INTRODUCTION

The Basler Electric SGC-150 Synchronous Generator Controller precisely and reliably regulates and controls the output of a rotary-excited (brushless or brush-type) synchronous generator. Power to the rotary exciter is controlled and delivered by Basler's DECS-150 Digital Excitation Control System.

Optional SGC-150 elements include dual DECS-150 controllers, onboard field flashing provisions, and an integrated power system stabilizer.

All SGC-150 components and connection terminals are mounted and wired on a single mounting plate intended for installation in a suitable enclosure.

This publication serves as an overview of the functions and capabilities of the SGC-150. System drawings and product documentation specific to the devices of the SGC-150 accompany this publication.

SAFETY

Warning!

Personal injury may result if contact is made with system components carrying high voltages. The circuit diagrams supplied with this document will disclose hazardous areas.

As with all electrical equipment, appropriate safety measures must be taken whenever dealing with the excitation equipment. High voltages are present at the equipment. The voltage magnitudes depend upon the characteristics of a particular system. Opening the power source connections does not completely remove the threat of high voltages. As long as the machine is physically connected to the system, the possibility of a safety hazard exists.

When working with the excitation control switchgear, every precaution must be taken to ensure that all high voltages are isolated and avoided. In addition to voltage at the power potential transformer (PPT), there may be other power sources connected to the equipment. These sources may include the user-supplied dc control power and the ac station power. Consider all connections to be live and dangerous until proven otherwise.

SPECIFICATIONS

Operating Power Input

Voltage Range

For full-load continuous field voltage of:

63 Vdc:	100 to 139 Vac or 125 Vdc
125 Vdc:	190 to 277 Vac 1-phase, 190 to 260 Vac 3-phase, or 250 Vdc
Frequency Range:	dc, 50 to 500 Hz

Control Power Input

Nominal:	24 Vdc
Range:	19.2 to 26.4 Vdc

Sensing Inputs

Voltage

Range:	100 to 600 Vac, 50/60 Hz
Configuration:	1-phase or 3-phase, 3-wire

Current

Nominal:	1 or 5 Aac
Configuration:	1-phase or 3-phase plus cross-current compensation

Contact Outputs (DECS-150)

Make, break, and carry ratings (resistive):

Rating:	7.0 Adc at 24 Vdc/240 Vac

Temperature

Operating

Up to 7 Adc Output:	0 to 60°C (32 to 140°F)
Up to 10 Adc Output:	0 to 55°C (32 to 131°F)
Storage:	–20 to 60°C (–4 to 140°F)

FCC Requirements

This product complies with FCC 47 CFR Part 15.

HANDLING AND MAINTENANCE

Careful handling and routine maintenance will promote SGC-150 longevity and preserve its performance. Basler Electric publication 9410100990, supplied with this document, provides guidelines for handling, installing, and maintaining the SGC-150.

EQUIPMENT OVERVIEW

SGC-150 features and options are defined and specified by a style number derived from the style chart shown in Figure 1. The features of the SGC-150's DECS-150 controller will vary according to the style number specified for the SGC-150.

Standard equipment elements include a DECS-150 Digital Excitation Control System, ES-74S DC Millivolt

Sensing Relay, auxiliary relays/contactors, a metering shunt, circuit breakers, and user terminals.

MOUNTING CONFIGURATION

Components are mounted and wired on a mounting plate constructed from 11-gauge, galvanized steel. The mounting plate is intended for installation in a suitable enclosure. The size and weight of the SGC-150 are dependent upon whether a single DECS-150 or dual DECS-150 configuration is specified. Mounting plate dimensions and weights for each configuration are listed in Table 1. A mounting dimensions drawing is provided in the documentation for a purchased system.

TERMINAL CONFIGURATIONS

User connections to the SGC-150 are made with compression (screw) terminals which accommodate wire sizes up to 12 AWG or 2.5 mm^2. When wiring to the terminals, a wire insulation stripping length of 8 to 10 millimeters (0.315 to 0.394 inches) is recommended. When tightening the terminal screws, apply a torque no greater than 0.6 N•m or 5.3 in-lb.

OPTIONAL EQUIPMENT

Optional equipment may include a second DECS-150, field flashing provisions, or a connection kit for CE compliance.

Redundant DECS-150

A dual DECS-150 option, specified by style Dxxxxx, provides continued operation in the event of a primary DECS-150 failure. The DECS-150's autotracking capability enables the secondary DECS-150 to track the operating setpoint of the primary DECS-150. This makes for a "bumpless" transfer from the primary DECS-150 to the secondary DECS-150 in the event of a primary DECS-150 failure.

Field Flashing

The field flashing option (style xxxxFx) is recommended in shunt-powered applications in order to reliably build terminal voltage at generator startup.

At startup, field flashing is applied automatically from an external source through an onboard resistor. The resistor can be adjusted to tailor the level of field flashing current to the application requirements. A diode prevents the excitation power supplied by the DECS-150 from flowing back into the field flashing power source. An ES-74S DC Millivolt Sensing Relay monitors the field current level through a metering shunt and automatically removes field flashing when appropriate.

Connection Kit for CE Compliance

If CE compliance is required, the SGC-150 must be connected using a kit consisting of an ac line filter and ferrite choke. Order Basler part number 9576530100.

SYSTEM ELEMENTS

Interconnected SGC-150 system elements work together to supply regulated excitation power to the field and protect the controlled equipment. All excitation system element connections are illustrated on the system interconnection diagrams.

Digital Excitation Control System DECS-150

The DECS-150 supplies regulated excitation power to the machine field. It also monitors parameters to control, limit, and protect the machine from operating beyond its capabilities.

The following paragraphs serve as an overview of DECS-150 functions. Detailed information about DECS-150 operation is available in Basler publication 9492600990.

Regulation

Machine parameters are monitored by the DECS-150 through sensing PTs and CTs. Field voltage and current are monitored directly by the DECS-150 through its excitation power output. The DECS-150 compares these monitored parameters with the system setpoint and supplies regulated excitation power to the field. Digital signal processing and precise regulation algorithms enable the DECS-150 to accurately regulate the level of excitation.

Multiple regulation modes enable the DECS-150 to accommodate a variety of machine applications and operating conditions.

Auto Mode

Auto mode regulates the generator rms voltage to within 0.25% of the setpoint over the range of no-load to full-load. Operation in Auto mode makes either of two control modes available: Var or Power Factor.

When operating in Var mode, the DECS-150 regulates the level of reactive power supplied by the generator.

In Power Factor mode, the DECS-150 controls the level of vars supplied by the generator to maintain a specific power factor despite a varying generator kW load.

Manual Mode

In Manual (or field current regulation) mode, the DECS-150 regulates the level of excitation power supplied to the field independently of all operating conditions. This makes Manual mode useful as a backup method of excitation control if a loss of sensing occurs.

When operating in Manual mode, the DECS-150 regulates only the level of supplied dc excitation current. The operator must manually vary the setpoint in order to achieve the desired operating conditions.

Autotracking

The setpoint of the active control mode is automatically tracked (followed) by the inactive control modes. In dual DECS-150 systems, the secondary DECS-150 tracks the setpoint of the primary DECS-150. This feature enables the initiation of “bumpless” transfers between operating modes and DECS-150 controllers.

Soft-Start Voltage Buildup

The adjustable soft-start feature controls the buildup rate of the generator voltage to prevent voltage overshoot during generator startup. Soft start is active in both Auto and Manual modes.

Limiters

Limiters restrain machine operation to avoid unsafe conditions and machine insulation degradation. The DECS-150 has limiters for overexcitation, underexcitation, stator current, reactive power, and underfrequency/volts per hertz.

Overexcitation Limiter (OEL)

If the level and duration of current applied to the field exceeds the OEL settings, the DECS-150 will stop further increases in field current and lower the current to a safe level for the machine. The OEL operates at three levels to permit short-term var boosting that could be beneficial for the application.

Underexcitation Limiter (UEL)

Pole slip is prevented by limiting the amount of reactive power absorbed by the machine. The UEL compares the level of real power (kW) with the level of reactive power (kvar). A decrease in kvar causes the DECS-150 to increase excitation to maintain synchronism (and prevent pole slip).

Stator Current Limiter (SCL)

The SCL prevents stator overheating by modifying the excitation level according to the direction of var flow into or out of the generator. High stator current with leading power factor initiates increased excitation while high stator current with lagging power factor initiates reduced excitation.

Low and high thresholds are available. Continuous operation is possible at the low threshold while a programmable limiting delay is implemented at the high threshold.

Reactive Power Limiter

The reactive power limiter restricts the level of vars exported from the generator to a predefined level.

Underfrequency Limiter

The underfrequency limiter is selectable for underfrequency limiting or volts per hertz limiting. These limiters protect the generator from damage due to excessive magnetic flux resulting from low frequency and/or overvoltage.

Protection

DECS-150 protective functions may be implemented as backup to the primary protection relays used in an application. Each protection feature has an adjustable tripping level and time delay and can be assigned to one of the DECS-150 programmable contact outputs. DECS-150 protective functions include:

- Configurable protection
- Exciter diode monitor
- Field overcurrent
- Field overvoltage
- Generator overvoltage
- Generator undervoltage
- Loss of sensing voltage
- Low generator frequency
- Overfrequency
- Sync-check
- Underfrequency

Operating Logic

In the SGC-150, the DECS-150 is preconfigured with operating logic for a rotary exciter application. If desired, this logic scheme can be customized by using the logic programming capabilities of BESTlogic™*Plus*. The BESTlogic™*Plus* chapter of Basler publication 9492600990 provides information about customizing DECS-150 logic.

PSS

An SGC-150 with style number xxxxxP is equipped with a DECS-150 that has a power system stabilizer (PSS). The PSS is a dual-input, IEEE type PSS2A stabilizer that utilizes the “integral of accelerating power” algorithm.

Stability Setting Groups

Two sets of PID (proportional + integral + derivative) settings optimize performance under two distinct operating conditions. For example, one set of stability settings can be used with the optional PSS in service and one set can be used when the PSS is disabled. Fast controller response settings would give optimum transient performance when the PSS is enabled. Slower controller response settings would provide improved damping of first-swing oscillations when the PSS is offline.

Event Reporting

DECS-150 reporting functions include sequence-of-events recording and data logging.

Sequence of Events

The sequence-of-events recorder monitors the internal and external status of the DECS-150. More than 400 data/status points are monitored and will trigger up to 63 events per record.

Data Logging

Up to four oscillography records are logged in nonvolatile memory using the COMTRADE format.

Logging of records is triggered by status changes in up to six user-selected parameters.

Communication

The DECS-150 is equipped with three communication ports. Each port is dedicated to a specific function.

The front-panel, Type-B USB port is intended for local, short-term communication with a PC operating BESTCOMS*Plus*® software. BESTCOMS*Plus*® is a Windows-based application used to program and customize the DECS-150. BESTCOMS*Plus*® also has metering screens for viewing machine and system parameters and control screens for control of the excitation system. An integrated PID calculator simplifies selection of stability settings. An integrated, automatic tuning feature reduces system commissioning time while ensuring excellent system performance.

A rear-panel CAN communication link is used in SGC-150 systems with dual DECS-150 controllers (style Dxxxxx). This link provides communication between the two DECS-150 controllers for the purpose of setpoint tracking.

Ethernet communication is provided through a copper (100Base-T) port. The Ethernet port uses the Modbus® TCP/IP protocol for communication of DECS-150 metering, annunciation, and control commands.

DC Millivolt Sensing Relay (ES-74S)

Depending upon an SGC-150's configuration, it will be equipped with one or two ES-74S relays designated ES-74S-1 and ES-74S-2. These relays monitor the level of exciter field current through an onboard metering shunt.

In all SGC-150 configurations, ES-74S-1 provides backup overexcitation protection for the DECS-150. An extended overexcitation event will cause the ES-74S-1 to trip and latch the SGC-150 Exciter Field Overexcitation output contacts.

Some SGC-150 configurations employ relay ES-74S-2 and its functionality varies according to the style designation of the SGC-150.

SGC-150 Style SxxxFx

In an SGC-150 with a single DECS-150 and field flashing, ES-74S-2 manages the application of flashing power to the field. Detection of satisfactory field buildup causes ES-74S-2 to remove the applied flashing power.

SGC-150 Style DxxxNx

In an SGC-150 with dual DECS-150 controllers and without field flashing, ES-74S-2 initiates a transfer of excitation control to the secondary DECS-150 if a failure to limit overexcitation occurs.

SGC-150 Style DxxxFx

In an SGC-150 with dual DECS-150 controllers and field flashing, ES-74S-2 has two setpoints which perform two functions.

The "Under" setpoint manages the application of flashing power to the field. Detection of satisfactory field buildup causes the ES-74S-2 to remove the applied flashing power.

The "Over" setpoint initiates a transfer of excitation control to the secondary DECS-150 if a failure to limit overexcitation occurs.

Inrush Current Reduction Module

For applications where the SGC-150 is powered by station power (instead of the generator output), field flashing is not typically required. Instead, in these applications (SGC-150 style xxxxNx), the SGC-150 is equipped with an Inrush Current Reduction Module (ICRM) for each DECS-150. The ICRM protects the DECS-150 from the excessive inrush current that is possible with a low-impedance power source.

Diode Assembly (SGC-150 Style Dxxxxx Only)

During a DECS-150 transfer in an SGC-150 equipped with dual controllers, a momentary condition may occur where field contactors K3 and K4 are both open. A diode assembly prevents excessive voltage from building up across the field during this transient condition.

Inputs and Outputs

SGC-150 inputs and outputs consist of power and sensing inputs, control inputs and outputs, the field output, and communication ports. For input and output connections, refer to the appropriate interconnection diagram provided with this publication.

Control Power

SGC-150 control power is supplied by an external 24 Vdc source. This source powers SGC-150 auxiliary relays, contactors, and timing modules. It also serves as a flashing source for an SGC-150 equipped with field flashing provisions (style xxxxFx). Onboard circuit breakers protect the control power circuitry from overcurrent conditions.

Operating Power

SGC-150 operating power is provided to the DECS-150 controllers and may be supplied by an external PPT, the controlled generator, or a PMG sized for the application. An onboard circuit breaker protects the operating power circuit from overcurrent conditions.

Sensing Inputs

SGC-150 sensing voltage and sensing current are supplied by external PTs and CTs configured to supply three-phase generator sensing. The PTs and CTs must be sized appropriately for the application and compatibility with the SGC-150. The DECS-150 must be configured with the PT and CT ratings prior to

commissioning. Basler publication 9492600990 provides information about configuring the DECS-150 sensing transformer ratings.

Start Input

Application of a Start input enables the SGC-150, initiating a startup sequence that varies according to the style of the SGC-150.

SGC-150 Style Sxxxxx

In a single-controller system, applying a Start input energizes AC Shutdown Contactor K3 through the auxiliary contacts of circuit breaker CB1 and the contacts of Failed to Flash Relay K13 (if equipped with field flashing). K3 applies operating power to the DECS-150 from an external power source. If the SGC-150 is equipped with field flashing (style xxxxFx), K3 energizes Field Flash Timer TD1 and Maximum Field Flash Timer TD2. TD1 energizes Field Flashing Contactor K1 through the contacts of the ES-74S-2 relay. K1 applies flashing power to the field until the level of field current exceeds the pickup threshold of ES-74S-2 and its output contacts de-energize K1. If field current fails to build before the time delay of TD2 expires, K13 will energize, operate the Exciter Failed to Build Up output contacts, and de-energize K3, disabling the SGC-150.

SGC-150 Style Dxxxxx

In a dual-controller system, applying a Start input energizes System On/Off Relays K12 and K12X through the contacts of Failed to Flash Relay K13 (if equipped with field flashing). K12X enables the DECS-150 controllers and K12 performs the following actions:

- Operates the Exciter On/Off output contacts
- Energizes Arming Timer TD1
- Energizes Field Flash Timer TD2 and Maximum Field Flash Timer TD3 (if equipped with field flashing)

The delay of TD1 prevents a transfer to the secondary DECS-150 due to a Watchdog trip from the primary DECS-150 while it is powering up.

TD2 energizes Field Flashing Contactor K1 through the contacts of the ES-74S-2 relay. K1 applies flashing power to the field until the level of field current exceeds the pickup threshold of ES-74S-2 and its output contacts de-energize K1. If field current fails to build before the time delay of TD3 expires, K13 will de-energize K12X which will disable the system by removing the Start input from both DECS-150 controllers.

Stop Input

As described in the following paragraphs, removal of the Start input disables the system according to the style of the SGC-150.

SGC-150 Style Sxxxxx

In a single-controller system, removing the Start input de-energizes AC Shutdown Contactor K3 which removes DECS-150 operating power, disabling the system.

SGC-150 Style Dxxxxx

In a dual-controller system, removing the Start input de-energizes System On/Off Relays K12 and K12X. K12X disables the DECS-150 controllers and K12 operates the Exciter On/Off output contacts.

AVR/FCR Inputs

Applying an AVR (automatic voltage regulation) mode input enables automatic regulation of the excitation setpoint by the DECS-150 in order to maintain the desired generator output.

Applying an FCR (field current regulation) mode input selects manual regulation of the field excitation level independently of all generator conditions.

In a single-controller SGC-150 (style Sxxxxx), AVR and FCR contact inputs are applied directly to the DECS-150. In a dual-controller SGC-150 (style Dxxxxx), AVR and FCR contact inputs are applied through AVR Mode Select Relay K92 and FCR Mode Select Relay K93.

Var/Power Factor Input

Opening the var/PF control (52J/K) input enables the DECS-150 to control the generator reactive power in either the var or power factor mode (if enabled in BESTCOMS*Plus*® software). The var/PF input takes priority over the unit/parallel input; if both inputs are open, the DECS-150 will operate in var/PF mode.

Unit/Parallel Input

Opening the unit/parallel control (52L/M) input enables parallel operation and the DECS-150 operates in reactive droop compensation mode. The var/PF input takes priority over the unit/parallel input; if both inputs are open, the DECS-150 will operate in var/PF mode.

Raise/Lower Input

Applying a contact input to the raise or lower control input raises or lowers the setpoint of the active system regulation mode.

In a single-controller SGC-150 (style Sxxxxx), raise and lower contact inputs are applied directly to the DECS-150. In a dual-controller SGC-150 (style Dxxxxx), raise and lower contact inputs are applied through Raise Select Relay K10 and Lower Select Relay K11.

DECS-150 Selection Inputs

An SGC-150 equipped with dual controllers (style Dxxxxx) accepts contact inputs for selecting the active DECS-150. By default, DECS-150-A is selected as the primary controller and DECS-150-B is selected as the secondary (backup) controller. Applying a DECS-B contact input closes DECS Select Relay K16 which configures DECS-150-B as active and changes the state of field contactors K3 and K4 to connect the output of DECS-B to the rotary exciter. Applying a DECS-A contact input trips K16 which configures

DECS-150-A as active and changes the state of K3 and K4 to connect the output of DECS-A to the rotary exciter.

Reset Input

A reset switch or contact can be connected for reset of latched system alarms. The reset input energizes relay K8 which resets the:

- Exciter Field Overexcitation output contacts through relay K32
- Exciter Failed to Buildup output contacts through relay K13 (applies only to SGC-150s equipped with field flashing [style xxxxFx])
- Exciter Transferred output contacts through relay K23. Resetting K23 also restores user control of DECS-150 selection through relay K16. (This functionality applies only to SGC-150s equipped with dual controllers [style Dxxxxx].)

Lockout Input

The contact of a lockout (86) device is connected to terminals TB1-22 and 23 for disabling of the SGC-150 during a lockout condition following a fault.

Accessory Inputs

Two accessory inputs accept analog signals for auxiliary control of the DECS-150 regulation setpoint. These inputs may also be used for limiter scaling and PSS control (if equipped).

The current-controlled accessory input accepts a 4 to 20 mAdc control signal. The voltage-controlled accessory input accepts a ±10 Vdc control signal. Only one accessory input may be used at a time. Accessory input wiring should be made using shielded, twisted-pair cable. A ground connection is provided for the cable shield.

Control Outputs

SGC-150 control outputs consist of preprogrammed output contacts and fixed-function output contacts. All control output connections are made at the SGC-150 terminal blocks. Refer to the appropriate interconnection diagram for control output functions and terminal assignments.

DECS-150 Watchdog Output Contacts

The DECS-150 has two programmable output contacts that may be user-configured to annunciate DECS-150 status, active alarms, active protection functions, and active limiter functions. In this application, Output 1 is preconfigured to annunciate all DECS-150 alarms.

The DECS-150 also has a breaker shunt trip output intended for control of an external circuit breaker.

An SGC-150 with dual controllers (style Sxxxxx) has the DECS-150 watchdog output contacts wired to the mounting plate terminal block. This SPDT (Form C) set of output contacts change state when DECS-150 control power is lost or normal execution of DECS-150 firmware ceases.

Exciter Field Overexcitation Output Contacts

This output contact latches closed when abnormally high field current is present for an extended period of time. During this condition, DC Millivolt Sensing Relay ES-74S-1 trips and energizes relay K32 after the time delay of timing module TD1 expires. When energized, K32 latches the Exciter Field Overexcitation output contacts.

Once an extended overexcitation condition is cleared, a reset control input can be applied to clear the annunciation.

Exciter Failed to Build Up Output Contacts (SGC-150 Style xxxxFx)

During field flashing, if the Maximum Field Flash Timer expires before field buildup occurs, relay K13 latches

Exciter System Critical Failure Output Contacts (SGC-150 Style Dxxxxx)

This output contact closes if a simultaneous failure of DECS-150-A and DECS-150-B occurs or DECS-150-B fails while selected as active. A DECS-150 failure is defined as a loss of operating power or failed execution of its firmware.

DECS-A Active Output Contacts (SGC-150 Style Dxxxxx)

This output contact closes when DECS-150-A is supplying regulated excitation power to the field.

DECS-B Active Output Contacts (SGC-150 Style Dxxxxx)

This output contact closes when DECS-150-B is supplying regulated excitation power to the field.

Exciter On/Off Output Contacts (SGC-150 Style Dxxxxx)

Two sets of SPDT (Form C) output contacts change state to indicate the enabled/disabled state of the SGC-150.

Exciter Transferred Output Contacts (SGC-150 Style Dxxxxx)

This set of SPDT (Form C) output contacts changes state if:

- A DECS-150-A failure occurs, or
- A transfer to DECS-150-B is initiated due to detection of extended overexcitation by the ES-74S-2 relay

Field Output

To obtain optimum metering resolution of the field current, one of the two field output ranges may be specified to suit the application requirements. Excitation current ranges of 1 to 4 Adc (style xxAxxx) or 4 to 10 Adc (style xxBxxx) are possible.

Communication Provisions

All SGC-150 communication is handled by the DECS-150 and includes:

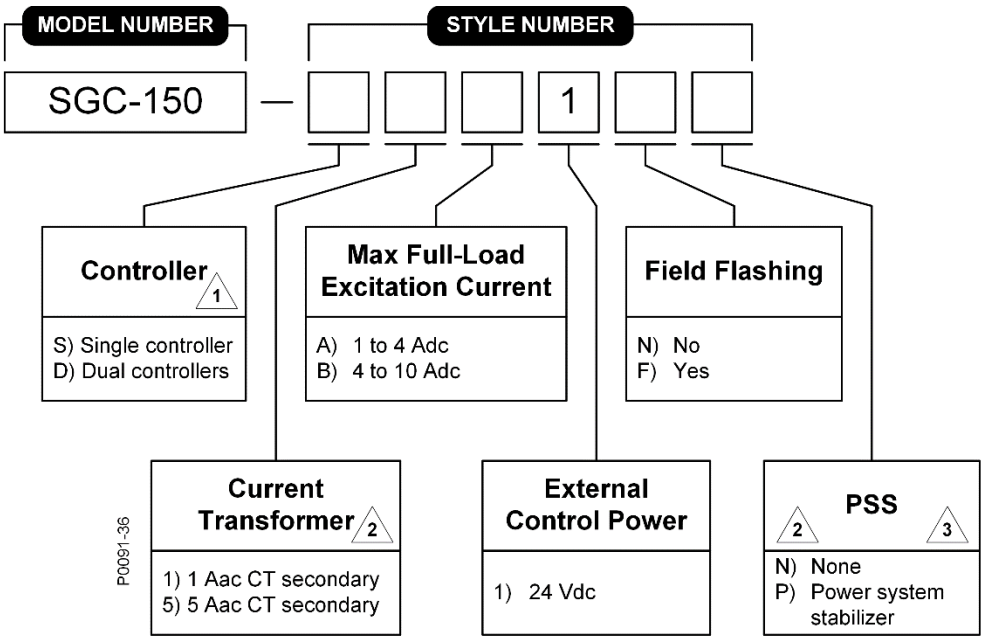
- A front-panel USB port intended for local, short-term communication with a PC operating BESTCOMS*Plus*® software
- A rear-panel CAN interface for communication between DECS-150s in a dual controller system (style Dxxxxx)
- Ethernet (Modbus TCP/IP) communication through an RJ45 connection

MAINTENANCE

Routine maintenance will promote excitation system longevity and preserve its performance. Basler publication 9410100990, supplied with the excitation system, provides guidelines for maintaining the equipment.

SPARE PARTS

A reasonable stock of spare parts will minimize downtime in the event of an equipment malfunction. A list of recommended spare parts accompanies this publication.



1 Selecting dual controllers enables automatic setpoint tracking between the DECS-150 controllers.

2 The DECS-150 controller will be automatically configured with the SGC-150 style selections made here.

3 Coordinating agency guidelines (Western Electricity Coordinating Council (WECC) or other grid codes) may require "negative field forcing" to be included with the voltage regulator system where a power system stabilizer is required. Negative forcing improves the effective response at the generator output due to dynamic load changes, particularly for plants that have rotating exciters. For these applications, consider using the SGC-250N Synchronous Generator Controller instead.

Figure 1. SGC-150 Style Chart

Table 1. SGC-150 Dimensions and Weights

Style	Controller	Dimensions (H x W x D)	Weight
Sxxxxx	Single	29.5 x 21.7 x 5.1 in. 750 x 550 x 130 mm	55 lb. 24.9 kg
Dxxxxx	Dual	37.4 x 29.5 x 5.1 in. 950 x 750 x 130 mm	90 lb. 40.8 kg