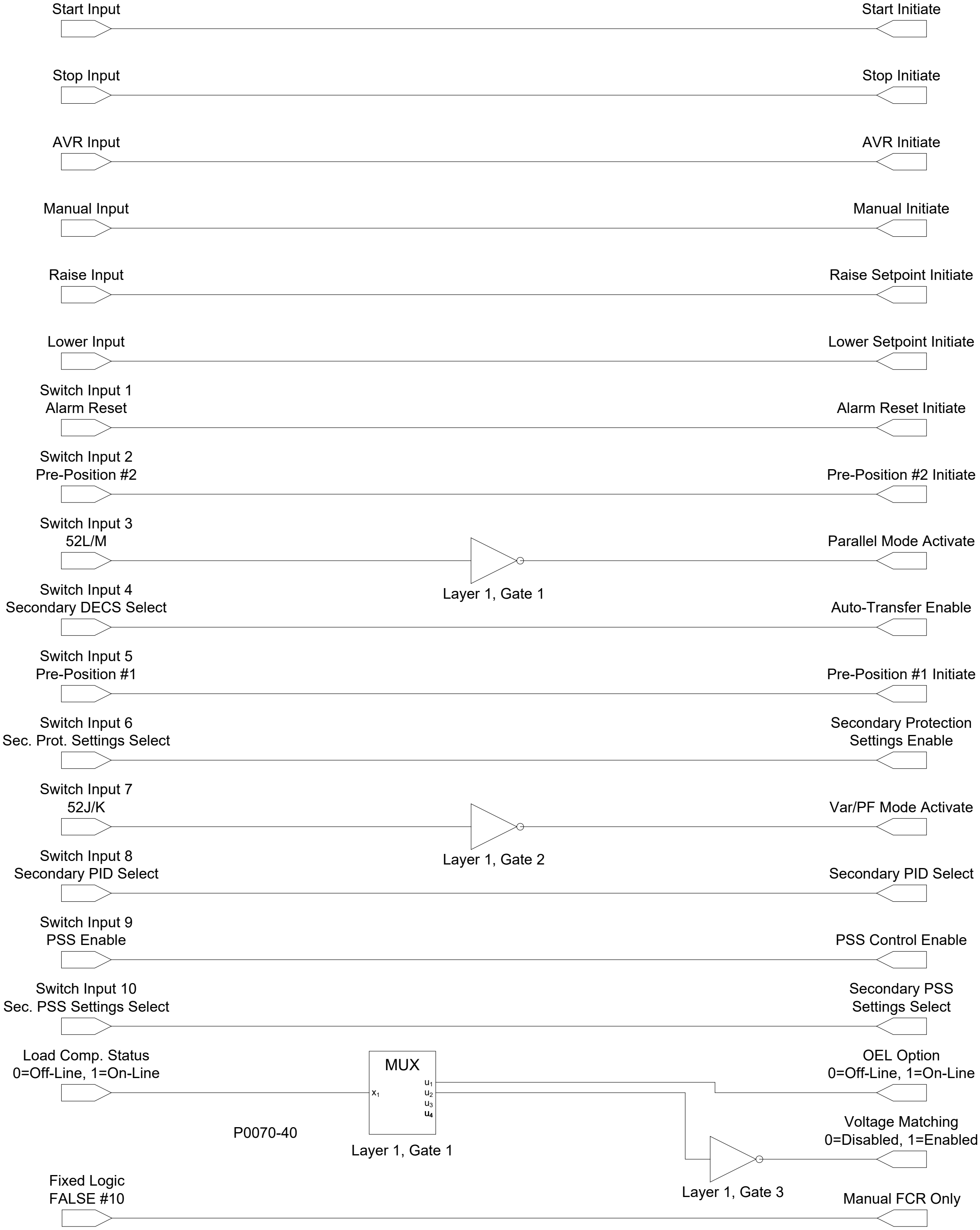


Figure 9-2. Default Logic

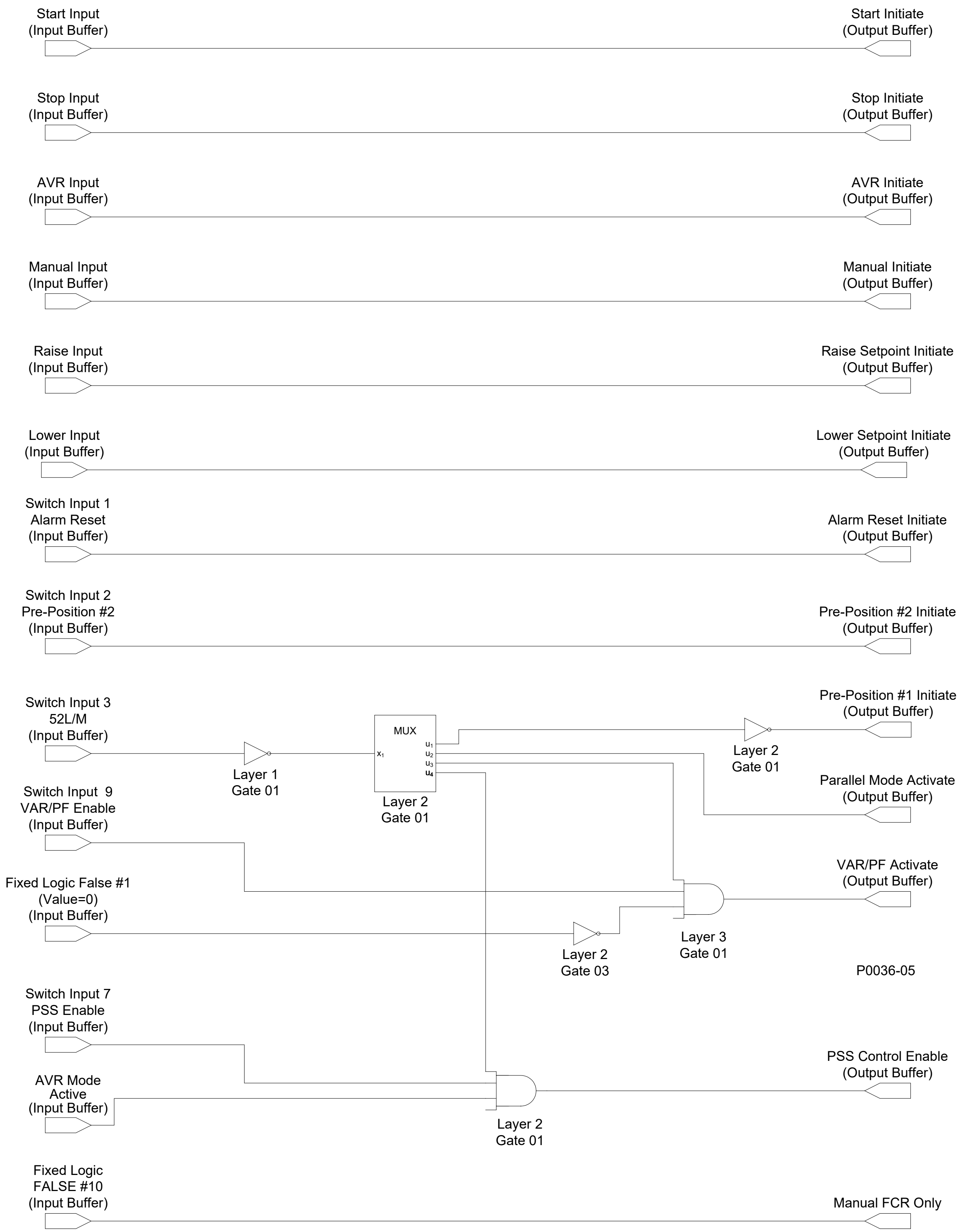


Figure 9-3. Single DECS-400 With PSS (Part 1 of 3)

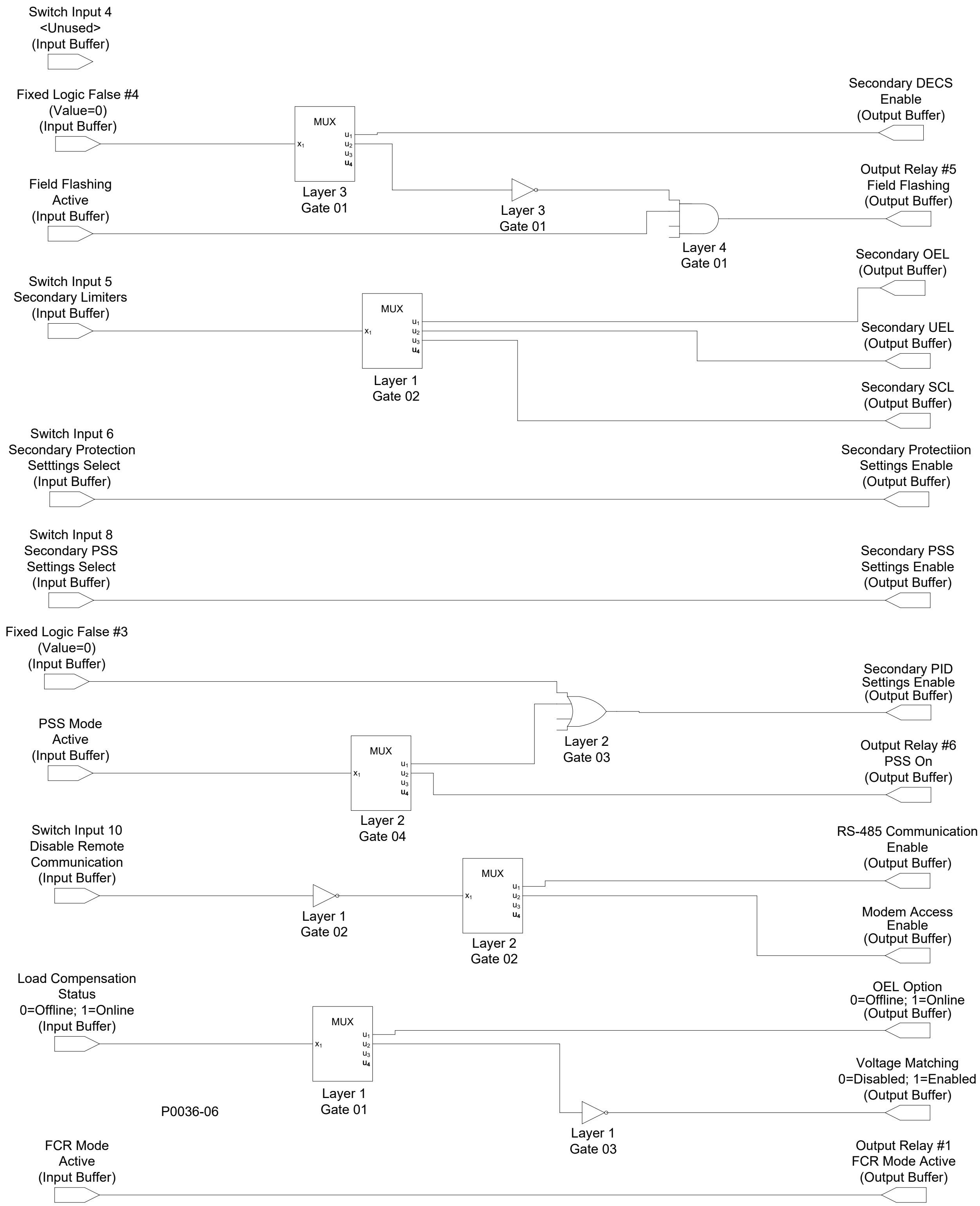


Figure 9-4. Single DECS-400 With PSS (Part 2 of 3)

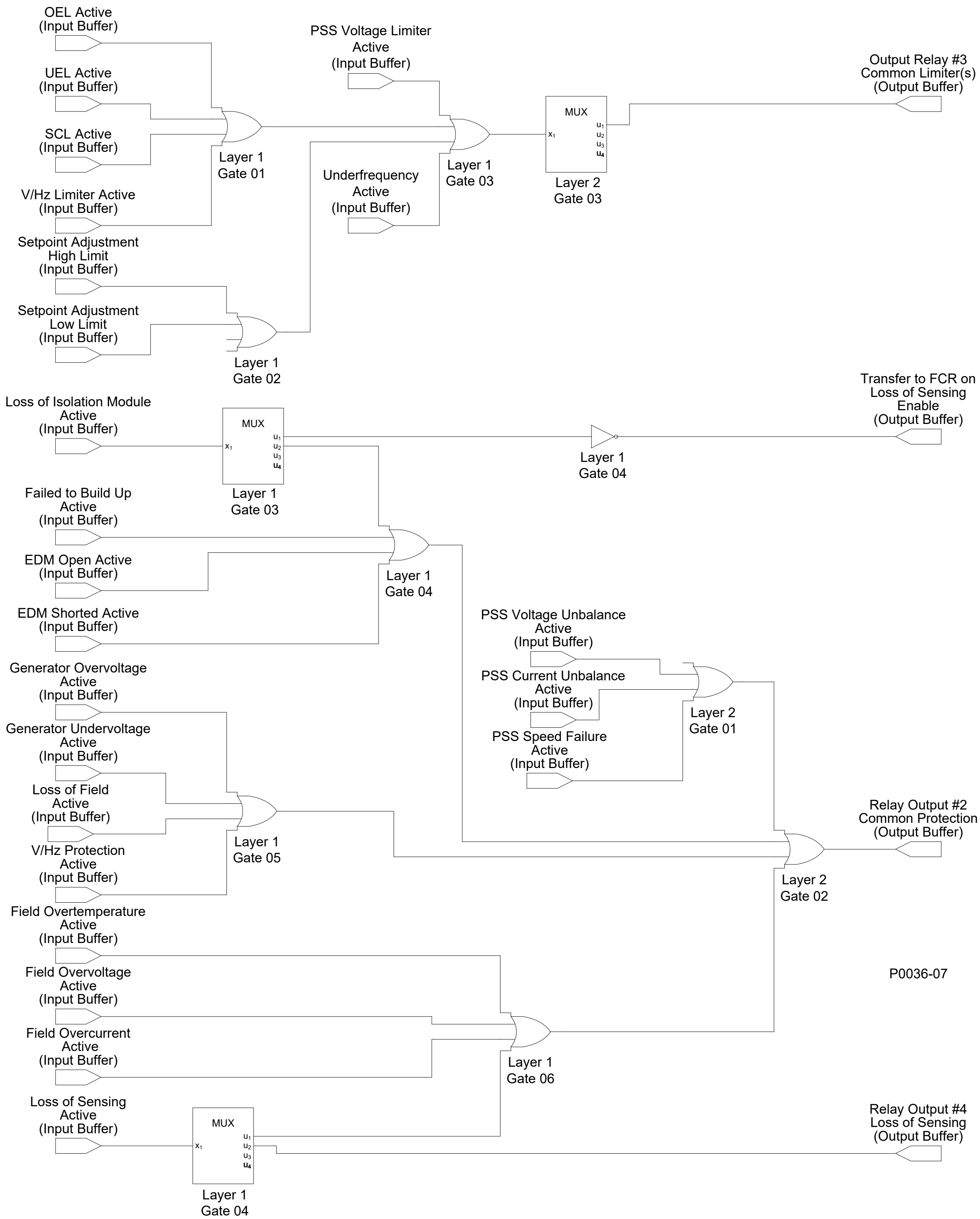


Figure 9-5. Single DECS-400 With PSS (Part 3 of 3)

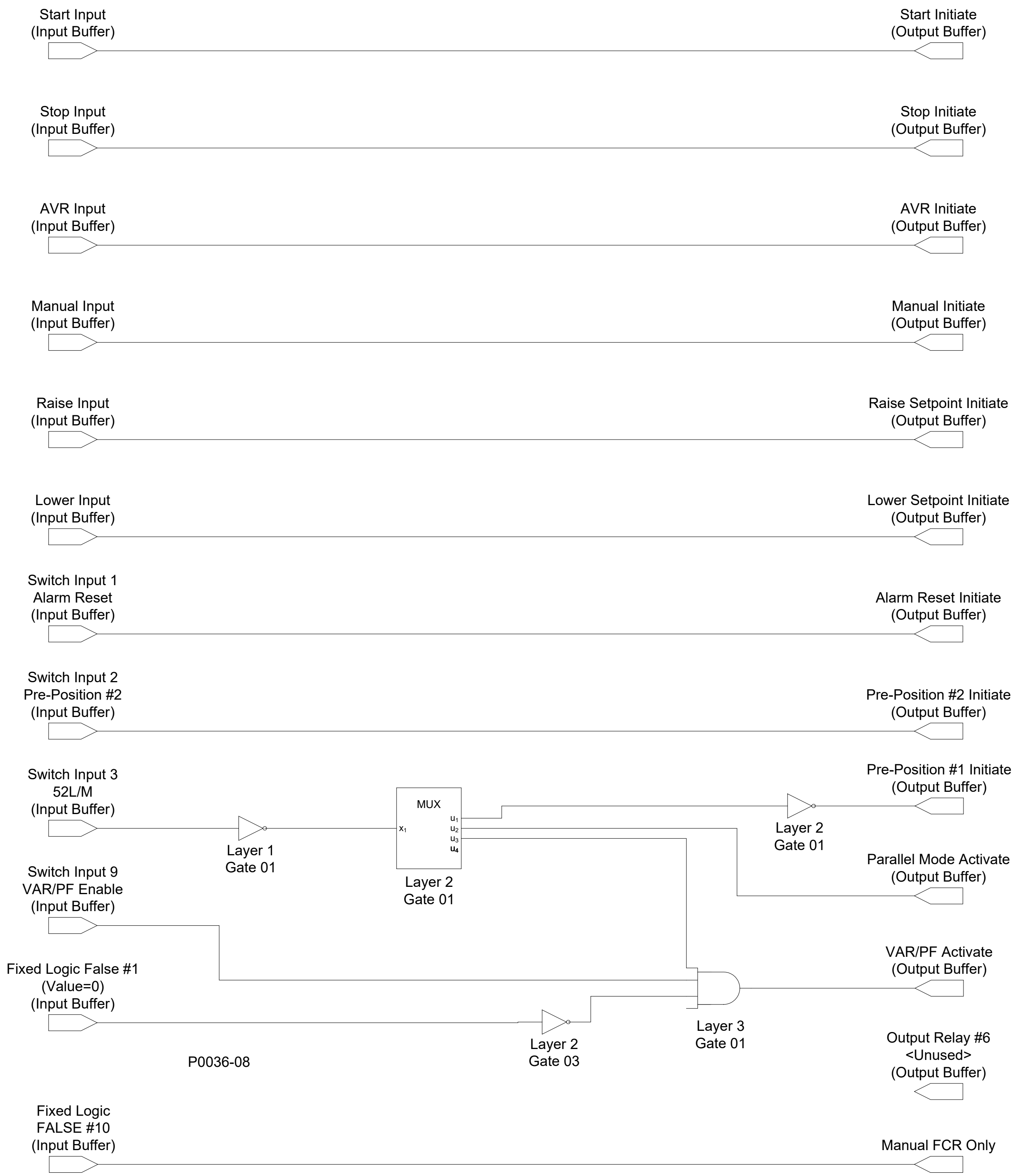


Figure 9-6. Single DECS-400 Without PSS (Part 1 of 3)

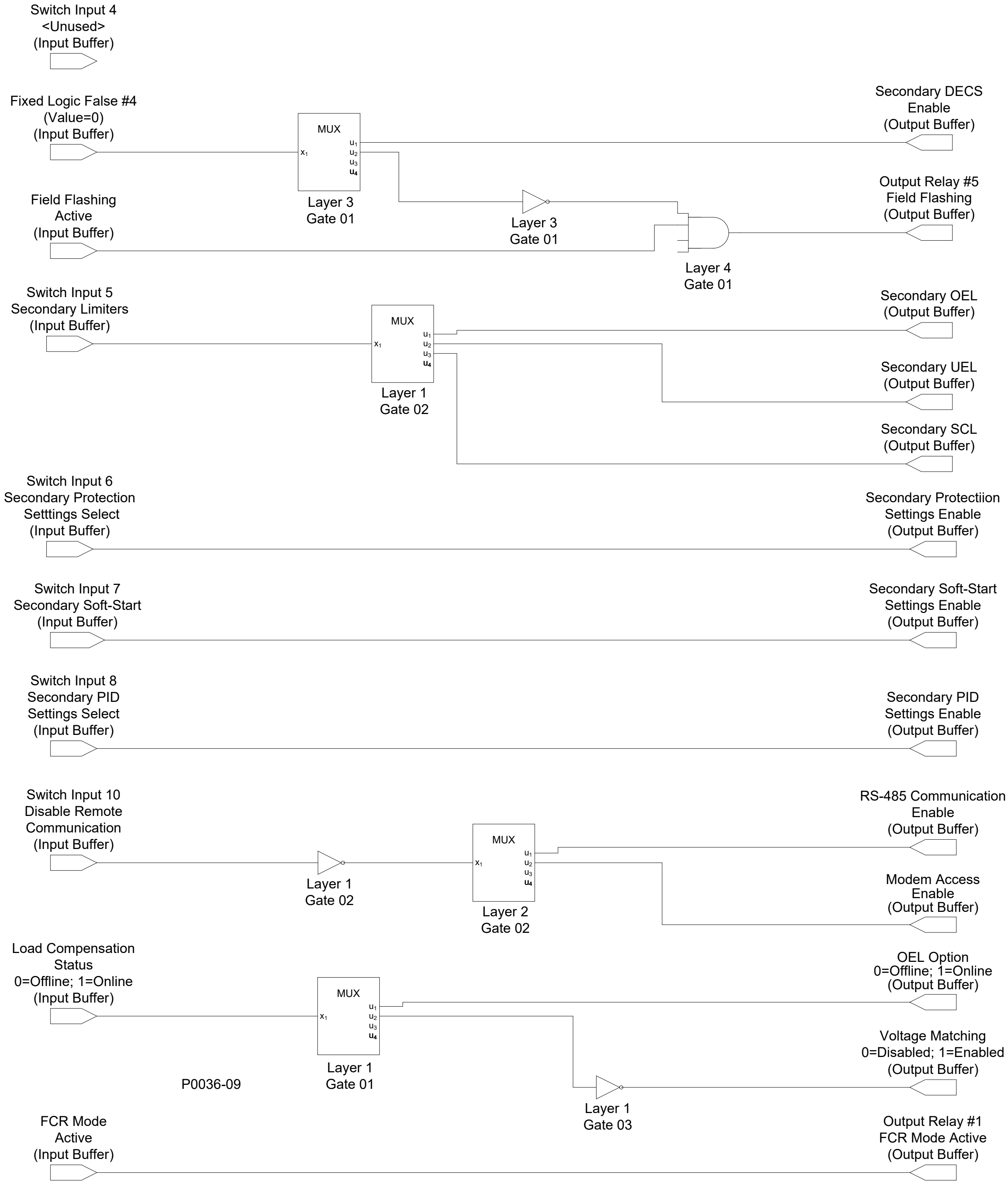


Figure 9-7. Single DECS-400 Without PSS (Part 2 of 3)

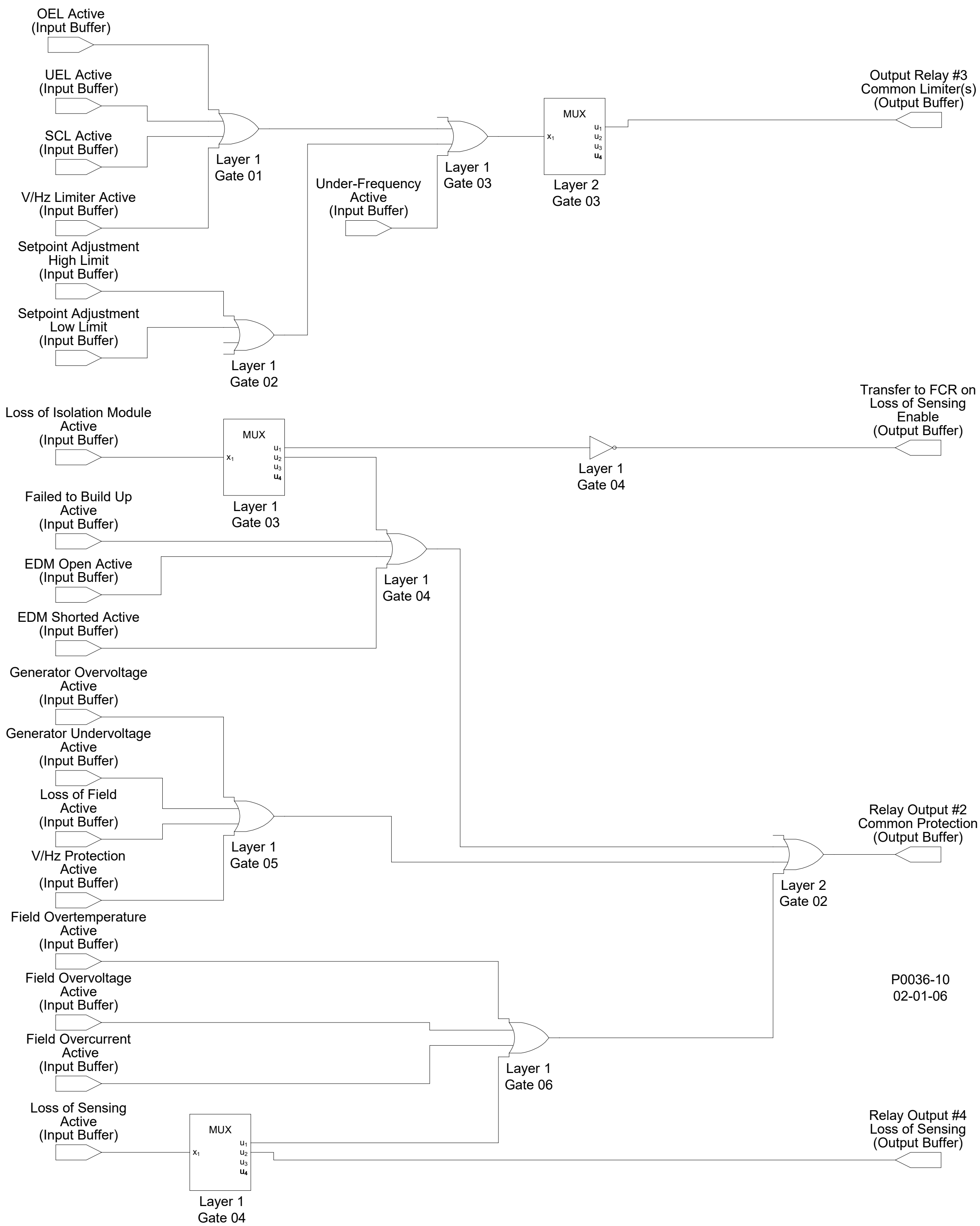


Figure 9-8. Single DECS-400 Without PSS (Part 3 of 3)

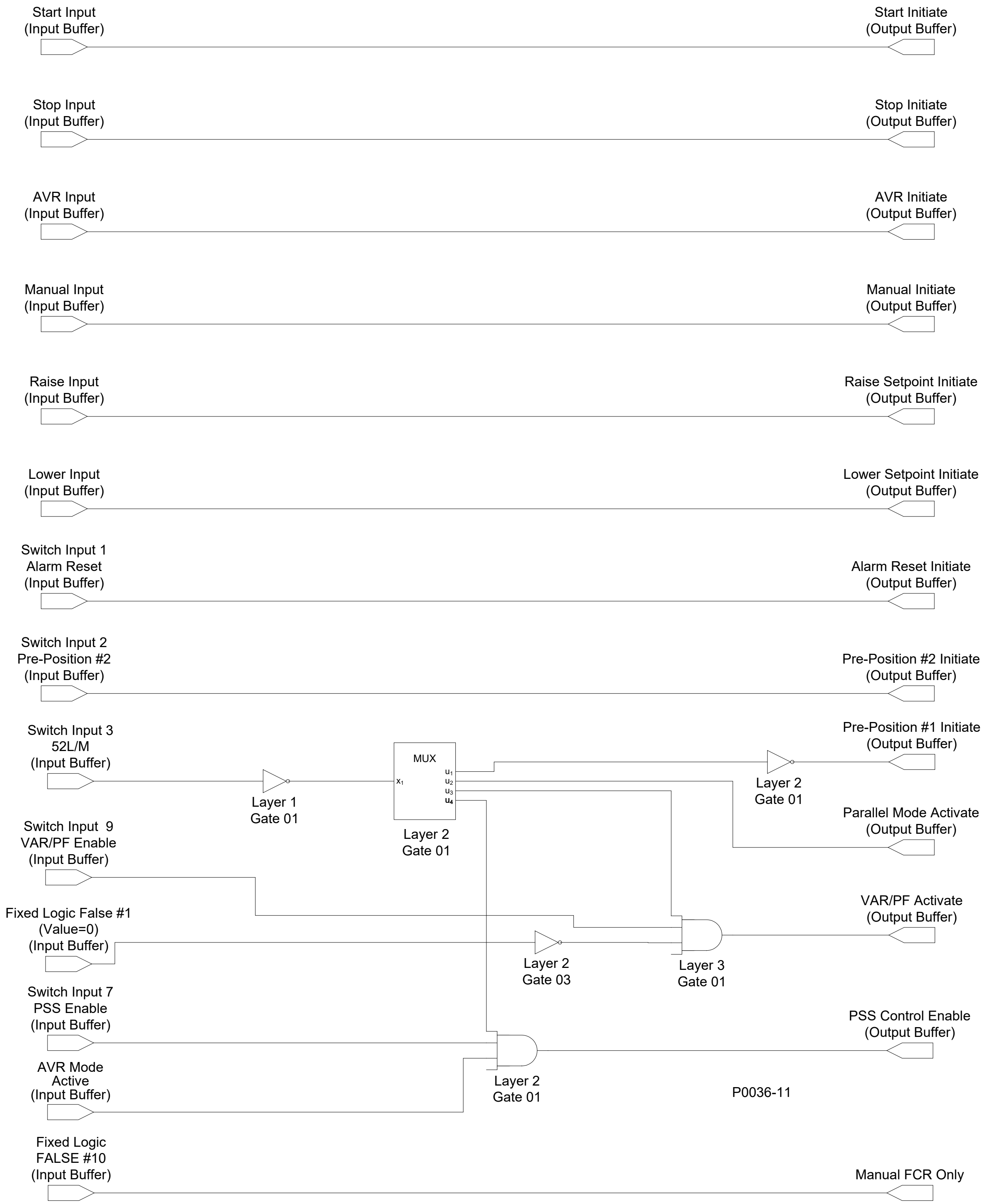


Figure 9-9. Dual DECS-400 With PSS (Part 1 of 3)

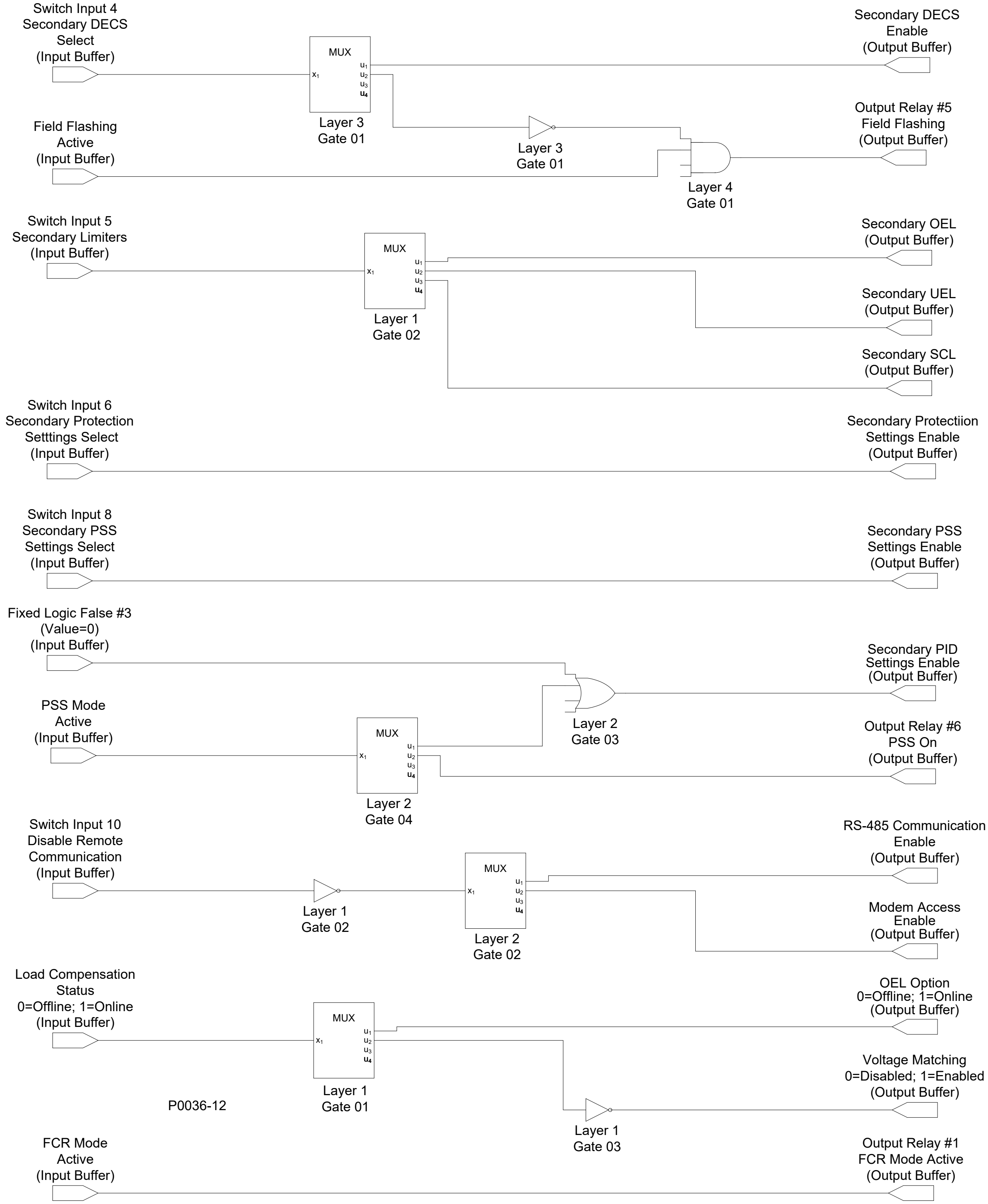


Figure 9-10. Dual DECS-400 With PSS (Part 2 of 3)

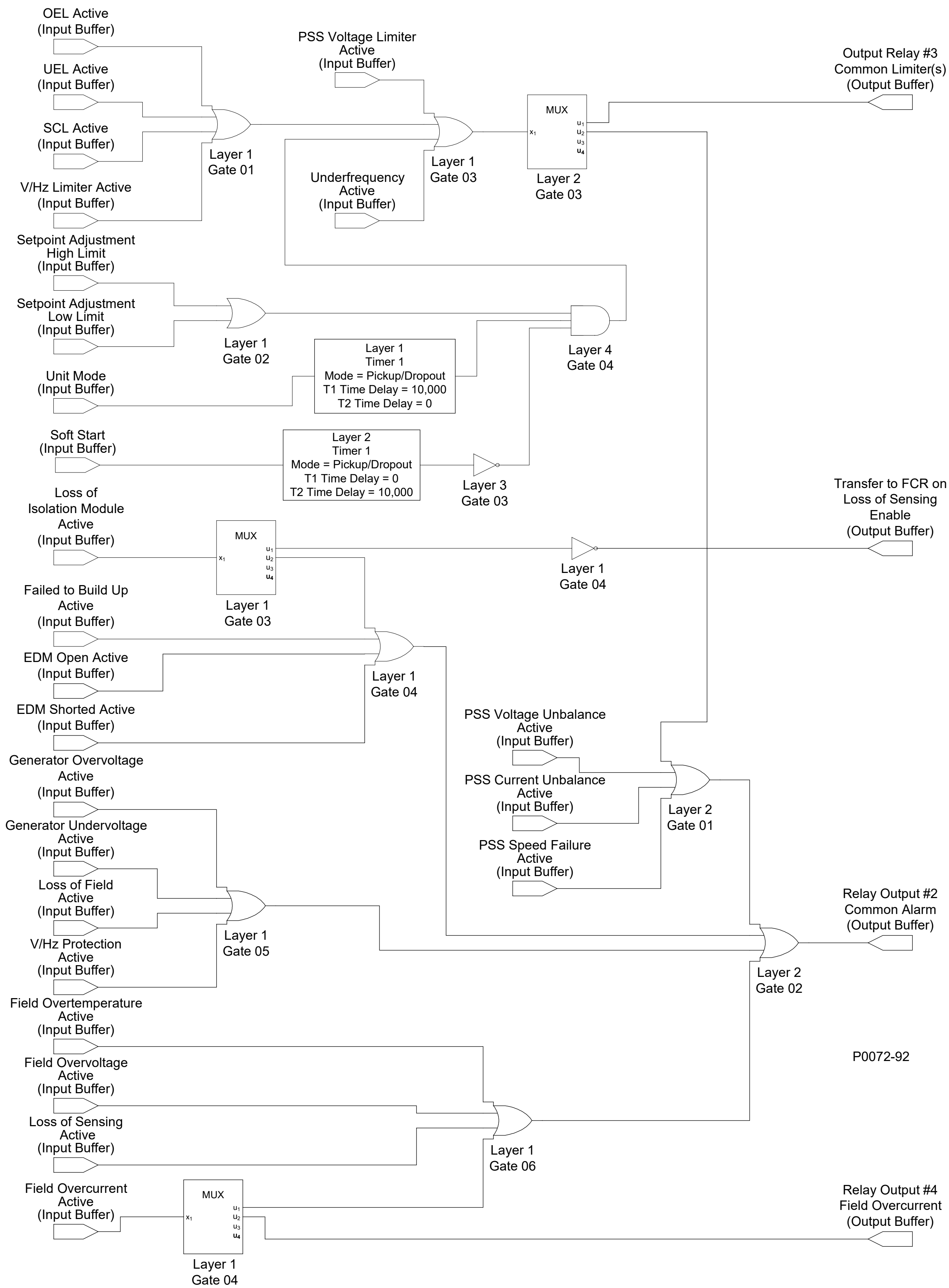


Figure 9-11. Dual DECS-400 With PSS (Part 3 of 3)

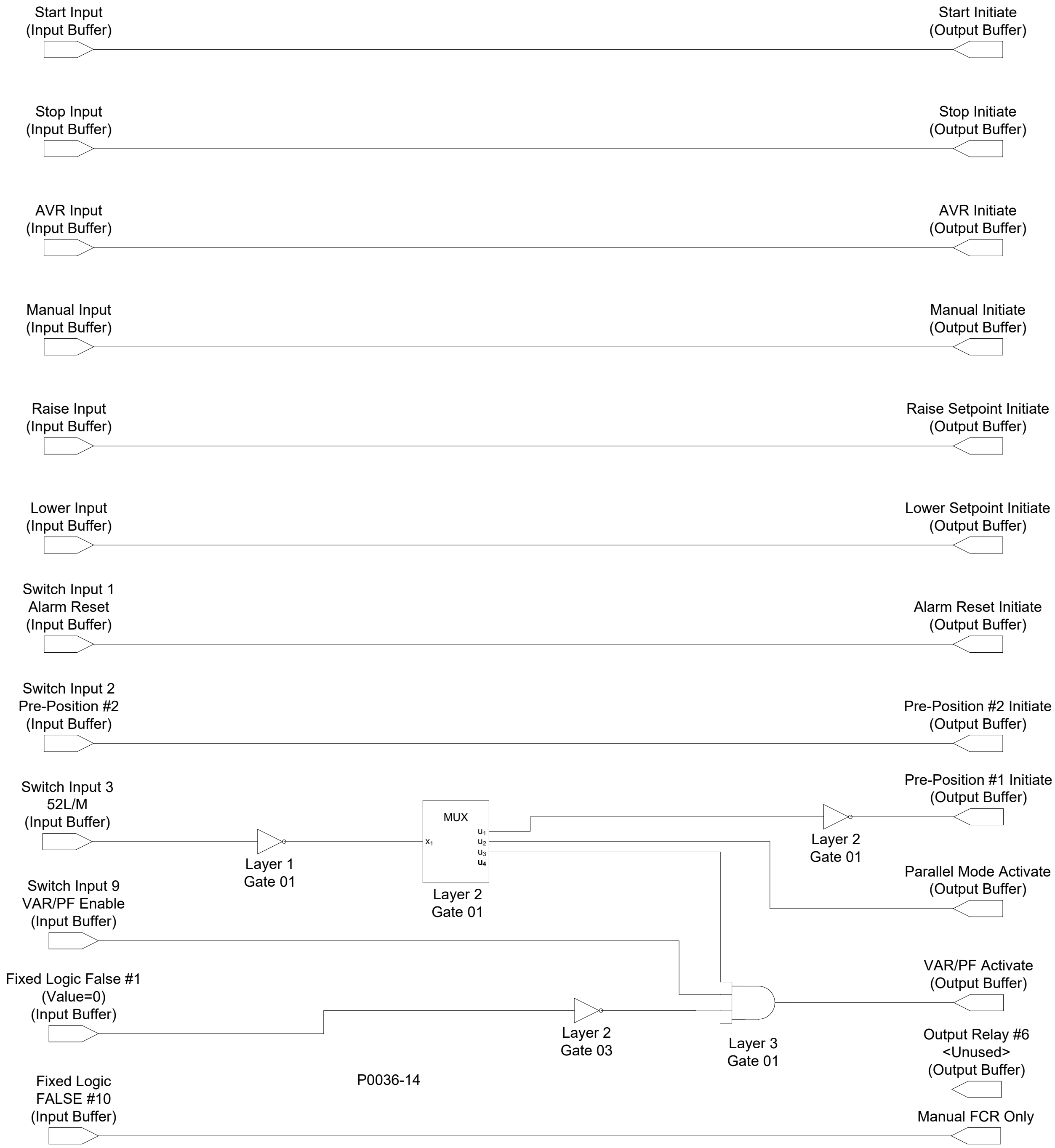


Figure 9-12. Dual DECS-400 Without PSS (Part 1 of 3)

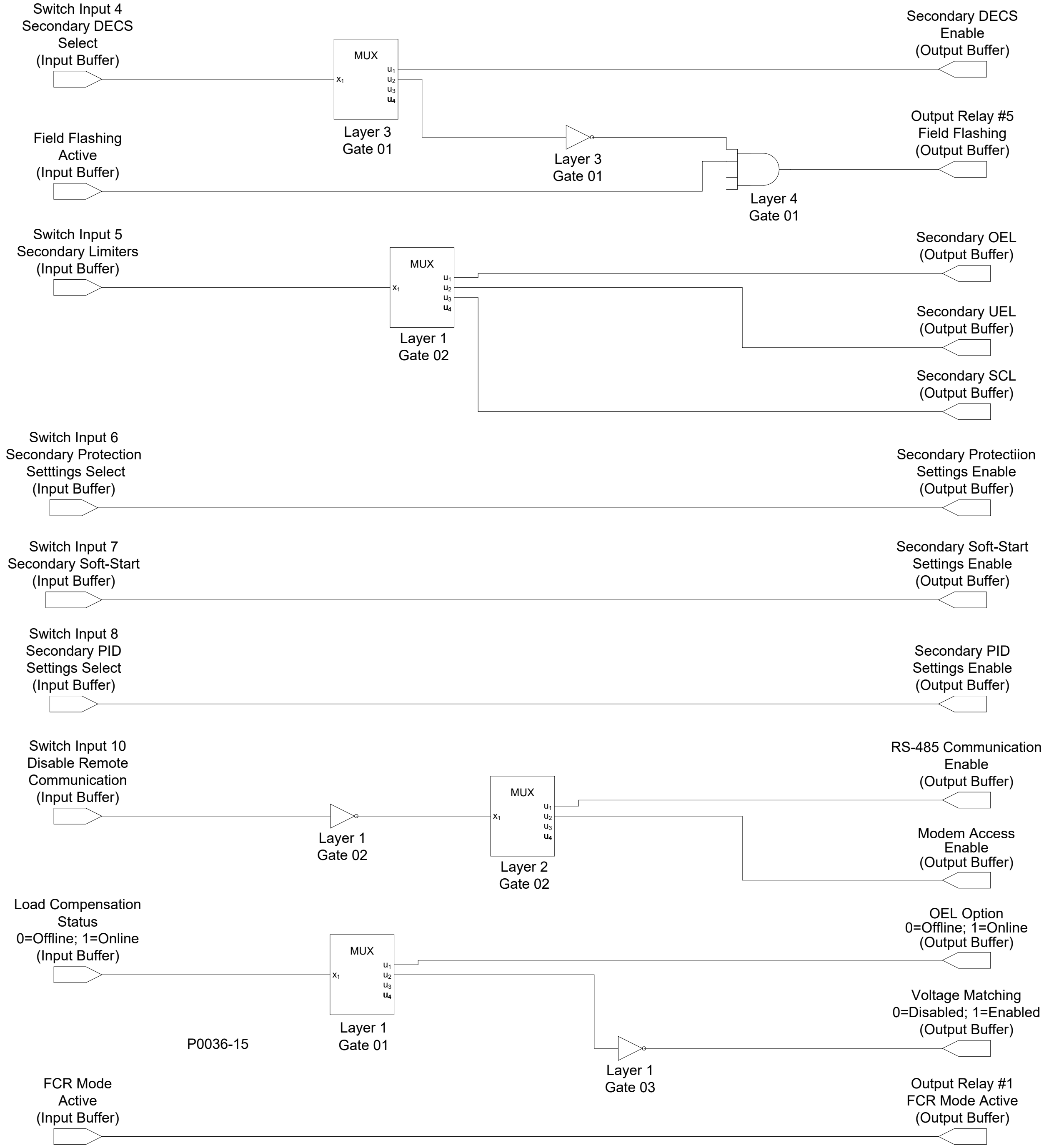


Figure 9-13. Dual DECS-400 Without PSS (Part 2 of 3)

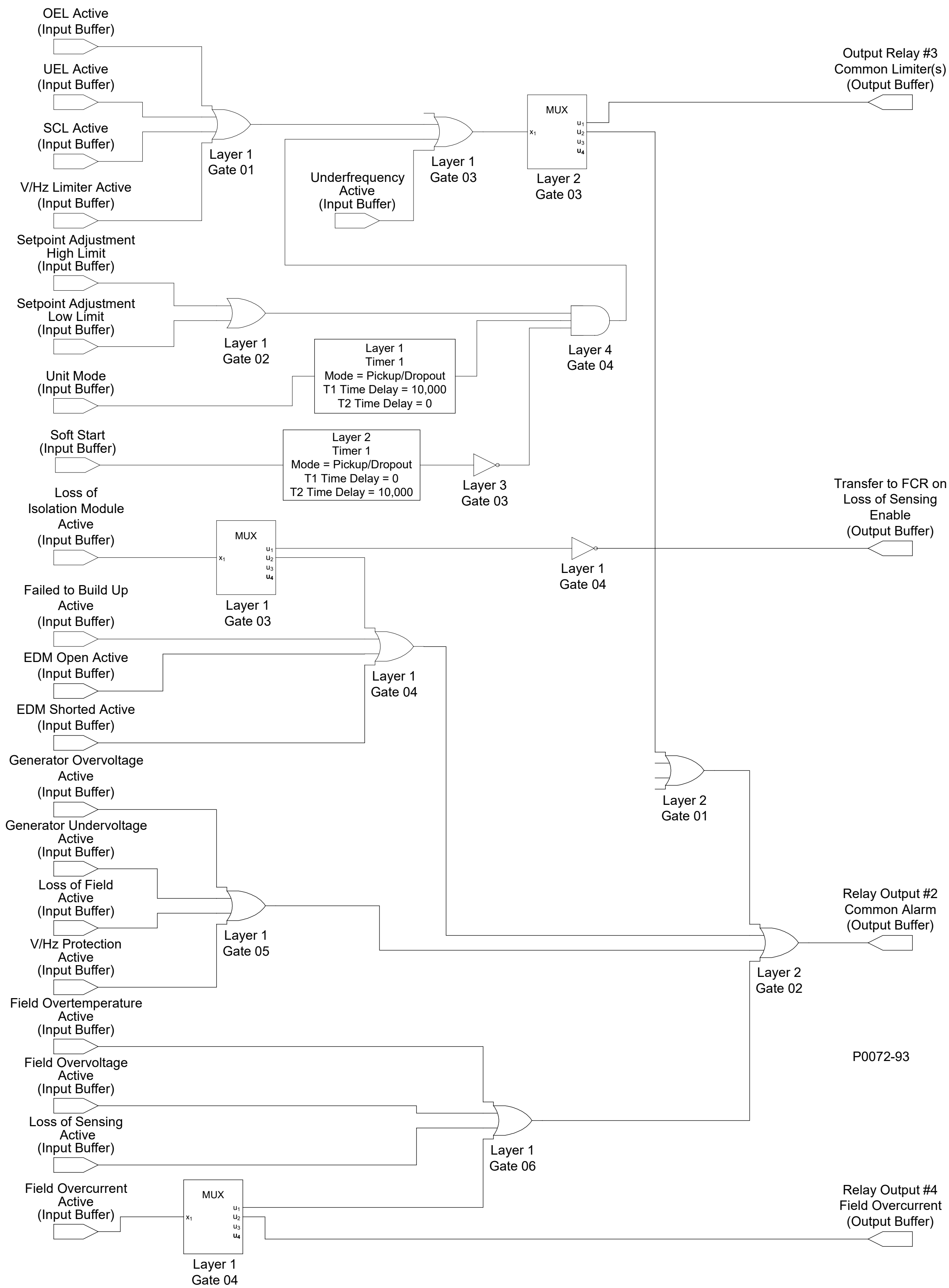


Figure 9-14. Dual DECS-400 Without PSS (Part 3 of 3)

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 15, 15, and 16) is altered as shown in Figure 9-15. Figure 9-15 illustrates the portion of the "Single DECS-400 Without PSS" logic scheme that will be modified. In Figure 9-15, 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

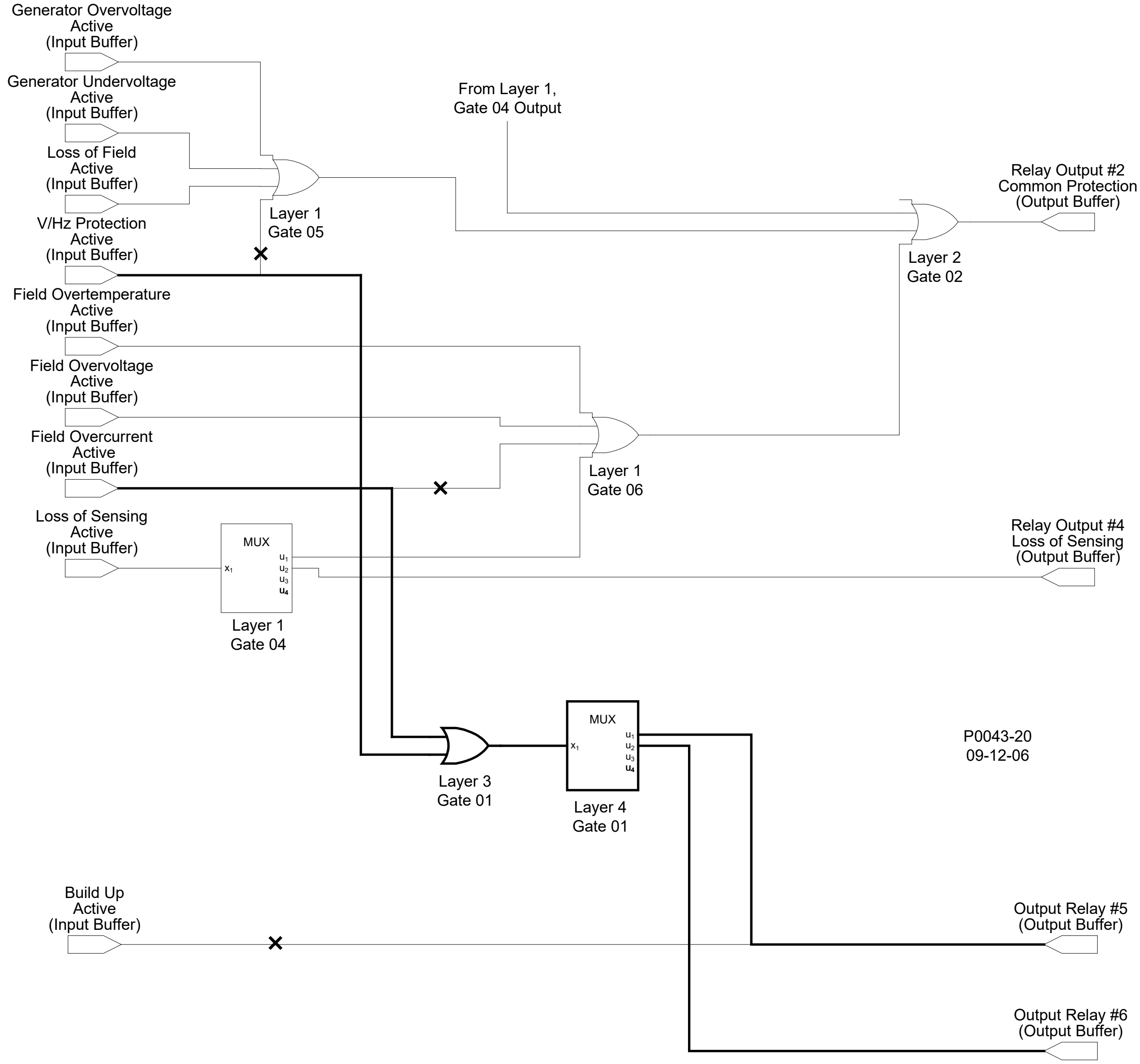


Figure 9-15. Logic Scheme Modification Illustration

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 9-16). 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.

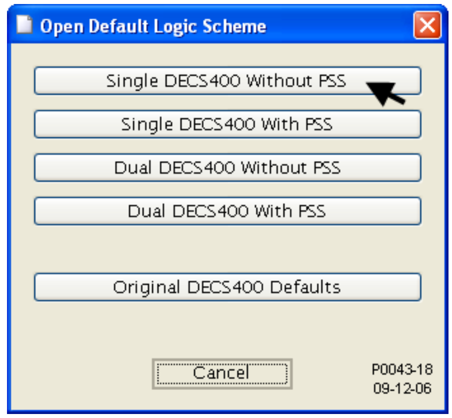


Figure 9-16. Open Default Logic Scheme Window

Table 9-2 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 9-2. Modified "Single DECS-400 Without PSS" Logic Scheme

{ SOURCE ---> DESTINATION }

=====> DESTINATION: Layer1

InputBuffer.Load Comp ---> Mux1.Input
InputBuffer.Contact Switch 5 ---> Mux2.Input
InputBuffer.Loss of Field Isolation Transducer ---> Mux3.Input
InputBuffer.Loss of Sensing ---> Mux4.Input
InputBuffer.Over Excitation Limit ---> Or1.Input1
InputBuffer.Under Excitation Limit ---> Or1.Input2
InputBuffer.Stator Current Limit ---> Or1.Input3
~~InputBuffer.Volts per Hz Limit ---> Or1.Input4~~
InputBuffer.Setpoint High Limit ---> Or2.Input1
InputBuffer.Setpoint Low Limit ---> Or2.Input2
Layer1.Or1.Output ---> Or3.Input2
Layer1.Or2.Output ---> Or3.Input3
InputBuffer.Under Freq Limit ---> Or3.Input4
Layer1.Mux3.Output2 ---> Or4.Input1
InputBuffer.Failed To Build Up ---> Or4.Input2
InputBuffer.EDM Open ---> Or4.Input3
InputBuffer.EDM Short ---> Or4.Input4
InputBuffer.Gen Over Voltage ---> Or5.Input1
InputBuffer.Gen Under Voltage ---> Or5.Input2
InputBuffer.Loss of Field ---> Or5.Input3
InputBuffer.Volts per Hz ---> Or5.Input4
InputBuffer.Field Over Temp ---> Or6.Input1
InputBuffer.Field Over Voltage ---> Or6.Input2
~~InputBuffer.Field Over Current ---> Or6.Input3~~
Layer1.Mux4.Output1 ---> Or6.Input4
InputBuffer.Contact Switch 10 ---> Not2.Input
Layer1.Mux1.Output2 ---> Not3.Input
Layer1.Mux3.Output1 ---> Not4.Input

=====> DESTINATION: Layer2

InputBuffer.Contact Switch 3 ---> Mux1.Input
Layer1.Not2.Output ---> Mux2.Input
Layer1.Or3.Output ---> Mux3.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
Layer2.Mux1.Output3 ---> Not2.Input

=====> DESTINATION: Layer3

Layer2.Not2.Output ---> And1.Input1
InputBuffer.Contact Switch 9 ---> And1.Input2
InputBuffer.Volts per Hz Limit ---> Or1.Input1
InputBuffer.Field Over Current ---> Or1.Input2

=====> DESTINATION: Layer4

Layer3.Or1.Output ---> Mux1.Input

=====> DESTINATION: OutputBuffer

InputBuffer.Start ---> Start
InputBuffer.Stop ---> Stop
Layer2.Not1.Output ---> Parallel
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
InputBuffer.Contact Switch 7 ---> Secondary Soft Start
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
Layer2.Mux3.Output1 ---> Relay Output 3
Layer1.Mux4.Output2 ---> Relay Output 4
~~InputBuffer.Field Flashing ---> Relay Output 5~~
Layer4.Mux1.Output1 ---> Relay Output 5
Layer4.Mux1.Output2 ---> Relay Output 6

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 9-14 and Table 9-2 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 9-17 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 9-2, this association is identified by "DESTINATION: Layer1 – InputBuffer.Volts per Hz Limit → Or1.Input4".

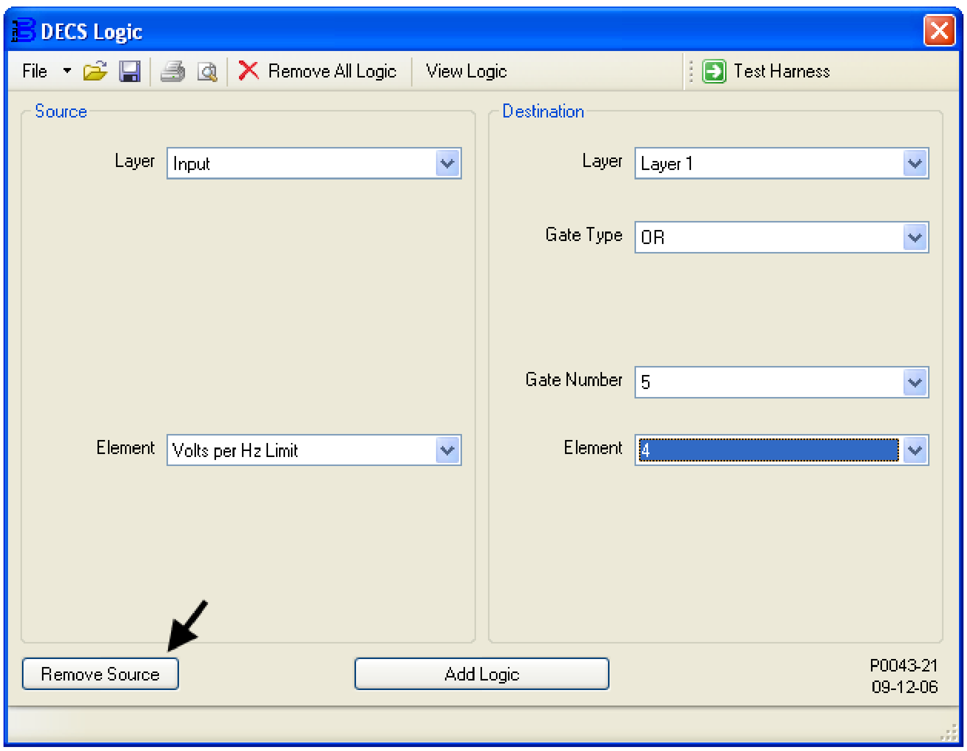


Figure 9-17. Deletion of Layer1 InputBuffer.Volts per Hz Limit --> Or1.Input4

2. Figure 9-18 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 9-2, this association is identified by "DESTINATION: Layer1 – InputBuffer.Field Over Current → Or6.Input3".

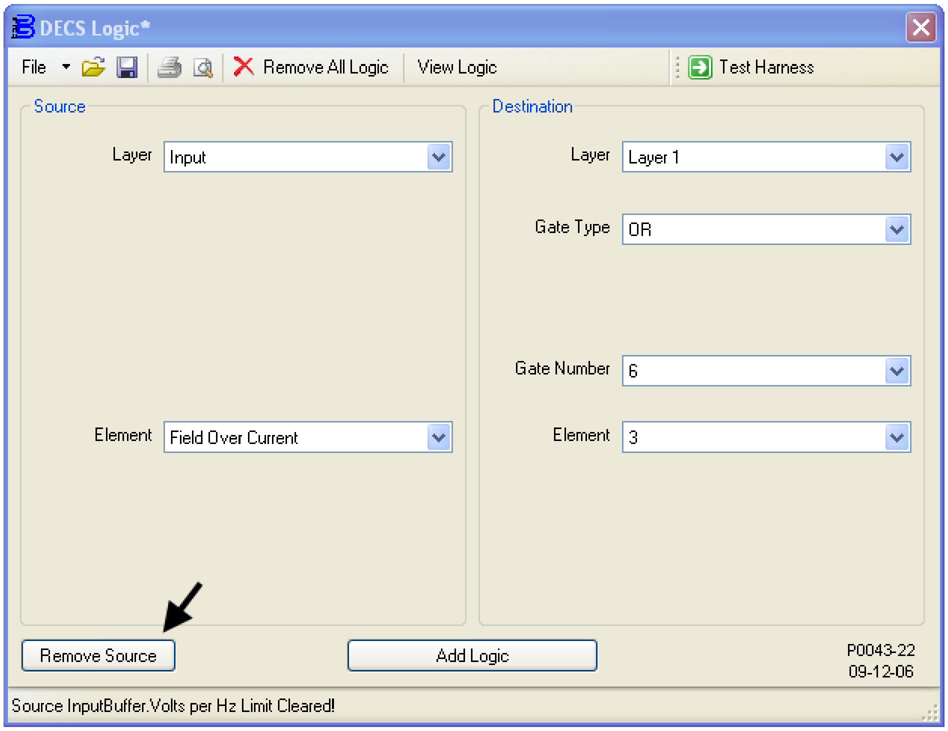


Figure 9-18. Deletion of Layer1 InputBuffer.Field Over Current ---> Or6.Input3

3. Figure 9-19 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-2, this association is identified by "DESTINATION: OutputBuffer – InputBuffer.Field Flashing → Relay Output 5".

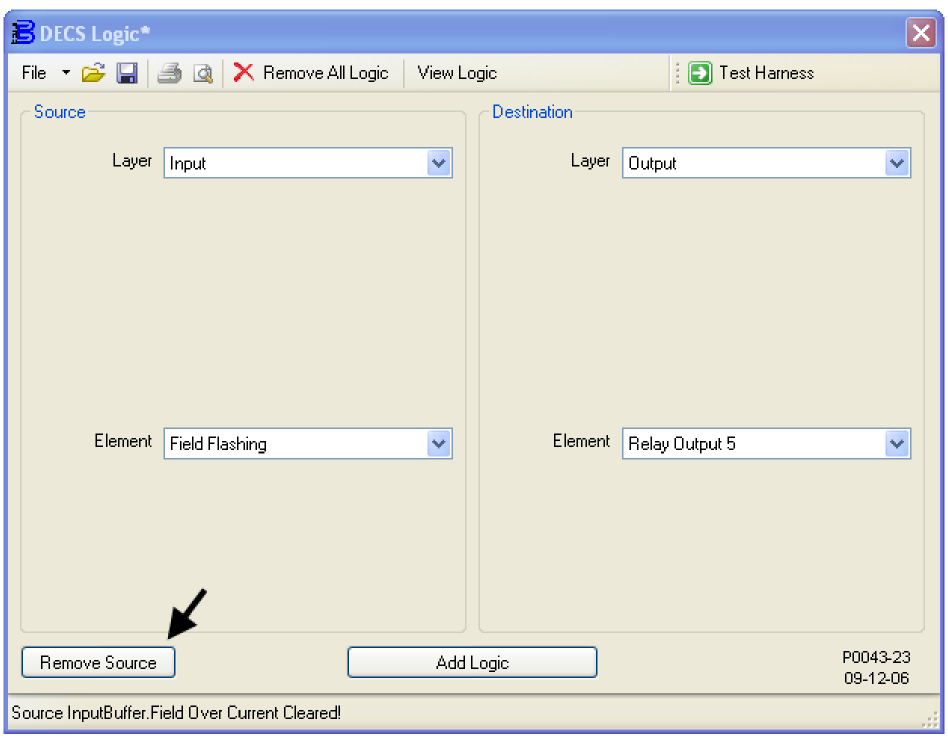


Figure 9-19. Deletion of OutputBuffer - InputBuffer.Field Flashing ---> Relay Output 5

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 9-20 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 9-2, this association is identified by “DESTINATION: Layer3 – InputBuffer.Volts per Hz Limit → Or1.Input1”.

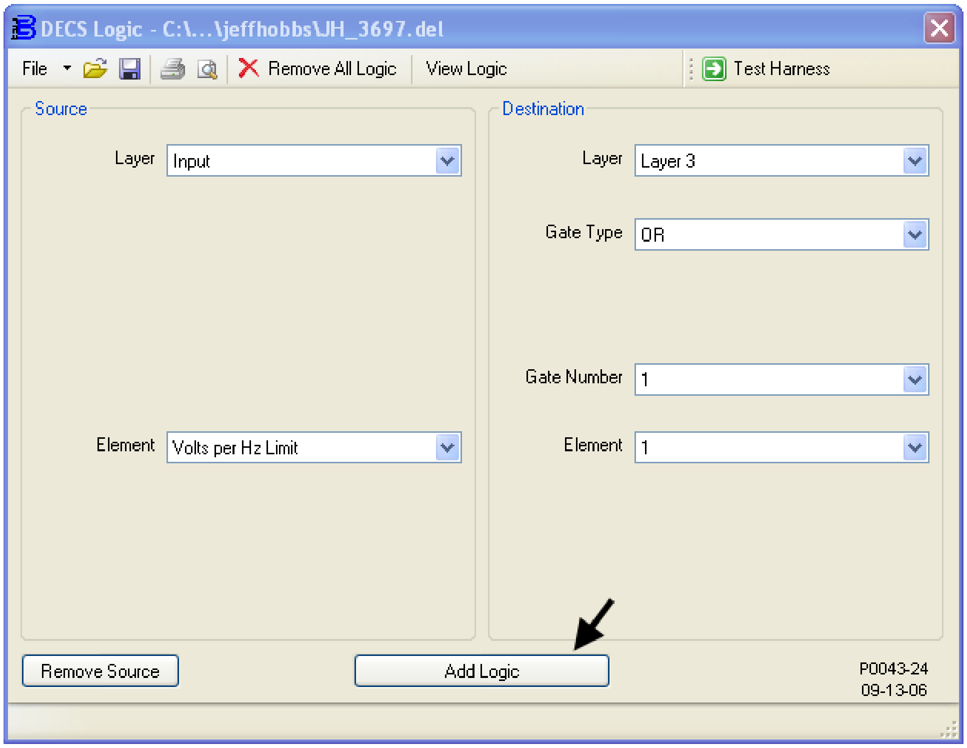


Figure 9-20. Addition of Layer3 InputBuffer.Volts per Hz Limit ---> Layer3.Or1.Input1

2. Figure 9-21 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 9-2, this association is identified by “DESTINATION: Layer3 – InputBuffer.Field Over Current → Or1.Input2”.

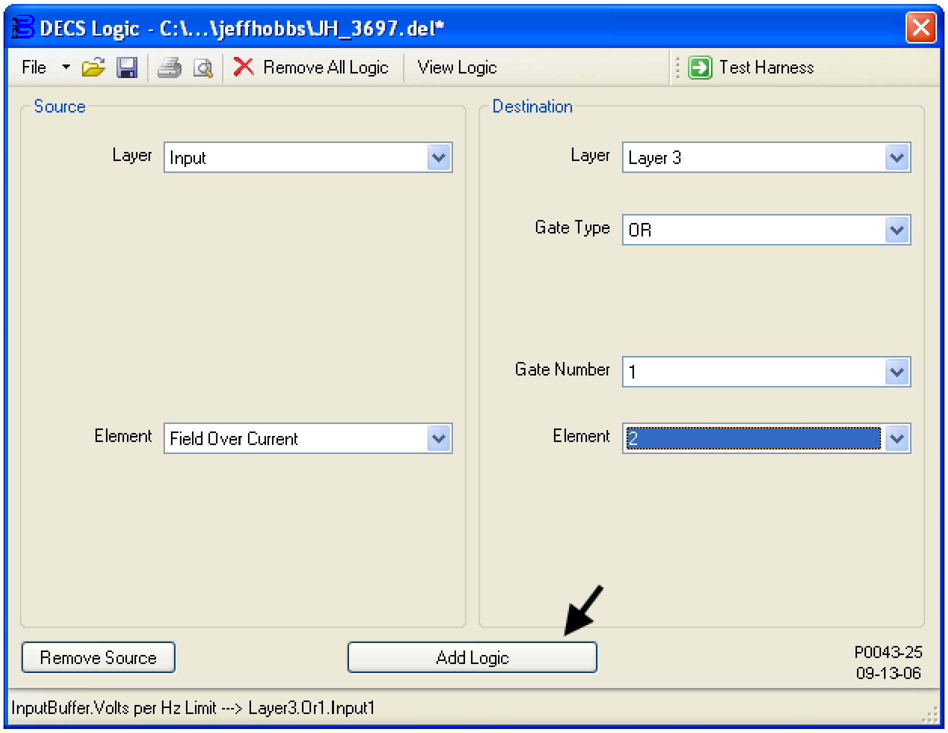


Figure 9-21. Addition of Layer3 InputBuffer.Field Over Current ---> Layer3.Or1.Input2

3. Figure 9-22 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 9-2, this association is identified by “DESTINATION: Layer4 – Layer3.Or1.Output → Mux1.Input”.

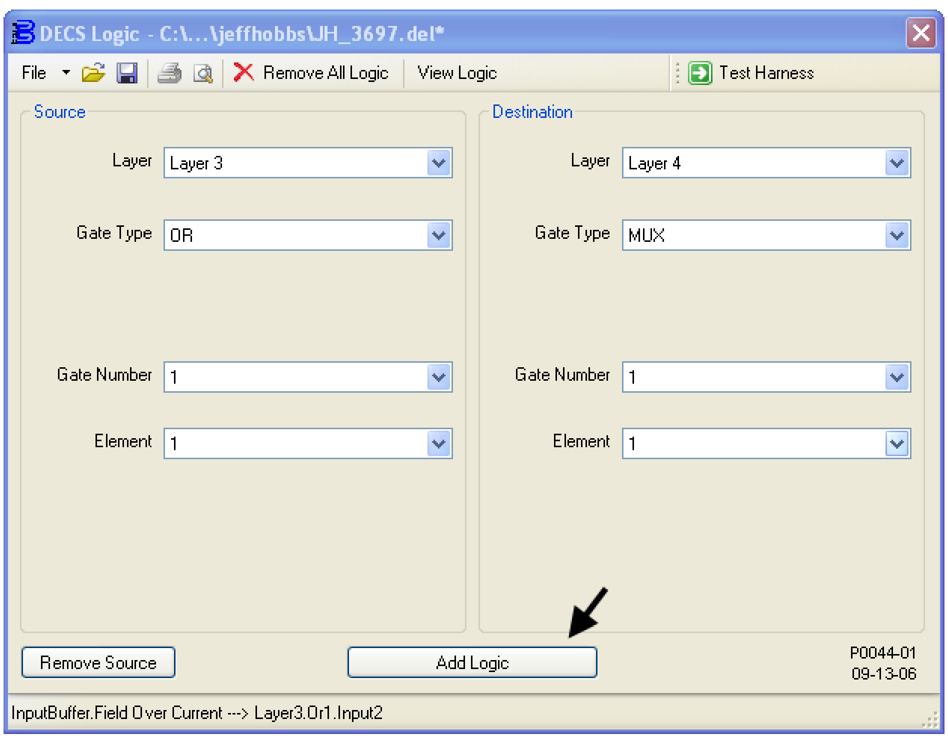


Figure 9-22. Addition of Layer4 - Layer3.Or1.Output ---> Mux1.Input

4. Figure 9-23 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 9-2, this association is identified by "DESTINATION: OutputBuffer – Layer4.Mux1.Output1 → Relay Output5".

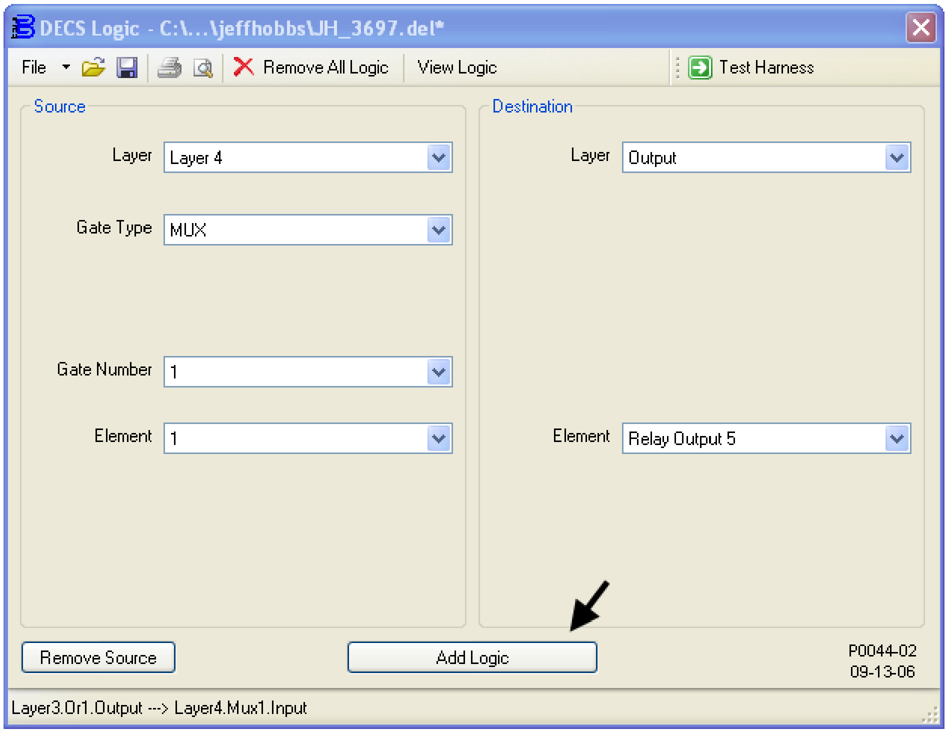


Figure 9-23. Addition of OutputBuffer – Layer4.Mux1.Output1 ---> Relay Output5

5. Figure A-24 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".

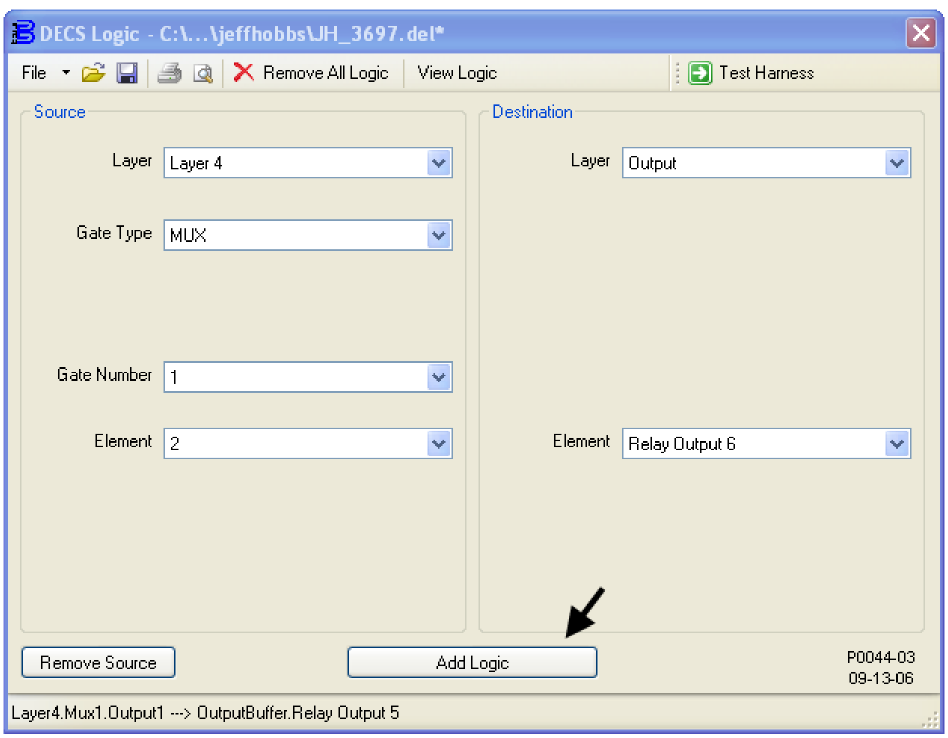


Figure 9-24. Addition of OutputBuffer – Layer4.Mux1.Output2 ---> Relay Output6

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 the *BESTCOMS Software* chapter for information about changing I/O label assignments.

Logic for Compound Machine Paralleling

The following logic modification instructions are provided for applications where the DECS-400 will control a compound machine. These instructions can be used to modify any one of the four default logic scheme files: Single DECS-400 Without PSS, Single DECS-400 With PSS, Dual DECS-400 Without PSS, or Dual DECS-400 With PSS. Modifying one of the default logic schemes forces the DECS-400 to always operate in parallel. Voltage matching and (online and offline) OEL settings are toggled based on the status of switch input 3 (52b). Perform the following steps to modify the DECS-400 logic for compound machine paralleling.

1. Select the desired, default logic scheme for modification. In BESTCOMS, click **File**, open **Default Scheme…** and click the button labeled with the desired logic scheme.
2. Access the DECS Logic window by clicking the **Logic** button on the BESTCOMS toolbar.
3. Figure 9-25 illustrates the DECS Logic window settings associated with this step. In the Source portion of the DECS Logic window:
    a. Select Layer 2 from the Layer pull-down menu.
    b. Select MUX as the Gate Type.
    c. Select 1 as the Gate Number.
    d. Select 2 as the Element.
    e. Click the Remove Source button.

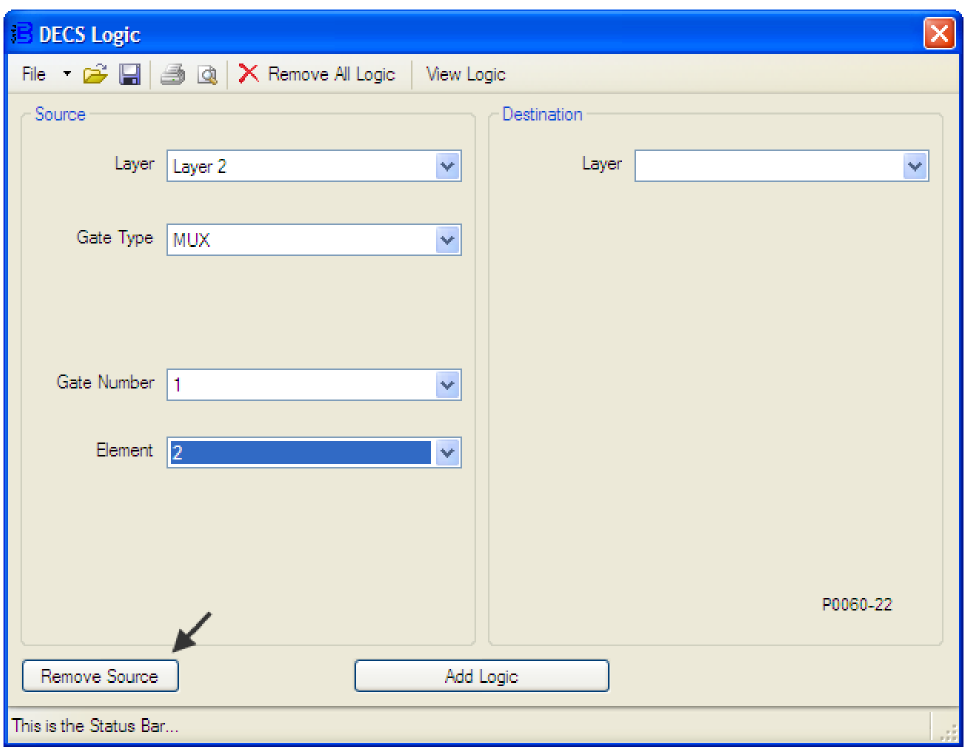


Figure 9-25. Disconnect Layer 2 Multiplexor 1, Output 2

4. Figure 9-26 illustrates the DECS Logic window settings associated with this step.
   a. Under Source, select Input as the Layer.
   b. Under Source, select Fixed Logic TRUE #10 as the Element.
   c. Under Destination, select Output as the Layer.
   d. Under Destination, select Parallel as the Element.
   e. Click the Add Logic button.

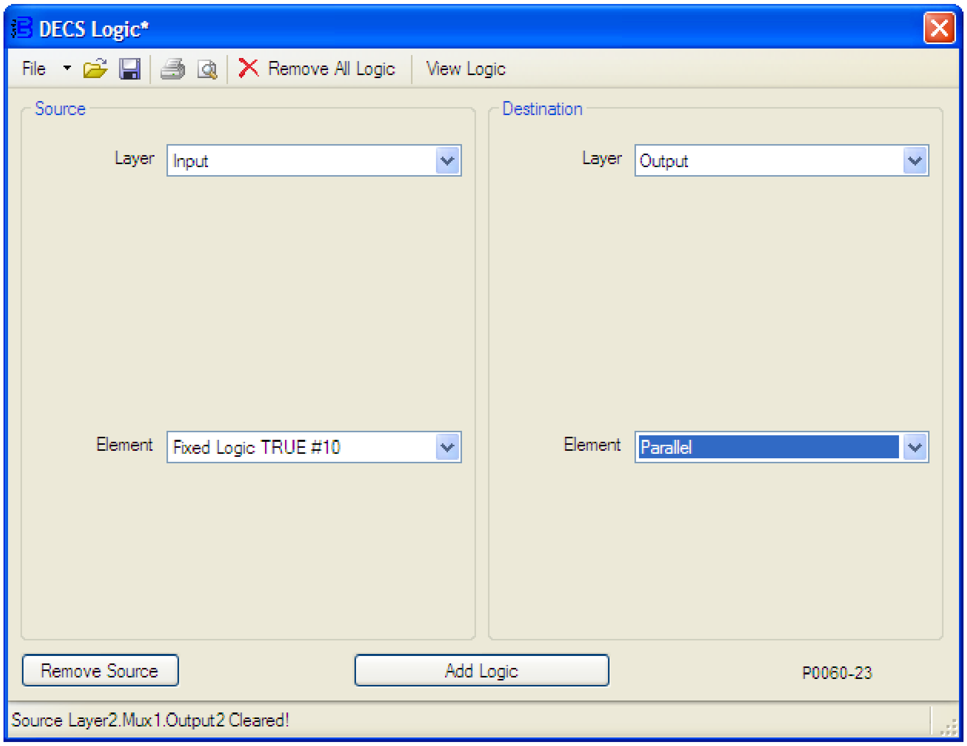


Figure 9-26. InputBuffer.Fixed Logic TRUE #10 ---> OutputBuffer.Parallel

5. Figure 9-27 illustrates the DECS Logic window settings associated with this step. In the Source portion of the DECS Logic window:
   a. Select Input from the Layer pull-down menu.
   b. Select Load Comp as the Element.
   c. Click the Remove Source button.
6. Figure 9-28 illustrates the DECS Logic window settings associated with this step.
   a. Under Source, select Layer 2 as the Layer.
   b. Under Source, select MUX as the Gate Type.
   c. Under Source, select 1 as the Gate Number.
   d. Under Source, select 2 as the Element.
   e. Under Destination, select Layer 1 as the Layer.
   f. Under Destination, select MUX as the Gate Type.
   g. Under Destination, select 1 as the Gate Number.
   h. Under Destination, select 1 as the Element.
   i. Click the Add Logic button.
7. Verify the logic scheme modifications by reviewing the logic associations displayed in the DECS Logic Viewer. (Click the View Logic button in the DECS Logic window.)

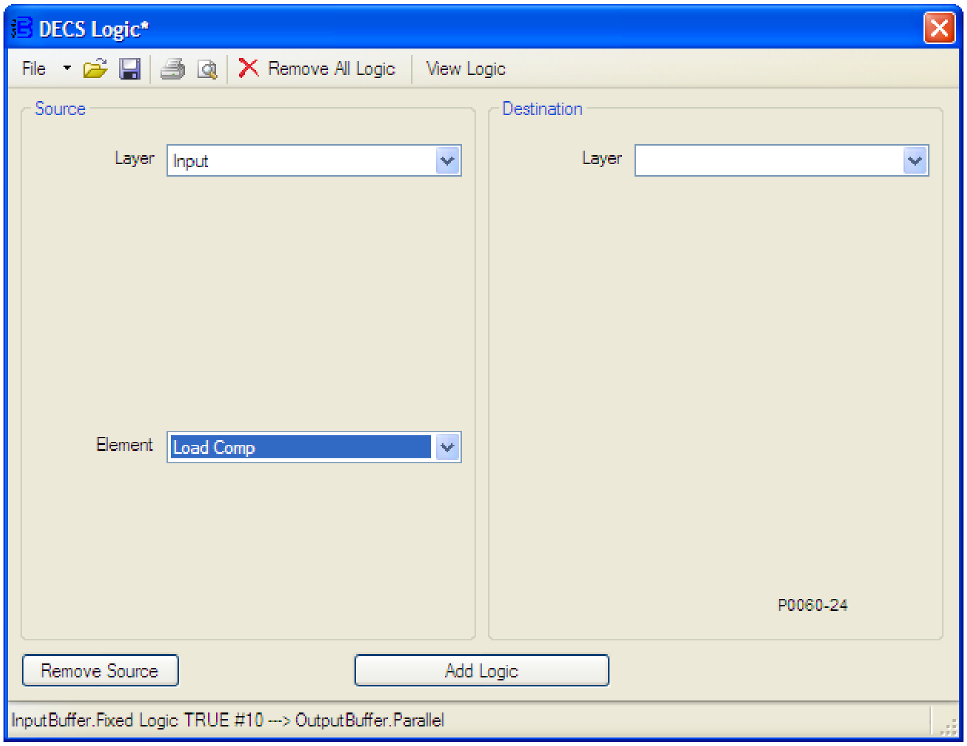


Figure 9-27. Disconnect Load Compensation Input

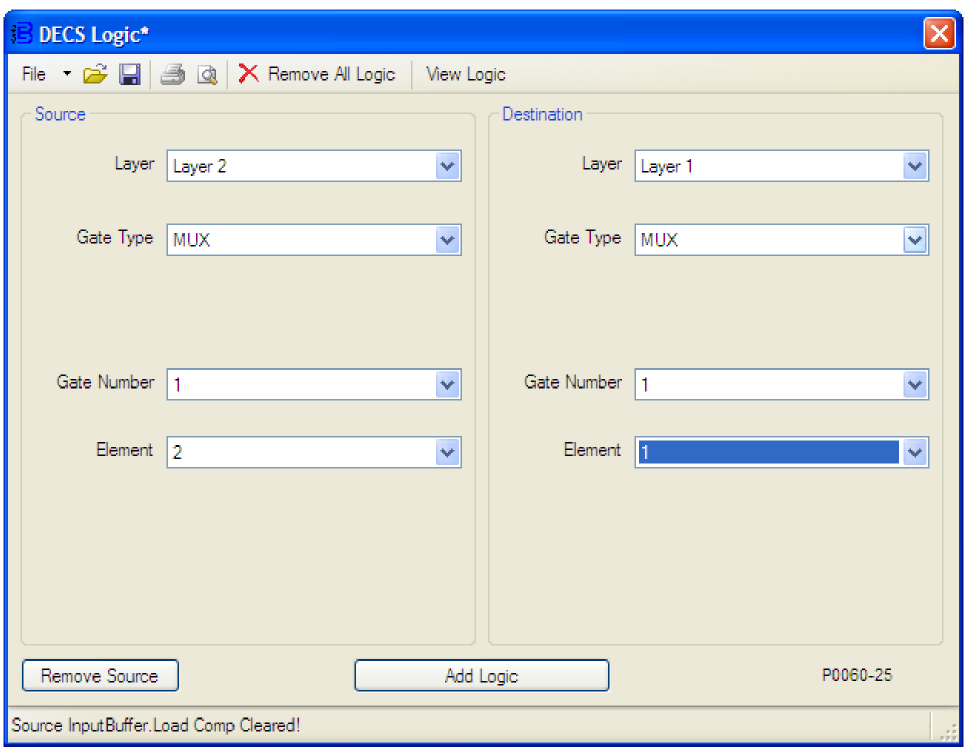


Figure 9-28. Layer2.Mux1.Output2 ---> Layer1.Mux1.Input

Logic Definitions

Logic definitions for DECS-400 inputs and outputs are described in the following paragraphs.

Logic Inputs

Start

Status indication of the dedicated start input (non-latching).

Stop

Status indication of the dedicated stop input (non-latching).

Contact Switches 1 through 10

Status indication of the 10 programmable inputs (non-latching).

AVR

Status indication of the dedicated auto input (non-latching).

Manual

Status indication of the dedicated manual input (non-latching).

Raise

Status indication of the dedicated raise input (non-latching).

Lower

Status indication of the dedicated lower input (non-latching).

PF State

Status indication of leading or lagging power factor (0=leading, 1=lagging).

Gen State

Status indication of generating or motoring operation (0=generator, 1=motor).

Null Balance

Indicates a null balance condition (1=active).

Pre Position 1

Indication that the active setpoint is at Preposition #1.

Pre Position 2

Indication that the active setpoint is at Preposition #2.

Unit Mode

Status indication of unit mode (0=off, 1=on).

FCR Mode

Status indication of FCR (0=off, 1=on) (DECS-400 does not need to be in Start).

AVR Mode

Status indication of AVR (0=off, 1=on) (DECS-400 does not need to be in Start).

VAR Mode

Status indication of VAR (0=off, 1=on) (DECS-400 does not need to be in Start).

PF Mode

Status indication of PF (0=off, 1=on) (DECS-400 does not need to be in Start).

Note
FCR, AVR, VAR, and PF mode indicate the mode the regulator is currently in. Only one of these four modes can be active at any time. This is not an indication of which mode (PF or VAR) the regulator will enter when the breaker is closed.

Droop Mode

Indication that the regulator is in droop mode.

Voltage Match

Indication of voltage matching (1=active).

Load Comp

0=offline, 1=online (directly follows the Parallel logic input).

Failed to Build Up

0=successful buildup, 1=failure (directly follows alarm).

Field Flashing

Flashing control (active for flash) (controls flashing contactor).

Soft Start

Indication of soft start (1=active) (active during flashing).

New Osc Record

A new osc record is available.

Gen Over Voltage

Indication of a generator overvoltage protection alarm.

Gen Under Voltage

Indication of a generator undervoltage protection alarm.

Field Over Voltage

Indication of a field overvoltage protection alarm.

Field Over Current

Indication of a field overcurrent protection alarm.

Field Over Temp

Indication of a field overtemperature protection alarm.

Loss of Field

Indication of a loss of field protection alarm.

Loss of Sensing

Indication of a loss of sensing protection alarm.

Below 10 Hz

Indication of a below 10 Hz protection alarm.

EDM Open

Indication of an open exciter diode protection alarm.

EDM Short

Indication of a shorted exciter diode protection alarm.

Volts per Hz

Indication of Volts per Hz protection alarm.

Over Excitation Limit

Indication that the overexcitation limiter is active.

Under Excitation Limit

Indication that the underexcitation limiter is active.

Under Freq Limit

Indication that the underfrequency limiter is active.

Volts per Hz Limit

Indication that the volts per hertz limiter is active.

Stator Current Limit

Indication that the stator current limiter is active.

Setpoint Low Limit

Indication that the active setpoint is at its lower limit.

Setpoint High Limit

Indication that the active setpoint is at its high limit.

Loss of Field Isolation Transducer

Indication of an FIT alarm.

Power Supply Low

Indication of a power supply low alarm.

Loss of IRIG

Indication of a loss of IRIG time signal alarm.

Modem Disconnect

Indication that the modem has been disconnected.

PSS Test On

Indication that the power system stabilizer test signal is active.

PSS Active

Indication that the power system stabilizer is active.

Volt Unbalance

Indication that the power system stabilizer is disabled by a volt unbalance condition.

Current Unbalance

Indication that the power system stabilizer is disabled by a current unbalance condition.

Power Below Threshold

Indication that the real power is below the threshold for the power system stabilizer to activate.

Speed Failure

Indication that the power system stabilizer is disabled due to an error in speed measurement.

PSS Volt Limit

Indication of an active power system stabilizer voltage limiter.

Clock Reset

Indication that the clock has been reset.

Manual Mode

Indication that the regulator is in manual mode.

FVR Mode

Status indication of field voltage regulation (0=off, 1=on) (DECS-400 does not need to be in Start).

Inner Loop Enable

Indication that the inner loop field regulator control function is enabled.

Pre-Position Traverse Enable

Indication that the pre-position traverse function is enabled.

PSS ROC Enable

Indication that the PSS rate-of-change function is enabled.

Var Limit

Indication that the reactive power limiter is active.

PSS Block

Indication that power system stabilizer operation is blocked.

Outputs

Start

Starts the DECS-400 (latching).

Stop

Stops the DECS-400 (latching).

Parallel

52L/M contact (forces the regulator into droop whenever it is true) (dependent upon BESTCOMS enable checkbox and/or Droop Enable logic input).

Pre Position 2

Returns the active setpoint to its programmed pre position 2 level.

AVR

Puts the DECS-400 in auto mode (latching).

Manual

Puts the DECS-400 in manual mode (latching).

Pre Position 1

Returns the active setpoint to its programmed pre position 1 level.

Raise

Raises the active setpoint (momentary).

Lower

Lowers the active setpoint (momentary).

PF Var

52J/K contact (forces the regulator in PF/var mode when it is true) (dependent upon BESTCOMS selection).

Dual PID Selection

Activates the secondary gains (non-latching) (secondary gains are only active when the output is active).

Alarm Reset

A momentary input resets all DECS-400 alarms.

Secondary DECS

Activates the tracking mode of the DECS-400 (non-latching).

Var PF Selection

0=Droop, 1=Droop/var/PF selection available through BESTCOMS.

Droop Enabled

Acts as a permissive for the checkbox in BESTCOMS (if this output is included in the logic, or it has been in the logic since the last time power was cycled, it must be set true before the regulator will enter droop mode).

Line Drop

Controls line drop compensation in the same way as the Droop Enabled output.

Cross Current Compensation

Controls CCC in the same way as the Droop Enabled output.

Internal Tracking

Acts as a permissive to the BESTCOMS enable switch, but the BESTCOMS switch is not a permissive to this output (if this output is included in the logic, or it has been in the logic since the last time power was cycled, it must be set true before the regulator will enter this mode).

External Tracking

Controls external tracking in the same way as the Internal Tracking output.

Voltage Matching

When this is set true, voltage matching is enabled (disabled when on-line).

Below 10 Hz

Below 10 Hz alarm.

Secondary Protect

Activates secondary protection settings only when it is active (non-latching).

Field Over Voltage

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Field Over Current

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Gen Over Voltage

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Gen Under Voltage

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Field Over Temp

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Loss of Field

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Loss of Sensing

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Volts per Hz

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

EDM Open

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

EDM Short

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Protection screen in BESTCOMS).

Loss of Sensing Transfer to Manual

0=Off, 1=On

OEL

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Limiters screen in BESTCOMS).

UEL

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Limiters screen in BESTCOMS).

SCL

0=Disabled, 1=Enabled (default=1) (Also must be enabled on the Limiters screen in BESTCOMS).

Secondary OEL

Activates secondary overexcitation limiter settings only when it is active (non-latching).

Secondary UEL

Activates secondary underexcitation settings only when it is active (non-latching).

Secondary SCL

Activates secondary stator current limiter settings only when it is active (non-latching).

Secondary Soft Start

Activates secondary soft start settings only when it is active (non-latching).

OEL Style

0=Summing Point, 1=Takeover (default=1)

OEL Off-Line/On-Line Option

Activates on-line overexcitation limiter settings only when it is active (non-latching).

UEL Style

0=Summing Point, 1=Takeover (default=1)

Secondary PSS

Activates the secondary power system stabilizer settings only when it is active (non-latching).

PSS Control Out

Power system stabilizer control enable.

PSS Test Out

Power system stabilizer test output enable.

PSS Motor Control

Power system stabilizer motor selection.

PSS Seq Control

Power system stabilizer phase rotation.

Modbus Write

RS-485 communication enable.

Modem Write

Modem access enable.

OEL Enabled in Manual Mode

Enables overexcitation limiter when the manual regulator is active.

UEL Enabled in Manual Mode

Enables underexcitation limiter when the manual regulator is active.

Manual FCR Only

Field voltage regulation mode disabled when true.

Inner Loop Enable

0 = disabled, 1 = enabled (default is 0)

Pre-Position Traverse Enable

0 = disabled, 1 = enabled (default is 0)

PSS ROC Enabled

0 = disabled, 1 = enabled (default is 0)

Secondary VARL

Activates the secondary reactive power limiter settings only when this output is active (non-latching).

VARL

0 = disabled, 1 = enabled (default is 0) This output must be enabled on the BESTCOMS Limiters screen.

Relay Output 1 through 6

Direct link to relay outputs 1 through 6.

10 • Modbus® Communication

This chapter 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.

Basic Modbus networking requirements for the DECS-400 include:

- RTU transmission mode is used
- All Modbus/TCP ADU are sent via TCP on registered port 502
- A slave address is not required with Modbus TCP
- Only 03 holding register commands are supported

Caution
This product contains one or more *nonvolatile memory* devices. Nonvolatile memory is used to store information (such as settings) that needs to be preserved when the product is power-cycled or otherwise restarted. Established nonvolatile memory technologies have a physical limit on the number of times they can be erased and written. In this product, the limit is 1,000,000 erase/write cycles. During product application, consideration should be given to communications, logic, and other factors that may cause frequent/repeated writes of settings or other information that is retained by the product. Applications that result in such frequent/repeated writes may reduce the useable product life and result in loss of information and/or product inoperability.

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-400 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-400 (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.

Modbus Modes of Operation

A standard Modbus network offers one of three possible transmission modes for communication: ASCII, remote terminal unit (RTU), or Modbus/TCP. The DECS-400 supports the RTU and Modbus/TCP modes depending on the communication option selected. For example, the TCP mode is employed when the Modbus/TCP setting is Enabled in BESTCOMS. Modbus communication over the RS-485 port is disabled when Modbus TCP is enabled. To enable Modbus over the RS-485 port, the Modbus/TCP setting in BESTCOMS must be disabled. ASCII mode is not supported by the DECS-400.

Serial Transmission Details

Communication settings for the DECS-400 rear RS-485 port are listed in Table 10-1. DECS-400 Communication Settings. The baud rate, data size, parity, stop bits and Modbus slave address are only for the RS-485 interface and are not used when the Modbus/TCP mode is enabled.

Table 10-1. DECS-400 Communication Settings

Setting	Programmable Y (Yes)/N (No)	Default Value	Value Range
Baud rate	Y	9600	4800, 9600, or 19200
Data Size (in bits)	N	8	N/A
Parity	Y	None	‘N’=None, ‘O’=Odd, ‘E’=Even
Stop Bits	Y	2	1 or 2
Modbus Slave Address	Y	247	0 for broadcast, 1 to 247 for slave
Modbus Response Delay Time (in ms)	Y	10 ms	From 0 to 200 ms in increments of 10 ms

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 10-2 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 10-2. Timing Considerations for 10 Character Bits (8 Data Bits + 1 Start Bit + 1 Stop Bit)

Baud Rate	1 character Time (ms)	3.5 characters Time (ms)	Max. Read Register Response Message (255 characters) Transmission Time (ms)
4800	2.083	7.292	531.165
9600	1.0417	3.645	265.6335
19200	0.52083	1.823	132.812

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 10-3.

Table 10-3. Supported Exception Response Codes

Code	Name	Meaning
01	Illegal Function	The query Function/Sub-function Code is unsupported; query read of more than 125 registers; query "preset multiple registers" of more than 100 registers
02	Illegal Data Address	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).
03	Illegal Data Value	A preset register data block contains an incorrect number of bytes or one or more data values out of range.

Communication Hardware Requirements

RTU Communication 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).

TCP Communication Requirements

The DECS-400 Ethernet port uses a RJ-45 connector. The DECS-400 supports 10BASE-T using Cat 5 or Cat 5e shielded twisted conductor pairs.

Modbus®/TCP

The Ethernet-enabled interface uses the Transmission Control Protocol/Internet Protocol (TCP/IP) to encapsulate Modbus messages. **The DECS-400 comes with DHCP (*Dynamic Host Configuration Protocol) enabled.*** A maximum of four simultaneous Modbus TCP/IP connections are possible with the DECS-400. Information about setting a static IP address (recommended) or using BESTCOMS Device Discovery feature is provided in the *BESTCOMS Software* chapter.

Ethernet configuration settings cannot be changed with Modbus register writes. BESTCOMS must be used to configure DECS-400 Ethernet settings. The front-panel display (Modbus, Ethernet and NTP) screens can be used to view the Modbus and Ethernet settings. See the *Human-Machine Interface* chapter for details.

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.

Device Address	Function Code = 03	Starting Address High	Starting Address Low	No. of Registers High	No. of Registers Low	CRC Low	CRC High

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.

Device Address	Function Code = 03	Byte Count	Data High	Data Low	For each requested register	Data High	Data Low	CRC Low	CRC High
		250 max.	First queried register High	First queried register Low	Data High and data Low	Last queried register High	Last queried register Low		

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 *Data Formats*).

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 *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 *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).

Device Address	Function Code = 10 (hex)	Starting Address High	Starting Address Low	Number of Registers High	Number of Registers Low	CRC Low	CRC High

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.

Device Address	Function Code = 08 (hex)	Sub-function High 00	Sub-function Low 00	Data High XX (don't care)	Data Low XX (don't care)	CRC Low	CRC High

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.

Device Address	Function Code = 08 (hex)	Sub-function High 00	Sub-function Low 01	Data High XX (don't care)	Data Low XX (don't care)	CRC Low	CRC High

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.

Device Address	Function Code = 08 (hex)	Sub-function High 00	Sub-function Low 04	Data High XX (don't care)	Data Low XX (don't care)	CRC Low	CRC High

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 10-4.

Table 10-4. Generic Data Types and Description

Generic Data Types	Corresponding built-in data type (Storage Format)	Data Range	Data Size in bytes	Total number of Modbus Registers to hold data
UI8	UCHAR: unsigned character	0 to 255	1	1
UI6	UINT16: unsigned short integer	0 to 65,535	2	1
UI32	UINT32: unsigned long integer	0 to 4,294,967,295	4	2
I8	CHAR: signed character	-128 to 127	1	1
I16	INT16: signed short integer	-32,768 to 32,767	2	1
I32	INT32: signed long integer	-2,147,483,648 to 2,147,483,647	4	2
R32_23	FLOAT: floating point number	Approximately 8.43 x 10^{-37} to 3.38 x 10^{38}	4	2

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 10-5.

Table 10-5. HR 44005 Contents

HR 44004 Low Byte	HR 44005 High Byte	HR 44005 Low Byte	HR 44006 High Byte
...	0x00	0x56	...

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 10-6.

Table 10-6. HR 47003 Mapping

HR 47002 Low Byte	HR 47003 High Byte	HR 47003 Low Byte	HR 47004 High Byte
...	0xF0	0x67	...

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, Low 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 10-7.

Table 10-7. Typical Mapping

Register	45003	45004
Hexadecimal	4567	E023
Binary	0100 0101 0110 0111	1110 0000 0010 0011

HR 45002 LO byte	HR 45003 HO byte	HR 45003 LO byte	HR 45004 HO byte	HR 45004 LO byte	HR 45005 HO byte
...	45	67	E0	23	...

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:

S EEE EEEE	E MMM MMMM	MMMM MMMM	MMMM MMMM
byte 3	byte 2	byte 1	byte 0

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 10-8 shows the floating point format.

Table 10-8. Floating Point Format

Sign	2's Complement Of (Exponent + 127)	Mantissa
1 Bit	8 Bits	23 Bits

The floating point format allows a maximum value of 3.38×10^{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 10-9.

Table 10-9. Number 123 in Floating Point Format

Register	45005	45006
Hexadecimal	0000	42F6
Binary	0000 0000 0000 0000	0100 0010 1111 0110

Caution

For DECS-400 Modbus, two consecutive holding registers that are mapped to any of the four-byte, generic data types, are considered to be linked together as an atomic, indivisible unit of information that 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 10-10 provides a statistical summary for each information category.

Table 10-10. Information Category Summary

Information Category ID	Information Category	Total # of Reserved Holding Registers	Holding Register Address Space	Number of Used Registers	Access Privilege	Data Types Mapped to Registers (Total # of Variables)
C1	Version Data	200	40001 to 40200	60	R	UINT8
C2	Metering, Group 1	199	40201 to 40399	61	R	UINT16: 11 FLOAT: 50
C3	System Configuration	199	40401 to 40599	40	RW: 39 R: 1	UINT16: 11 FLOAT: 29
C4	Operating Mode Parameters	97	40604 to 40700	45	RW: 23 R: 22	UINT: 45
C5	Setpoint Parameters	449	40701 to 41149	58	RW: 34 R: 24	UINT16: 8 FLOAT: 50
C6	Startup Parameters	199	41151 to 41349	17	RW: 16 R: 1	FLOAT: 16 UINT16: 1
C7	Limiter Parameters	1,124	41351 to 42474	68	RW: 65 R: 3	FLOAT: 62 UINT16: 6
C8	Gain Registers	524	42476 to 42999	33	RW: 32 R: 1	UINT16: 1 FLOAT: 32
C9	Protection Function Parameters	127	43001 to 43127	29	RW: 23 R: 6	UINT16: 13 FLOAT: 16

Information Category ID	Information Category	Total # of Reserved Holding Registers	Holding Register Address Space	Number of Used Registers	Access Privilege	Data Types Mapped to Registers (Total # of Variables)
C10	Exciter Diode Monitor Parameters	149	43376 to 43492	26	RW	UINT16: 8 FLOAT: 18
C11	Relay Parameters	600	43526 to 44125	24	RW	UINT16
C12	ASCII and Modbus Communication Parameters	125	44126 to 44250	16	RW: 14 R: 2	UINT8: 2 UINT14: 6
C13	Metering, Group 2	50	44201 to 44250	3	RW	UINT16
C14	PSS Parameters	749	44251 to 44999	91	RW: 89 R: 2	UINT16: 23 FLOAT: 68

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 10-11. Information Category C1—Version Data

Registers	Data Description	Access	Data Format
40001	1st character of the model information	R	UINT8
40002	2nd character of the model information	R	UINT8
40003	3rd character of the model information	R	UINT8
40004	4th character of the model information	R	UINT8
40005	5th character of the model information	R	UINT8
40006	6th character of the model information	R	UINT8
40007	7th character of the model information	R	UINT8
40008	8th character of the model information	R	UINT8
40009	Last character of the model information	R	UINT8
40010	1st character of the application program version	R	UINT8
40011	2nd character of the application program version	R	UINT8
40012	3rd character of the application program version	R	UINT8
40013	4th character of the application program version	R	UINT8
40014	5th character of the application program version	R	UINT8
40015	6th character of the application program version	R	UINT8
40016	7th character of the application program version	R	UINT8
40017	Last character of the application program version	R	UINT8
40018	1st character of the date of the application program	R	UINT8
40019	2nd character of the date of the application program	R	UINT8
40020	3rd character of the date of the application program	R	UINT8
40021	4th character of the date of the application program	R	UINT8
40022	5th character of the date of the application program	R	UINT8
40023	6th character of the date of the application program	R	UINT8

Registers	Data Description	Access	Data Format
40024	7th character of the date of the application program	R	UINT8
40025	8th character of the date of the application program	R	UINT8
40026	Last character of the date of the application program	R	UINT8
40027	1st character of the DSP program version	R	UINT8
40028	2nd character of the DSP program version	R	UINT8
40029	3rd character of the DSP program version	R	UINT8
40030	4th character of the DSP program version	R	UINT8
40031	5th character of the DSP program version	R	UINT8
40032	6th character of the DSP program version	R	UINT8
40033	7th character of the DSP program version	R	UINT8
40034	Last character of the DSP program version	R	UINT8
40035	1st character of the date of the DSP program	R	UINT8
40036	2nd character of the date of the DSP program	R	UINT8
40037	3rd character of the date of the DSP program	R	UINT8
40038	4th character of the date of the DSP program	R	UINT8
40039	5th character of the date of the DSP program	R	UINT8
40040	6th character of the date of the DSP program	R	UINT8
40041	7th character of the date of the DSP program	R	UINT8
40042	8th character of the date of the DSP program	R	UINT8
40043	Last character of the date of the DSP program	R	UINT8
40044	1st character of the boot program version	R	UINT8
40045	2nd character of the boot program version	R	UINT8
40046	3rd character of the boot program version	R	UINT8
40047	4th character of the boot program version	R	UINT8
40048	5th character of the boot program version	R	UINT8
40049	6th character of the boot program version	R	UINT8
40050	7th character of the boot program version	R	UINT8
40051	Last character of the boot program version	R	UINT8
40052	1st character of the boot program date	R	UINT8
40053	2nd character of the boot program date	R	UINT8
40054	3rd character of the boot program date	R	UINT8
40055	4th character of the boot program date	R	UINT8
40056	5th character of the boot program date	R	UINT8
40057	6th character of the boot program date	R	UINT8
40058	7th character of the boot program date	R	UINT8
40059	8th character of the boot program date	R	UINT8
40060	Last character of the boot program date	R	UINT8
40061 to 40200	Reserved for future C1 data	R	Not Defined

Holding Registers for Metering, Group 1

Table 10-12. Information Category C2—Metering, Group 1

Registers	Data Description	Access	Data Format
40201	Leading/lagging load indicator 0 = leading load, 1 = lagging load	R	UINT16
40202	Motoring/generating indicator 0 = motoring, 1 = generating	R	UINT16
40203	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	R	UINT16
40204	Contact input states: b0 = start, b1 = stop, b2 = auto, b3 = manual, b4 = raise, b5 = lower, b6 = sw1, b7 = sw2, b8 = sw3, b9 = sw4, b10 = sw5, b11 = sw6, b12 = sw7, b13 = sw8, b14 = sw9, b15 = sw10	R	UINT16
40205	Voltage matching status indicator	R	UINT16
40206	Adjustment range, in percent, of the active setpoint	R	UINT16

Registers	Data Description	Access	Data Format
40207	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	R	UINT16
40208	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	R	UINT16
40209	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	R	UINT16
40210	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	R	UINT16
40211	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	R	UINT16
40212 to 40250	Not used	R	Not Supported
40251	Phase A to B rms generator voltage	R	FLOAT
40253	Phase B to C rms generator voltage	R	FLOAT
40255	Phase C to A rms generator voltage	R	FLOAT
40257	RMS bus voltage	R	FLOAT
40259	Generator phase A current rms	R	FLOAT
40261	Generator phase B current rms	R	FLOAT
40263	Generator phase C current rms	R	FLOAT
40265	Average generator line-to-line rms voltage	R	FLOAT
40267	Average generator phase current	R	FLOAT
40269	DC field voltage	R	FLOAT
40271	DC field current	R	FLOAT
40273	Auxiliary input volts	R	FLOAT
40275	Magnitude of A-B voltage fundamental phasor	R	FLOAT
40277	Magnitude of B-C voltage fundamental phasor	R	FLOAT
40279	Magnitude of C-A voltage fundamental phasor	R	FLOAT
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 Iaux 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

Registers	Data Description	Access	Data Format
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 10-13. Information Category C3—System Configuration

Registers	Data Description	Access	Data Format
40401	Sensing Configuration	RW	UINT16
40402	Auxiliary Input Summing Mode	RW	UINT16
40403	Bridge Control Signal	RW	UINT16
40404	Generator Field Type	RW	UINT16
40405	Voltage Sensing H/W Gain Control	R	UINT16
40406	Auxiliary Input Type	RW	UINT16
40407	Temperature Mode	RW	UINT16
40408	Number of CT's	RW	UINT16
40409	Selected CT's	RW	UINT16
40410	Motor/Generator Mode	R	UINT16
40411	Auxiliary Input Function; 0=DECS, 1=PSS, 2=LIMITER, 3=METONLY	RW	UINT16
40412 to 40450	Reserved for future C3 use	R	Not Defined
40451	Rated Generator Frequency	RW	FLOAT
40453	Generator PT Primary Voltage	RW	FLOAT
40455	Generator PT Secondary Voltage	RW	FLOAT
40457	Generator CT Primary Current	RW	FLOAT
40459	Generator CT Secondary Current	RW	FLOAT
40461	Field Current Shunt Rating	RW	FLOAT
40463	Field Voltage Isolation Module Input	RW	FLOAT
40465	Bus PT Primary Voltage	RW	FLOAT
40467	Bus PT Secondary Voltage	RW	FLOAT
40469	Maximum Field Flash Time	RW	FLOAT
40471	Field Flash Dropout Level	RW	FLOAT
40473	Generator Rated Voltage	RW	FLOAT
40475	Generator Rated kVA	RW	FLOAT
40477	Generator Rated Field Voltage	RW	FLOAT
40479	Generator Rated Field Current	RW	FLOAT
40481	Bus Voltage	RW	FLOAT

Registers	Data Description	Access	Data Format
40483	Auxiliary Voltage Input Gain	RW	FLOAT
40485	Internal Tracking Time Delay	RW	FLOAT
40487	Internal Tracking Traverse Rate	RW	FLOAT
40489	Reserved		
40491	Auxiliary Current Input Gain	RW	FLOAT
40493	External Tracking Time Delay	RW	FLOAT
40495	External Tracking Traverse Rate	RW	FLOAT
40497	Auxiliary Input Gain for FCR Mode	RW	FLOAT
40499	Auxiliary Input Gain for VAR Mode	RW	FLOAT
40501	Auxiliary Input Gain for PF Mode	RW	FLOAT
40503	Exciter Field Resistance	RW	FLOAT
40505	Ambient Temperature	RW	FLOAT
40507	Brush Voltage Drop	RW	FLOAT
40509	Generator Power Factor	RW	FLOAT
40511	Auxiliary Input Gain for FVR Mode	RW	FLOAT
40513 to 40599	Reserved for future C3 use	R	Not Defined

Holding Registers for Operating Mode Parameters

Table 10-14. Information Category C4—Operating Mode Parameters

Registers	Data Description	Access	Data Format
40601	Virtual toggle switch for changing unit mode from stop to start. Value 1 is only valid to apply. Reading this register provides the status: 0=STOP, 1=START.	RW	UINT16
40602	Virtual toggle switch for changing control from AVR mode to Manual mode. Value of 1 is the only valid value to apply. Reading this register provides the control mode status: 0=base mode, 1=manual, 2=AVR.	RW	UINT16
40603	Virtual toggle switch for changing operation between unit and parallel. Value 1 is only valid to apply. Read value of register is aloways 0.	RW	UINT16
40604	PF/Var Enabled 0=off, 1=PF, 2=var	RW	UINT16
40605	Internal Tracking Enabled	RW	UINT16
40606	Pre-position 1 Enabled	RW	UINT16
40607	Raise Enabled	RW	UINT16
40608	Lower Enabled	RW	UINT16
40609	LimiterMode; 0=off, 1=UEL, 2=OEL, 3=UEL&OEL, 4=SCL, 5=UEL&SCL, 6=OEL&SCL, 7=UEL&OEL&SCL, 8=VARL, 9=VARL&OEL, 10=VARL&OEL, 11=VARL&OEL&UEL, 12=VARL&SCL, 13=VARL&SCL&OEL, 14=VARL&SCL&OEL, 15=VARL&SCL&UEL&OEL	RW	UINT16
40610	Voltage Matching Mode (0=off, 1=on)	R	UINT16
40611	Operating Mode (0=off, 1=PF, 2=var)	R	UINT16
40612	Unit mode where 0=stop, 1=start	R	UINT16
40613	Control Mode (1 = Manual, 2 = AVR)	R	UINT16
40614	Internal Tracking Enabled	R	UINT16
40615	Pre-position Enabled	R	UINT16
40616	Auto Transfer Enabled	R	UINT16
40617	Load Comp Mode (0=off, 1=droop, 2=L droop, 4=CCC)	R	UINT16
40618	Alarm Reset Enabled	RW	UINT16
40619	Loss Of Sensing Mode	RW	UINT16
40620	No Sense To Manual Mode	RW	UINT16
40621	External Tracking Enabled	RW	UINT16
40622	Underfrequency Mode	RW	UINT16
40631	Droop Enabled	RW	UINT16
40632	L Drop Enabled	RW	UINT16
40633	CC Enabled	RW	UINT16
40634	OEL Style Mode	R	UINT16
40635	External Tracking Enabled	R	UINT16

Registers	Data Description	Access	Data Format
40636	OEL Style Enabled	RW	UINT16
40637	Pre-position 2 Enabled	R	UINT16
40638	UEL Style Mode	R	UINT16
40639	OEL Option Mode	R	UINT16
40640	Pre-position Selection	R	UINT16
40641	UEL Style Enabled	RW	UINT16
40642	Voltage Matching Enabled	RW	UINT16
40643	OEL Enabled	RW	UINT16
40644	UEL Enabled	RW	UINT16
40645	SCL Enabled	RW	UINT16
40646	Internal Tracking Mode	R	UINT16
40647	External Tracking Mode	R	UINT16
40648	Voltage Matching Mode	R	UINT16
40649 to 40674	Reserved for future C4 use	R	Not Defined
40675	Var limiter enable; 0=disable, 1=enable	RW	UINT16
40720	Enables traverse rate to pre-position 1 for the mode	RW	UINT16
40721	Enables traverse rate to pre-position 2 for the mode	RW	UINT16
40722	Enables traverse rate to pre-position 1 for the mode	RW	UINT16
40723	Enables traverse rate to pre-position 2 for the mode	RW	UINT16
40724	Enables traverse rate to pre-position 1 for the mode	RW	UINT16
40725	Enables traverse rate to the pre-position 2 for the mode	RW	UINT16
40726	Enables traverse rate to the pre-position 1 for the mode	RW	UINT16
40727	Enables traverse rate to the pre-position 2 for the mode	RW	UINT16
40728	Enables traverse rate to the pre-position 1 for the mode	RW	UINT16
40730 to 40899	Reserved for future C4 use	R	Not Defined
40900	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40902	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40904	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40906	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40908	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40910	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40912	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40914	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40916	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT
40918	Traverse time, in seconds, between mode’s min and max settings	RW	FLOAT

Holding Registers for Setpoint Parameters

Table 10-15. Information Category C5—Setpoint Parameters

Registers	Data Description	Access	Data Format
40701	FCR pre-position 1 mode: 0=maintained, 1=release	RW	UINT16
40702	AVR pre-position 1 mode: 0=maintained, 1=release	RW	UINT16
40703	VAR pre-position 1 mode: 0=maintained, 1=release	RW	UINT16
40704	PF pre-position 1 mode: 0=maintained, 1=release	RW	UINT16
40705	FCR pre-position 2 mode: 0=maintained, 1=release	RW	UINT16
40706	AVR pre-position 2 mode: 0=maintained, 1=release	RW	UINT16
40707	VAR pre-position 2 mode: 0=maintained, 1=release	RW	UINT16
40708	PF pre-position 2 mode: 0=maintained, 1=release	RW	UINT16
40709	FVR pre-position 1 mode: 0=maintained, 1=release	RW	UINT16
40710	FVR pre-position 2 mode: 0=maintained, 1=release	RW	UINT16
40751	FCR (Field Current Regulator) mode setpoint in amps; adjustment range is determined by registers (40761-62) and (40769-70)	RW	FLOAT
40753	AVR (Automatic Voltage Regulator) mode setpoint in volts; adjustment range is determined by registers(40763-64) and (40771-72)	RW	FLOAT
40755	VAR mode setpoint in kvars; adjustment range is determined by registers (40765-66) and (40773-74)	RW	FLOAT

Registers	Data Description	Access	Data Format
40757	PF mode setpoint; adjustment range is determined by registers (40767-68) and (40775-76)	RW	FLOAT
40759	Reactive Droop setting in % of rated generator voltage; adjustable from -30 to +30% in .1% increments	RW	FLOAT
40761	FCR minimum setpoint (in amps) = % of nominal x rated field current:(regs. 40801-02) x (regs. 40479-80) / 100	R	FLOAT
40763	AVR minimum setpoint (in volts) = % of nominal x rated generator voltage:(regs. 40803-04) x (regs. 40473-74) / 100	R	FLOAT
40765	VAR minimum setpoint (in kvars) = % of nominal x rated generator VA:(regs. 40805-06) x rated VA / 100	R	FLOAT
40767	PF maximum setpoint = registers 40807-08	R	FLOAT
40769	FCR maximum setpoint (in amps) = % of nominal x rated field current:(regs. 40809-10) x (regs. 40479-80) / 100	R	FLOAT
40771	AVR maximum setpoint (in volts) = % of nominal x rated generator voltage:(regs. 40811-12) x (regs. 40473-74) / 100	R	FLOAT
40773	VAR maximum setpoint (in kvars) = % of nominal x rated generator VA:(regs. 40813-14) x rated VA / 100	R	FLOAT
40775	PF minimum setpoint = registers 40815-16	R	FLOAT
40777	FCR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments	RW	FLOAT
40779	AVR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments	RW	FLOAT
40781	VAR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments	RW	FLOAT
40783	PF mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments	RW	FLOAT
40785	FCR mode setpoint pre-position 1; adjustment range is determined by registers (40761-62) and (40769-70)	RW	FLOAT
40787	AVR mode setpoint pre-position 1; adjustment range is determined by registers (40763-64) and (40771-72)	RW	FLOAT
40789	VAR mode setpoint pre-position 1; adjustment range is determined by registers (40765-66) and (40773-74)	RW	FLOAT
40791	PF mode setpoint pre-position 1; adjustment range is determined by registers (40767-68) and (40775-76)	RW	FLOAT
40793	FCR mode setpoint step size = setpoint range / (traverse rate x 10):[(regs. 40769-70) - (regs. 40761-62)] / [(regs. 40777-78) x 10]	R	FLOAT
40795	AVR mode setpoint step size = setpoint range / (traverse rate x 20):[(regs. 40771-72) - (regs. 40763-64)] / [(regs. 40779-80) x 20]	R	FLOAT
40797	VAR mode setpoint step size = setpoint range / (traverse rate x 20):[(regs. 40773-74) - (regs. 40765-66)] / [(regs. 40781-82) x 20]	R	FLOAT
40799	PF mode setpoint step size = setpoint range / (traverse rate x 20):[2 + (regs. 40775-76) - (regs. 40767-68)] / [(regs. 40783-84) x 20]	R	FLOAT
40801	FCR mode setpoint's minimum (in % of rated field current), adjustable from 0 to 100%, in .1% increments	RW	FLOAT
40803	AVR mode setpoint's minimum (in % of rated generator output voltage), adjustable from 70 to 100%, in .1% increments	RW	FLOAT
40805	VAR mode setpoint's minimum (in % of rated generator VA), adjustable from -100 to +100%, in .1% increments	RW	FLOAT
40807	PF mode setpoint maximum, adjustable from 0.5 to 1.0, in .005 increments	RW	FLOAT
40809	FCR mode setpoint's maximum (in % of rated field current), adjustable from 100 to 120%, in .1% increments	RW	FLOAT
40811	AVR mode setpoint's maximum (in % of rated generator output voltage), adjustable from 100 to 110%, in .1% increments	RW	FLOAT
40813	VAR mode setpoint's maximum (in % of rated generator VA), adjustable from -100 to +100%, in .1% increments	RW	FLOAT
40815	PF mode setpoint minimum, adjustable from -1.0 to -0.5, in .005 increments	RW	FLOAT

Registers	Data Description	Access	Data Format
40817	Minimum value for FCR mode setpoint's adjustable minimum (in % of rated field current) = 0%	R	FLOAT
40819	Minimum value for AVR mode setpoint's adjustable minimum (in % of rated generator ouput voltage) = 70%	R	FLOAT
40821	Minimum value for VAR mode setpoint's adjustable minimum (in % of rated generator VA) = -100%	R	FLOAT
40823	Maximum value for PF mode setpoint's adjustable minimum	R	FLOAT
40825	Maximum value for FCR mode setpoint's adjustable maximum (in % of rated field current) = 120%	R	FLOAT
40827	Maximum value for AVR mode setpoint's adjustable maximum (in % of rated generator ouput voltage) = 110%	R	FLOAT
40829	Maximum value for VAR mode setpoint's adjustable maximum (in % of rated generator VA) = 100%	R	FLOAT
40831	Minimum value for PF mode setpoint's adjustable maximum	R	FLOAT
40833	Step size for FCR mode setpoint's adjustable maximum (in % of rated field current) = 0.1%	R	FLOAT
40835	Step size for AVR mode setpoint's adjustable maximum (in % of rated generator output voltage) = 0.1%	R	FLOAT
40837	Step size for VAR mode setpoint's adjustable maximum (in % of rated generator VA) = 0.1%	R	FLOAT
40839	Step size for PF mode setpoint's adjustable maximum (in % of rated field current) = .005	R	FLOAT
40841	FCR mode setpoint pre-position 2; adjustment range is determined by registers (40761-62) and (40769-70)	RW	FLOAT
40843	AVR mode setpoint pre-position 2; adjustment range is determined by registers (40763-64) and (40771-72)	RW	FLOAT
40845	VAR mode setpoint pre-position 2; adjustment range is determined by registers (40765-66) and (40773-74)	RW	FLOAT
40847	PF mode setpoint pre-position 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	FVR mode setpoint (in volts). Adjustment range is determined by registers 40853-54 and 40855-56	RW	FLOAT
40853	FVR maximum setpoint (in volts). Equal to % of nominal x rated field voltage (Registers 40863-64 x 40477-78 ÷ 100)	R	FLOAT
40855	FVR maximum setpoint (in volts). Equal to % of nominal x rated field voltage (Registers 40865-66 x 40477-78 ÷ 100)	R	FLOAT
40857	FVR mode traverse rate, adjustable from 10 to 200 seconds in 1 second increments	RW	FLOAT
40859	FVR mode setpoint pre-position 1 adjustment range. Determined by registers (40853-54) and (40855-56)	RW	FLOAT
40861	FVR mode setpoint step size. =setpoint range ÷ (traverse rate x 10):[regs. 40855-56) –regs. 40853-54)] ÷[(regs. 40857-58) x 10]	R	FLOAT
40863	FVR mode setpoint minimum (in % of rated field voltage), adjustable from 0 to 100% in 0.1% increments	RW	FLOAT
40865	FVR mode setpoint maximum (in % of rated field voltage), adjustable from 100 to 120% in 0.1% increments	RW	FLOAT
40867	Minimum value for FVR mode setpoint’s adjustable minimum (in % of rated field voltage) =0%	R	FLOAT
40869	Maximum value for FVR mode setpoint’s adjustable maximum (in % of rated field voltage) = 120%	R	FLOAT
40871	Step size for FVR mode setpoint’s adjustable maximum (in % of rated field voltage) = 0.1%	R	FLOAT
40873	FVR mode setpoint pre-position 2: adjustment range is determined by registers (40853-54) and (40855-56)	RW	FLOAT

Holding Registers for Startup Parameters

Table 10-16. Information Category C6—Startup Parameters

Registers	Data Description	Access	Data Format
41151	Active Startup Setting Group	R	UINT16
41153	PSS Power Level Enable	R	UINT16
41154 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	Reserved	RW	FLOAT
41201	Reserved	RW	FLOAT
41203	PF Active Power Level	RW	FLOAT
41205 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 10-17. Information Category C7—Limiter Parameters

Registers	Data Description	Access	Data Format
41351	Active OEL Limiter Setting Group	R	UINT16
41352	OEL dv/dt Enable	RW	UINT16
41353	Setting group selection for var limiter	R	UINT16
41354 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
41377	Primary Takeover Off-Line OEL High Current Level	RW	FLOAT
41379	Primary Takeover Off-Line OEL Low Current Level	RW	FLOAT
41381	Primary Takeover Off-Line OEL Time Dial	RW	FLOAT
41383	Primary Takeover On-Line OEL High Current Level	RW	FLOAT
41385	Primary Takeover On-Line OEL Low Current Level	RW	FLOAT
41387	Primary Takeover On-Line OEL Time Dial	RW	FLOAT

Registers	Data Description	Access	Data Format
41389 to 41409	Not used	R	Not Defined
41411	Active UEL Limiter Setting Group	R	UINT16
41412 to 41420	Not used	RW	Not Defined
41421	Primary UEL Curve Real Power 1st Point	RW	FLOAT
41423	Primary UEL Curve Real Power 2nd Point	RW	FLOAT
41425	Primary UEL Curve Real Power 3rd Point	RW	FLOAT
41427	Primary UEL Curve Real Power 4th Point	RW	FLOAT
41429	Primary UEL Curve Real Power 5th Point	RW	FLOAT
41431	Primary UEL Curve Reactive Power 1st Point	RW	FLOAT
41433	Primary UEL Curve Reactive Power 2nd Point	RW	FLOAT
41435	Primary UEL Curve Reactive Power 3rd Point	RW	FLOAT
41437	Primary UEL Curve Reactive Power 4th Point	RW	FLOAT
41439	Primary UEL Curve Reactive Power 5th Point	RW	FLOAT
41441	Primary UEL Bias	RW	FLOAT
41443	Real power filter time constant	RW	FLOAT
41445	Real power exponent	RW	FLOAT
41471	Active SCL Limiter Setting Group	R	UINT16
41472 to 41480	Not used	R	Not Defined
41481	Primary SCL High Current Level	RW	FLOAT
41483	Primary SCL High Current Time	RW	FLOAT
41485	Primary SCL Medium Current Level	RW	FLOAT
41487	Primary SCL Medium Current Time	RW	FLOAT
41489	Primary SCL Low Current Level	RW	FLOAT
41491	Primary SCL No Respoonse Time	RW	FLOAT
41493 to 41584	Reserved for future C7 use	R	Not Defined
41585	OEL dv/dt Setting	RW	FLOAT
41587	Var limiter setpoint for primary selection	RW	FLOAT
41589	Var limiter initial delay for primary selection	RW	FLOAT
41590 to 41720	Reserved for future C7 use	R	Not Defined
41721	Secondary On-Line OEL Setting - High Current Level	RW	FLOAT
41723	Secondary On-Line OEL Setting - High Current Time	RW	FLOAT
41725	Secondary On-Line OEL Setting - Medium Current Level	RW	FLOAT
41727	Secondary On-Line OEL Setting - Medium Current Time	RW	FLOAT
41729	Secondary On-Line OEL Setting - Low Current Level	RW	FLOAT
41731	Secondary Off-Line OEL Setting High Current Level	RW	FLOAT
41733	Secondary Off-Line OEL Setting Low Current Level	RW	FLOAT
41735	Secondary Off-Line OEL Setting High Current Time	RW	FLOAT
41737	Secondary Takeover Off-Line OEL High Current Level	RW	FLOAT
41739	Secondary Takeover Off-Line OEL Low Current Level	RW	FLOAT
41741	Secondary Takeover Off-Line OEL Time Dial	RW	FLOAT
41743	Secondary Takeover On-Line OEL High Current Level	RW	FLOAT
41745	Secondary Takeover On-Line OEL Low Current Level	RW	FLOAT
41747	Secondary Takeover On-Line OEL Time Dial	RW	FLOAT
41749 to 41780	Reserved for future C7 use	R	Not Defined
41781	Secondary UEL Curve Real Power 1st Point	RW	FLOAT
41783	Secondary UEL Curve Real Power 2nd Point	RW	FLOAT
41785	Secondary UEL Curve Real Power 3rd Point	RW	FLOAT
41787	Secondary UEL Curve Real Power 4th Point	RW	FLOAT

Registers	Data Description	Access	Data Format
41789	Secondary UEL Curve Real Power 5th Point	RW	FLOAT
41791	Secondary UEL Curve Reactive Power 1st Point	RW	FLOAT
41793	Secondary UEL Curve Reactive Power 2nd Point	RW	FLOAT
41795	Secondary UEL Curve Reactive Power 3rd Point	RW	FLOAT
41797	Secondary UEL Curve Reactive Power 4th Point	RW	FLOAT
41799	Secondary UEL Curve Reactive Power 5th Point	RW	FLOAT
41801	Secondary UEL Bias	RW	FLOAT
41803 to 41840	Reserved for future C7 use	R	Not Defined
41841	Secondary SCL High Current Level	RW	FLOAT
41843	Secondary SCL High Current Time	RW	FLOAT
41845	Secondary SCL Medium Current Level	RW	FLOAT
41847	Secondary SCL Medium Current Time	RW	FLOAT
41849	Secondary SCL Low Current Level	RW	FLOAT
41851	Secondary SCL No Respoonse Time	RW	FLOAT
41853	Var limiter setpoint for secondary selection	RW	FLOAT
41855	Var limiter initial delay for secondary selection	RW	FLOAT
41856 to 42474	Reserved for future C7 use	R	Not Defined

Note

Effective with firmware version 1.07, AVR and FCR have individual gain settings. AVR gain settings are read/write with registers 42503 through 42507. FCR gain settings are read/write with registers 42553 through 42559. In versions prior to 1.07, gain settings for both AVR and FCR are read/write with registers 42503, 42505, and 42507.

Holding Registers for Gain Parameters

Table 10-18. Information Category C8—Gain Parameters

Registers	Data Description	Access	Data Format
42476	Active AVR/FCR Gain Setting Group	R	UINT16
42477 to 42500	Reserved for future C8 use	R	Not Defined
42501	Primary Stability Range (Gain Table Index)	RW	FLOAT
42503	Primary AVR - Proportional Gain Kp	RW	FLOAT
42505	Primary AVR - Integral Gain Ki	RW	FLOAT
42507	Primary AVR - Derivative Gain Kd	RW	FLOAT
42509	OEL - Proportional Gain Kp	RW	FLOAT
42511	OEL - Integral Gain Ki	RW	FLOAT
42513	PF - Integral Gain Ki	RW	FLOAT
42515	VAR - Integral Gain Ki	RW	FLOAT
42517	FCR - Loop Gain Kg	RW	FLOAT
42519	Primary AVR - Loop Gain Kg	RW	FLOAT
42521	VAR - Loop Gain Kg	RW	FLOAT
42523	PF - Loop Gain Kg	RW	FLOAT
42525	OEL - Loop Gain Kg	RW	FLOAT
42527	UEL - Loop Gain Kg	RW	FLOAT
42529	Voltage Matching - Loop Gain Kg	RW	FLOAT
42531	Voltage Matching - Proportional Gain Kp	RW	FLOAT
42533	Voltage Matching - Integral Gain Ki	RW	FLOAT

Registers	Data Description	Access	Data Format
42541	UEL - Proportional Gain Kp	RW	FLOAT
42543	UEL - Integral Gain Ki	RW	FLOAT
42545	Primary AVR - Derivative Time Constant Td	RW	FLOAT
42547	SCL - Loop Gain Kg	RW	FLOAT
42549	SCL - Proportional Gain Kp	RW	FLOAT
42551	SCL - Integral Gain Ki	RW	FLOAT
42553	FCR - Proportional Gain Kp	RW	FLOAT
42555	FCR - Integral Gain Ki	RW	FLOAT
42557	FCR - Derivative Gain Kd	RW	FLOAT
42559	Primary FCR - Derivative Time Constant Td	RW	FLOAT
42561	FVR Proportional Gain Kp	RW	FLOAT
42563	FVR Integral Gain Ki	RW	FLOAT
42565	FVR Derivative Gain Kd	RW	FLOAT
42567	FVR Derivative Time Constant Td Gain	RW	FLOAT
42569	FVR Loop Gain Kg	RW	FLOAT
42570 to 42608	Reserved for future C8 use	R	Not Defined
42609	Loop gain for var limiter	RW	FLOAT
42611	Integral gain for var limiter	RW	FLOAT
42613 to 42675	Reserved for future C8 use		Not Defined
42676	Secondary Stability Range (Gain Table Index)	RW	FLOAT
42678	Secondary AVR - Proportional Gain Kp	RW	FLOAT
42680	Secondary AVR - Integral Gain Ki	RW	FLOAT
42682	Secondary AVR - Derivative Gain Kd	RW	FLOAT
42684	Secondary AVR - Loop Gain Kg	RW	FLOAT
42686	Secondary AVR - Derivative Time Constant Td	RW	FLOAT
42688 to 42999	Reserved for future C8 use	R	Not Defined

Holding Registers for Protection Function Parameters

Table 10-19. Information Category C9—Protection Function Parameters

Registers	Data Description	Access	Data Format
43001	Primary Exciter Field Overvoltage	RW	UINT16
43002	Primary Exciter Field Overcurrent	RW	UINT16
43003	Primary Generator Undervoltage	RW	UINT16
43004	Primary Generator Overvoltage	RW	UINT16
43005	Primary Field Over Temperature	RW	UINT16
43006	Primary Loss of Field	RW	UINT16
43007	Primary Loss of Field Isolation Transducer	RW	UINT16
43008	Primary Power Low	RW	UINT16
43009	24 Volts/Hz	RW	UINT16
43010 to 43012	Not used	R	Not Defined
43013	Inverse Time Curve Exponent	RW	UINT16
43014 to 43024	Not used	R	Not Defined
43025	Active Protection Setting Group	R	UINT16
43026	Primary Field Overvoltage Level	RW	FLOAT
43028	Primary Field Overcurrent Level	RW	FLOAT
43030	Primary Generator Undervoltage Level	RW	FLOAT
43032	Primary Generator Overvoltage Level	RW	FLOAT
43034	Primary Field Overvoltage Time Delay	RW	FLOAT

Registers	Data Description	Access	Data Format
43036	Primary Field Overcurrent Time Dial	RW	FLOAT
43038	Primary Generator Undervoltage Time Delay	RW	FLOAT
43040	Primary Generator Overvoltage Time Delay	RW	FLOAT
43042	Primary Field Over Temperature Level	RW	FLOAT
43044	Primary Field Over Temperature Time Delay	RW	FLOAT
43046	Primary Loss of Field Level	RW	FLOAT
43048	Primary Loss of Field Time Delay	RW	FLOAT
43052	Primary Loss of Field Isolation Transducer Time Delay	RW	FLOAT
43054	Primary Power Low Level	R	FLOAT
43056	Primary Power Low Time Delay	R	FLOAT
43058	24 Function Inverse Time Pickup Setpoint	RW	FLOAT
43060	24 Function Inverse Time Pickup Time Dial	RW	FLOAT
43062	24 Function Reset Time Dial	RW	FLOAT
43064	24 Function Definite Time Pickup #1	RW	FLOAT
43066	24 Function Definite Time Delay #1	RW	FLOAT
43068	24 Function Definite Time Pickup #2	RW	FLOAT
43070	24 Function Definite Time Delay #2	RW	FLOAT
43126	Secondary Exciter Field Overvoltage	R	UINT16
43127	Secondary Exciter Field Overcurrent	R	UINT16

Holding Registers for Exciter Diode Monitor Parameters

Table 10-20. Information Category C10—Exciter Diode Monitor Parameters

Registers	Data Description	Access	Data Format
43376	Primary Number of Main Poles	RW	UINT16
43377	Primary Number of Exciter Poles	RW	UINT16
43378	Primary Open Diode Monitoring	RW	UINT16
43379	Primary Shorted Diode Monitoring	RW	UINT16
43380 to 43400	Not used	R	Not Defined
43401	Primary Open Diode Pickup Level	RW	FLOAT
43403	Primary Shorted Diode Pickup Level	RW	FLOAT
43405	Primary Disable Open Diode Level	RW	FLOAT
43407	Primary Open Diode Detection Time Delay	RW	FLOAT
43409	Primary Shorted Diode Detection Time Delay	RW	FLOAT
43411	Primary Pole Ratio of Exciter Field to Main Field	RW	FLOAT
43413	Deadband - not used	RW	FLOAT
43415	Primary Open Diode Smoothing Filter Coefficient	RW	FLOAT
43417	Primary Shorted Diode Smoothing Filter Coefficient	RW	FLOAT
43419 to 43449	Not used	R	Not Defined
43451	Secondary Number of Main Poles	RW	UINT16
43452	Secondary Number of Exciter Poles	RW	UINT16
43453	Secondary Open Diode Monitoring	RW	UINT16
43454	Secondary Shorted Diode Monitoring	RW	UINT16
43455 to 43475	Not used	R	Not Defined
43476	Secondary Open Diode Pickup Level	RW	FLOAT
43478	Secondary Shorted Diode Pickup Level	RW	FLOAT
43480	Secondary Disable Open Diode Level	RW	FLOAT
43482	Secondary Open Diode Detection Time Delay	RW	FLOAT
43484	Secondary Shorted Diode Detection Time Delay	RW	FLOAT
43486	Secondary Pole Ratio of Exciter Field to Main Field	RW	FLOAT

Registers	Data Description	Access	Data Format
43488	Deadband - not used	RW	FLOAT
43490	Secondary Open Diode Smoothing Filter Coefficient	RW	FLOAT
43492	Secondary Shorted Diode Smoothing Filter Coefficient	RW	FLOAT

Holding Registers for Relay Parameters

Table 10-21. Information Category C11—Relay Parameters

Registers	Data Description	Access	Data Format
43526	Relay 1 State	RW	UINT16
43527	Relay 1 Contact Type	RW	UINT16
43528	Relay 1 Contact Status	RW	UINT16
43529	Relay 1 Momentary Time	RW	UINT16
43530 to 43575	Reserved for future C11 use	R	Not Defined
43576	Relay 2 State	RW	UINT16
43577	Relay 2 Contact Type	RW	UINT16
43578	Relay 2 Contact Status	RW	UINT16
43579	Relay 2 Momentary Time	RW	UINT16
43580 to 43625	Reserved for future C11 use	R	Not Defined
43626	Relay 3 State	RW	UINT16
43627	Relay 3 Contact Type	RW	UINT16
43628	Relay 3 Contact Status	RW	UINT16
43629	Relay 3 Momentary Time	RW	UINT16
43630 to 43675	Reserved for future C11 use	R	Not Defined
43676	Relay 4 State	RW	UINT16
43677	Relay 4 Contact Type	RW	UINT16
43678	Relay 4 Contact Status	RW	UINT16
43679	Relay 4 Momentary Time	RW	UINT16
43680 to 43725	Reserved for future C11 use	R	Not Defined
43726	Relay 5 State	RW	UINT16
43727	Relay 5 Contact Type	RW	UINT16
43728	Relay 5 Contact Status	RW	UINT16
43729	Relay 5 Momentary Time	RW	UINT16
43730 to 43775	Reserved for future C11 use	R	Not Defined
43776	Relay 6 State	RW	UINT16
43777	Relay 6 Contact Type	RW	UINT16
43778	Relay 6 Contact Status	RW	UINT16
43779	Relay 6 Momentary Time	RW	UINT16
43780 to 44125	Reserved for future C11 use	R	Not Defined

Holding Registers for General ASCII and Modbus Communication Parameters

Table 10-22. Information Category C12—General ASCII and Modbus Communication Parameters

Registers	Data Description	Access	Data Format
44126	Baud rate of Front communication port 0, RS-232, Data Range:1200, 2400, 4800, 9600,19200, Default 9600	R	UINT16
44127	Baud rate of Rear communication port 1, RS-485, Data Range:1200, 2400, 4800, 9600,19200, Default 9600	R	UINT16

Registers	Data Description	Access	Data Format
44128	Baud rate of Rear communication port 2, RS-485, Data Range:4800, 9600,19200, Default 9600	RW	UINT16
44129	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	RW	UINT8
44130	Modbus port Stop Bits, 1 for 1 Stop Bit, 2 for 2 Stop bits, Default value: 2	RW	UINT8
44131	DECS400 Polling Address, valid only for Rear RS-485 port. 0 for Broadcast address, 1 to 247 for slave address, Default: 247	RW	UINT16
44132	Modbus Response Delay Time Parameter in ms (Default value: 10ms) Data Range 0-200, step size 10	RW	UINT16
44133	System Clock Month	RW	UINT16
44134	System Clock Day	RW	UINT16
44135	System Clock Year	RW	UINT16
44136	System Clock Daylight Savings Time, 0 = Daylight Savings Time On, 1 = Daylight Savings Time Off	RW	UINT16
44137	System Clock Hour	RW	UINT16
44138	System Clock Minute	RW	UINT16
44139	System Clock Second	RW	UINT16
44140	System Clock Time Format, 0 = 12 hour format, 1 = 24 hour format.	RW	UINT16
44141	System Clock AM/PM. 'A' = 0 for AM, 'P' = 1 for PM	RW	UINT16
44142 to 44200	Reserved for future C12 use	R	Not Defined

Holding Registers for Metering Parameters, Group 2

Table 10-23. Information Category C13—Metering, Group 2

Registers	Data Description	Access	Data Format
44201	1st Metering Display Field	RW	UINT16
44202	2nd Metering Display Field	RW	UINT16
44203	3rd Metering Display Field	RW	UINT16
44204 to 44250	Reserved for future C13 use	R	Not Defined

Holding Registers for Power System Stabilizer Parameters

Table 10-24. Information Category C14—PSS Parameters

Registers	Data Description	Access	Data Format
44251	PSS Algorithm	RW	UINT16
44252	Active PSS Setting Group	R	UINT16
44253	PSS ROC mode blocking; 0=disable, 1=enable	R	UINT16
44254	Block PSS ROC mode; 0=disable, 1=enable	R	UINT16
44255 to 44259	Not used	R	Not Defined
44260	Primary PSS Software Switch 0	RW	UINT16
44261	Primary PSS Software Switch 1	RW	UINT16
44262	Primary PSS Software Switch 2	RW	UINT16
44263	Primary PSS Software Switch 3	RW	UINT16
44264	Primary PSS Software Switch 4	RW	UINT16
44265	Primary PSS Software Switch 5	RW	UINT16
44266	Primary PSS Software Switch 6	RW	UINT16
44267	Primary PSS Software Switch 7	RW	UINT16
44268	Primary PSS Software Switch 8	RW	UINT16
44269	Primary PSS Software Switch 9	RW	UINT16

Registers	Data Description	Access	Data Format
44270 to 44300	Not used	R	Not Defined
44301	Primary PSS High Pass Filter Time Constant Tw1	RW	FLOAT
44303	Primary PSS High Pass Filter Time Constant Tw2	RW	FLOAT
44305	Primary PSS Unit Inertia	RW	FLOAT
44307	Primary Low Pass Filter Time Constant Tl	RW	FLOAT
44309	Primary Phase Comp. First Phase Lead t1	RW	FLOAT
44311	Primary Phase Comp. First Phase Lag t2	RW	FLOAT
44313	Primary Phase Comp. Second Phase Lead t3	RW	FLOAT
44315	Primary Phase Comp. Second Phase Lag t4	RW	FLOAT
44317	Primary Phase Comp. Third Phase Lead t5	RW	FLOAT
44319	Primary Phase Comp. Third Phase Lag t6	RW	FLOAT
44321	Primary Phase Comp. Fourth Phase Lead t7	RW	FLOAT
44323	Primary Phase Comp. Fourth Phase Lag t8	RW	FLOAT
44325	Primary Terminal Voltage Limiter Time Constant	RW	FLOAT
44327	Primary Terminal Voltage Limiter Set Point	RW	FLOAT
44329	Primary Torsional Filter #1 Zeta Numerator	RW	FLOAT
44331	Primary Torsional Filter #1 Zeta Denominator	RW	FLOAT
44333	Primary Torsional Filter #1 Wn1	RW	FLOAT
44335	Primary Torsional Filter #2 Zeta Numerator	RW	FLOAT
44337	Primary Torsional Filter #2 Zeta Denominator	RW	FLOAT
44339	Primary Torsional Filter #2 Wn2	RW	FLOAT
44341	Primary Logic Output Limiter Upper Limit	RW	FLOAT
44343	Primary Logic Output Limiter Lower Limit	RW	FLOAT
44345	Primary Logic Output Limiter Time Delay	RW	FLOAT
44347	Primary Logic Limiter Washout Filter Normal Time	RW	FLOAT
44349	Primary Logic Limiter Washout Filter Limit Time	RW	FLOAT
44351	Primary Gain	RW	FLOAT
44353	Primary Output Limiter Upper Limit	RW	FLOAT
44355	Primary Output Limiter Lower Limit	RW	FLOAT
44357	Primary Quadrature Axis Reactance	RW	FLOAT
44359	Primary Output Scale Factor	RW	FLOAT
44361	Primary Timed Power-on Threshold	RW	FLOAT
44363	Primary Timed Power Hysteresis	RW	FLOAT
44365	Primary Instantaneous Power-on Threshold	RW	FLOAT
44367	Primary Instantaneous Power Hysteresis	RW	FLOAT
44368 to 44394	Reserved for future C14 use	R	Not Defined
44395	PSS Power Level Threshold	RW	FLOAT
44397	PSS Power Level Hysteresis	RW	FLOAT
44399 to 44418	Reserved for future C14 use	R	Not Defined
44419	PSS frequency dependent mode threshold, Hz/s	RW	FLOAT
44421	PSS frequency dependent mode block time delay	RW	FLOAT
44423	PSS frequency dependent mode unblock time delay	RW	FLOAT
44425	PSS frequency dependent mode low-pass filter time constant	RW	FLOAT
44427	PSS frequency dependent mode washout time	RW	FLOAT
44429	Rate of frequency change (metering and screen selection)	R	FLOAT
44435 to 44509	Not used	R	Not Defined
44510	Secondary PSS Software Switch 0	RW	UINT16
44511	Secondary PSS Software Switch 1	RW	UINT16
44512	Secondary PSS Software Switch 2	RW	UINT16
44513	Secondary PSS Software Switch 3	RW	UINT16

Registers	Data Description	Access	Data Format
44514	Secondary PSS Software Switch 4	RW	UINT16
44515	Secondary PSS Software Switch 5	RW	UINT16
44516	Secondary PSS Software Switch 6	RW	UINT16
44517	Secondary PSS Software Switch 7	RW	UINT16
44518	Secondary PSS Software Switch 8	RW	UINT16
44519	Secondary PSS Software Switch 9	RW	UINT16
44520 to 44550	Not used	R	Not Defined
44551	Secondary PSS High Pass Filter Time Constant Tw1	RW	FLOAT
44553	Secondary PSS High Pass Filter Time Constant Tw2	RW	FLOAT
44555	Secondary PSS Unit Inertia	RW	FLOAT
44557	Secondary Low Pass Filter Time Constant Tl	RW	FLOAT
44559	Secondary Phase Comp. First Phase Lead t1	RW	FLOAT
44561	Secondary Phase Comp. First Phase Lag t2	RW	FLOAT
44563	Secondary Phase Comp. Second Phase Lead t3	RW	FLOAT
44565	Secondary Phase Comp. Second Phase Lag t4	RW	FLOAT
44567	Secondary Phase Comp. Third Phase Lead t5	RW	FLOAT
44569	Secondary Phase Comp. Third Phase Lag t6	RW	FLOAT
44571	Secondary Phase Comp. Fourth Phase Lead t7	RW	FLOAT
44573	Secondary Phase Comp. Fourth Phase Lag t8	RW	FLOAT
44575	Secondary Terminal Voltage Limiter Time Constant	RW	FLOAT
44577	Secondary Terminal Voltage Limiter Set Point	RW	FLOAT
44579	Secondary Torsional Filter #1 Zeta Numerator	RW	FLOAT
44581	Secondary Torsional Filter #1 Zeta Denominator	RW	FLOAT
44583	Secondary Torsional Filter #1 Wn1	RW	FLOAT
44585	Secondary Torsional Filter #2 Zeta Numerator	RW	FLOAT
44587	Secondary Torsional Filter #2 Zeta Denominator	RW	FLOAT
44589	Secondary Torsional Filter #2 Wn2	RW	FLOAT
44591	Secondary Logic Output Limiter Upper Limit	RW	FLOAT
44593	Secondary Logic Output Limiter Lower Limit	RW	FLOAT
44595	Secondary Logic Output Limiter Time Delay	RW	FLOAT
44597	Secondary Logic Limiter Washout Filter Normal Time	RW	FLOAT
44599	Secondary Logic Limiter Washout Filter Limit Time	RW	FLOAT
44601	Secondary Gain	RW	FLOAT
44603	Secondary Output Limiter Upper Limit	RW	FLOAT
44605	Secondary Output Limiter Lower Limit	RW	FLOAT
44607	Secondary Quadrature Axis Reactance	RW	FLOAT
44609	Secondary Output Scale Factor	RW	FLOAT
44611	Secondary Timed Power-on Threshold	RW	FLOAT
44613	Secondary Timed Power Hysteresis	RW	FLOAT
44615	Secondary Instantaneous Power-on Threshold	RW	FLOAT
44617	Secondary Instantaneous Power Hysteresis	RW	FLOAT
44619 to 44999	Reserved for future C14 use	R	Not Defined

11 • Math Model

Introduction

This chapter describes and illustrates the DECS-400 mathematical model.

References

DECS-400 mathematical models and timing characteristics are based on the following.

- IEEE Standard 421.5™-2016, IEEE Recommended Practice for Excitation System Models for Power System Stability Studies
- IEEE Standard C37.112™-1996, IEEE Standard Inverse Time Characteristic Equations for Over Current Relays
- IEEE Standard C50.13™-2014, IEEE Standard for Cylindrical-Rotor 50 Hz and 60 Hz Synchronous Generators Rated 10 MVA and Above
- P. Kundur and O. Malik, “Excitation Systems” in Power System Stability and Control, 2nd ed. New York, NY, USA: McGraw-Hill, 2022, ch. 8, sec. 5.7, pp. 255–303.

Symbols

Symbols used in the illustrations of this chapter are defined in Figure 11-1.

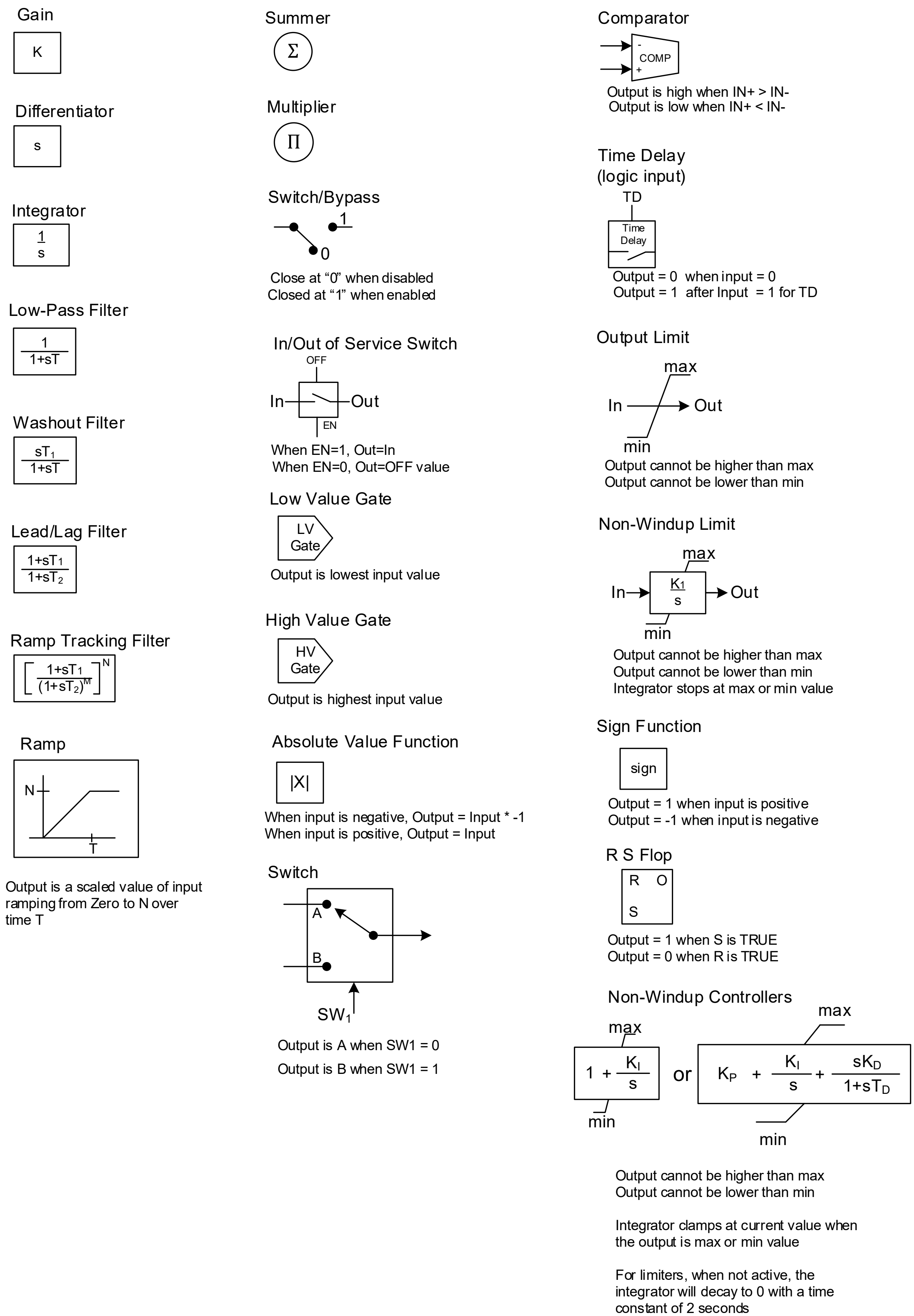


Figure 11-1. Symbol Definitions

Synchronous Machine Terminal Voltage Transducer and Load Compensator Model

The Basler DECS-400 implements the load compensation by using the vector sum of the magnitudes of the terminal voltage and of the terminal current. The model provided in IEEE Std 421.5™-2016 for terminal voltage transducers and load compensators can be used to model this function in the Basler DECS-400 system as shown in Figure 11-2.

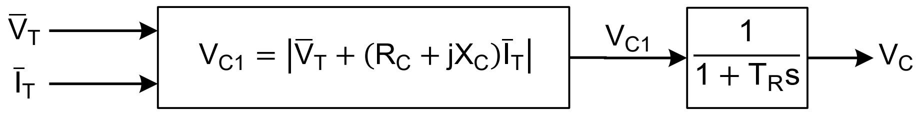


Figure 11-2. Terminal Voltage and Load Compensation Elements

The values used in this model can be derived from the Basler DECS-400 settings as follows:

R_c = 0 (Resistive load compensation not available)

X_C = 0.01 ∗ DRP

T_R = 5 ms

where DRP is the percent droop programmed into the Basler DECS-400 (values range from 0 to 20).

Voltage Regulator

Figure 11-3 and Figure 11-4 show the 50- and 60-Hz models of the Basler DECS-400 excitation system used with a simplified rotating exciter, brush or brushless type. The rotary exciter depicted in Figure 11-3 and Figure 11-4 is an ac rotary exciter. If the actual system utilizes a dc rotary exciter instead, the ac rotary exciter's block diagram would be replaced with the block diagram of a dc rotary exciter similar to the one depicted in Figure 3 in IEEE Std 421.5™-2016. The rotating exciter parameters are not included in this discussion since they are the responsibility of the exciter manufacturer. V_P is the input from the power source for the excitation system.

The typical value for the amplifier time constant (T_A) is 0.004 s. The forcing limit V_{RLMT} is related to the power-input voltage (V_{P_VOL}) to the regulator and the base exciter field voltage (E_{FE_BASE}) as follows:

$$V_{RLMT} = 1.17 * \frac{V_{P\_VOL}}{E_{FE\_BASE}} \text{ for the three-phase power input}$$

$$V_{RLMT} = 0.78 * \frac{V_{P\_VOL}}{E_{FE\_BASE}} \text{ for the single-phase power input}$$

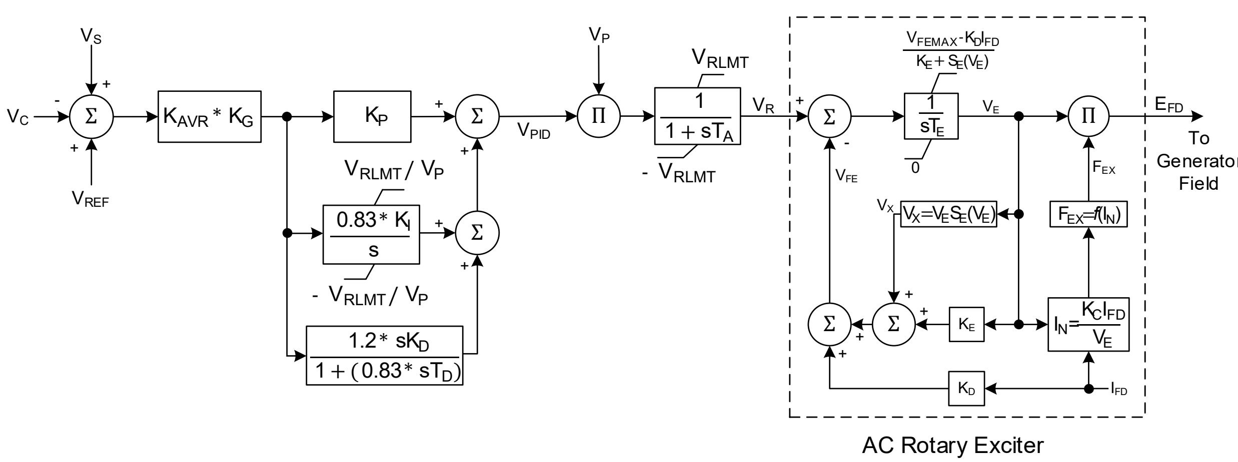


Figure 11-3. Per-Unit Block Diagram for a Simplified Rotating Exciter (50 Hz)

In the model, the gain K_G is a programmable parameter, which is used for compensating variations in system configuration-dependent gains such as power input voltage. The per-unit base of the parameters V_P (power input) and V_R (regulator output) is the nominal exciter field voltage at no load (E_{EF_BASE}).

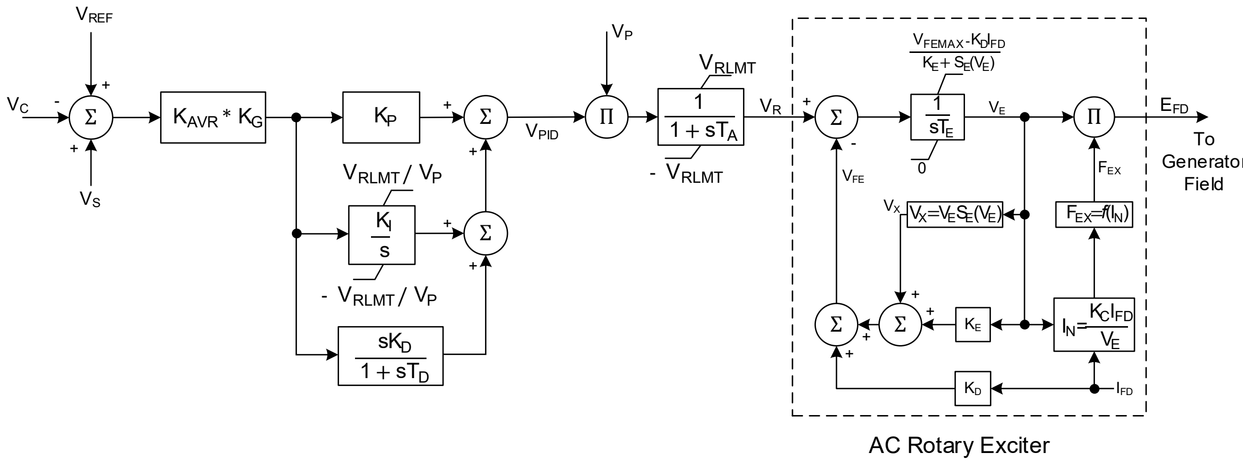


Figure 11-4. Per-Unit Block Diagram for a Simplified Rotating Exciter (60 Hz)

A typical value for K_{AVR} in the first gain block in Figure 11-3 and Figure 11-4 is 0.005 for the three-phase power input and 0.0033 for the single-phase power input.

The PID gains K_P, K_I, and K_D are custom-designed for the best performance for each generator/exciter system. These continuous time gains are discretized and implemented in the DECS-400 digital controller.

Static Exciter

When the Basler DECS-400 excitation system is used with a static exciter, it can be modeled as shown in Figure 11-5, Figure 11-6, Figure 11-7, and Figure 11-8. A PI controller is used for the static exciter application. The forcing limit (V_{RLMT}) is related to the power-input voltage (V_{P_VOL}) to the power stage and the base generator field voltage (E_{FD_BASE}) as follows:

$$V_{RLMT} = 1.17 * \frac{V_{P\_VOL}}{E_{FD\_BASE}} \text{ for the three-phase power input}$$

$$V_{RLMT} = 0.78 * \frac{V_{P\_VOL}}{E_{FD\_BASE}} \text{ for the single-phase power input}$$

A typical value of K_{AVR} in the first gain block in Figure 11-5 and Figure 11-6 is 0.005 for the three-phase power input and 0.0033 for the single-phase power input.

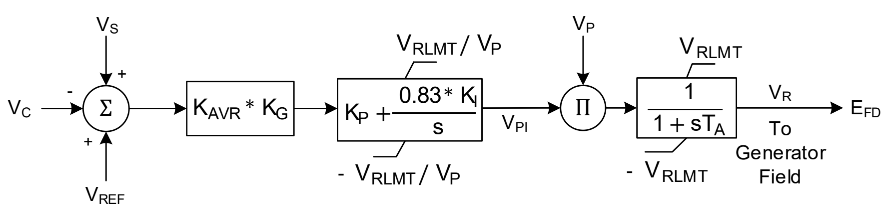


Figure 11-5. Per-Unit Block Diagram for Static Excitation System (50 Hz)

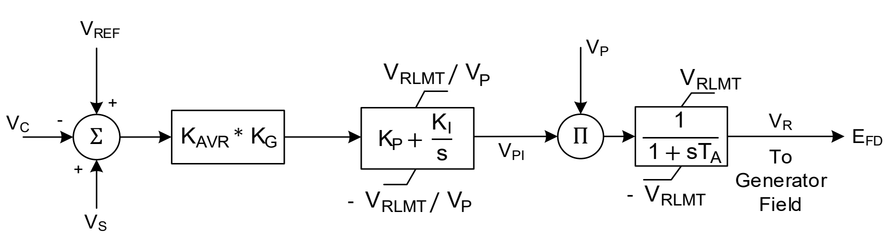


Figure 11-6. Per-Unit Block Diagram for Static Excitation System (60 Hz)

The inner loop field voltage regulator in Figure 11-7 and Figure 11-8 is comprised of the gains K_{GFVR} and K_{IFVR}, which are used to linearize the exciter control output by compensating the nonlinear characteristics due to power source variation.

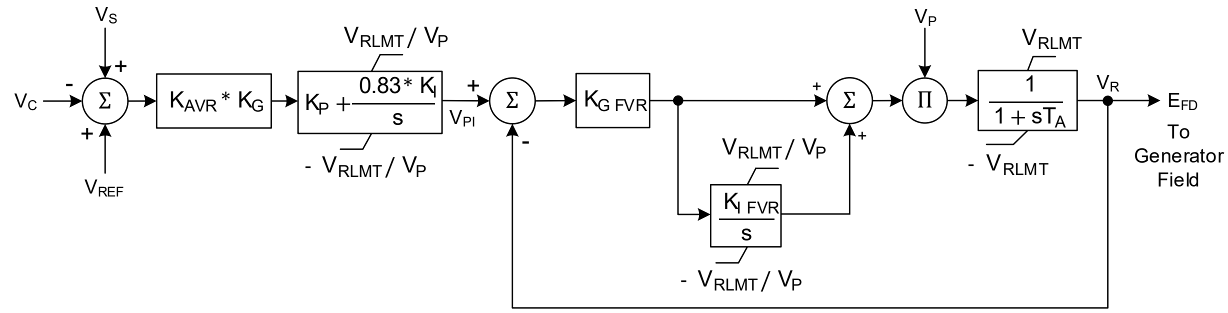


Figure 11-7. Per-Unit Block Diagram for Static Excitation System with the Inner Loop Field Voltage Regulator (50 Hz)

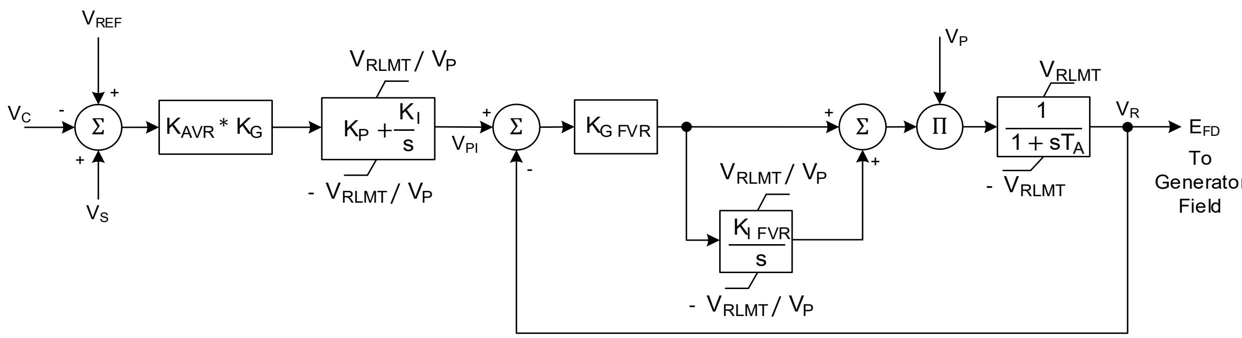


Figure 11-8. Per-Unit Block Diagram for Static Excitation System with the Inner Loop Field Voltage Regulator (60 Hz)

Var/Power Factor Controller

The var and power factor (PF) controllers are summing point-type controllers and make up the outside loop of a two-loop system. These controllers are implemented as a slow PI-type controller. The voltage regulator forms the inner loop and is implemented as a fast PID controller.

The models of the Basler DECS-400 var and power factor controllers are shown in Figure 11-9 and Figure 11-10, respectively. They may be modelled as IEEE Std 421.5™ Type 2 var and PF controllers. The PTMIN threshold of the PF controller is based on a settable percentage of rated power. The non-windup limit (V_{CLMT}) is used for bounding the var and PF controllers' output voltages (V_Q and V_{PF}). V_{CLMT} is related to the programmed parameter "Fine Voltage Adjustment Band" (FVAB) as follows:

$$V_{CLMT\_HIGH} = \frac{FVAB}{100}$$

$$V_{CLMT\_LOW} = -\frac{FVAB}{100}$$

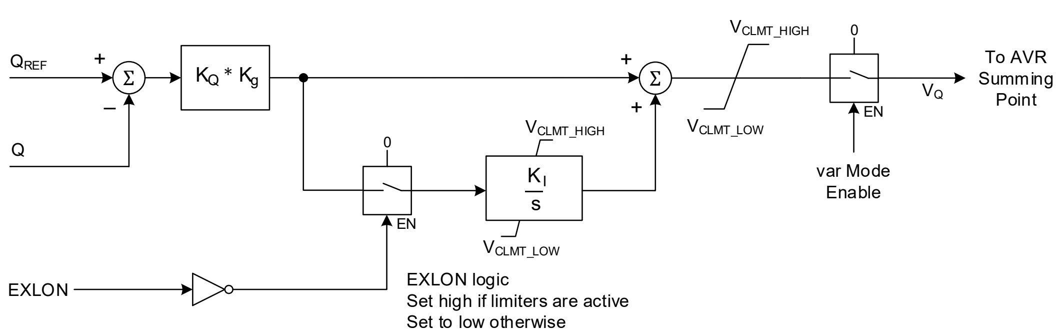


Figure 11-9. Per-Unit Block Diagram for Var Controller

A typical value of K_Q and K_{PF} in the first gain blocks in Figure 11-9 and Figure 11-10, respectively, is 0.00833.

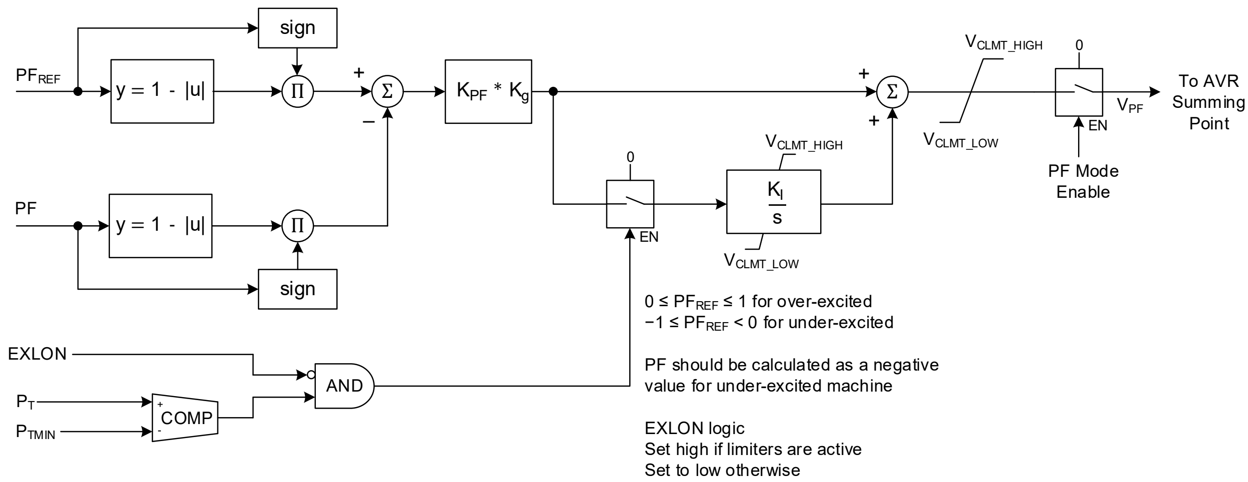


Figure 11-10. Per-Unit Block Diagram for PF Controller

Limiters

The Basler DECS-400 has six limiters: the underexcitation limiter (UEL), the overexcitation limiter (OEL), the stator current limiter (SCL), the var limiter (varL), the underfrequency limiter (UFL), and the volts-per-hertz limiter (V/Hz). The UEL and OEL can be implemented as either summing point-type limiters or takeover-type limiters. The SCL, varL, UFL, and V/Hz are only available as summing point type-limiters. With regards to the underfrequency limiter and the volts-per-hertz limiter, only one of these limiters may be enabled at a time.

Underexcitation Limiter (UEL)

Figure 11-11 shows the model of the summing point-type UEL. It makes up the outer loop, and the voltage regulator makes up the inner loop. The UEL uses a PI-type controller. In addition to the summing point UEL, the DECS-400 has a takeover-style UEL as depicted in Figure 11-12. A typical value of K_Q in the first gain block of Figure 11-11 is 0.00833. Typical values of $K_{G\ UEL}$ and $K_{I\ UEL}$ in Figure 11-12 are 0.0023 and 0.4, respectively.

The UEL operating characteristic is selected from one of the following methods:

1. The internal UEL operating characteristic is designed to mimic the characteristics of the limiter on the P-Q plane as illustrated in Figure 11-13. The UEL reference (QUEL_REF) is generated based on the user input parameter “UEL Bias (QBIAS)” and the active power (P) as follows:

$$Q_{UEL\_REF} = \left(0.49 * P^2 - 1\right) * Q_{BIAS}$$

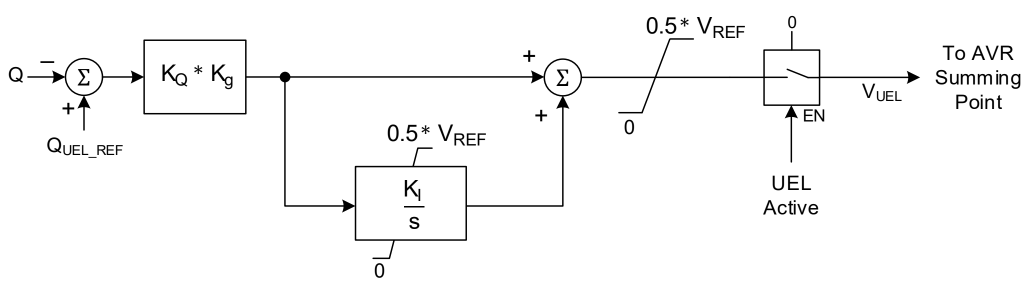


Figure 11-11. Per-Unit Block Diagram for Summing Point-Type Underexcitation Limiter

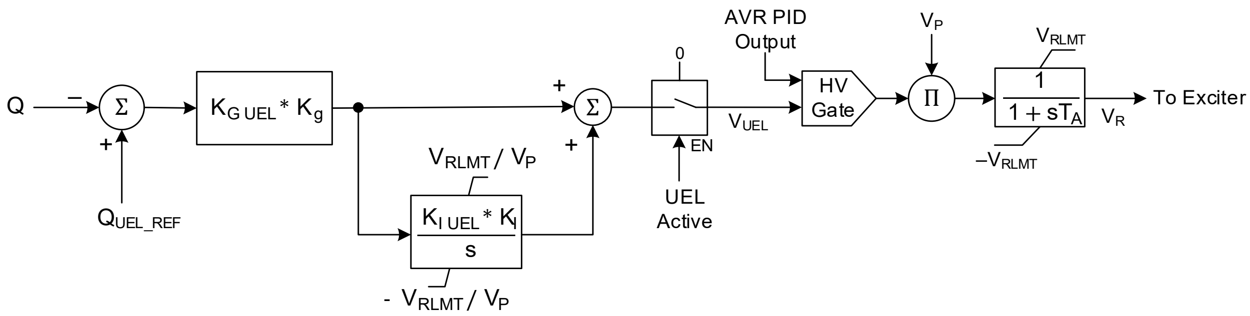


Figure 11-12. Per-Unit Block Diagram for Takeover Style Underexcitation Limiter

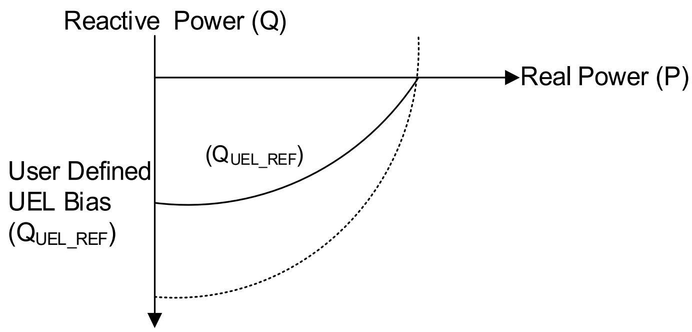


Figure 11-13. Underexcitation Limiter Reference

2. The levels entered for the user-defined curve are defined for operation at the rated generator voltage. The user-defined UEL curve is automatically adjusted based on generator operating voltage and real power by using the UEL voltage dependency real-power exponent as shown in Figure 11-14. Figure 11-15 shows the customized UEL operating characteristic for a UEL in which the limit is comprised of multiple straight-line segments, showing up to six segments.

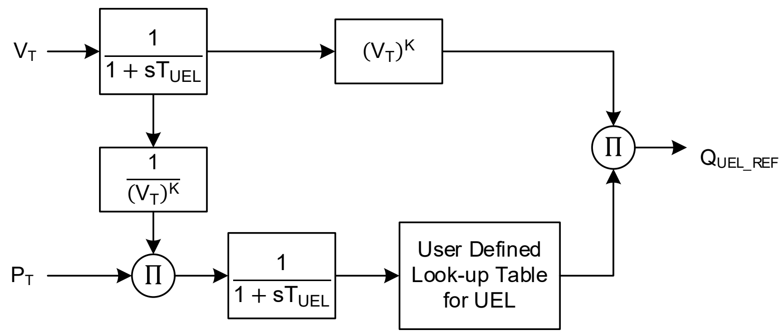


Figure 11-14. Adjustment of UEL Curve Based on Generator Voltage and Real Power

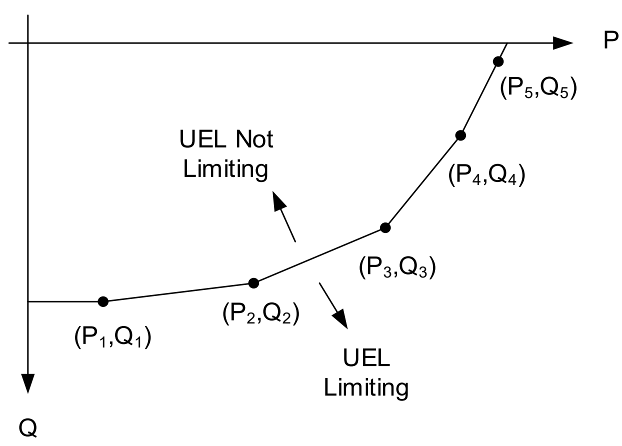


Figure 11-15. User-Defined UEL Curve Characteristic with Five Points

Overexcitation Limiter (OEL)

The Basler DECS-400 has two types of OEL: summing point-type and takeover-type. These are shown in Figure 11-16 and Figure 11-17, respectively. In the summing point-type of the Basler DECS-400 OEL, a PI-type controller is used, and the OEL output is added to the summing point of the voltage regulator. The takeover style of the Basler DECS-400 OEL uses a PI-type controller. In this control scheme, the actual field current is compared with the OEL setpoint. In order to allow for a large field voltage due to a transient response in the AVR loop, the actual field current is filtered before comparing it with the OEL setpoint. The integrator of the OEL loop is reinitialized every 4 ms with the current excitation level if the field current is below the limit. When the field current is above the limit, the OEL limiter output becomes less than the AVR output, and the OEL takes over to control at a proper excitation level. When the OEL is active, the AVR loop stops integration and compares its output with the OEL output to get out of the OEL loop. Note that the I_{FD} per-unit base in the OEL model is the shunt rating programmed into the Basler DECS-400.

A typical value of K_{OEL} is 0.00833 for the summing point type of OEL (Figure 11-16). Typical values of K_{GOEL} and K_{IOEL} for the takeover type OEL (Figure 11-17) are 0.0305 and 0.05, respectively.

Two methods for calculating the field current reference for the OEL loop are implemented in the DECS-400. For the summing point OEL, the reference field current is calculated based on the user input parameters as shown in Figure 11-18. It approximates the field current short-time overload capability given in IEEE Std C50.13™. The low level (OEI3) is continuous field current. The OEL loop becomes inactive if field current lower than OEI3 is required by an external event. It is illustrated at time t_O in Figure 11-18. When the summing point OEL is active, the field current will be limited to follow the reference field current as depicted in Figure 11-18 until time t_O.

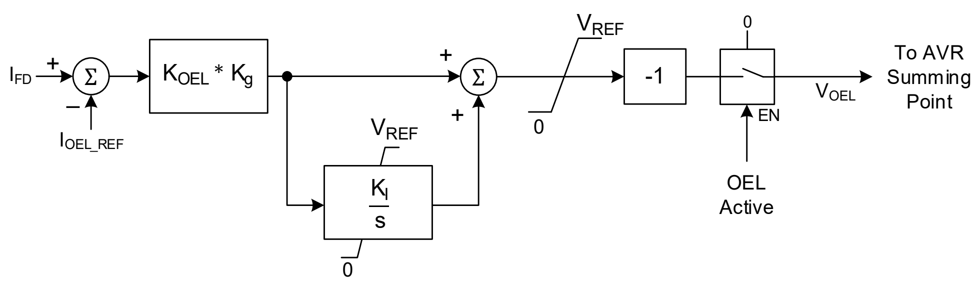


Figure 11-16. Per-Unit Block Diagram for Overexcitation Limiter (Summing Point Type)

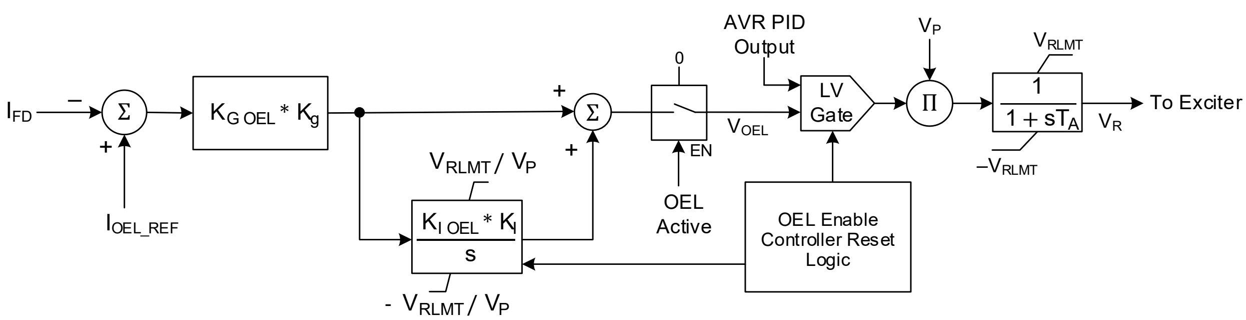


Figure 11-17. Per-Unit Block Diagram for Overexcitation Limiter (Takeover Type)

In the takeover OEL, the reference field current (I_{OEL_REF}) is calculated based on the inverse-time characteristic curve. The curve implemented in the Basler DECS-400 takeover OEL approximates the inverse-time characteristic curve found in IEEE Std C37.112™-2018. The input parameters from the user are as follows:

I_{FD_max} – Maximum allowed field current (OEL high level current)

I_{FD_min} – Maximum continuous field current (OEL low level current)

TD – Time dial setting

The reference field current (I_{OEL_REF}) in per-unit is obtained by:

$$I_{OEL\_REF} = \frac{\frac{1}{192} * \left[490 - \left\{\frac{-95.9 * (TD)}{Time} + 17.17\right\}^2\right] * I_{BASE}}{I_{FE\_BASE}}$$

where $I_{BASE} = \frac{I_{FD\_min}}{1.03}$. When the takeover OEL is active, the field current will be limited to follow the curve of the reference field current given by the equation above.

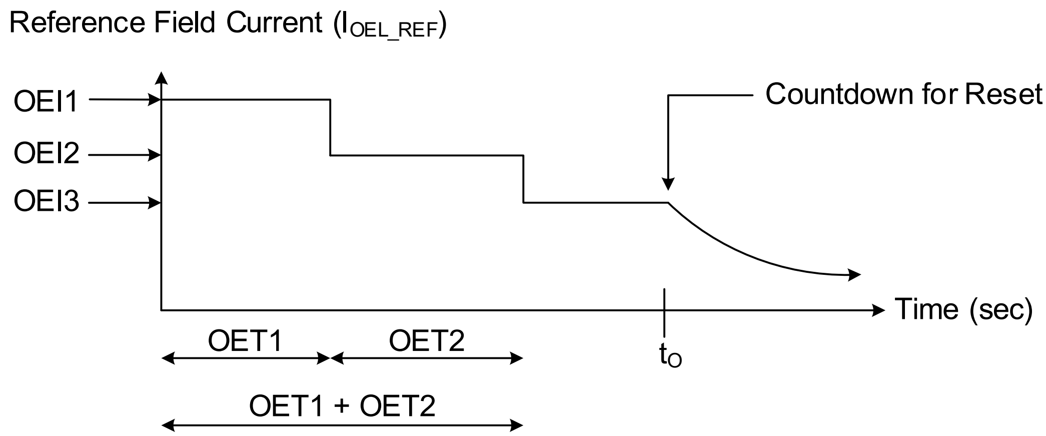


Figure 11-18. Overexcitation Limiter Reference for Summing Point Type OEL

Stator Current Limiter (SCL)

The stator current limiter (SCL) modifies the excitation level based on whether vars are being absorbed (leading) or exported (lagging) by the synchronous machine. Figure 11-19 shows the model of the SCL. The SCL makes up the outer loop, and the voltage regulator makes up the inner loop. The PI-type controller is used to achieve a desired response. The sign (Q) is defined as positive (+1) for the overexcitation condition and negative (–1) for the underexcitation condition.

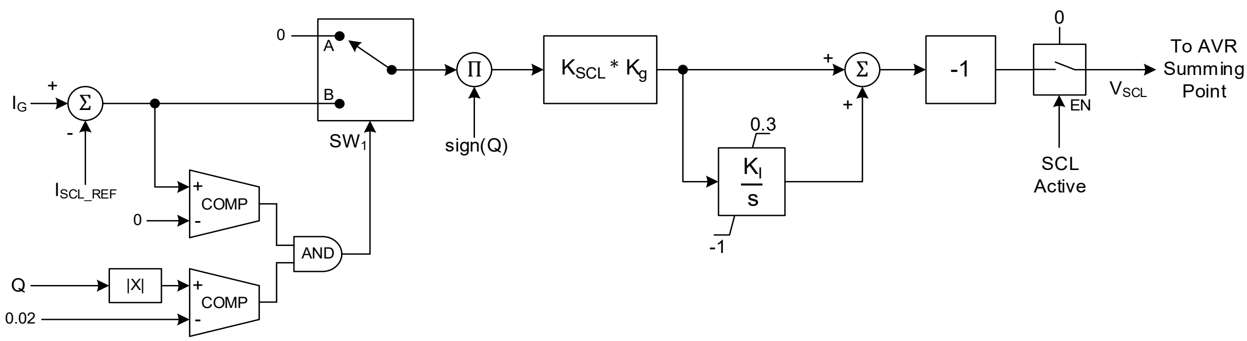


Figure 11-19. Per-Unit Block Diagram for the Stator Current Limiter

The SCL current reference (I_{SCL_REF}) is generated based on a two-step waveform with a high current level (I_{high}), a high current time (T_{high}), and a low current level (I_{low}) as shown in Figure 11-20.

The SCL loop becomes inactive if stator current lower than the low current level (I_{low}) is required by an external event. It is illustrated at time t_O in Figure 11-20. A typical value of K_{SCL} in the first gain block of Figure 11-19 is 0.00833.

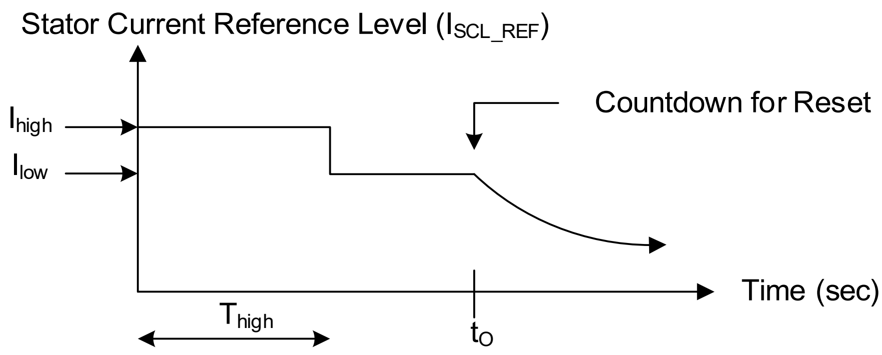


Figure 11-20. Stator Current Limiter Reference

Var Limiter (varL)

The var limiter (varL) acts to limit the level of reactive power exported from the generator. A PI-type controller is used, and the varL output is subtracted from the summing point of the voltage regulator. A delay setting establishes a time delay between when the var threshold is exceeded and when the DECS-400 acts to limit the generator's exported reactive power level.

A typical value of K_Q in the first gain block in Figure 11-21 is 0.00833.

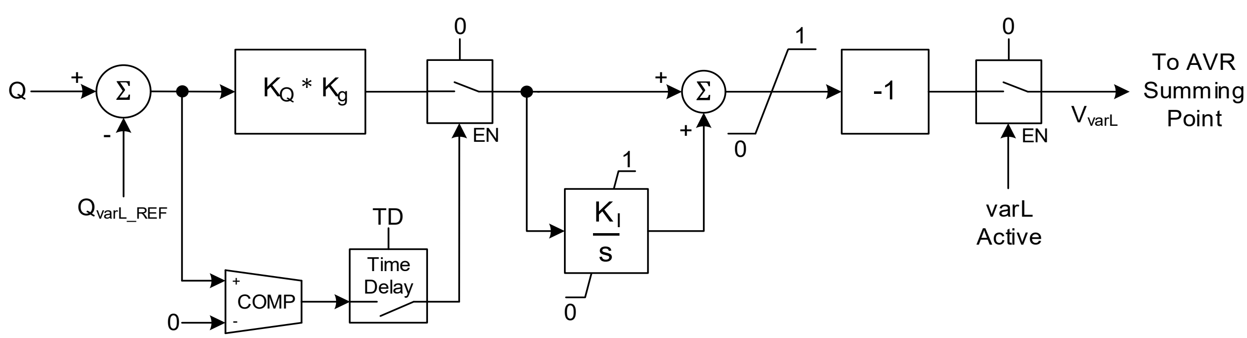


Figure 11-21. Per-Unit Block Diagram of Var Limiter

Volts-per-Hertz (V/Hz) and Underfrequency (UFL) Limiters

Volts-per-hertz and underfrequency limiters are designed to protect the generator and step-up transformer from damage due to excessive magnetic flux resulting from low frequency operation and/or overvoltage.

The underfrequency limiter has been designed with an adjustable slope (K_{VHz}) from 0 pu to 3 pu (V/Hz). When the system is in an underfrequency condition, the voltage reference is adjusted by the amount calculated based on two programmable parameters: the corner frequency and the volts-per-hertz slope. Its mathematical model is shown in Figure 11-22.

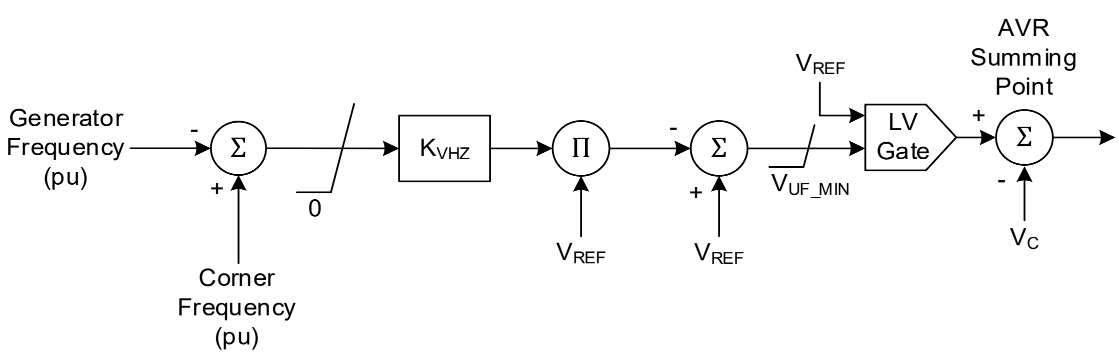


Figure 11-22. Underfrequency Limiter

The V/Hz limiter has been designed with an adjustable slope (K_{VHZ}) from 0 pu to 3 pu (V/Hz). When the system frequency and voltage are above the volts-per-hertz line, the setpoint is adjusted to maintain operation on the volts-per-hertz line. Its mathematical model is shown in Figure 11-23.

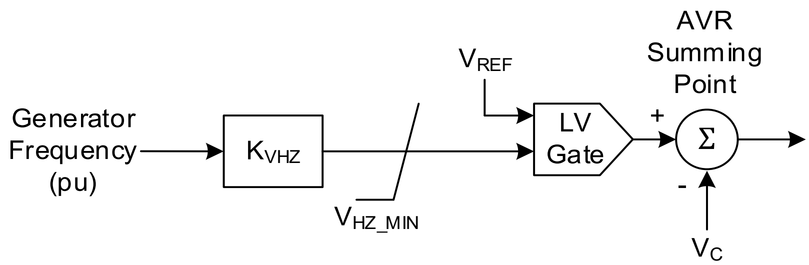


Figure 11-23. Volts-per-Hertz Limiter

Soft Start Control

The soft start control function is provided to cause orderly build-up of terminal voltage from residual to the rated voltage in the desired time with minimal overshoot. In the Basler DECS-400, the fast dynamic response is used while the voltage reference is adjusted based on the elapsed time. When the system is under startup condition, the voltage reference is adjusted by the amount calculated based on two programmable parameters: initial soft start voltage level (V_0) and desired time to build up to the rated voltage (T_{SS}). Its mathematical model is shown in Figure 11-24. The soft start gain (K_{SS}) is calculated as follows:

$$K_{SS} = \frac{V_{REF} - V_0}{T_{SS}}$$

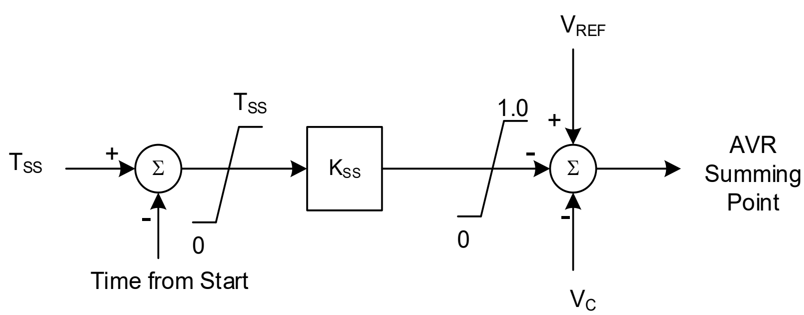


Figure 11-24. Soft Start Control

Manual Regulators

The DECS-400 has two manual regulators: the field current regulator (FCR) and the field voltage regulator (FVR). Figure 11-25 shows the model of the Basler DECS-400 field current regulator used with a rotating exciter, brush or brushless type. V_P is the input from the power source for the excitation system.

Typical value for T_A is 0. The forcing limit V_{RLMT} is related to the power-input voltage (V_{P_VOL}) and the base exciter field voltage (E_{EF_BASE}) as follows:

$$V_{RLMT} = 1.17 * \frac{V_{P\_VOL}}{E_{FE\_BASE}} \text{ for the three-phase power input}$$

$$V_{RLMT} = 0.78 * \frac{V_{P\_VOL}}{E_{FE\_BASE}} \text{ for the single-phase power input}$$

In the model, the gain K_G is a programmable parameter, which is used for compensating variations in system configuration-dependent gains such as power input voltage. The per-unit base of the parameters V_P (power input) and V_R (regulator output) is the base exciter field voltage at no load (E_{EF_BASE}).

The gains K_{FCR} and K_{FVR} in the first gain block in Figure 11-25 and Figure 11-27 depend on the sensing option for the isolation module.

The gain K_{FCR} in the first gain block in Figure 11-25 and Figure 11-26 has typical values of 0.0000412 for the three-phase power input and 0.0000275 for the single-phase power input.

The gain K_{FVR} in the first gain block in Figure 11-27 has typical values of 0.0000557 for the three-phase power input and 0.0000372 for the single-phase power input.

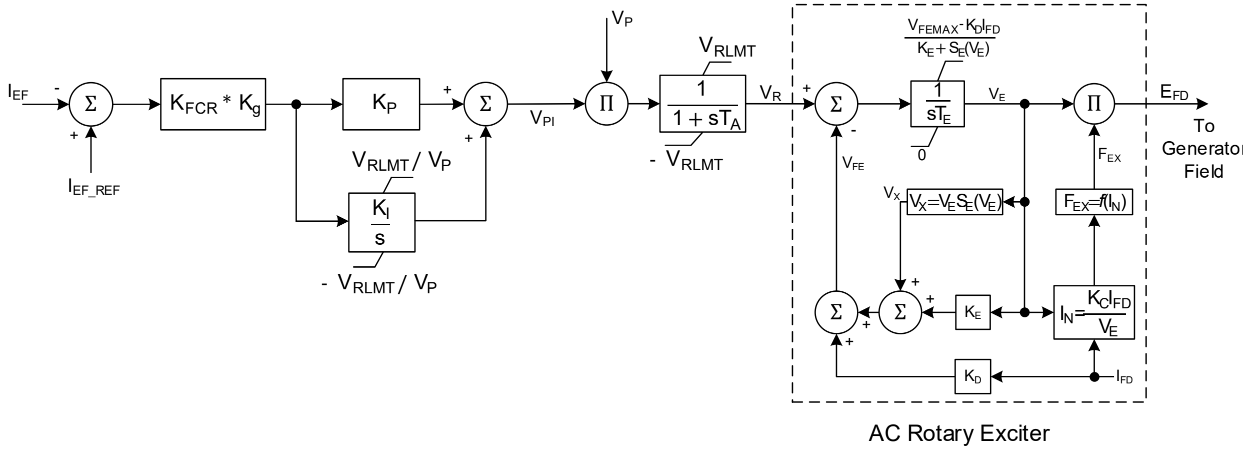


Figure 11-25. Per-Unit Block Diagram for a Simplified Rotating Exciter

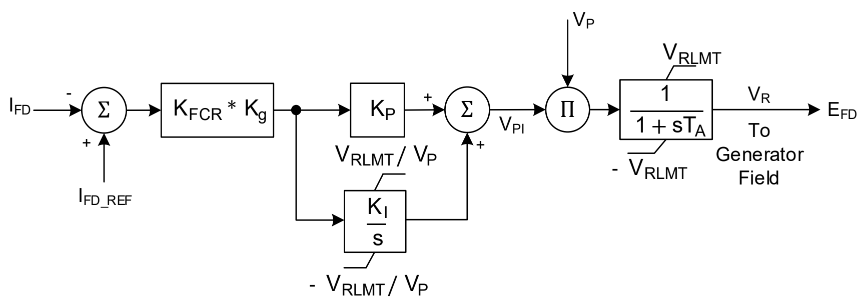


Figure 11-26. Per-Unit Block Diagram for Static Excitation System with a Field Current Regulator

The model of the Basler DECS-400 manual regulator used as a static exciter is shown in Figure 11-26 and Figure 11-27. The PI controller is used for the manual regulator. The forcing limit V_{RLMT} is related to the power-input voltage (V_{P_VOL}) to the power stage and the base generator field voltage (E_{FD_BASE}) as follows:

$$V_{RLMT} = 1.17 * \frac{V_{P\_VOL}}{E_{FD\_BASE}} \text{ for the three-phase power input}$$

$$V_{RLMT} = 0.78 * \frac{V_{P\_VOL}}{E_{FD\_BASE}} \text{ for the single-phase power input}$$

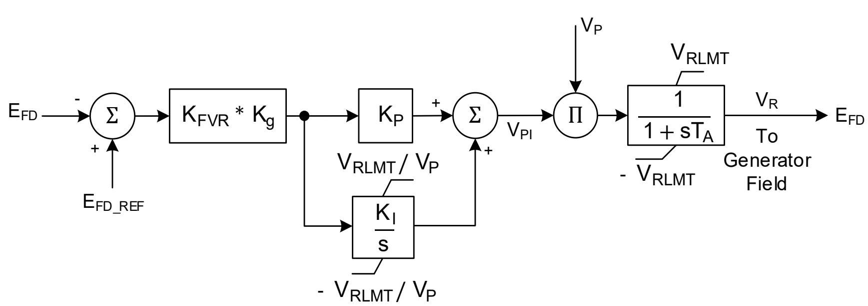


Figure 11-27. Per-Unit Block Diagram for Static Excitation System with a Field Voltage Regulator

Dual Input Power System Stabilizer (PSS)

The Basler power system stabilizer (PSS) is a dual input PSS that uses combinations of power and speed to derive the stabilizing signal. It is based on the type PSS2B model available in IEEE Std 421.5™.

The PSS is designed to add damping to the generator rotor oscillations by controlling its excitation using a supplemental stabilizing signal. To supplement the generator's natural damping, it produces a component of electrical torque that opposes changes in rotor speed and introduces a signal proportional to measured rotor speed deviation into the automatic voltage regulator (AVR) input.

As depicted in Figure 11-28, the PSS monitors frequency and power to produce the integral of accelerating power, which is used for obtaining a derived speed deviation signal (ω_{DEV}). Filtering of the derived speed signal provides a phase lead at the electro-mechanical frequency of interest. This phase lead compensates for the phase lag introduced by the closed-loop voltage regulator. Prior to connecting the stabilizer output signal to the voltage regulator input, adjustable gain and limiting are applied as depicted in Figure 11-28.

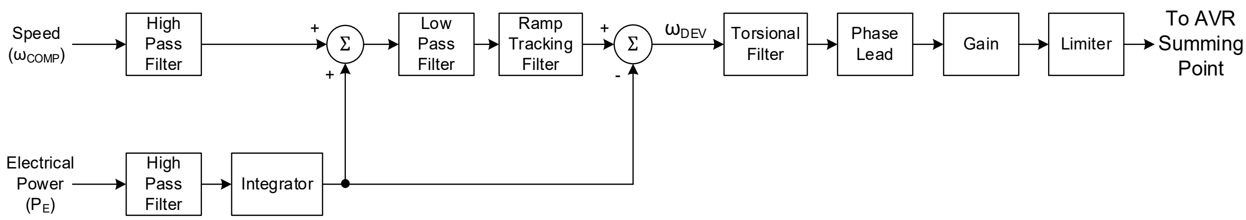


Figure 11-28. Functional Block Diagram of PSS

The PSS performance is configured using filter time constants and software control switches. Figure 11-29 illustrates the detailed block diagram including the position of each software switch, and Table 11-1 contains the list of locations for the PSS variables displayed in BESTCOMS*Plus*®.

High-Pass Filtering and Integration

High-pass filtering is used to remove low frequency components from electrical power and rotor speed (or compensated frequency) signals. This ensures that the stabilizer does not alter the steady-state reference to the voltage regulator. High-pass filtering is implemented using time constants T_{w1}, T_{w2}, and T_{L1}. Integration of the electrical power signal is accomplished using time constants (T_{w3}, T_{w4}, and T_{L2}) and the rotor inertia constant H. The outputs of these are added together to obtain the integral of mechanical power deviation. Time constants T_{w1}, T_{w2}, T_{w3}, and T_{w4} are also called the washout time constants.

Low-Pass/Ramp Tracking Filter

A fourth-order low-pass filter processes the calculated mechanical power deviation signal. This filtering may be excessive for units with high rates of mechanical power change. An optional filter stage is provided to allow for ramp changes to the input mechanical power.

Torsional Filter

Torsional filter provides desired gain reduction at the specified frequency. The filter is used to compensate the torsional frequency components present in the input signal. There are two stages of torsional filters that can be selected by SW4 and SW5.

Phase Compensation

Filtering of the derived speed signal provides a phase lead at the electro-mechanical frequency of interest. As depicted in Figure 11-29, the derived speed signal is modified before it is applied to the voltage regulator input. The signal is filtered to provide phase lead at the electromechanical frequencies of interest (i.e., 0.1 Hz to 5.0 Hz). The phase lead requirement is site-specific, and it is required to compensate for phase lag introduced by the closed-loop voltage regulator. With switches SW2 and SW3 in the closed position, the derived speed deviation is used as the stabilizing signal. These software switches allow the user to select an alternate configuration based upon the available input signals. The first two lead-lag blocks are normally adequate to match the phase compensation requirements of a unit; however, two additional stages may be added by opening software switches SW6 and SW7. The transfer function for each stage of phase compensation is a simple pole-zero combination.

Table 11-1. PSS Variable Names Used in BESTCOMS*Plus*® and their Corresponding Location in Figure 11-29

Callout Number	BESTCOMS*Plus*® Variable	BESTCOMS*Plus*® Variable Name
1	Ptest	Time Response Signal
2	CompF	Compensated Frequency Deviation
3	PssW	PSS Electric Power
4	Vtmag	PSS Term Voltage
5	x2	Speed HP #1
6	WashW	Washed Out Speed
7	x5	Power HP #1
8	WashP	Washed Out Power
9	x7	Mechanical Power
10	x8	Mechanical Power LP #1
11	x9	Mechanical Power LP #2
12	x10	Mechanical Power LP #3
13	x11	Mechanical Power LP #4
14	MechP	Filtered Mechanical Power
15	Synth	Synthesized Speed
16	Tflt1	Torsional Filter #1
17	x29	Torsional Filter #2
18	x15	Lead-Lag #1
19	x16	Lead-Lag #2
20	x17	Lead-Lag #3
21	x31	Lead-Lag #4
22	Tvlpf	Terminal Voltage Low-Pass Filter
23	Tvrl	Terminal Voltage Ramp Limiter
24	Llwf	Logic Limiter Washout Filter
25	Prelim	Pre-Limit Output
26	Post	Post-Limit Output
27	POut	Final PSS Output

Washout Filter and Logic Limiter

If software switch SSW 9 is set to its enabled position, the scaled PSS signal will be passed through an additional washout filter and logic limiter. The logic limiter allows for the user to automatically change the time constant of the washout filter if the signal from the washout filter exceeds either of the logic limiter's bounds for a user-defined amount of time. The logic limiter will instantaneously return the washout filter's time constant to its original value once the washout filter's output returns to within the bounds of the logic limiter.

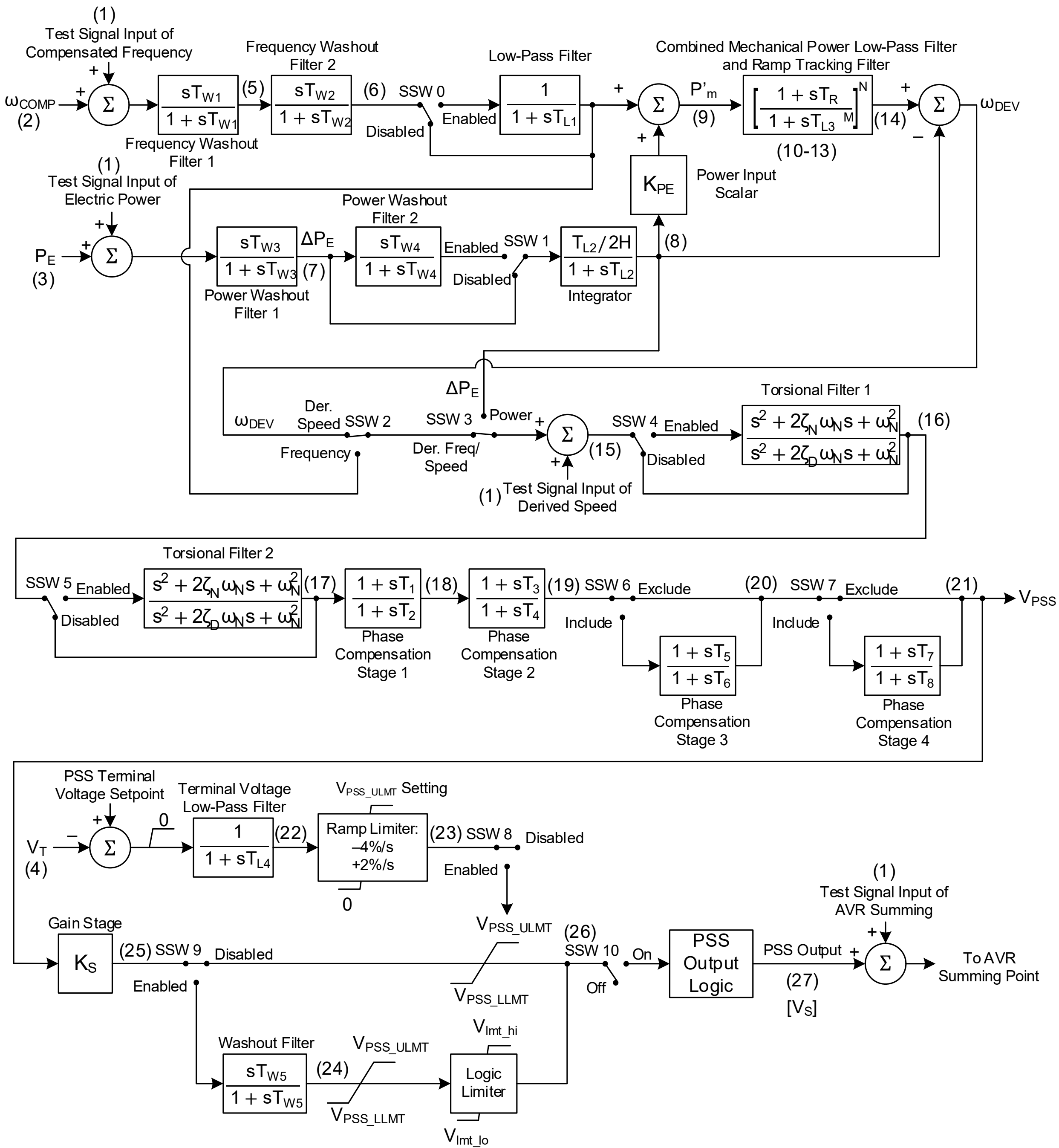


Figure 11-29. Detailed PSS Block Diagram

Terminal Voltage Limiter

If software switch SSW 9 is instead set to its disabled position, the scaled PSS signal will be passed through a limiter whose upper bound can be controlled based on the generator's terminal voltage. If the generator's terminal voltage rises above the terminal voltage level selected by the user in the PSS settings while software switch SSW 8 is enabled, the PSS's terminal voltage limiter will act to reduce the upper limit of the PSS output signal at a fixed rate of –4% per second until zero is reached or the overvoltage condition is no longer present. Once the overvoltage condition is no longer present, the upper limit of the PSS output signal will increase at a rate of 2% per second until the upper limit returns to the user-defined setpoint. If software switch SSW 8 is disabled, then the scaled PSS signal will just be bound by the user-defined limits.

Output Logic

If the PSS is not enabled; the real power level is below the kW threshold setpoint of the PSS; or the DECS-400 is not regulating in AVR mode, then the final PSS output will be equal to 0.

PSS Blocking with Rate-of-Change (ROC) in Frequency

The PSS output is blocked when the rate-of-change in the generator frequency is greater than the programmable level. Figure 11-30 provides a means to measure the rate-of-change of generator frequency. The absolute value of the measured rate-of-change is compared to a programmable threshold value ($ROC_{THRESHOLD}$). If the absolute value of the measured rate-of-change is above the threshold and ROC is enabled, then the algorithm will begin counting. If the count exceeds a programmable timeout (ROC TD), then a ramp signal (K_{S_SF}) will be produced with a programmable blocking time duration ($BLOCK_{TIME}$). The maximum ramp output becomes 1.0 after the blocking time duration. The PSS output is multiplied by the ramp signal.

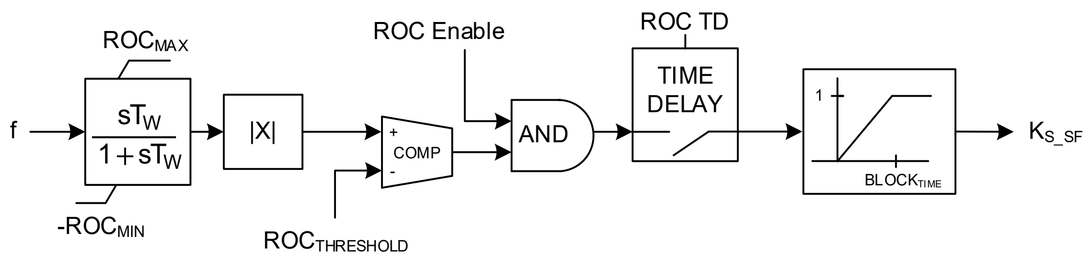


Figure 11-30. Per-Unit PSS Rate-Of-Change Blocking Block Diagram

Discontinuous Transient Excitation Boosting

The transient boost function provides a means to potentially improve system response to successive faults by providing increased excitation support. If a simultaneous increase in line current above the fault current threshold and a decrease in line voltage below the fault voltage threshold occurs for a fixed amount of time, the regulator reference setpoint will be increased. Once the line voltage rises above the clearing voltage threshold for fixed duration, the regulator reference setpoint will be restored to the pre-fault value. Figure 11-31 shows the model of the transient boost function. The transient boost function output (V_{TB}) is added to the summing point of the PID controller.

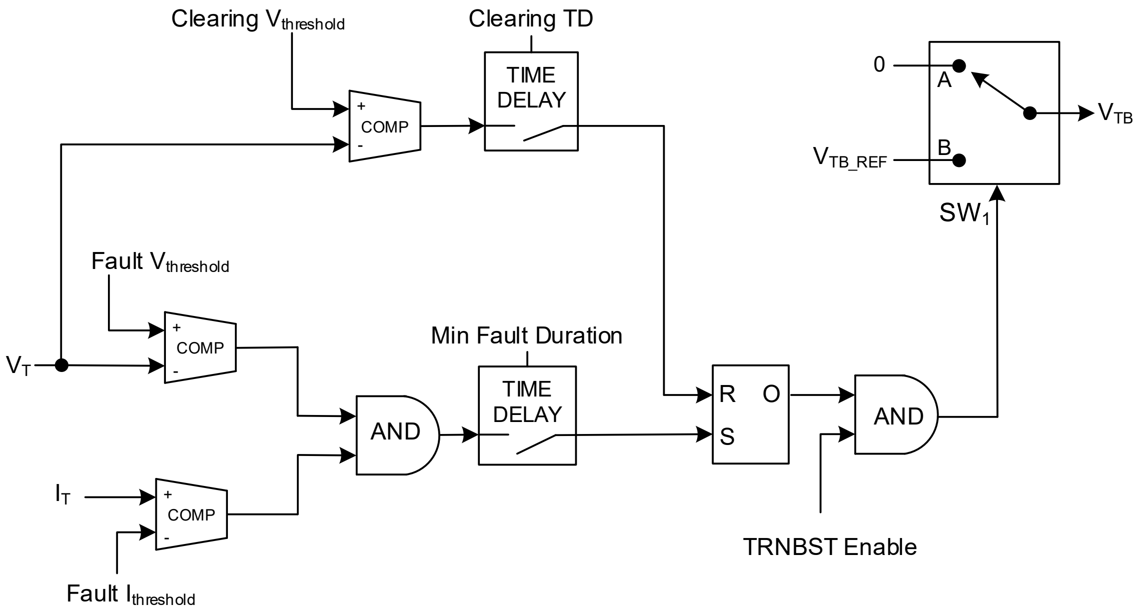


Figure 11-31. Transient Excitation Boost Block Diagram

12 • Revision History

Table 12-1 provides a historical summary of the changes made to the DECS-400 hardware. Application firmware changes are listed in Table 12-2 and BESTCOMS™ changes are listed in Table 12-3. The corresponding revisions made to this instruction manual are summarized in Table 12-4. Revisions are listed in chronological order.

Table 12-1. Hardware Revision History

Hardware Version and Date	Change
—, Jan-05	• Initial release
A, Aug-05	• Firmware revised to accommodate LCD variations
B, Sep-05	• Adjusted case for easier extraction and insertion of draw-out assembly
C, Oct-05	• I/O circuit board revised
D, Nov-06	• Firmware version 1.04 and BESTCOMS version 1.02 released
E, Mar-07	• Updated IRIG circuitry
F, May-07	• Firmware version 1.05 and BESTCOMS version 1.03 released
G, Nov-07	• Firmware version 1.06 released
H, Jan-08	• Firmware version 1.07.00 released
I	• This revision letter not used
J, Jan-09	• Modified latch stop for draw-out assembly
K, May-09	• Firmware version 1.08.00 and BESTCOMS version 1.05.00 released
L, Jun-09	• Added/modified hardware to support Ethernet communication
M, Jul-09	• BESTCOMS version 1.05.01 released
N, Dec-09	• Firmware version 1.08.03 released
O	• This revision letter not used
P, Feb-10	• Escutcheon mounting plate modified
Q	• This revision letter not used
R, Feb-10	• Firmware version 1.08.04 and BESTCOMS version 1.07.01 released
S, Apr-10	• Firmware version 1.08.05 and BESTCOMS version 1.07.02 released
T, Jul-10	• Firmware version 1.08.06 released
U, Nov-12	• Updated current sensing circuit board
V, Mar-13	• Firmware version 1.09.00 released
W, May-13	• Firmware version 1.09.01 released
X, Aug-13	• Digital circuit board revised
Y, Dec-13	• Firmware version 1.09.02 released
AA, Jun-15	• Firmware version 1.09.03 released
AB, Jun-17	• Firmware version 1.10.00 released
AC, Sep-17	• Revised PCB assembly alignment to improve manufacturability
AD, Sep-18	• Adjusted metal treatment process during manufacture
AE, Apr-19	• Updated analog circuit board
AF, Jul-19	• Internal hardware change
AG, Aug-19	• Updated communication circuit board

Table 12-2. Application Firmware Revision History

Firmware Version and Date	Change
1.00, Jan-05	• Initial release
1.01, Jun-05	• Corrected/enhanced operation of two-step V/Hz limiter • Adjusted increment for 24 V/Hz Inverse Time Pickup Setpoint • Changed setting range and increment of 24 V/Hz Definite Time Pickup #1 and #2
1.02, Oct-05	• Minor improvements
1.03, Feb-06	• Minor improvements
1.04, Nov-06	• Decreased contact input recognition time • Expanded setting range of rated generator voltage • Added Var/PF to PSS circuitry points where a test signal can be applied • Added field temperature to the available parameters for meter drivers 1 and 2
1.05, May-07	• Added Russian language HMI • Updated US daylight saving time switch dates
1.06, Nov-07	• Minor improvements
1.07, Jan-08	• Added SCL Initial Delay setting • Separated AVR/FCR gain settings on HMI • Added Transient Boost settings
1.08, May-09	• Added FVR mode functionality
1.08.01, Jul-09	• Added Ethernet communication functionality
1.08.04, Feb-10	• Expanded range of allowable generator ratings and protection settings
1.08.05, Apr-10	• Minor improvements
1.08.06, Jul-10	• Minor improvements
1.08.08, Apr-12	• Minor improvements
1.09.00, Mar-13	• Added adjustable traverse rate for pre-position #1 and #2 setpoints • Added reactive power limiter (VARL) • Revised transient boost function—is now based on the voltage setpoint instead of the rated voltage • Added PSS rate-of-change blocking function
1.09.01, May-13	• Minor improvements
1.09.02, Dec-13	• Minor improvements
1.09.03, Jun-15	• Minor improvements
1.10.00, Jun-17	• Improved PSS parameter ranges for TI2, TI3, Tr, and Ks. • Minor improvements
1.10.02, Oct-21	• Minor improvements

Table 12-3. BESTCOMS™ Software Revision History

Software Version and Date	Change
1.00.00, Jan-05	• Initial Release
1.00.01, Jun-05	• Frequency response function of *Analysis* screen enhanced • Adjusted increment for 24 V/Hz Inverse Time Pickup Setpoint • Changed setting range and increment of 24 V/Hz Definite Time Pickup #1 and #2
1.01.00, Sep-05	• Enhanced *Test Signal* screen by added *FCR Summing* as a *Signal Input* option • Improved order of settings on *RTM Step Response* screen, *VAR* tab • Improved *Pole Ratio Calculator*

Software Version and Date	Change
1.02.00, Nov-06	• Expanded setting range of rated generator voltage • Added Var/PF to PSS circuitry points where a test signal can be applied • Added field temperature to the available parameters for meter drivers 1 and 2
1.03.00, May-07	• Added Russian language interface
1.04.00, Jan-08	• Added SCL Initial Delay setting • Added Transient Boost settings screen • Separated AVR/FCR Gain tab into two separate tabs
1.05.00, May-09	• Added FVR mode functionality
1.06.00, Jul-09	• Added settings for Ethernet communication
1.07.01, Feb-10	• Expanded range of allowable generator ratings and protection settings
1.07.03, May-11	• Expanded Backward Compatibility • Expanded French Language interface • Improved UEL internal curve plotting
1.07.04, Jan-12	• Minor improvements
1.08.03, Mar-13	• Added PSS rate-of-change blocking function • Revised transient boost function—is now based on the voltage setpoint instead of the rated voltage • Added reactive power limiter (VARL) function • Added adjustable traverse rate for the pre-position #1 and #2 setpoints • Added settings file converter to transfer DECS-300 settings into DECS-400 settings file format
2.00.00, Aug-14	• Added Windows 8 compatibility
2.01.00, Jun-17	• Added Windows 10 compatibility • Added NVRAM Upgrade Tool • Added Phase Compensation parameters to Bode Plot screen • Minor improvements

Table 12-4. Instruction Manual Revision History

Manual Revision and Date	Change
—, Jan-05	• Initial release
A, Jul-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, Oct-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

Manual Revision and Date	Change
C, Oct-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 Section 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
D, May-07	• Added burden specification for metering outputs • Corrected watchdog terminal number references in Section 3 • Corrected labeling of contact inputs SW7 and SW9 in Figure 5-9, *Typical DC Connection Diagram* • Added descriptions for Modbus registers 40601, 40602, and 40603 to Table B-14
E, Dec-07	• Made Battery Backup a standard feature and updated manual accordingly
F, Jan-08	• Added SCL Initial Delay setting description • Added description for Transient Boost settings • Added new screenshots for AVR and FCR Gain tabs • Updated the HMI menu in Figures 2-4 and 2-9 • Added Modbus registers 42553 through 42559. Removed Modbus registers 42535 through 42539. Changed Modbus registers 42503 through 42507
G, May-09	• Updated manual to cover added FVR mode
H, Jul-09	• Added material covering Ethernet communication
I	• This revision letter not used
J, Feb-10	• Expanded range of allowable generator ratings and protection settings • Added FVR Modbus register descriptions • Corrected Com 2 terminals designation listed in Specifications portion of Section 1 • Added instructions for modifying DECS-400 logic for compound machine paralleling
K, Apr-11	• Added *Exciter Diode Monitor* Settings in Section 3. • Added *Logic Definitions* in Appendix A • Improved descriptions of Modbus™ registers 40204, 40475, 40795, 40797, and 40799 in Appendix B
L, May-12	• Added exciter diode protection specifications to Section 1 • Made minor text edits in Section 2 • Added Voltage/Current Unbalance Detection to Section 3 • Added UEL internal curve equation to Section 3 • Clarified voltage balanced and unbalanced level descriptions in sections 3 and 4. Added Figures 4-30 and 4-31 • Changed conductor length from "238" to "328" in Section 5 • Removed Modbus™ registers 40602 and 40612 in Appendix B • Corrected Modbus™ register names 40701 through 40710 in Appendix B

Manual Revision and Date	Change
M, Mar-13	• Added information about adjustable traverse rate for the pre-position #1 and #2 setpoints • Added information covering reactive power limiter (VARL) operation • Revised description of transient boost function—is now based on the voltage setpoint • Added information about using BESTCOMS to convert DECS-300 settings files into DECS-400 settings files • Added equation for inverse timing of the takeover OEL • Added description of the PSS rate-of-change frequency blocking function • Made minor corrections to the default and predefined logic scheme illustrations • Added description and illustration of the logic timer configuration modes available • Updated Modbus register tables to reflect added functions • Replaced HMI illustrations with structured list of HMI screens and settings
N, Jun-13	• Restored previously removed descriptions for Modbus registers 40602 and 40612 • Corrected logic scheme illustrations of Appendix A • Corrected menu system entries listed in Section 2 • Listed the types and number of connections possible through communication port Com 3 • Added Modbus modes of operation descriptions to Sections 1 and 3
O	• This revision letter not used
P, Feb-14	• Added NIIPT, JSC Russian certification statement • Removed product registration information • Corrected Modbus™ register information for PF setpoints
Q	• This revision letter not used
R, Jan-15	• Converted manual into new style and structure • Minor text edits throughout manual
S, Jan-17	• Added caution statement about nonvolatile memory • Added and corrected Modbus® register entries • Minor, assorted edits throughout manual
T, Jun-17	• Improved PSS parameter ranges for Tl2, Tl3, Tr, and Ks. • Added Windows 10 compatibility • Added NVRAM Upgrade Tool • Added Phase Compensation parameters to Bode Plot screen
U, Jan-18	• Corrected axis descriptions in Figures 9 and 10. • Added loss of speed alarm description. • Added description of optional escutcheon and Figure 89. • Added firmware downgrade caution statement. • Removed GOST-R certification statement.
V, Nov-18	• Clarified description of volts per hertz limiter operation • Added information about grounding in applications with a DECS-400 that is mounted remotely • Clarified PSS model compliance • Added warning statements related to California Proposition 65
V1, May-19	• Added California Proposition 65 notice

Manual Revision and Date	Change
W, Apr-19	• Corrected field overcurrent protection reset equation • Added guidance for making connections to achieve CE compliance • Removed obsolete Modbus® register 43050
X, Mar-25	• Corrected inaccurate reference from RJ-45 jack to RJ-11 jack • Corrected Field Overcurrent Protection Reset Equation • Added chapter for math models • Clarified voltage matching band description

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