



Custom-designed DIGITAL EXCITATION CONTROL SYSTEMS For synchronous generators

Basler Electric engineers excitation systems to meet the specific needs of your power plant!

More than 60 years of experience in the Power Industry guarantee to provide all the advanced technology required to precisely control, protect and monitor virtually all types of synchronous generators. Today, Basler Electric boast a first-class, worldwide reputation for advanced product development, fully integrated with total precision design and manufacturing of complete excitation systems. Whether designed for **Steam, Gas, Diesel or Hydro** generator applications. The equipment is customised to meet your individual application requirements with an interface guaranteed to make your new, as well as your renovated, system perform.

Basler Electric provides Digital Excitation Control Systems rated up to 10,000A suitable for low voltage, medium voltage, and high voltage generators driven by all types of prime movers. This bulletin outlines a truly versatile design for Control Systems that are intended to operate as a voltage regulator for brushless generators or as a static exciter with ratings up to 3600A. *(For higher ratings, please contact your Basler representative).*

FEATURES

- Microprocessor based "Basler DECS" Digital Controller.
- $\pm 0.2\%$ Voltage Regulation Accuracy.
- Performance response $< 20\text{ms}$.
- Option for integrated Dual Input Power System Stabiliser Type PSS2A.
- Multiple Excitation Limiters with on-line and off-line settings.
- Built in Protection Functions within the DECS Controller.
- Enhanced protection through dedicated Relays.
- Full Redundancy Option for Power and Control sections.
- Auto tracking between Redundant Control Units.
- Full Wave Six - SCR Power Rectifier Bridges.
- Negative Field Forcing for highest system performance.
- Motorised Circuit Breaker or Contactor Option for Power Input.
- Multiple Fast Discharge Method options including Crowbar or DC Field Breaker.
- Boost Circuit option for short circuit support.
- Provisions for Field Flashing Circuit.
- Air Conditioned enclosure Option for extreme temperature environments.
- HMI Touch Screen for Local and/or Remote Monitoring and Control.
- Digital Communication.
- May be supplied CE Compliant, GOST-R Certified, CSA Certified or UL Recognised.

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B Basler Electric

BASLER ELECTRIC "DIGITAL EXCITATION CONTROL SYSTEMS" Type DECS-CUSTOM

Enhanced features for better generator systems control make **Basler Electric a reference for both New and Renovation applications**. Years of experience and results, coupled with Basler innovative state of the art technology, give global customers full confidence when entrusting total control projects to the Basler engineering team. We are proud to be in a position to custom design and manufacture, with a short turnaround time and in a way that will permit you to integrate our excitation control to almost any other manufacturer's main, auxiliary or peripheral equipment including distributed control systems (DCS).

Basler Custom Designed digital excitation control provides significant improvements in generator performance that make it possible to achieve a higher level of control of the generator system.

REPLACING OLD CONTROLS WITH MODERN CUSTOM-DESIGNED DIGITAL STATIC EXCITERS

Many power generation plants are faced with obsolescence, high maintenance and down time due to the excitation system. DC field breakers, motorized rheostats, rotating exciter failures, commutator deterioration, vibration and obsolescence of replacement parts for the automatic voltage regulator are just a few of the problems typical of these aged power plants. The result is high overheads and potentially long downtime of the generator system. Replacing a rotating exciter, a compound excitation system or an SCT/PPT control system with a Basler static excitation system provides a positive solution to all these problems. The static exciter offers the design flexibility of an easy retrofit for both small and larger rotating exciter systems. Additionally, it eliminates the maintenance overhead common to the brush type exciter.

Typical reasons that justify replacement of existing aging controls or rotating exciter are:

- Your uprated generators require more field excitation than the existing rotating exciter can provide.
- Your rotating exciter has shorted windings.
- Increased maintenance is affecting the reliability of your pilot exciters.
- Carbon dust from commutator brush wear is causing low insulation and stator overheating.
- You have safety concerns about asbestos insulation in rotary exciters.
- You are experiencing belt problems associated with separately connected rotating exciters.
- You have commutator problems such as sparking or dielectric breakdown caused by carbon dust.
- Your commutators are worn and require replacement.
- Your commutator brushes need frequent maintenance or are difficult to maintain properly.
- You cannot find parts for obsolete electromechanical voltage regulators and associated devices.
- DC field breakers are causing operating problems, and replacement is expensive, with long delivery times.
- You need to interface your exciter with automated supervisory controls to streamline your unit startup sequence and automatic synchronising procedures.
- You need fast system voltage recovery to improve relay coordination and to avoid nuisance tripping.
- You want to increase your operating efficiency and increase unit output by reducing the energy used for excitation.
- You do not have enough maintenance personnel to maintain your old rotating / electromechanical excitation system.
- You need the data recording capability and software tools available with digital exciter / regulators to simplify troubleshooting and to perform the periodic generator response testing required for certification.



TYPICAL CUSTOMIZED SYSTEMS – MAIN COMPONENTS

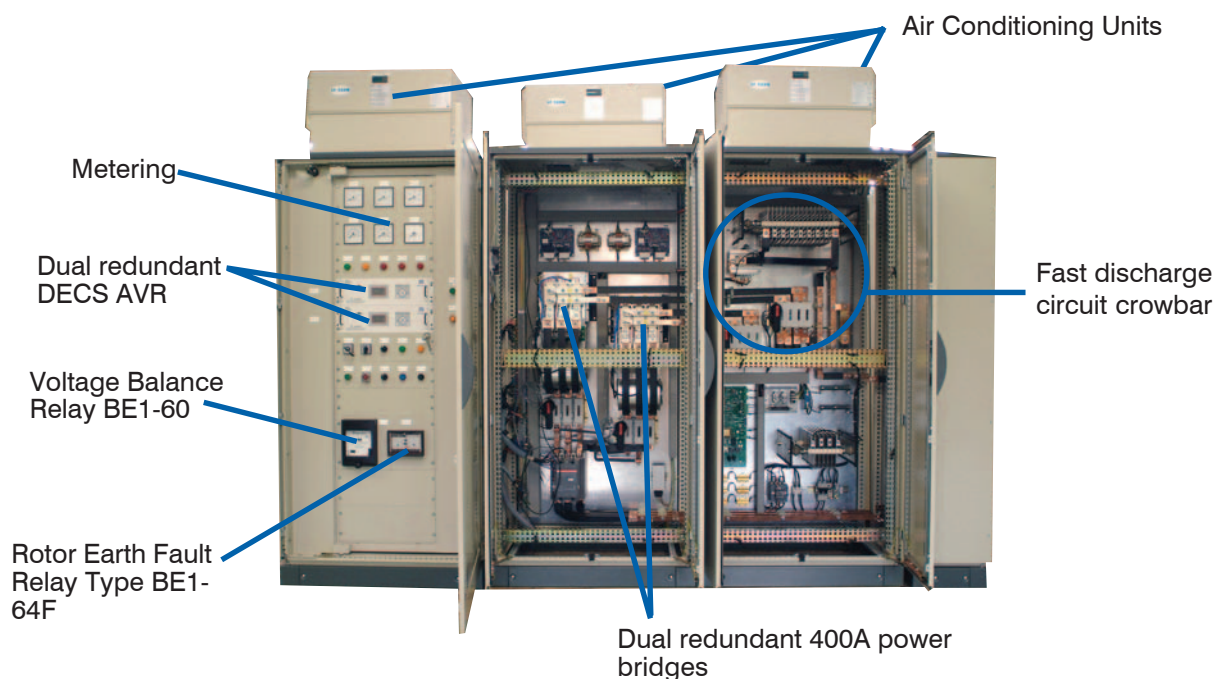


Figure 1 – Customized 400A Dual Channel System – As Built

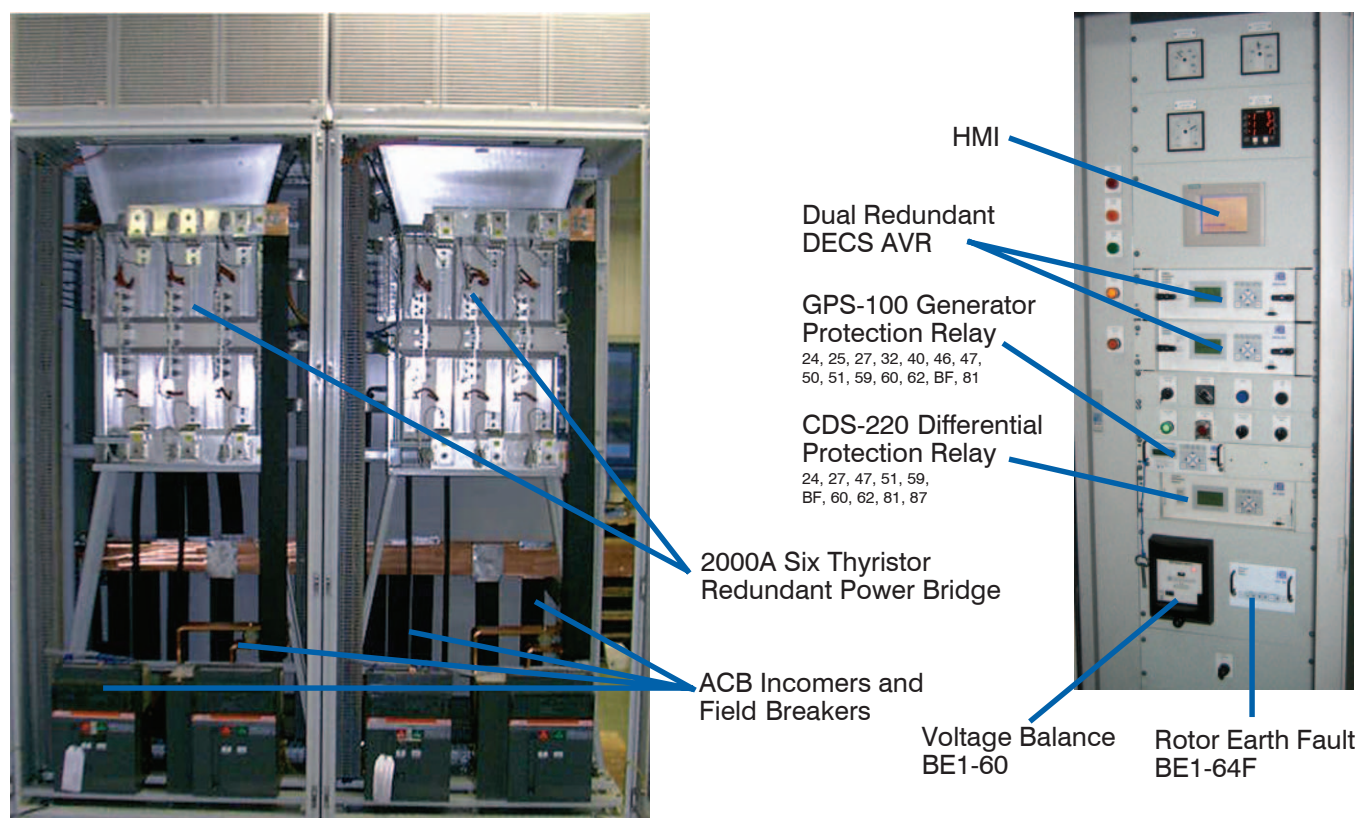


Figure 2 – Customized 2000A Dual Channel System – As Built

TYPICAL CUSTOMISED SYSTEM FUNCTIONAL DESCRIPTION

The basic principle of a static exciter regulator may be compared functionally to an automatic voltage regulator working directly into the exciter field. When the excitation system senses a low generator voltage, field current increases, and when a high generator voltage is sensed, the field current is decreased.

In the case of a static exciter, dc power is applied directly into the main field through slip rings.

A custom designed static excitation system may consist of several configurations; however, there are five fundamental components that always constitute the core of the system.

Fundamental components are:

- Control Electronics – DECS Digital AVR (page 4)
- Power Electronics – Thyristor Bridge (page 12)
- SCR Firing Card – Digital or Analogue (page 13)
- HMI – Touch screen or Switches (page 15)
- Power – Shunt Transformer or PMG (page 16)



The design of customised excitation systems permits virtually unlimited functional integration that is selected as most appropriate for your application. Proposed configurations include:

- Redundancy of the Power Electronics
- Redundancy of the Control Electronics
- Multiple Communication Protocol possibilities
- Digital Generator Protection Relays
- Remote control and integration to Distributed Control System (DCS) and Turbine Control Panel
- Boost Circuit for short circuit support
- Field Flashing Circuit
- Fast de-excitation circuits
- Automatic Synchronising
- Power System Stabiliser PSS 2A - IEEE Model
- Designed to fit specific space limitations.
- Mounting Plate assembly solutions to fit into your existing or auxiliary control cabinets.
- AC Units for high ambient and special filters for corrosive atmospheres such as H₂S.
- Designed to specific norms such as CSA, UL, GOST-R and IEC

CONTROL ELECTRONICS – AUTOMATIC EXCITATION REGULATOR – BASLER "DECS"

The heart of Basler Custom Designed Excitation Systems is based on Basler state of the art – DECS Digital AVR's. The DECS-400 is Basler's most recent high end micro-processor-based controller that provides excitation control, flexible logic control, and optional power system stabilization for synchronous machines in an integrated package.



Figure 3 - DECS-400

INTRODUCTION

The controller provides an analog output to control the DC output of an external rectifier bridge and monitors machine parameters to control, limit, and protect the synchronous machine from operating beyond its capability limitations. The optional Power System Stabilizer is an IEEE Type PSS2A, dual input, "integral of accelerating power" stabilizer that provides supplementary damping for low-frequency local mode, inter-area, and inter-unit power system oscillations. Setup and initial operation are facilitated by Basler Electric's user-friendly BESTCOMS PC software that incorporates real time monitoring test analysis, flexible oscillography, trending, and expanded testing capabilities, including means for performing frequency response tests with a graphic display of results. This replaces the need for an external Dynamic System Analyzer.

DECS FEATURES

- Microprocessor-based design
- 4 Control Modes, with autotracking between modes
 - Automatic Voltage Regulation (AVR)
 - Field Current Regulation (FCR)
 - Power Factor Regulation (PF)
 - Var Control
- 0.20% Voltage Regulation Accuracy
- Two pre-position set points for each mode
- Two Programmable Analog Outputs (Meter Drivers)
- Setup from Front Panel HMI or by PC
- 40 Standard Stability Settings
- Customizable Stability Setting with 2 PID setting groups
- Reactive Droop, Line Drop Compensation
- Voltage Soft-Start Buildup
- Real Time Metering for 19 Generator Parameters
- Voltage Matching
- Autotracking with Optional Backup DECS-400
- Flexible Remote Set point Control
 - Contact inputs
 - Proportional Analog input, ± 10 Vdc or 4-20 mA
 - Digital Communications
 - Local RS-232, ASCII, Modem Capabilities
 - RS-485, Modbus™
- Built-in limiting functions
 - Overexcitation Limiters - Summing Point or Takeover
 - Underexcitation Limiters - 5 point user programmable or internally generated, summing point or takeover
 - Dual Slope Voltz/Hz Ratio or Underfrequency Limiter
 - Stator Current Limiter (single phase or three phase)
- Built-in Protective Functions
 - Field Overvoltage and Overcurrent
 - Generator Undervoltage and Overvoltage
 - Loss of Sensing Voltage
 - Loss of Field (40Q)
 - Field Overtemperature (for main field)
 - Dual Slope Volts/Hertz (24)
 - Exciter Diode Failure (for brushless exciters)
 - Generator Frequency less than 10 Hz
- Optional Integral Power System Stabilizer
 - Dual input, integral of accelerating power
 - Customer selectable speed-only sensing
 - Two wattmeter power measurement
 - Optional Frequency Based Operation
 - Generator or Motor control modes
- IRIG Time synchronization
- Sixteen Contact inputs - 10 user-programmable
- Eight Contact Outputs - 6 user-programmable
- Metering
 - Two 4-20mA meter drivers
 - Customer programmable
- Four Communication Ports
- Data Logging, Sequence of Events Recording, Trending, real time monitoring test analysis, and built-in frequency response test capabilities
- UL recognized, CSA certified, CE compliant, GOST-R certified #POCC US.ME05.B03393

DECS SPECIFICATIONS

DECS-400 Specifications are listed in the following paragraphs.

Operating Power

<i>DECS-400 L:</i>	24/48Vdc nominal (16-60Vdc), Burden=30W.
<i>DECS-400 C:</i>	120Vac nominal (85-132Vac, 50 or 60Hz), Burden=50VA. 125Vdc nominal (90-150Vdc), Burden=30W.

Generator Voltage Sensing

Single-phase or three-phase line voltage, two ranges:

- 100V/50Hz nominal (85-127Vac), 120V/60Hz nominal (94-153V)
- 200V/50Hz nominal (170-254Vac), 240V/60Hz nominal (187-305V)

Bus Voltage Sensing

Single-phase line voltage, two ranges:

- 100V/50Hz nominal (85-127V), 120V/60Hz (94 -153V)
- 200V/50Hz nominal (170 -254V), 240V/60Hz (187-305V)

DECS SPECIFICATIONS, continued

Generator Current Sensing	Single or three phases; separate cross-current compensation input. 1 A ac or 5 A ac nominal.
Sensing Burden	Voltage: <1 VA per phase. Current: <1 VA. Parallel Compensation: <1VA.
Field Voltage and Current Isolation Module	Field current and voltage values are provided by the Isolation Module. Power +5 Vdc, ±12 Vdc from DECS-400. Five field voltage sensing ranges: 63 Vdc, 125 Vdc, 250 Vdc, 375 Vdc, and 625 Vdc Output: 0.9-9.1 Vdc (5.0 Vdc = zero field volts) Two nominal shunt ranges: 50 mVdc and 100 mVdc Output: 2.0-9.5 Vdc (2.0 Vdc = zero field current)

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

- Fixed Function Inputs*
- AVR*
 - FCR*
 - Lower**
 - Raise**
 - Start*
 - Stop*
- *Functions activated by a momentary input. **Functions active only when corresponding contact input is active.

- Programmable Inputs*
Any of the 10 programmable inputs can be programmed with the following functions. However, these are normally preassigned by selecting one of the preprogrammed logic schemes.
- 2nd PID settings
 - Pre-Position
 - Reactive Droop Compensation Enable
 - PSS Enable
 - PSS Motor Pump/Generator Mode
 - PSS Parameters Set Selection
 - Phase Rotation
 - Unit/Parallel Operation (52 L/M)
 - Var/Power Factor Enable (52 J/K)
 - Secondary Enable
 - Reactive Differential Compensation Enable
 - 2nd Pre-Position

Accessory Input (Remote Set Point Control)
Analog input for remote set point control. Select one of two configurations: ±10 Vdc or 4-20 mA dc.

Control Outputs
Isolated analog output for set point control. Output drives external Firing Circuit/Rectifier Bridge. Select one of three configurations: ±10 Vdc, 0-10 Vdc, or 4-20 milliamperes dc.

Meter Drivers
Two programmable 4 to 20 mA analog meter drivers. Meter side isolated from DECS-400. Programmable to meter field voltage or current, generator voltage or current, bus voltage, generator or bus frequency, active power, reactive power, apparent power, power factor, field temperature, tracking error, position indication and PSS parameters. 64 selectable parameters in all.

Contact Outputs
Two dedicated contact outputs and six programmable contact outputs.
Make 30 A for 0.2 seconds per IEEE C37.90; Carry 7 A continuous. Break (Resistive or Inductive) 0.3 A at 120 Vdc or 250 Vdc (L/R = 0.04 maximum)

<i>Dedicated Outputs</i>	<i>Programmable Outputs</i>	(All programmed through integrated logic; however, they are normally preassigned when using one of the pre-programmed logic schemes.)
• Watchdog	• DECS-400 Status	
• On/Off	• Active Limiter Functions	
• Active Alarms	• Active Protective Functions	

Communication Ports	
COM 0	RS-232 front panel female DB-9, 1200-19200 Baud, 8N1 Full Duplex, ASCII commands
COM 1	RS-485 rear panel screw terminals, 4800-19200 Baud, 8N1 Half Duplex, ASCII commands
COM 2	RS-485 rear panel screw terminals, 4800-19200 Baud, 8N2 Half Duplex, Modbus™ protocol
J1	FCC Part 68 approved modem, rear panel RJ-11

DECS SPECIFICATIONS, continued

IRIG-B Time Sync

Standard: 200-98, Format B002, Demodulated (dc level-shifted digital signal)

Regulation Accuracy

AVR Mode Voltage regulation $\pm 0.2\%$ over the load range, at rated power factor and constant generator frequency. Steady state stability is $\pm 0.1\%$ at constant load and frequency. Temperature Stability $\pm 0.5\%$ between 0 to 50°C at constant load and frequency. Response Time < 1 cycle.

FCR Mode Field Current Regulation is $\pm 1.0\%$ of the nominal value for 10% of the rectifier bridge input voltage change or 20% of the field resistance change. Otherwise, $\pm 5.0\%$.

VAR Control Mode Reactive Power Regulation is $\pm 2.0\%$ of the nominal VA rating at the rated frequency.

PF Control Mode ± 0.02 Power Factor for real power between 10 and 100% at rated frequency. (e.g. set point PF = 0.8, PF regulation is between 0.78 and 0.82)

Metering Accuracy

Generator and Bus Voltage:	$\pm 1.0\%$	Generator and Bus Frequency:	± 0.1 Hz
Generator Line Current:	$\pm 1.0\%$	Power Factor:	± 0.02 PF
Field Current and Voltage:	$\pm 2.0\%$	Aux. Voltage and Current Input:	$\pm 1.0\%$
Generator Power:	Apparent Power (VA) $\pm 2.0\%$; Active Power (W) $\pm 2.0\%$; Reactive Power (var) $\pm 2.0\%$		

Power System Stabilizer (PSS)

Operating Mode: Generator or Motor, ABC or ACB phase sequence
Sensing Configuration: Power and Speed or Speed only
Power Measurement: 2 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.

Soft Start Two sets of soft start settings are available when operating in AVR or FCR mode. Bias level is adjustable from 0-90% in 1% increments; time to reach nominal value is adjustable from 1-7,200 s in 1 s increments.

Sequence of Events Recording Events are time- and date-stamped and stored in volatile memory. 127 event capacity, 50 ms scan interval. SER can be triggered by input/output status changes, alarms, or system operating status changes.

Data Logging (Oscillography) Stores 6 records, with up to 6 variables per record. Sampling rate: 600 data points per record, pre-trigger adjustable from 0 to 599 data points. Record interval adjustable from 4 ms to 10 s.

Trending Stores 1 record, with up to 6 variables per record. Sampling rate is 1200 data points per record, with total record duration adjustable from 1 hour to 30 days.

Paralleling/Line Drop Compensation Can use either reactive droop or reactive differential (cross-current) compensation. Droop adjustable from 0% to 30% in 0.1% increments. Parallel compensation burden is less than 1 VA. Negative droop settings provide line drop compensation. Adjustable from -30% to 0% in 0.1% increments.

Limiters

Underfrequency Compensation Choice: Underfrequency compensation with slope adjustable from 0 to 3.00 PU in .01 PU increments and knee frequency between 15 and 90 Hz, or Volts/Hertz ratio limiter with slope adjustable from 0 to 3.0 PU in 0.1 PU increments. Provisions for two levels of protection, with duration of high V/Hz limit adjustable in the range of 0 to 10 s.

Overexcitation On-line and off-line limiters provided, each a choice between summing point and takeover type controllers. Dual settings groups. Provisions to scale settings for both type limiters based on an auxiliary analog input (by others) representing air temperature, hydrogen pressure, etc. Includes a cool down feature to prohibit repeated high forcing level operation that could be damaging to the rotor.

DECS SPECIFICATIONS, continued

Summing Point Type OEL Limiter response time is less than three cycles.

- On-Line
 - Level One – Highest current level (instantaneous) set point adjustable from 0 to 11,999Adc in 0.1% increments of the rated field current. Limiting occurs for a time period ranging from 0 to 60 seconds, settable in 1 second increments.
 - Level Two – Medium current level set point adjustable from 0 to 11,999Adc in 0.1% increments of the rated field current. Limiting occurs for a time period ranging from 0 to 120 seconds, settable in 1 second increments.
 - Level Three – Lowest current level set point adjustable from 0 to 11,999Adc in 0.1% increments of the rated field current. Limiting occurs indefinitely.
- Off-Line
 - Level One – Highest current level set point adjustable from 0 to 11,999Adc in 0.1% increments of the rated field current. Limiting occurs for a time period ranging from 0 to 60 seconds, settable in 1 second increments.
 - Level Two – Lowest current level set point adjustable from 0 to 11,999Adc in 0.1% increments of the rated field current. Limiting occurs indefinitely.

Takeover Type OEL The Takeover OEL uses an I²t characteristic. Limiter response time is less than three cycles.

- On-Line
 - High Level – High current level (instantaneous) set point is adjustable from 0 to 11,999 Adc in 0.1 Adc increments.
 - Low Level – Low current set point is adjustable from 0 to 11,999 Adc in 0.1 Adc increments. Limiting occurs indefinitely.
 - Time Dial – This setting determines the inverse time curve selected.
- Off-Line
 - High Level – High current level (instantaneous) set point is adjustable from 0 to 11,999 Adc in 0.1 Adc increments.
 - Low Level – Low current set point is adjustable from 0 to 11,999 Adc in 0.1 Adc increments. Limiting occurs indefinitely.
 - Time Dial – This setting determines the inverse time curve selected.

Underexcitation Customer selectable summing point type of takeover type limiter. The UEL curve can be selected either by specifying acceptable reactive power level at zero active power output, or by entering a five point UEL characteristic. Dual settings groups available. UEL limiter adjusts characteristics with changes in terminal voltage.

Stator Current Single or three phase stator current limiter, adjustable between 100% and 300% of nominal generator output current. Includes a two-step limiter with a definite time delay for the higher limit level, adjustable between 0 and 60 s. Summing point type limiter with PI control loop.

Protection Functions

- Field Overvoltage* Range 1 to 2000 Vdc, time delay 0.2 to 30 s, dual setting groups
- Field Overcurrent* Range from 0.1 to 9,999 Adc, time delay 0.1 to 20 s, dual setting groups
- Generator Undervoltage* Range from 0 to 34,500 Vac, time delay 0.5 to 60 s, dual setting groups
- Generator Overvoltage* Range from 0 to 34,500 Vac, time delay 0.1 to 60 s, dual setting groups
- Loss of Sensing Voltage* Pickup level 0 to 100% with balanced or unbalanced conditions; time delay 0 to 30s
- Generator Frequency* <10 Hertz
- Loss of Field (40Q)* Range 0 to 3000 Mvar, time delay 0 to 9.9 s
- Field Overtemperature* Calculated from field voltage and current. Setting range from 0 to 572°C, time delay from 0.1 to 60s
- Volts per Hertz (24)* Range from 0.5 to 6 V/Hz, integrating reset range 0 to 9.9 V/Hz
- Exciter Diode Failure* Shorted and/or Open; Exciter to Stator Poles Ratio less than or equal to 10, generator frequency range 40 to 70 Hz (for brushless exciter applications)

DECS SPECIFICATIONS, continued

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	Impulse:	IEC 60255-5
Surge Withstand Capability:	IEEE C37.90.1-1989	Radio Frequency Interference:	IEEE C37.90.2
Electrostatic Discharge:	IEEE C37.90.3 Draft 2.3		

Agencies

CE Compliant
 UL recognized per Standard 508 and Standard CAN/CSA-C22-2
 Number 14-M91, UL File Number E97035.
 GOST-R certified #POCC US.ME05.B03393

Environment

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

DECS FEATURES/FUNCTIONS

Voltage Regulation

The DECS-400 regulates the generator RMS voltage to within 0.20% from no-load to full-load, utilizing digital signal processing and precise regulation algorithms developed by Basler Electric, using the experience gained over longer than a decade of manufacturing tens of thousands of digital voltage regulators.

Output

The DECS-400 supplies an isolated output signal of 4-20 mA, 0-10 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 or the exciter. The DECS-400 can control virtually any bridge capable of accepting these signals, that is suitable for use on synchronous generators/motors.

Stability

The DECS-400 utilizes proportional (P), integral (I) and derivative (D) stability control. DECS-400 has preprogrammed stability (PID) settings for both main field (20 settings) and exciter field (20 settings) applications. Thus, a suitable standard stability set is available for most machines and applications. The DECS-400 also provides an additional setting group that can be customized to provide optimum generator transient performance. Setup software includes a PID selection program to assist in choosing the correct PID settings. The DECS-400 also provides for customizing the stability and transient performance of the minimum and maximum Excitation Limiters, the VAR/ PF controllers, and the stator current limiter, by providing additional stability adjustments.

Two PID Setting Groups

The DEC-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 off line.

Optional Power System Stabilizer

The DECS-400 may be purchased with an integral Power System Stabilizer function that 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 Hz 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 programmed to respond to frequency only if required for unusual applications. Required inputs include three phase voltages and two or three phase line currents.

Underfrequency Limiter or V/Hz Ratio Limiter

DECS-400 includes a customer selectable choice of an Underfrequency Limiter or a V/Hz Ratio Limiter to avoid overfluxing the generator or other connected magnetic devices. The under-frequency limiter slope can be set at 0-3 PU Volts/Hz in 0.1 PU increments, and the frequency roll-off kneepoint can be set across a range of 15 to 90 Hz, in 0.1Hz increments, with fixed voltage above the knee frequency. The V/Hz Ratio Limiter regulates voltage based on a customer defined V/Hz

DECS FEATURES/FUNCTIONS, continued

slope adjustable between 0.0 and 3.0 PU, and includes two limiting levels to permit operation above the primary V/Hz range for a customer adjustable time limit to inhibit limiter response to transient frequency or voltage excursions.

Soft-Start Voltage Buildup

The DECS-400 includes a voltage soft-start feature with a user-adjustable setting to control the rate at which the generator voltage is allowed to build up and to prevent voltage overshoot during start-up of the generator system. The soft-start feature is active in both AVR and FCR modes.

Reactive Droop and Line Drop Compensation

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

Set Point Control

DECS-400 includes means for external adjustment of the set point of the controlling mode of operation using raise/lower contact inputs or an auxiliary analog input of 4-20 mA or ± 10 Vdc. The active mode set point may also be adjusted using BESTCOMS Windows® based software in a PC connected to the RS-232 communication port, or using Modbus™ protocol (floating point) to communicate digitally using the RS-485 port. The traverse rates of all modes of operation are independently adjustable, so the operator can customize the rate of adjustment and "feel" to meet his/her needs.

Dual Pre-position Inputs

DECS-400 provides the added flexibility of two customer-adjustable sets of predetermined operating points for each mode of operation. On startup and with the appropriate contact inputs to the DECS-400, the operating mode is driven to one of two preset operating or regulation levels, depending on the configuration of the system. This feature allows the DECS-400 to be configured for multiple system and application needs.

Field Current Regulation Operating Mode

DECS-400 provides a manual channel of operation called Field Current Regulation (FCR) Mode. In this

mode, DECS-400 regulates the DC output current of the power bridge. It is not dependent on the generator voltage sensing input to the DECS-400 and, therefore, provides backup excitation control when loss of sensing is detected. In FCR mode, the operator must manually vary field current to maintain nominal generator voltage as load varies.

VAR/Power Factor Controller Operating Mode

DECS-400 has two additional control modes for use when the generator is operating in parallel with the utility power grid. In the VAR control mode, the DECS-400 can regulate the VAR output of the generator at an operator adjustable VAR setting or, in the Power Factor mode, it can control the VAR output of the generator 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 cooldown 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 type limiter is applied to the summing junction of the AVR control loop in addition to the AVR controller output, while the output of a takeover type limiter overrides the normal AVR output.

Summing Point Type 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 high and medium 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 Type OEL

The Takeover-style Overexcitation Limiter determines the field current level at which limiting occurs using an inverse time characteristic. Two current levels and a time dial setting are defined for the takeover-style 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. The selection of on-line or off-line OEL levels and curves is determined by an OEL option selection.

DECS FEATURES/FUNCTIONS, continued

Minimum Excitation Limiter

The Minimum Excitation Limiter prevents the excitation being supplied to the field of the generator from dropping below safe operating levels. This prevents the machine from possibly slipping poles and damaging the machine. This action also limits the amount of VARs being absorbed by the machine, based on user-definable settings. An internally generated Under-excitation Limiting (UEL) curve based on a permissible VAR level at 0kW can be utilized, or a 5 point UEL curve can be created to match specific generator characteristics. UEL Limiter action is optional in FCR mode.

Stator Current Limiter

The stator current limiter (SCL) senses the level of stator current and limits it to prevent stator overheating. The SCL operates in all modes except FCR. In FCR mode, the DECS-400 provides indication that a stator overcurrent condition exists, but limiter action is inhibited. Two SCL current levels are provided: high and low. The generator can operate continuously at the low SCL level, but only for a programmed time at the high SCL level.

Autotracking Between DECS-400 Operating Modes

DECS-400 is an intelligent device that can provide autotracking (autofollowing) 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

The protective functions built into the DECS-400 may be used as backup to the primary protection relays and can be assigned to up to six programmable output contacts via the PC software. The protection features offer fully adjustable tripping levels and time delays. The protective features are as follows:

- Generator Overvoltage*
- Generator Undervoltage*
- Field Overvoltage*
- Field Overcurrent*
- Field Overtemperature*
- Loss of Field*
- Loss of Voltage Sensing
- Microprocessor Watchdog
- Loss of Field Isolation Transducer
- Volts/Hertz Protection
- Exciter Diode Open (Brushless App.)
- Exciter Diode Shorted (Brushless App.)

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

Integrated Logic

The DECS-400 utilizes integrated 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 logic module can be used to control the relay outputs as well as various other functions inside the DECS 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 includes tools for customizing the system control logic for specific applications.

Metering

The DECS-400 is provided with two programmable 4 to 20 mA analog meter drivers for the customer's use. The meter side is isolated from the DECS-400 circuitry. Either can be programmed to meter a broad range of generator and system parameters. 64 parameters are available.

Sequence of Events Recording (SER)

A sequence of events report (SER) is a very powerful tool for reconstructing the exact timing of an event or disturbance. The DECS-400 monitors its contact inputs and outputs for changes of state, system operation changes, and alarm conditions. If any of these events occurs, the DECS-400 will log that event with a date and time stamp using IRIG B and an internal clock with optional battery backup, allowing the user to analyze a chain of events with accurate information regarding the sequence in which they occurred. The DECS-400 can store 127 events in volatile memory, and those events are retrievable using BESTCOMS.

Oscillography

The data recording feature can record up to six (6) oscillographic records stored in volatile memory. The user can select up to six (6) variables to be monitored when triggered by the DECS-400 BESTCOMS, a Logic Trigger, or a Level Trigger. Variables that can be selected are: generator voltage, current (single phase), frequency, kW, Power Factor, field voltage,

DECS FEATURES/FUNCTIONS, continued

and field current. The user can utilize the DECS-400 BESTCOMS to trigger and save a record of a voltage step response during commissioning. Once commissioned, 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 exceeds a predetermined setting, such as when the exciter field current exceeds a predetermined setting.

The 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 allows the user to view the oscillography records saved by the DECS-400.

Real Time Monitoring

The DECS-400 also provides for real time monitoring for any of the parameters available for oscillography. The real time monitoring screen will display two parameters at a time, and data can be stored in a file for later examination.

Internal Testing Provisions

Using BESTCOMS, the operator can set up and run both frequency and step response tests to facilitate commissioning or to demonstrate system performance. The frequency response test has a frequency range from 0.1 to 10 Hz, 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. This feature eliminates the need for an external Dynamic System Analyzer (DSA) and associated transducers.

Communications

DECS-400 comes complete with Windows® based PC software designed to make the programming and customization of the DECS-400 easy and fast. The software includes a PID selection program that allows the user to select stability settings quickly and easily in a user-friendly format. The PC software has monitoring screens that allow the user to view all settings, metering screens for viewing all machine parameters, and control screens for remote control of the excitation system. The rear-mounted RS-485 port supports Modbus™ (floating point) communications protocol. This is an open protocol with all registers and operating instructions available in the instruction manual, to make it simple for the user to develop custom communications software. A rear-mounted modem is also provided to facilitate access to DECS-400 settings and alarms from remote locations.

Password Protection

All DECS-400 parameters are viewable via the front panel LCD display, the PC software, or via 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 for global access to all parameters and one for limited access to parameters normally associated with operator control.

POWER CONVERTER ASSEMBLY SECTION

The power converter assembly uses thyristors in a three-phase configuration. The configuration selected may be either a 3 SCR half wave rectifier bridge or a 6 SCR full wave bridge. The 6 SCR bridge applies positive and negative forcing voltage to the generator field for dual directional forcing of field voltage. Both 3 and 6 SCR bridges include heat sinks and/or cooling fans containing the power semiconductors, in-line current limiting fuses, fuse blow indicators and an RC network for filtering of any spikes. These components are all mounted together on a chassis that forms the rectifier bridge.

SIX THYRISTOR SYSTEM

For machines greater than 10 - 20 MVA, or above 150 amperes on the field, the 6 thyristor system is generally preferred. Although the reaction time of the 3 thyristor system can be very responsive, its output performance is limited to a positive ceiling voltage in the field circuit. When fast generator voltage changes are required, the zero minimum voltage on the 3 thyristor bridge limits the speed of voltage decay, while the voltage recovery time will be related to the rate of field decay caused by the freewheeling diode located across the field. The 6 thyristor bridge identifies a two quadrant system because the field output voltage swings both the positive and negative directions, allowing faster machine voltage recovery. When the 6 thyristor full wave bridge gates in the negative direction, the power flows from the field back into the machine via a power potential transformer.

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS

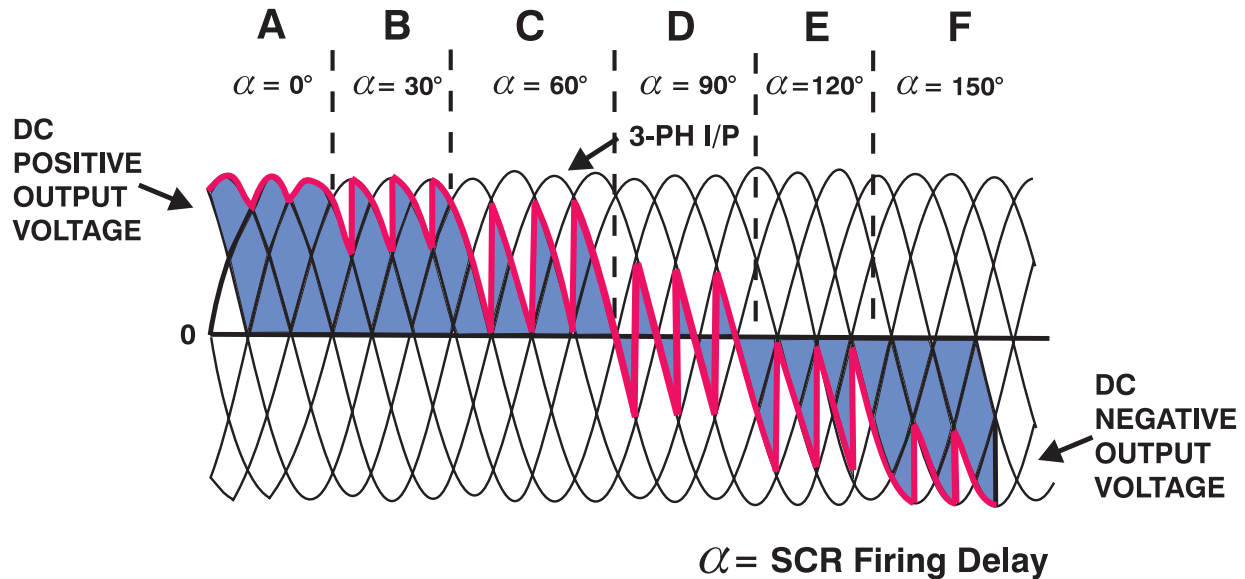


Figure 4 – SCR Firing Delay

The maximum thyristor conduction at the field occurs when the generator voltage becomes depressed, such as during a momentary system fault. Figure 4 identifies the power thyristors output typical of a system that has a depressed generator voltage at locations A, B and C. Note how the conduction angle changes from 0 to 60 degrees positive as the AVR commands low field power. When angle = 0, maximum field forcing voltage is available. During normal generator loading, the thyristors are phased on at Location D, with a conduction angle of approximately 90 degrees. When the generator voltage raises above the set point, thyristor output conduction immediately goes negative to quickly collapse the field flux. The thyristor output may vary from 120 to 150 degrees maximum conduction. See location E and F.

FIRING MODULE OPTIONS

ANALOGUE FIRING MODULE

The variable frequency three phase firing circuit board produces six sets of high current SCR gate pulses. Each set consists of a burst of duty cycle pulses having a carrier frequency that is a phase locked multiple (384) of the mains frequency. The initial pulse of each burst is delayed by an angle α from the line-to-line crossing of the associated mains voltage. The delay angle varies in negative proportion to a voltage or milliamp delay enable command signal. The gate pulse burst profile is selected to provide a precise circuit suitable for use with the SCR controller included.



Figure 5 – Example, Analogue Firing Module

Analogue firing cards are suitable for a large spectrum of input frequencies. Typical readily available are 50 – 400Hz+. An open collector transistor is provided for use as an external Enable/Inhibit indicator. If any portion of the applied waveform is outside of the window (due to a phase loss or large phase imbalance), the inhibit circuit is activated (phase loss information).

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS, continued

DIGITAL FIRING MODULE



Figure 6 – BASLER IFM-150 Firing Module

Interface Firing Module receives a control signal from the AVR and then calculates a time delay based on the zero crossing of each phase of voltage from the synchronizing transformer. At the end of the time delay, the IFM-150 produces properly synchronized pairs of pulses to drive the SCRs of the excitation system rectifier chassis. As the AVR control signal increases (or decreases), the time interval between the zero crossing of each phase voltage and the start of its next output pulse decreases (or increases). This results in an increase (or decrease) in the rectifier chassis output voltage. A terminal voltage limiter within the IFM-150 can be enabled to monitor the line voltage through the synchronising transformer and compare the measurement with a user-adjustable reference level (generator application). If the voltage exceeds the reference level for a user-adjustable amount of time, the IFM-150 will modify the SCR firing pulses and limit the generator voltage.

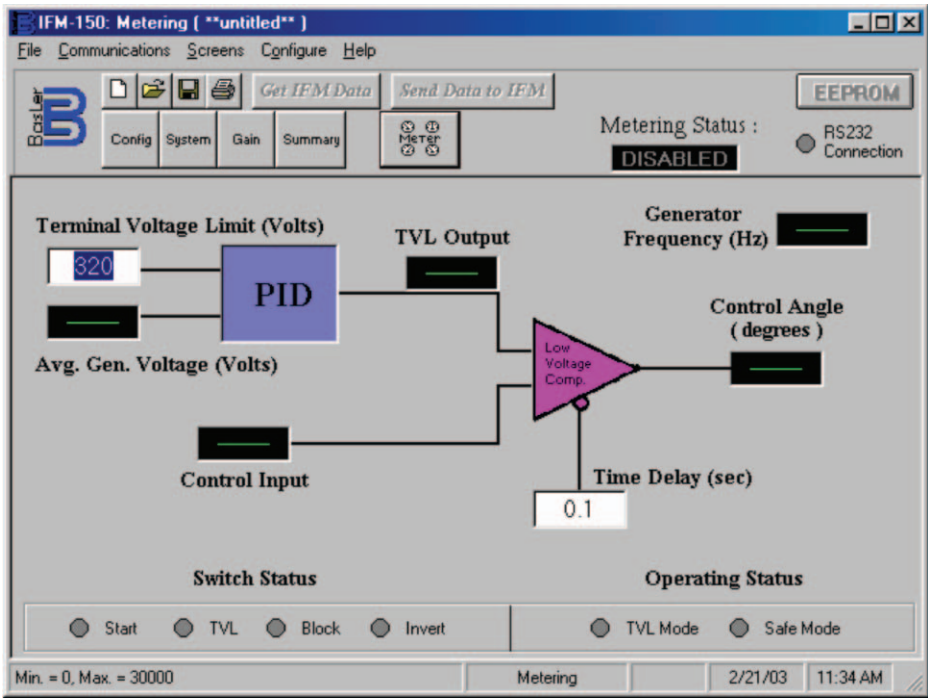


Figure 7 – IFM-150 Metering Screen

Setting changes in the IFM-150 are made by using ASCII communication commands transmitted through the RS-232 communication connector. Terminal emulation software such as Windows® HyperTerminal can be used with a personal computer (PC) to send setting commands to the IFM-150. The better configuration choice is to use the BESTCOMS software delivered with the product. This software provides the communication link between the IFM150 and the user. All IFM150 settings are entered through BESTCOMS and all metering values are read through BESTCOMS. PID (Proportional + Integral + Derivative) software within BESTCOMS enables the user to establish proper PID parameters based on specified exciter time constants. Within BESTCOMS, IFM-150 settings can be saved in a computer file and used later to configure other units with the same settings.

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS

FAST DISCHARGE CIRCUIT

INTRODUCTION

The excitation system must withstand faults or abnormal system operating conditions that are caused by transients induced into the generator field. These conditions occur when major system short circuits (faults), having little impedance between the fault and the generator, occur or when a synchronous machine pulls out-of-step. A generator pulls out-of-step, or loses synchronism, when insufficient excitation is available for the amount of Megawatts being delivered into the power system. Most voltage transients are less than 150 microseconds in duration and are clamped by a low power device(s) such as a metal oxide varistor(s). Voltage transients caused by major system faults, however, require larger power handling devices to dissipate the energy being induced into the field without producing potentially damaging field overvoltages. Excessively high voltage transients can damage power semiconductors in the power rectifier bridge.

DISCHARGE CIRCUIT OPTIONS

Basler offer several options to prevent this high transient, and the best one for you depends mainly on customer choice with close attention to the application. After deciding on the preferred switching method, the circuit is completed with a power resistor placed in series with the continuity circuit. This method considerably decreases the discharge duration. The resistor is sized according to your generator data and usually to the maximum possible value in order to keep the voltage on its terminals during the discharge at an acceptable level. The type of resistor may be selected of the linear or nonlinear type. In nonlinear requirements the component we include is usually a varistor, and availability depends on size required. The particularity of this device is that the resistor value is very high when the voltage applied is low, and then becomes very low when the voltage applied reaches a certain knee point. The varistor also is used to protect the field in case any high voltage transients appear on the field.

DISCHARGE CIRCUIT SWITCHING OPTIONS

Typical switching options available in Basler custom designed excitation systems are as described below.

DC FIELD BREAKER

The continuity circuit with a dc field breaker is made of a DC field contactor or breaker. This is a specific DC contactor specifically designed for disconnecting inductive loads. The contactor includes 2 normally open poles and 1 normally closed pole. During the opening/closing transition of the contactor, there is an overlapping zone, while all poles are closed, in order to never stop the field current loop. *(The DC Field Breaker option may also be designed to include a crowbar)*. See Figure 10.

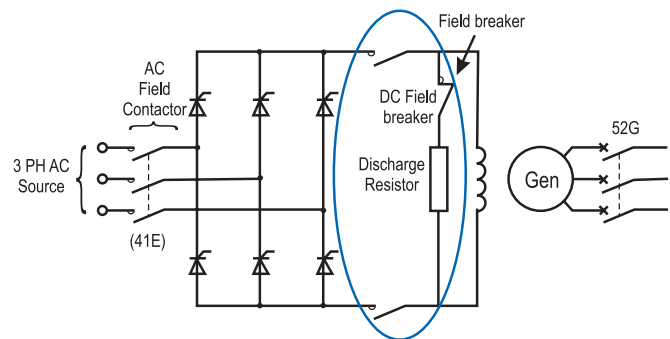


Figure 8 – DC Field Breaker

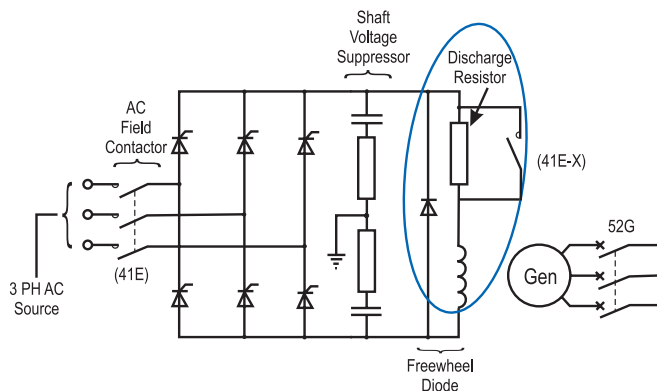


Figure 9 – Free Wheel Diode

FREE WHEEL DIODE

This type of discharge method includes for half wave rectification and, in this case, the continuity circuit is made by using a free wheel diode (Fig. 11) placed in parallel with the excitation circuit. As the excitation voltage is always positive, the diode only begins conducting when the power is turned off. The free wheel diode handles the current until it is brought down to zero.

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS, continued

CROWBAR CIRCUIT

The continuity circuit is made of a crowbar. 2 SCRs are mounted in anti-parallel, and controlled by a firing circuit. This system has a dual function: it realizes the continuity circuit, and it also protects the field during transient overvoltages positive or negative (such as during a pole slip). When a transient that is caused by a short circuit is induced into the field, a large negative voltage and positive current results. During this condition, the peak current from the fault will combine with the rectifier output and overload the rectifier bridge. A directional voltage sensitive crowbar circuit detects a specific overvoltage level that is negative and gates on SCR(A). In Fig. 10, SCR(A) shunts the positive current from the field through the discharge resistor and simultaneously disables the 6 SCR rectifier bridge to prevent overload. The MOV clamps the voltage for the initial 200 microseconds until the crowbar takes over.

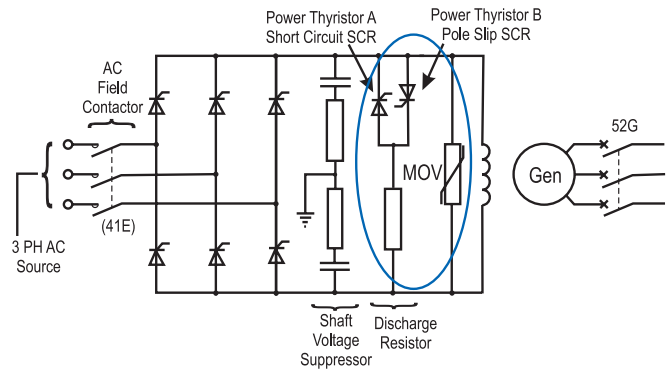


Figure 10 – Crowbar Circuit

Features of the Crowbar SCR Shunting System:

- Response time less than 200 microseconds.
- No contacts in the field circuit.
- Predictable overvoltage turn-on of crowbar SCRs.
- Low cost, reliable, short lead time.
- No maintenance (compared to DC Breaker).
- 50 times faster than a DC Breaker

HUMAN MACHINE INTERFACE – HMI

PUSHBUTTONS AND SWITCHES

The excitation control cubicle is designed for local/remote control and includes as a minimum:

- PUSHBUTTONS: Lamp test, Reset, Excitation ON, Excitation OFF (with protection cover)
- SWITCHES: Voltmeter phase switch (if applicable), AUTO/MANUAL mode switch (with centre position), AVR Raise/Lower (with centre position), Remote / Local control keyed selector switch.

The selection between the local or remote control mode is done by means of a key protected switch. The key can only be removed in the remote position, and this function disables the front door pushbuttons in the normal mode of operation. During commissioning, or if specific operations such as maintenance are required, the key is necessary to enable local control mode. This will, in turn, disable the remote control I/O.

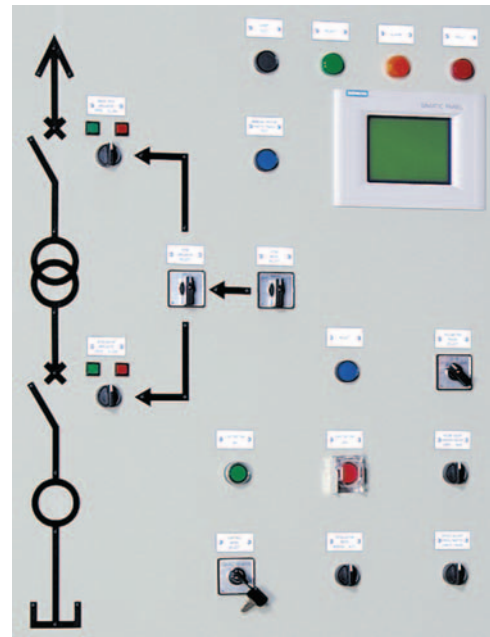


Figure 11 – HMI and Touch Screen

TOUCH SCREEN

Optionally, the system may be designed to include for HMI through a touch screen of your choice. When a PLC is included, the touch screen is usually selected to be compatible with the PLC to facilitate communication through the same protocol. The most commonly selected HMI touch screen currently used with Basler custom designed excitation systems is the Siemens touch screen type TP177A or similar.

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS, continued

REMOTE DISPLAY PANEL

The RDP-300 Remote Display Panel is a Human-Machine Interface (HMI) option used with single or dual DECS based Digital Excitation Control Systems to provide remote control, to view metered quantities, and to provide annunciation of digital controller status and alarms. The RDP-300 uses a touch sensitive six inch diagonal monitoring screen with RS-485 Modbus communication protocol, which may be located up to 1km away from the DECS Controller(s).

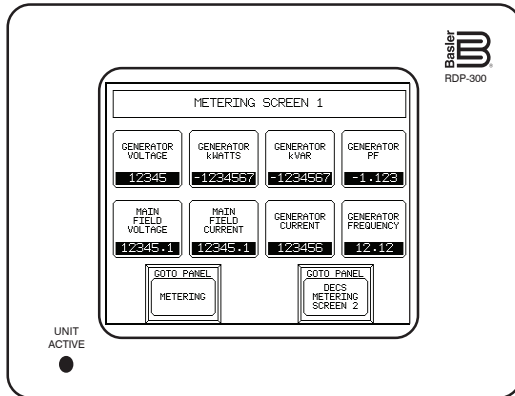


Figure 12 – RDP-300

RDP-300 Features include:

- 6 inch (diagonal) monochrome LCD with fluorescent backlight.
- Low power consumption.
- Suitable for semi-flush mounting.
- User-friendly Touch Screen Navigation Map for easy system control and monitoring.
- Metering, Control and Status screens provide alarm indication with one-touch transfer to Alarm screen.
- For dual controller applications, Title Bar on each screen identifies which controller is controlling.
- Includes provision for Operator confirmation of control changes.
- RS-485 serial communications with DECS for easy installation.
- Factory programmed and tested for immediate use.

SHUNT EXCITATION – POWER POTENTIAL TRANSFORMER (PPT)

Power for the excitation system is usually derived from the generator via a large kVA Power transformer. It will be designed to step down the generator terminal voltage (HV, MV or LV) to be compatible with the generator field requirements. The transformer will provide the excitation system's full load rating, including a small margin to accommodate for field forcing required to handle the generator transient overload requirements. The power (kVA) and secondary voltage will be selected to limit the maximum amount of power delivered to the field under forcing conditions. Typically, the PPT is sized to have a forcing ratio (Max. voltage / Nominal voltage) of 1.6 to 3 pu. A power potential transformer could be replaced by any other 50 – 400Hz source (such as PMG or Aux winding), as long as the power needed for the excitation is available. The power transformer is usually delivered loose for on-site installation. Options available for transformers proposed are Dry type, Resin filled or Oil.

The PPT may be delivered with a protection cover, increasing the protection level to IP23. The standard cover color is RAL 7035; however, other specific colours are available upon request.

The PPT may locally include HV/LV fuses, Current Transformers and PT100 Temperature Probes, while the excitation cabinet may house further PPT protection through Differential and Over-Current Protection Relays.

FIELD FLASHING THE GENERATOR

Depending on the origin of the excitation power (Shunt, PMG or Aux Winding), it may be necessary to add a voltage buildup circuit to the system. Especially in the case when the excitation power is derived from a power potential transformer connected on output of the generator stator windings (shunt connected), the initial voltage is the generator residual voltage value. This may not be high enough to trigger the power onto the excitation power bridge. In this case, external power needs to be made available to trigger the system. This external source can be either AC voltage (from an external service utility) or DC (from a station battery). When field flashing is required, we include a Field Flashing Circuit and force a current into the field circuit. This current forcing allows the thyristors to begin conducting and the system to power up. A diode in series with the positive side of the battery source prevents the reverse current from the power thyristors to feed back into the battery. Typically, the battery source is 125 Vdc, although 220 Vdc is also common. In special cases, an ac source may be used which is then stepped down, rectified and directed into the field as an alternative field flashing source. The voltage buildup circuit includes the removal of the battery source after a determined time to prevent over flashing.

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS, continued

PROGRAMMABLE LOGIC CONTROL – PLC

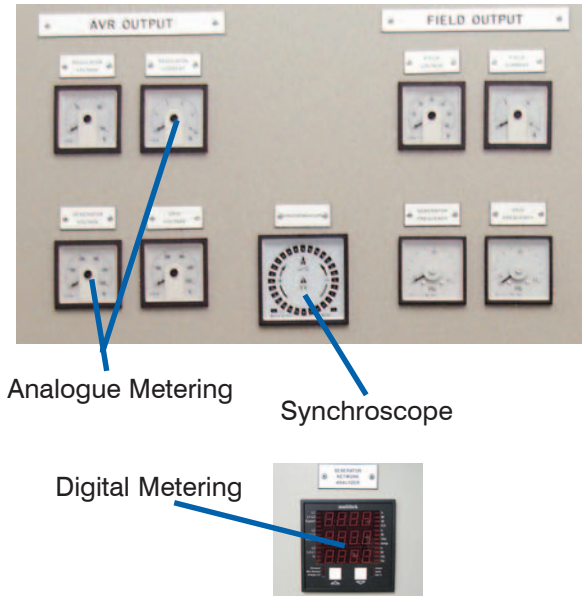
Basler custom design provides for inclusion of a PLC to supervise the complete excitation system. Besides supervision, the PLC also helps to allow for more flexibility to control and communicate with maximum flexibility. In this way, we increase the effective management of information, and this helps to increase the life of the entire system. It is important to note that the system may optionally be designed such that the PLC is not involved in the regulation process. In this case should the PLC fail, the excitation system and regulation process will not be affected.

PLC FEATURES AND FUNCTIONS

The PLC receives digital and/or analogue signals from various checkpoints in the excitation system for supervision purposes. Points monitored may include the power rectifiers, fans, circuit breaker status and others of your choice. In case of failure, the PLC includes a watchdog that will give an alarm signal. For systems designed with the PLC independent of the regulation process, the supervision will be disabled while the excitation system will remain operating safely. The PLC supervision may include troubleshooting, system settings, automatic transfer to a backup controller, rectifier or fan in case of redundant systems. Provision may be included for communication links such as MODBUS, PROFIBUS AND ETHERNET.

When including a touch screen, the PLC can be used to indicate the system's state. It indicates and identifies any faults or alarms. It may also record the date and time and the chronology of events. It also permanently displays the control and regulation mode in service. The PLC also gives the possibility to achieve special synchronous generator applications (such as for co-generation) where a "green energy" capability is requested. The PLC allows for such functionality through night/day signals received from the energy kWh meter. The PLC also may supervise a complete site electricity network and perform high level supervision.

METERING



Custom designed excitation systems offer all the metering choice and flexibility you would expect from a system. Based on your requirements or preference, we may offer classic 96x96mm digital or analogue meters as well as versatile multifunction digital network analysers. As a minimum, we include metering for:

- Excitation Voltage
- Excitation Current
- Generator Voltage

We also suggest:

- Frequency
- Bus Voltage (In case of synchronising)
- Synchroscope (In case of synchronising)

Figure 13 – Metering Example

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS, continued

CONSTRUCTION

Custom designed excitation systems may be built in virtually any approved and industrial grade enclosure of your choice as long as the space available is sufficient to safely contain the system. Typical excitation systems are delivered in a free-standing metal structure built to the following specifications:

- 1.5 mm steel understructure and panels, 2.0 mm steel front door hinged with removable pins, Galvanized mounting plate. (Special heavy duty 3mm sheet steel enclosures are also available on request.)
- Bolt-on side, rear, and top covers with gaskets.
- 100 mm channel base, bottom cable entry.
- Keyed door handle with 4-point latch mechanism.
- 4 x M12 size lifting eye bolts.
- Epoxy resin powder coat paint system with colour case, RAL 7035 as standard. (Other nonstandard colours accepted in the industry can also be requested.)
- The protection classes, such as IP20 or IP21 or IP31 or IP54, may be applied according to your requirements.
- Nonexhaustive list of accessories may include: Space heater (sized to match the final climatic storage environment) and a suitable thermostat. Cubicle light with automatic switch coupled to the doors and a service plug based on your standards.
- High current capacity systems (up to 3000A) are usually equipped with a rear compartment to support the main copper bus bars.



Figure 14 – Typical Excitation System

WIRING

Excitation system internal wiring may be carried out to virtually any standard or specification you require. Unless requested otherwise, the wiring is done according to the following:

- Cables – Flexible multistrand copper wire.
- Insulation – Polyethylene Insulation.
- Terminals – Crimped, insulated sleeves on each end of wire.
- Maximum number of 2 wires per terminals or pins.
- Cable marking – Markers on each end of every wire, made with individual color coded sleeves corresponding to the drawings.
- EN 60204-1 Compliant.

POWER CONVERTER ASSEMBLY FEATURES/FUNCTIONS, continued

SYNCHRONISING

MANUAL SYNCHRONISATION – CONTROL

For manual synchronization we may include, as a minimum, the following components to realize a manual control and generate the closure signal to the generator circuit breaker:

- 1 synchronizing switch (OFF / MANUAL / AUTO) with key or removable handle.
- 1 generator breaker control switch (OPEN / OFF / CLOSE).
- 1 voltage adjust switch (LOWER / OFF / RAISE).
- 1 speed adjust switch (LOWER / OFF / RAISE).
- Sync Check Relay Type Basler BE3-25 or similar.

INDICATION

To complete manual synchronizing, a number of meters, as listed below, is necessary:

- 2 Voltmeters for bus and generator volts.
- 2 Frequency meters for bus and generator.
- 1 LED-type Synchroscope.

AUTOMATIC SYNCHRONISATION – CONTROL

Besides Manual Synchronising, Basler offer the possibility to design excitation systems complete with automatic synchronisation control.



Figure 15 – BE1-25A

The controls are based on the Basler microprocessor based BE1-25A Automatic synchronizer. The BE1-25A is a system that includes features to bring any generator on line in a minimum time, from small diesel units to large hydros. It may be configured for simple manual control systems or equipped for complete automatic control of up to six generators.

PROTECTION POSSIBILITIES

GENERATOR PROTECTION RELAY BE1-GPS100

The Basler BE1-GPS100 is a multifunction, programmable numerical protection, metering, and control relay. Functions provided include three phase voltage controlled, voltage restrained, or standard over current, phase residual and independent ground over current, negative sequence over current, breaker failure, over/under frequency, phase over/under voltage, zero sequence over/under voltage, and negative sequence over voltage, forward or reverse power, loss of excitation, volts per hertz, sync check, sensitive third harmonic ground fault monitoring, breaker monitoring and control and metering functions, all in an integrated system.

Non exhaustive list of the features included:

- **INSTRUMENTATION:** Real Time A, B, C phase current, voltage, frequency and derived neutral and negative sequence current and voltage. Real Time 3 phase Watts, VARs, and Power Factor.
- **REPORTS:** Current demands for phase, ground, and negative sequence currents, and forward and reverse Watts and VARs magnitudes and time stamps are recorded for today's peak, yesterday's peak, and peak since reset. kWh and kVARh, forward and reverse. Breaker operations counter and contact interruption duty. Breaker operate time also available.
- **FAULT RECORDING:** 255 event sequence of events report with I/O and alarm sub-reports. Fault Reporting, 1 or 2 oscillography records per fault report. 16 fault summary reports; two most recent Fault Summary Records saved to nonvolatile memory. Total number of fault and oscillography records settable from 6 to 16. Total of 240 cycles oscillography memory @ 12 samples/cycle. COMTRADE format.
- **COMMUNICATION:** 3 independent general purpose communication ports: Front RS-232 ASCII communications, rear RS-232 ASCII communications, and a rear RS-485 using ASCII, Modbus, DNP3.0 or TNP protocols (must be specified). IRIQ-B time sync (unmodulated).
- **PROGRAMMABLE I/O:** 4 programmable I/P, 5 programmable O/P and 1 dedicated programmable alarm O/P.



Figure 16 – BE1-GPS100

24, 25, 27, 32, 40, 46, 47, 50,
51, 59, 60, 62, BF, 81

PROTECTION POSSIBILITIES

PROTECTION WITH 64F



Figure 17 – Option for Rotor Earth Fault Protection

The field winding protection is used to detect a wiring failure on the rotor. The relay will inject into the field a small amount of current/voltage referenced from ground. In case of a winding failure, the current will increase as the voltage decreases.

The BE1-64F **Ground Fault Relay** is a solid-state device designed to detect abnormal grounding of ungrounded circuits, such as the field winding of a generator or motor. The BE1-64F contains two fixed levels of ground detection – a pre-alarm level and a trip level. Each level has an independent LED indicator and output contact. There is also a latching Target LED to indicate a trip condition even after the ground is removed. The Target LED drive circuit is magnetically latched, so that the LED will return to the illuminated state following an interruption of control power to the BE1-64F.

The BE1-64F Ground Fault Relay detects and annunciates ground faults in the normally ungrounded field circuit of a synchronous machine. BE1-64F relays are compatible with continuous field voltages up to 600 Vdc and forcing voltages up to 750Vdc for one minute.

PROTECTION WITH BE1-CDS240

The BE1-CDS240 **Current Differential Protection System** is a 3 phase multifunction numerical relay that provides percentage restrained differential protection along with overcurrent, voltage, frequency, breaker failure, control, metering, monitoring, and alarm functions in an integrated system. The BE1-CDS240 Current Differential Protection System is available with 2, 3, or 4 sets of low impedance 3 phase restraint inputs. All configurations include one set of 3 phase voltage inputs.



Figure 18 – BE1-CDS240

24, 25, 47, 50, 51, 59, BF, 60,
62, 81, 87

Non exhaustive details of the main features and advantages:

- Up to 4 sets of 3 phase current inputs, plus standard 3 phase voltage and independent ground inputs provide complete protection and metering for 2 to 4 terminal differential applications.
- 10 to 14 contact outputs and 8 to 12 contact inputs, all BESTlogic programmable, plus a dedicated alarm output.
- “Virtual Circuits” allow internal summing of 2 or 3 sets of currents for use in protection and metering.
- Nonvolatile storage of all target, oscillography, fault records, and SER data.
- Variable sample rate for frequency tracking allows for high accuracy in generator and motor differential applications.
- BESTlogic provides the user with complete flexibility in configuring a protection and control system. User programmable variable and switch names make the CDS240 relays completely self-documenting.
- Each CT circuit is low burden and isolated to allow improving zones of protection with fewer costly CTs.
- Large Bit Addressable LCD display allows the relay to replace local indication and control functions such as panel metering, alarm annunciation, and control switches.
- Expansion slot for communications coprocessor module provides a future upgrade path for Ethernet, IEC 61850, and other high-speed protocols.
- Three independent communications ports allow integration with distributed control systems, modems, and fixed or portable PCs. DNP protocol is available as an option. Consult factory for availability of Modbus™ protocol.
- Current circuits not used for differential protection can be used for independent overcurrent protection functions.
- The CDS240 uses a drawout module with automatic CT shorting facilities and fits cutout and drilling dimensions for many common Basler Electric, GE (BDD), and Westinghouse (HU) differential relays.
- BESTCOMS GUI software available to aid in setup.

EXCITATION SYSTEM SOFTWARE

Basler Excitation Systems come complete with the user software for all Basler manufactured devices at no extra charge. Software for non-Basler devices included in the system may be included in the Basler offer on request. All Basler digital devices are supplied with BESTCOMS PC-based software to facilitate system setup and testing.

As shown in the DECS-400 typical Protection screen (Fig. 19), choices are made using drop-down menus and screens, and parameters are familiar. Reminders are also provided at the bottom of the screen for input units and available parameter range. Tabs identify general functions and related functions are on adjacent pages. As shown on the Underexcitation Limiter screen (Fig. 20), graphics are also used to help visualize input parameters.

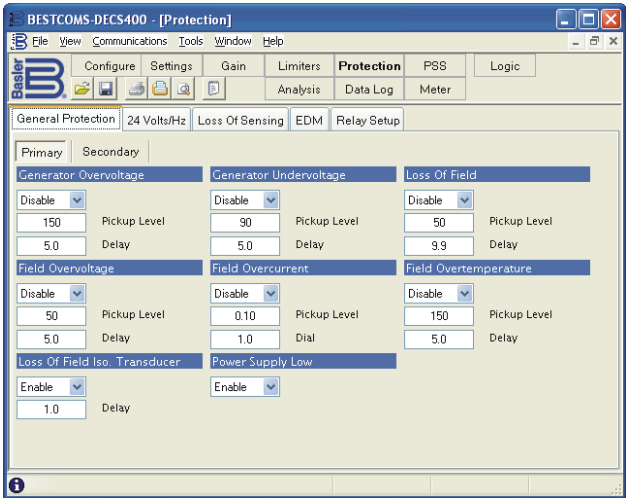


Figure 19 – Protection

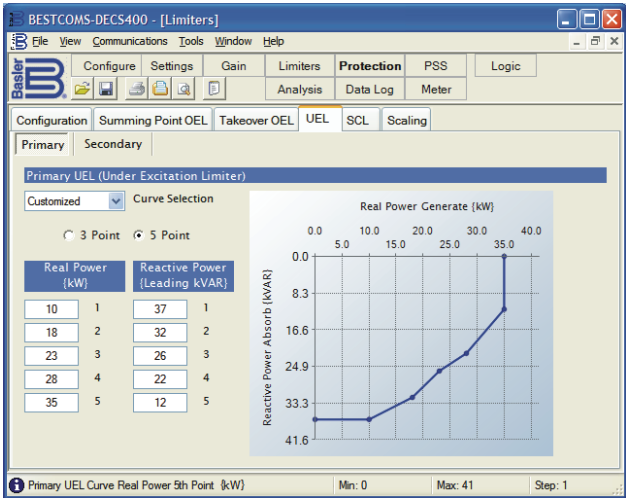


Figure 20 – Underexcitation Limiter

As shown in the Metering screen, (Fig. 21) a broad range of machine and system parameters can be displayed, along with key system status information, such as operating status, operating mode, and key parameter set points. Adjustments to the current operating mode set point can also be made from this screen. On-line PSS and AVR testing can also be performed using screens such as the Test Signal screen, which can initiate pre-programmed tests that may be monitored using the Real Time Monitoring function illustrated in the Analysis screen, Fig. 22.



Figure 21 – Metering

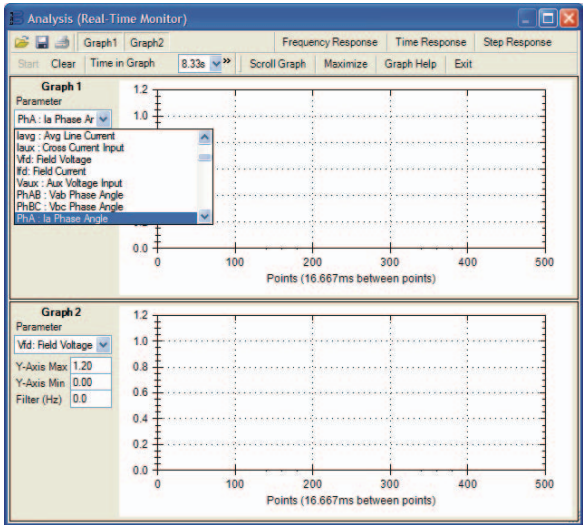


Figure 22 – Real Time Monitoring

EXCITATION SYSTEM SOFTWARE

BESTCOMS for the DECS-400 also incorporates greater "Windows" functionality, as shown in the screen shot, Fig. 23. The screen simultaneously displays the systems status and alarms window, other available systems screens using the familiar Explorer View, along with other screens, such as the metering display, the protection screen and the UEL settings screen shown. Multiple screens can be tiled, cascaded or otherwise manipulated using familiar Windows commands.

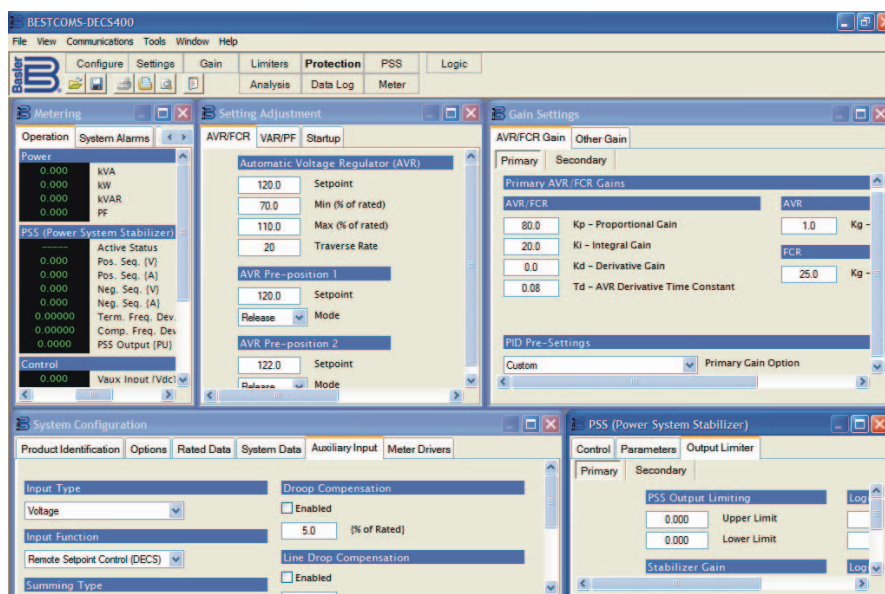


Figure 23 – Example of Multiple Screen Capability

EXCITATION SYSTEM DOCUMENTATION

The standard system is delivered with Qty. 2 sets of documentation, each set containing:

- Qty. 1 instruction manual of each major component.
- Drawing package containing mechanical and electrical drawings, interconnection drawing and equipment list.
- Qty. 1 Instruction manual of the complete system.
- Qty. 1 Storage instructions details.
- PC Software for all Basler manufactured digital devices.
- Basler General Catalogue, Power Systems – eCatalogue.

All the above may be included on a CD on request.

MULTI-LINGUAL DOCUMENTATION

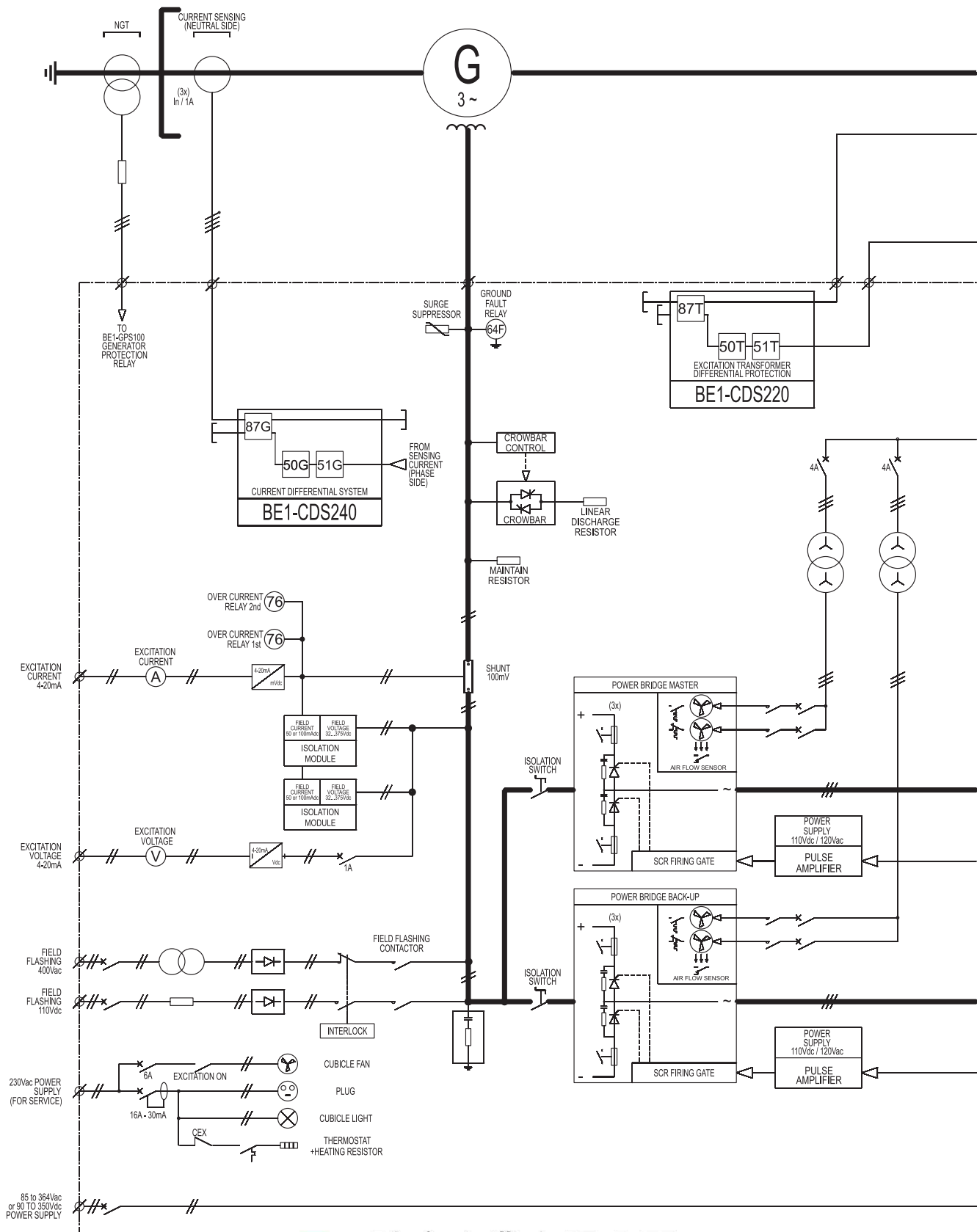
Basler Excitation system documentation is by default supplied in the English language.

Documentation may be made available in many languages other than English. If this is your requirement, please indicate details so we may confirm the possibility and quote accordingly.

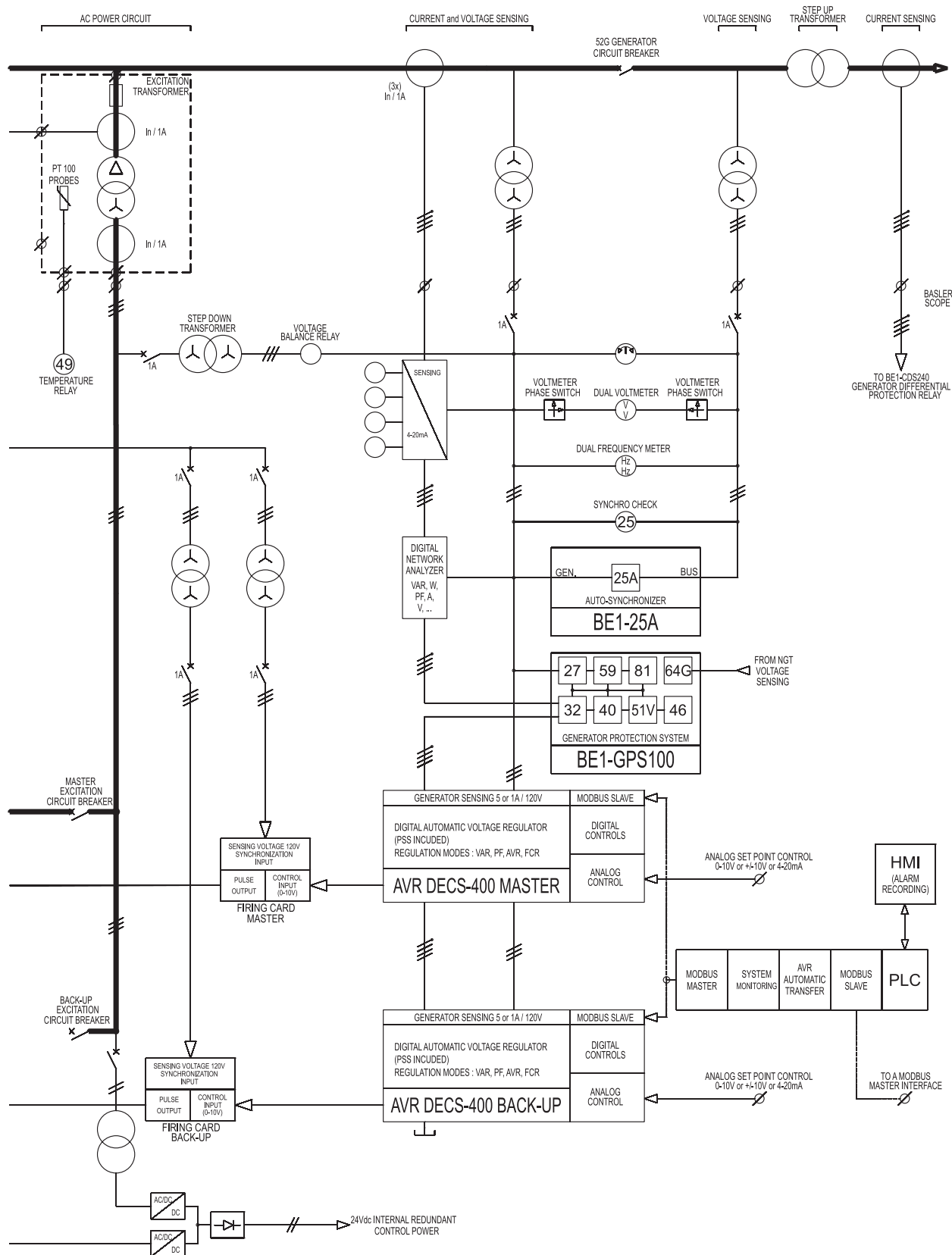


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TYPICAL SINGLE LINE WITH FULL REDUNDANCY: DUAL



AVR - DUAL BRIDGE – FULL SET OF PROTECTION RELAYS



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 網址：http://www.arith.com.tw

CUSTOM DESIGNED EXCITATION SYSTEM – REQUEST FOR QUOTE

Simply fill in the following data sheet and forward it to your nearest Basler Electric Representative.
 Items marked with an (*) sign are essential to enable us to quote any budgetary price accurately.
 If you have other details, such as a technical specification, please include this together with your request.

Company: _____	Contact Name: _____	Project name: _____
Address: _____	Tel: _____	Email: _____

1) Generator Output data:
 Power (in kVA): (*) _____ Voltage (in V) (*) _____
 Frequency (in Hz): _____ Power Factor: _____

2) Excitation Field Data:
 Current at no load: _____ Voltage at no load: _____
 Current at full load: (*) _____ Voltage at full load: (*) _____

3) Forcing ratio:
 Typically 1.6 times the excitation voltage at full load: _____

4) SHUNT EXCITATION – POWER POTENTIAL TRANSFORMER (PPT)

Quotation requested? Yes/No _____	Type: (Dry, Resin filled or Oil) _____
Vp directly off Gen terminals: Yes/No _____	If no, specify voltage available: _____
Protection Cover: Yes/No _____	If yes, RAL 7035 or specify colour _____
IP 20, IP 23 or other: _____	Protection? LV/HV Fuses, 87, 50/51 _____
Temperature Probes: Yes/No _____	Current Transformers: Yes/No _____
Any space limitations: Yes/No _____	If yes, max. space available: _____

5) CT and PT ratio for the sensing circuit:

PT RATIO	CT RATIO
a) Primary voltage: _____	a) Prim Current: _____
b) Secondary voltage: _____	b) Sec Current (1 or 5A): _____
c) App Power (25VA min): _____	c) Burden (in VA): _____
d) Single or 3 Phase: _____	d) Plugged on V phase?: _____

6) Control power supply available on site (24Vdc if available, is preferred):
 Voltage available (Please also confirm AC or DC): (*) _____

7) Power source available for the field flashing (if used):
 Voltage available (Please also confirm AC or DC): (*) _____

8) Firing Card Option:
 Analogue: Yes/No _____ Digital? Yes/No _____

9) Space available on site for excitation system enclosure:
 Any site constraints? Yes/No _____
 If yes, please indicate Maximum available Height: _____ Width: _____ Depth: _____
 Other Specifics: _____

10) Space available on site for excitation system enclosure:

Complete Cubicle solution: Yes/No _____

Mounting Plate solution: Yes/No _____

Any site constraints? Yes/No _____

If yes, please indicate Maximum available Height: _____ Width: _____ Depth: _____

11) Redundancy

Redundancy of Power Electronics (Power Bridge): Yes/No _____

Redundancy of Control Electronics (DECS AVR): Yes/No _____

12) Protection

Generator Protection: Yes/No _____ Transformer Protection: Yes/No _____

Generator Protection Relay – Basler BE1-GPS-100: Yes/No _____

Current Differential Relay – Basler BE1-CDS-240 or -220: Yes/No _____

Rotor Earth Fault Relay – Basler BE1-64F: Yes/No _____

Free issued or other specified manufacturer: _____

Other (Specific protection functions or relays): _____

13) Boost Circuit

Boost circuit for short circuit support? Yes/No _____

Boost CT's to be quoted? Yes/No _____

14) Fast De-excitation Circuit preferred (Tick one only as Yes where appropriate)

DC Field Contactor with nonlinear discharge resistor _____

DC Field Contactor with linear discharge resistor _____

De-excitation contactor with nonlinear discharge resistor _____

De-excitation contactor with linear discharge resistor _____

Crowbar with nonlinear discharge resistor _____

Crowbar with linear discharge resistor _____

DC Field contactor and crowbar with nonlinear discharge resistor _____

DC Field contactor and crowbar with linear discharge resistor _____

Simple nonlinear discharge resistor _____

15) Power System Stabiliser

Power System Stabiliser PSS 2A requirement: Yes/No _____

16) Synchronising

Manual Synchronising requirement? Yes/No _____

Automatic Synchronising requirement? Yes/No _____

17) HMI / PLC Options

Touchscreen: Yes/No _____ Pushbuttons and Switches: Yes/No _____

Standard PLC: Yes/No _____ If No, please specify _____

PLC Independent of Regulation process: Yes/No _____

Day/Night or other PF set points through PLC: Yes/No _____

18) Metering and Remote Display

Basler RDP-300 Option _____ Classic RDP _____ Other _____

Excitation Voltmeter _____ Excitation Ampmeter _____ Gen Voltage Meter _____

Bus Voltage Meter _____ Frequency Meter _____ Other _____

19) Other Specifics

Special Norms such as CSA, UL, GOST R, IEC: _____

Language for Documentation: (Standard English or specify) _____

Services Required: _____

Other Specifics: _____

BASLER SERVICES

EXCITATION SYSTEM ASSOCIATED SERVICES

Typical services Basler offer include:

- System **Witness Testing** at the Basler factory in Wasselonne, France.
- **Training on Excitation Systems** (AVR Software, System Hardware and Commissioning)
- **Training on Protection** (Relay Hardware and Software)
- **Hands on Training** with Basler Regulators and Relays on a fully protected **Test Bench**
- Protection Relay – **Setting Calculation Study** and On Site Commissioning.
- Power System Study for **PSS – System Analysis**, Setting Study and On Site Commissioning.
- **Turnkey retrofit of excitation controls** including design, supply, installation and commissioning.
- **On site surveys** of existing excitation system controls.

Basler Electric offers you global support and distribution and is proud to be in a position to support your needs with a short turnaround time. Besides the Basler International division based in France, the Basler Headquarters in the U.S.A. and the Basler Sales office in China, today Basler have selected a circle of approved and certified partners that actively contribute toward the specialised services related to excitation systems. **Details of Basler partners near you are available on our website.**

Visit us at: www.basler.com

Basler Electric – France SAS are in a position to meet diverse customised and non-standard requirements. Therefore, should your specific needs not be listed in this document, please do not hesitate to contact us or your closest Basler Representative with details. Whenever feasible, Basler will customise any system and can integrate virtually any customer specified make of auxiliary or protection devices within the same excitation system cubicle.

Feel free to discuss any of your customised requirements and we will do our best to satisfy your needs.

This document is intended as an overview of what Basler Electric – France SAS may offer you in terms of CUSTOM DESIGNED Digital Excitation Control Systems for Synchronous Generators.

This document is the property of Basler Electric - France SAS and is subject to revision without notice.



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