GE Energy Services

Switch Controller
Product Description, Information and Specification

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About this Guide

Purpose of this Document

The purpose of this document is to describe the features and capabilities of the Switch Controller. GE Energy Services staff and customers should use the document to specify, design and test systems that employ GE Energy Services Switch Controllers.

Distribution of this Document

GE Energy Service's Product Management Department will distribute this document to the people outlined in the Document Distribution List. GE Energy Service's Product Management Department manages the Document Distribution List.

Control of this Document

The master copy is retained under the control of the Product Manager.

All errors or omissions related to this document are to be brought to the attention of the Product Manager.

Reference Documents

Additional products that will be of interest to the reader are discussed in the following documents. These documents are referred to throughout this specification:

PRPI-003 – SCD Product Line

PRPI-023 – Auto-Sectionalizing Firmware

PRPI-024 – Auto-Restoration Data Translation Application

PRPI-028 – DART Product Family

PRPI-029 – DART Charger

P132-OUG-DDP – Data Display Panel User's Guide

Chapter 1: Product Background

The Switch Controller allows for remote and local monitoring/control of 24V switches that utilize the motorized spring stored energy principle. The Switch Controller is generally comprised of the following sub-assemblies: a power supply system, batteries, a GE Energy Services pole-top IED, the GE Energy Services switch control, an outdoor enclosure and field connectors. Most of these sub-assemblies have been in use for the last eight years in thousands of installations.

GE Energy Services switch controllers can be very “simple” or relatively complex to suit the varying demands of today’s electric utilities. Consider the following examples:

- A straightforward Switch Controller implementation may be prescribed for reducing line patrol costs. This basic SCADA need can be met using a GE Energy Services DART IED equipped with DNP3.0, a charging system, the switch control, field connectors and an outdoor enclosure.
- A more advanced application may consist of basic SCADA using a host computer equipped with a legacy protocol plus a degree of automation intended to reduce outage frequency. This may be implemented using a GE Energy Services SCD9650 IED equipped with Auto-Sectionalizing Firmware and the user’s choice of communication protocol(s).
- Another advanced application may require an improved response to service interruptions for important utility accounts. This necessitates two Switch Controllers employing an automatic throw-over algorithm and in communication with each other and the host computer. This is realized using the SCD9650 IED equipped with multiple protocols and GE Energy Service's ProLogic ladder logic package as an automation tool.
- Yet a more advanced application may include the need to improve a utility’s SAIFI index. Outage duration over the entire service area can be reduced using Switch Controllers equipped with Auto-sectionalizing firmware and communicating with upstream devices (for example an integrated Substation Control System or host-resident front-end processor) equipped with Auto-Restoration.

The hardware and software architecture of the GE Energy Services Switch Controller permits implementation of all of the above schemes. Coupled with strong Project Management, System Engineering, Integration, Configuration and Test personnel as well as a worldwide network of Value Added Resellers, GE Energy Services stands ready to help utilities improve their bottom lines.

Chapter 2: Product Information

2.1 Features of the Switch Controller

A typical Switch Controller features the following:

- Nominal input voltage of 120VAC or 220VAC.
- Typical idle input power draw of less than 7 Watts.
- A choice of power supply systems: a single voltage charging system or alternatively two independent dual voltage charging systems for applications requiring greater battery back up time.
- A choice of the GE Energy Services DART or SCD IEDs.
- Local and remote indication of loss of AC, overvoltage, low battery voltage and battery test on a per charger basis; overvoltage charger disconnect and battery test function on a per charger basis.
- The GE Energy Services switch control which features large diameter pushbuttons, switch and auxiliary status visual indicators, an indicator control switch and a control local/remote switch.
- The GE Energy Services Transient Protection Module, which provides an immediate defense barrier for line-to-line and line-to-ground surges.
- Field interface connector(s).

- High quality painted aluminum, NEMA 3R enclosure with 3-point latch and padlock hasp with an integrated pole-mounting bracket suitable for lag or band mounting. The enclosure includes integrated ground studs, varmint-proof vents, equipment mounting panels and 150 degrees door open latch.
- Easy ordering via a configured item number to speed up order processing and reduce lead time.

2.2 Ordering the Switch Controller

Switch controllers can be ordered using a ten digit configured item number. GE Energy Service's configured item number system presently supports the SCADA-Mate and Yaskawa LFG switches.

The configured item number matrix is shown on the following page.

Fields 1 and 2 specify the switch interface. The Yaskawa LFG may be ordered with or without electrical and mechanical interlocks. Specify Y1 if you are interfacing to Yaskawa's standard offering or Y2 if you have selected Yaskawa's electrical and mechanical interlock option. GE Energy Services recommends the Y2 option. Note that the physical and electrical interfaces are different for each option.

Field 3 identifies the available IEDs. When using non-S&C sensors, specify option 5 for the SCADA-Mate. The standard interface for the Yaskawa LFG is 120V PTs and 5A CTs. Specify option 5 if using other sensors.

Field 4 specifies a switch control mounted at the back of the enclosure (panel mounted) or one mounted on a swing panel (flush mounted). This field also allows you to specify your color preference for pushbuttons and indicators. Note that the swing panel option is only available with the SCD. The Data Display Panel is only available with the SCD965X IED.

Field 5 specifies 120VAC power or 220VAC input.

Field 6 specifies your preference of the DC control power supply. Specify option 1 if you have a 12VDC communication link and want the most battery back-up time.

Field 7 is an option for a door switch to alarm intrusion.

Field 8 consists of a thermostat and heater for humidity control.

Field 9 is an option for radio surge suppressor and accompanying superflex cable.

Field 10 allows you to choose a sample configuration with standard firmware or alert us that you are looking for a custom configuration with possibly custom firmware.

All of these options are explained further in a future section of this document.

Figure 1 Configured Item Number Matrix

	1	2	3	4	5	6	7	8	9	10
				USER	AC INPUT	CONTROL		HUMIDITY	COM. LINK	BASE
	S	C	IED	CONTROLS	POWER	POWER	ALARM	CONTROL	ACCESSORIES	FIRMWARE
SCADA-MATE SWITCH CONTROLLER										
INTELLIGENT ELECTRONIC DEVICE 1=SCD9651LVDC24/24 2=SCD9601LVDC24/24 3=DART (3V/3I) 4=DART (6V/6I) -For dual side sensing 5=Custom – defined externally										
USER INTERFACE CONTROLS 1=panel mounted; red=closed/green=open 2=panel mounted; green=closed/red=open 3=flush mounted: red=closed/green=open 4=flush mounted; green=closed/red=open 5=flush mounted with Data Display Panel: red=closed/green=open 6=flush mounted with Data Display Panel; green=closed/red=open Note: Options 3 to 6 available only with the SCD. Options 5 & 6 are available only with the SCD9650 or SCD9651.										

AC INPUT POWER

1=120VAC

2=220VAC

DC POWER SUPPLY

1=high power (dual chargers; one 24VDC and one 12VDC) – available with the SCD only

2=low power (single 24VDC charger & 24VDC/12VDC, 25W converter) – standard for the DART

3=single 24VDC charger

INTRUSION ALARM

0=No

1=Yes

ENVIRONMENTAL CONTROL

0=No

1=Yes

COM. LINK ACCESSORIES

0=No

1=radio surge protector and superflex cable

Note: Please specify com. Link of choice at time of order

IED BASE FIRMWARE

1=single feeder

2=two feeder (available with DART only)

3=single feeder auto-sectionalizing

4=two feeder auto-sectionalizing (available with DART only)

5=custom

Note: Sample configurations are provided with the above. These can be customized by the user.

YASKAWA LFG SWITCH CONTROLLER

Y1 = FORM A INTERFACE

Y2 = FORM C INTERFACE

INTELLIGENT ELECTRONIC DEVICE

1=SCD9650LVDC24/24

2=SCD96001LVDC24/24

3=DART (3V/3I)

4=DART (6V/6I) –For dual side sensing

5=Custom – defined externally

USER INTERFACE CONTROLS

1=panel mounted; red=closed/green=open

2=panel mounted; green=closed/red=open

3=flush mounted: red=closed/green=open

4=flush mounted; green=closed/red=open

5=flush mounted with Data Display Panel: red=closed/green=open

6=flush mounted with Data Display Panel; green=closed/red=open

Note: Options 3 to 6 available only with the SCD. Options 5 & 6 are available only with the SCD9650 or SCD9651.

AC INPUT POWER

1=120VAC

2=220VAC

DC POWER SUPPLY

1=high power (dual chargers; one 24VDC and one 12VDC) – available with the SCD only

2=low power (single 24VDC charger & 24VDC/12VDC, 25W converter) – standard for the DART

3=single 24VDC charger

INTRUSION ALARM

0=No

1=Yes

ENVIRONMENTAL CONTROL 0=No 1=Yes
COM. LINK ACCESSORIES 0=No 1=radio surge protector and superflex cable Note: Please specify com. Link of choice at time of order
IED BASE FIRMWARE 1=single feeder 2=two feeder (available with DART only) 3=single feeder auto-sectionalizing 4=two feeder auto-sectionalizing (available with DART only) 5=custom Note: Sample configurations are provided with the above. These can be customized by the user.

Chapter 3: Product Description

The following describes in detail the functions and features of each field of the configured item number.

3.1 Field 3: IED

IED details are provided in the documents outlined in *0 Product Background* in applications where dual side voltage sensing is required. Order the SCD9651 in applications where a swing panel and a data display panel is necessary.

3.2 Field 4: User Controls

User controls consist of the Switch Control and the Data Display Panel. The DART-based switch controller comes equipped with a Switch Control only. The SCD-based switch controller can be equipped with a swing panel that houses the Switch Control and the Data Display Panel.

3.2.1 Switch Control

The Switch Control interfaces the switch to the IED and the power supply system while allowing the user to control and monitor the switch locally. The Switch Control features the following:

- Open and close interface (via socketed relays) to 24V switches that utilize the motorized spring stored energy principle.
- Local control via 0.69-inch diameter, color-coded, momentary on, positive feel/audible click, push buttons.
- Bright, low power, color-coded, switch status visual indicators (LEDs).

- Open and close push buttons and indicators can be ordered as red for close and green for open or red for open and green for close.
- Control mode switch allows the control to be placed into local or remote positions.
- Indicator control switch allows the indicators to be enabled, disabled (for extending battery life) or momentarily tested.
- Staggered pole, quick-disconnect, 14AWG terminal blocks facilitate meter probes and easy installation.
- Voltage sensor input and output terminals. Voltage sensor inputs are burdened for S&C voltage sensors (jaw and hinge side). Switch Control output is 5.7 VAC RMS nominal for use with IED voltage sensor inputs.
- Integrated artwork labeling all functions.
- Auxiliary status input, output and indicator for monitoring the status of an auxiliary micro switch.
- Panel-mount (for mounting on a back-panel) or flush-mount (on a swing- panel cutout) options.
- Small, compact mounting footprint of 5.68 inches wide by 4.36 inches long by 2.5 inches high. Mounts via four 0.125-inch diameter holes.
- Operates in the range of 23VDC to 34VDC (this is the operating range of the 24V charging system) from –40C to +80C.

The Switch Control's local/remote switch interacts with the IED's enable/disable switch as shown in the following table:

Switch Control's local/remote switch position	IED's enable/disable switch	Sectionalizing switch operated via:
remote	enabled	IED or manual disconnect
remote	disabled	manual disconnect
local	enabled	pushbuttons or manual disconnect
local	disabled	pushbuttons or manual disconnect

Table 1 Switch Control

3.2.2 Data Display Panel

The Data Display Panel gives maintenance personnel a quick view of selected analog and digital input points as well as alarms. IED database points can be mapped into the unit with engineering values and text descriptions. GE Energy Services provides a number of pre-configured screens or the user can choose to display up to 30 different screens. Analog alarms can be set by programming analog inputs with limits. Alarms are acknowledged using the Alarm Acknowledge key on the keypad. For more information on the Data Display Panel please consult the reference manual identified at the beginning of this document.

The Data Display Panel mounts on the swing panel of the SCD965X-based switch controller. The Data Display Panel communicates with the SCD's database via the SCD's IED port. ConfigPro is used to configure the Data Display Panel software application.

3.3 Field 5: AC Input Power

Specify 120VAC RMS nominal or 220VAC RMS nominal input power. The Switch Controller supports an AC input voltage of nominal +/- 10%.

3.4 Field 6: Control Power

3.4.1 Introduction

The single most important sub-system of the Switch Controller is the DC power supply system. A well-designed DC power supply system will give years of reliable and trouble-free operation. The following is presented so that the reader can make an informed decision when choosing from the systems GE Energy Services makes available.

The DC power supply system presents a challenge in the design of Switch Controllers because Switch Controllers typically employ 12V and 24V components. The 24V components include the switch motor and the switch control. GE Energy Services pole-top IEDs can be powered from either 12V or 24V. Additional complexity is introduced however because most communication links available today utilize a 12V power supply input which forces switch control manufacturers to make dual voltage systems available.

There are a number of factors that are of concern when specifying the DC power delivery system of a Switch Controller: quantity of equipment that must be maintained and maintenance frequency, battery back-up time, battery drain during AC operation and number of hours required to recharge the batteries. Usually, maximizing one factor leads to a reduction in another. For example, an increase in battery back-up time may lead to more batteries that must be maintained and possibly additional hardware and an increased time to recharge the batteries. The following describes how GE Energy Services allows you to tailor the Switch Controller's power delivery system to your particular application.

3.4.2 Architecture Trade-Offs

The battery back-up time depends on the following factors: communication link baud rate, communication link receive demand, communication link transmit demand, communication link idle demand, IED demand, polling rate, charger output, charger alarm circuit demand, charger alarm circuit design, battery capacity, temperature, average load current, battery discharge factor, configuration of IED, protocol used and protocol configuration. A typical GE Energy Services Switch Controller will consist of the following:

- A 12V, 4800 BPS radio that draws 150 mA during receive, 1.2 Amps during transmit and 150 mA during idle.
- A GE Energy Services SCD965X IED equipped with DNP 3.0 (or a DART) and configured to return all points upon a demand scan with data link and application layer confirmations enabled and unsolicited report by exception enabled.
- An IED polling interval of once every minute (absolute worst case in the pole-top environment when using unsolicited reporting).
- Two independent power supply systems consisting of a GE Energy Services 12V charger and a 24V charger with independent battery banks (field 6, option 1) or
- A single power supply system consisting of a GE Energy Services 24V charger, a battery bank and a DC/DC converter (field 6, option 2).

The next table compares the above two power supply systems for the above configuration.

The first power supply consists of two independent systems. This is essentially composed of a 12V charger and two, 8 Amp-hour, 6V battery packs connected in series. The 12V system powers the communication link. The 24V system consists of a 24V charger and four 6V, 8 Amp-hour battery packs connected in series. The 24V system powers the switch motor and the IED.

The second power delivery system consists of a single 24V charger, four 6V, 8 Amp-hour battery packs connected in series and an 80% (minimum) efficient, 24V to 12V DC/DC converter. The converter powers the communication link; the switch motor and IED are powered from 24V. The table that follows compares the two systems based on a number of factors. Values are shown for GE Energy Service's SCD965X vs. the DART (shown as x/y).

Factor	Independent Charging Systems		Single 24V System With 80% Efficient 24V/12V Converter
	12V sub-system	24V sub-system	
Hours to discharge @ - 20C	14.8	8.5	5/9
Hours to discharge @ +40C	28.9	16.6	9.8/17.6
Average load current (Amps)	0.17	0.29	0.49/0.27
Hours to recharge @ -20C	2.6	6.8	8/6
Hours to recharge @ 40C	3.8	9.7	11.6/9
Battery drain with AC connected	No		No.
Relative cost factor	low		lower
Number of batteries	6		4
Reliability	Best		Adequate

Table 2 Compared Power Supply Systems

Using the above chart, a number of important conclusions can be drawn to aid the user in selecting the optimum power system topology:

- The split system provides better back-up performance.
- The split system costs more (although not much more) than the single system.
- The split system requires 2 additional battery packs be maintained.

3.4.3 Battery Life

Routine Switch Controller maintenance consists of replacing the battery packs. The frequency of replacement depends on designed battery life, ambient temperature, float charge voltage and frequency of discharge.

The batteries employed have a life of 8 years at 25 degrees C and a float voltage of 13.8 VDC without any charge/discharge cycles. These ideal conditions of course are never encountered in Switch Controller applications. GE Energy Service's research has lead to the development of a Switch Controller power supply architecture that maximizes battery life under harsh environmental conditions. For example, GE Energy Services has “tuned” the chargers to disconnect the battery packs from the load prior to deep discharge. The batteries will therefore easily last for 100 charge/discharge cycles. Without this feature, performance of the battery packs would be impaired after 10 charge/discharge cycles. Therefore frequency of discharge is not a practical concern. GE Energy Service's chargers also maintain the output voltage to within a 100-mV swing eliminating life concerns associated with float charge voltage. If this “ripple” were above 400 mV, the battery life would be halved for each 100-mV increase. GE Energy Service's battery chargers also employ a temperature compensation circuit that varies the float voltage with ambient temperature as per the battery manufacturer’s recommended profile. This maximizes life from below freezing up to a temperature of 40 degrees C. Without this temperature compensation circuit, the battery life would be reduced to 2 years at 40 degrees C. Beyond 40 degrees C, the enclosure’s flow-through venting system prevents thermal run-away.

Above 40 degrees C, battery life is halved for each seven degree Celsius rise. GE Energy Services customer experience has shown that batteries should be replaced every two years for hot environments and three years for colder environments. Battery performance in cold environments is not an issue with spring stored energy operators.

3.4.4 Battery Testing

The GE Energy Services Switch Controllers also feature a battery test circuit. The user can start and stop the test through a control command or configure the IED to invoke the test automatically. During the test, AC is disconnected and the batteries supply all loads. The chargers monitor the batteries and automatically disable the test if alarm limits are reached. The test is carried out for a maximum of one half hour. When the dual charging system is used, GE Energy Services wires both chargers at the factory to test their batteries via a single control command. Alarms are monitored separately for each charger.

3.5 Field 7: Intrusion Alarm

The intrusion alarm consists of a bracket-mounted switch that is activated by door operation. The contacts of this switch are wetted with 24V and are alarmed by the IED's status input.

3.6 Field 8: Humidity Control

Humidity is controlled with a thermostatically controlled heater. The heater is activated at 15 degrees C (60 deg. F) and has a hysteresis of 9 degrees C (15 degrees F).

3.7 Field 9: Com. Link Accessories

Transient protection for the radio link is provided via an enclosure-mounted surge protector. Connection from the surge suppressor to the radio is made by ¼" Superflex cable equipped with type N plugs. Protector installation is made with an "O" ring to prevent water egress and a solid ground to the enclosure's ground stud. This system has been field-proven to protect the radio in thousands of installations.

3.8 Field 10: Base Firmware

Base firmware consists of the latest operating code (DNP & DSP) of the DART or SCD96XX products, a sample configuration and the latest version of the configuration system. GE Energy Services always makes available the latest firmware versions; should the user wish to have an older firmware version or a custom software configuration, this can be specified separately (by selecting option 5). Also, if the SCD9650X product is used, the application and configuration software for the SAM must be specified separately.
Four base software packages are available. Options 1 & 2 offer standard firmware. The sample configurations for these two options are used to monitor a single feeder or two feeders (for dual side voltage sensing). Options 3 & 4 are for auto-sectionalizing firmware for one or two feeders. Please consult the appropriate document listed at the beginning of this document for more information on the auto-sectionalizing firmware.

The user can modify the sample configurations with the provided configuration system.

3.9 Transient Protection for Field I/O

All GE Energy Services electronic equipment used in the switch controller contains on-board transient protection and protection against electromagnetic interference. GE Energy Services recognizes however that equipment provided by others is very often required to provide a complete solution for our customers. GE Energy Services therefore designed a Transient Protection Module (TPM) to provide an economical means of preventing electrical transients impressed on the power, analog and status/control lines from entering too far into the switch controller and disrupting operation of sensitive electronic equipment.

The TPM features line-to-line and line-to-ground transient protection for all field connections. The maximum input voltage for the TPM is 132VAC (beyond this level the TPM begins to conduct). The TPM provides a line-to-ground clamping voltage of 200V peak and a line-to-line clamping voltage of 400V peak. Large diameter MOVs dissipate transient energy without suffering any ill effects. Capacitors shunt high frequency transients before they can propagate into sensitive equipment. Quick disconnect terminal blocks allow the TPM to be quickly replaced.

The TPM, coupled with the transient protection on the charger(s) and IED, forms a formidable barrier to the electrical transients typically experienced inside or outside the substation fence. The TPM has been designed to shunt the oscillatory and fast transient waveforms found in most ANSI/IEEE and IEC standards.

The TPM has an input capacitive reactance of approximately 265KOhms at 60 Hz and 318KOhms at 50 Hz. The TPM should therefore not be used indiscriminately to protect AC analog inputs that require a larger burden than the TPM offers. For these applications and applications where the user demands a higher degree of accuracy, should the user require the added security and protection the TPM offers, the burdened signal should be viewed via the IED's maintenance display and then scaled to eliminate the error. For all practical intents and purposes, the TPM impedance introduces virtually no error when shunted across a CT.

The TPM measures 5.75" long by 3" wide by 1.25" tall (not including standoffs). The TPM mounts in the enclosure via four mounting holes outlined by ground pads. These ground pads are grounded to the enclosure via the integrated standoffs.

Chapter 4: Switch Controller Interface to Switches

The Switch Controller currently interfaces with the S&C SCADA-Mate and Yaskawa LFG switches. Interface details are provided below.

4.1 S&C SCADA-Mate

4.1.1 Operation & Performance of Switch Controller & SCADA-Mate System

The SCADA-Mate's actuator consists of a trip coil and a spring charge motor. The open and close signals are fed to the trip coil. The spring charge motor is fed from a separate supply line.

The actuator operates from 24VDC. The trip coil requires 12 amps for 50 msec to open or to close. The spring charge motor draws 1.5 Amps for 15 to 20 sec. for each change of state to re-charge the spring.

The disconnect is equipped with 2 sets of aa and bb contacts. One set of contacts is connected in series with the trip coil and open/close signals. This set of contacts breaks the trip coil power. The second set of contacts is externally wetted and is used for switch status. When the switch is fully closed, aa is open and bb is closed. When the switch is fully open, aa is closed and bb is open. When the switch is in transition, it is possible for the aa and bb contacts to be in the same state. This can be mapped into a "travel" state for the host operators.

The spring charge limit switch (SCL) interrupts supply to the spring charge motor when the spring has stored six changes of state. A low charge limit switch (LCL) prevents the trip coil from closing if the spring is undercharged (less than 2 operations remaining).

The disconnect requires two manual actions to fully engage: a close and a latch. Since it is possible to close but not necessarily latch, S&C provides an optional microswitch called DCL (Disconnect Closed and Latched). GE Energy Service's Switch Controller accepts the DCL input and alerts the user visually and via SCADA whether or not the disconnect is closed and latched.

The switch is typically provided with S&C's voltage and current sensors. S&C provides single side voltage sensing or dual side voltage sensing with two sets of voltage sensors. The voltage sensor outputs are fed to GE Energy Service's switch control where burdening resistors reduce the voltage to 5.7VAC nominal. The current sensors have a 5 Amp nominal rating. These are fed into the CT inputs of the IED. Other sensors can be accommodated. GE Energy Services has interfaced with virtually every available sensor. Consult the appropriate IED documents for sensor interface specifications and availability.

The S&C current sensors have an absolute magnitude accuracy of 1.5% of reading in the range of 200 to 900 Amps and 2 degrees for phase angle between –40 degrees C and +40 degrees C. Specifications are not supplied outside of these ranges however S&C may be able to provide the user with transfer function curves outside these ranges. The transfer function characteristics vary from sensor to sensor making linearization impractical. The GE Energy Services IEDs have an absolute accuracy of 0.2% of full scale (2.5 times nominal) for current magnitude. For a Switch Controller and sensor system, the user can expect a worst case current magnitude limiting (limit of deviation from specified value) error of +/-1.5% of reading+/-0.2% of full scale. In engineering units, this translates to a current magnitude limiting error of +/-6A at 200A and +/-16.5A at 900 A. This translates to a full scale (900A) current magnitude limiting error of +/-1.8%. This limiting error can be considered to lie six standard deviations away from the mean of a normal probability distribution. For all practical purposes therefore, the user can expect a 95% confidence that the full scale current magnitude error will lie within two standard deviations of the mean or +/-0.6%.

The S&C 14.4KV voltage sensors have an absolute magnitude accuracy of 2% of reading and 2 degrees for phase angle in the range of 11.43KV to 17.0 KV between –40 degrees C and +40 degrees C. The GE Energy Services IEDs have an absolute accuracy of 0.25% of full scale (1.33 times nominal) for voltage magnitude. For a Switch Controller and 14.4 KV sensor system, the user can expect a worst case voltage magnitude limiting error of +/-2% of reading+/-0.25% of full scale. In engineering units, this translates to a phase voltage magnitude limiting error of +/-277V at a primary line voltage of 11.43KV and +/-388V at a primary line voltage of 17.0KV. This translates to a full scale (17.0 KV) voltage magnitude limiting error of +/-2.3%. This limiting error can be considered to lie six standard deviations away from the mean of a normal probability distribution. For all practical purposes therefore, the user can expect a 95% confidence that the full scale voltage magnitude error will lie within two standard deviations of the mean or +/-0.8%.

The S&C 25KV voltage sensors have an absolute magnitude accuracy of 2% of reading and 2 degrees for phase angle in the range of 20.44KV to 29 KV between –40 degrees C and +40 degrees C. The GE Energy Services IEDs have an absolute accuracy of 0.25% of full scale (1.33 times nominal) for voltage magnitude. For a Switch Controller and 25 KV sensor system, the user can expect a worst case voltage magnitude limiting error of +/-2% of reading+/-0.25% of full scale. In engineering units, this translates to a phase voltage magnitude limiting error of +/-492V at a primary line voltage of 20.44KV and +/-663V at a primary line voltage of 29KV. This translates to a full scale (29 KV) voltage magnitude limiting error of +/-2.3%. This limiting error can be considered to lie six standard deviations away from the mean of a normal probability distribution. For all practical purposes therefore, the user can expect a 95% confidence that the full scale voltage magnitude error will lie within two standard deviations of the mean or +/-0.8%.

The phase angle limiting error for a Switch Controller and sensor system is +/- 5 degrees between 200 to 900 Amps, 11.43KV to 17KV (for 14.4KV sensor) or 20.44KV to 29KV(for 25KV sensor), unity power factor and –40 degrees C to +40 degrees C (2 degrees from the voltage sensor, 2 degrees from the current sensor and 1 degree from the IED). This limiting error can be considered to lie six standard deviations away from the mean of a normal probability distribution. For all practical purposes therefore, the user can expect a 95% confidence that the phase angle error will lie within two standard deviations of the mean or +/-1.7 degrees.

4.1.2 Interface

The Switch Controller interfaces to the SCADA-Mate switch with an S&C-supplied control cable (ordered separately from S&C). The control cable is terminated with connectors from the Harting Corporation. GE Energy Services equips the Switch Controller with the mating end of this Harting connector. The interface between the Switch Controller's Harting connector and other Switch Controller components is as shown below. S&C does not change this interface unless there is a customer-specified reason for doing so.

Table 3 Interface

Harting connector pole I.D.	Switch Control interface	Description	Notes
1	J1-1	Command to solenoid – open (+VDC)	Rated 20 Amps resistive for 4 seconds; S&C switch requires 12 Amps for 50 msec.
2	J1-2	Command to solenoid – close (+VDC)	
3	J1-3	Motor/solenoid common out	
4	J1-4	Motor out (+VDC)	Rated 2.5 Amps resistive for 30 seconds; S&C switch requires 1.5 Amps for 15 to 20 sec. per change of state
5	No connection	No connection	
6	J2-2	Wetting voltage out (+VDC)	To switch position contacts and DCL switch
7	J2-3	Switch status in – aa contact	Wetted by J2-2
8	J2-4	Switch status in – bb contact	
9	To IED's current inputs	Current sensor – phase A	
10		Current sensor – phase B	
11		Current sensor – phase C	
12		Current sensor – common	To enclosure ground stud
13	J3-1	Voltage sensor jaw side – phase A in	Burdened to 5.7VAC +/- 1 mVAC @ 24 deg. C with S&C sensor
14	J3-2	Voltage sensor jaw side – phase B in	
15	J3-3	Voltage sensor jaw side – phase C in	
16	J3-4	Voltage sensor jaw side – common	
17	J4-1	Voltage sensor hinge side – phase A in	
18	J4-2	Voltage sensor hinge side – phase B in	
19	J4-3	Voltage sensor hinge side – phase C in	
20	J4-4	Voltage sensor hinge side – common	
21	J2-1	Auxiliary status in	Wetted by J2-2 of switch control
22, 23, 24	No connection	No connection	
	J5-1	Motor in (+VDC)	To power interposing relay
	J5-2	Solenoid in (+VDC)	
	J5-3	Motor/solenoid common in	To 0V
	J5-4	Motor/solenoid common in	To 0V
	J6-1	Solenoid in (+VDC)	To power interposing relay
	J6-2	Wetting voltage in (+VDC)	
	J6-3	Switch status out –aa contact	Wetted by J6-2 of switch control; to IED status inputs
	J6-4	Switch status out – bb contact	
	J7-1	Control mode status out	
	J7-2	Remote open in (+VDC wetted)	To IED control outputs

Harting connector pole I.D.	Switch Control interface	Description	Notes
	J7-3	Remote open/close common	
	J7-4	Remote close in (+VDC wetted)	
	J8-1	Remote open/close common	
	J8-2	Auxiliary status out	To IED status input
	J8-3	Voltage sensor jaw side – phase A out	To IED's voltage inputs
	J8-4	Voltage sensor jaw side – phase B out	
	J9-1	Voltage sensor jaw side – phase C out	
	J9-2	Voltage sensor jaw side – common	Enclosure ground stud
	J9-3	Voltage sensor hinge side – phase A out	To IED's voltage inputs
	J9-4	Voltage sensor hinge side – phase B out	
	J10-1	Voltage sensor hinge side – phase C out	
	J10-2	Voltage sensor hinge side – common	Enclosure ground stud
	J10-3	unused	
	J10-4	unused	

4.2 Yaskawa Type LFG

4.2.1 Operation & Performance of Switch Controller & LFG System

The type LFG's actuator consists of a trip coil and a spring charge motor. The open signal is fed to the trip coil. The close signal is fed to the motor.

The actuator operates from a nominal 24VDC. The trip coil (opening) requires 10 Amps (15 Amps peak) for 100 msec to open the switch (typically 50 to 70 msec). The motor (closing) requires 5 amps (20 Amps peak) for 1.5 seconds to close the switch (typically 700 to 900 msec). Since the opening and closing times are directly proportional to the applied voltage, the switch is expected to operate faster with AC connected and slower on battery back up.

The standard Yaskawa disconnect comes equipped with a Form A contact for indicating switch position. The standard disconnect is not equipped with a mechanical and electrical interlock to prevent the switch from operating if gas pressure is low. GE Energy Services recommends the user to request the Form C contact option for switch position indication and the electrical and mechanical interlocks for low gas pressure.

Yaskawa can optionally provide integrated three phase CTs with 400:1 (1 VA rated burden) or 600:1 (5 VA rated burden) ratios. The CTs operate between 50-60 Hz. These CTs provide an accuracy of 1% of measured value at the rated primary current (i.e. 400 Amps or 600 Amps), frequency, power factor of 1 and rated burden. Phase angle accuracy is not specified and neither is temperature or current operating range. For a Switch Controller and sensor system, the user can therefore expect an over-all error of +/-7 Amps at 400A and +/- 9 Amps at 600 Amps.

4.2.1.1 Form C Option

The disconnect is equipped with one Form C contact (AUX), two form A contacts (3LS, 2PS) and three form B contacts (1LS, 2LS, 1PS). Contact forms are referenced to the switch open. The AUX contact is used for switch status. AUX is in position 1 & 3 when the switch is open and in position 2 & 3 when the switch is closed. 3LS is in series with the trip coil and interrupts open signal power when the switch has opened. When the switch is closed, 3LS is closed. 1LS and 2LS are paralleled together; this shunt combination is placed in series with the motor. 1LS and 2LS interrupt close signal power once the switch has closed. 1PS is a pressure switch that prevents the trip coil and the motor from being energized upon a loss of gas pressure. 2PS is a pressure switch which closes upon loss of pressure. This contact is connected to the switch control’s auxiliary status input. This option comes equipped with an 8-pole (8P) connector.

4.2.1.2 Form A Option

The disconnect is equipped with two Form A contacts (AUX, 3LS), two Form B contacts (1LS, 2LS) and a Form X contact (PS). Contacts are referenced to the switch open. The AUX contact is used for switch status. AUX is open when the switch is open and closed when the switch is closed. 3LS is in series with the trip coil and interrupts open signal power when the switch has opened. When the switch is closed, 3LS is closed. 1LS and 2LS are paralleled together; this shunt combination is placed in series with the motor. 1LS and 2LS interrupt close signal power once the switch has closed. PS is a pressure switch that is connected to the switch control's auxiliary status input. This option comes equipped with a 7-pole (7P) connector.

4.2.2 Interface

The Switch Controller interfaces to the LFG switch with a Yaskawa-supplied, 6-meter long control cable (ordered separately from Yaskawa). The control cable is terminated with connectors from the Nanaboshi Electric Manufacturing Company. One connector is 7-pole (7P) or 8-pole (8P) and the other (if the Yaskawa-provided CT is selected) is 4-pole (4P). GE Energy Services equips the Switch Controller with the mating end of these connectors. The interface between the Switch Controller’s Nanaboshi connectors and other Switch Controller components is as shown below. Yaskawa does not change this interface unless there is a customer-specified reason for doing so.

4.2.2.1 Form C Option

Connector pole I.D.	Switch control interface	Description	Notes
8P-6	J1-1	Command to solenoid – open (+VDC)	Rated 20 Amps resistive for 4 seconds; LFG switch requires 15 Amps for 100 msec.
8P-4	J1-2	Command to solenoid – close (+VDC)	Rated 20 Amps resistive for 4 seconds; LFG switch requires 20 Amps for 1.5 sec.
8P-5	J1-3	Motor/solenoid common out	
	J1-4	Motor out (+VDC)	
	No connection	No connection	
8P-3,8P-7	J2-2	Wetting voltage out (+VDC)	To switch position contacts and 2PS switch
8P-1	J2-3	Switch status in – aa contact	Wetted by J2-2 of switch control
8P-2	J2-4	Switch status in – bb contact	
4P-2	To IED's current inputs	Current sensor – phase A	
4P-3		Current sensor – phase B	
4P-4		Current sensor – phase C	
4P-1		Current sensor – common	
User-defined connector	To IED's voltage inputs	Voltage sensor – phase A in	
		Voltage sensor – phase B in	
		Voltage sensor – phase C in	
		Voltage sensor – common	
8P-8	J2-1	Auxiliary status in	Wetted by J2-2 of switch control
	J5-1	Motor in (+VDC)	To power interposing relay
	J5-2	Solenoid in (+VDC)	
	J5-3	Motor/solenoid common in	To 0V
	J5-4	Motor/solenoid common in	To 0V
	J6-1	Solenoid in (+VDC)	To power interposing relay
	J6-2	Wetting voltage in (+VDC)	
	J6-3	Switch status out –aa contact	Wetted by J6-2 of switch control; to IED status inputs
	J6-4	Switch status out – bb contact	
	J7-1	Control mode status out	
	J7-2	Remote open in (+VDC wetted)	To IED control outputs
	J7-3	Remote open/close common	
	J7-4	Remote close in (+VDC wetted)	
	J8-1	Remote open/close common	
	J8-2	Auxiliary status out	To IED status input

Table 4 Form C Option

4.2.2.2 Form A Option

Connector pole I.D.	Switch control interface	Description	Notes
7P-5	J1-1	Command to solenoid – open (+VDC)	Rated 20 Amps resistive for 4 seconds; LFG switch requires 15 Amps for 100 msec.
7P-4	J1-2	Command to solenoid – close (+VDC)	Rated 20 Amps resistive for 4 seconds; LFG switch requires 20 Amps for 1.5 sec.
	J1-3	Motor/solenoid common out	
	J1-4	Motor out (+VDC)	
	No connection	No connection	
7P-3,7P-6	J2-2	Wetting voltage out (+VDC)	To switch position contacts and 2PS switch
7P-2	J2-3	Switch status in – aa contact	Wetted by J2-2 of switch control
	J2-4	Switch status in – bb contact	
4P-2	To IED's current inputs	Current sensor – phase A	
4P-3		Current sensor – phase B	
4P-4		Current sensor – phase C	
4P-1		Current sensor – common	
User-defined connector	To IED's voltage inputs	Voltage sensor – phase A in	
		Voltage sensor – phase B in	
		Voltage sensor – phase C in	
		Voltage sensor – common	
7P-1	J2-1	Auxiliary status in	Wetted by J2-2 of switch control
	J5-1	Motor in (+VDC)	To power interposing relay
	J5-2	Solenoid in (+VDC)	
	J5-3	Motor/solenoid common in	To 0V
	J5-4	Motor/solenoid common in	To 0V
	J6-1	Solenoid in (+VDC)	To power interposing relay
	J6-2	Wetting voltage in (+VDC)	
	J6-3	Switch status out –aa contact	Wetted by J6-2 of switch control; to IED status inputs
	J6-4	Switch status out – bb contact	
	J7-1	Control mode status out	
	J7-2	Remote open in (+VDC wetted)	To IED control outputs
	J7-3	Remote open/close common	
	J7-4	Remote close in (+VDC wetted)	
	J8-1	Remote open/close common	
	J8-2	Auxiliary status out	To IED status input

Table 5 Form A Option

Chapter 5: Product Specifications

These specifications apply to a switch controller covered by the configured item number system and may not apply to switch controllers that have been customized. Specifications for internal modules are described elsewhere.

5.1 Voltage Inputs

input	S&C SCADA Mate: from S&C 14.4KV or 25KV voltage sensors; burdened to 5.7VAC RMS nominal/7.6VAC RMS full scale
	Yaskawa LFG: 120VAC RMS nominal/132VAC RMS full scale from customer-supplied PTs
burden	32.3 Ohms maximum for S&C SCADA-Mate
	0.05VA maximum for Yaskawa LFG
magnitude measuring range	1% to 100% of full scale
accuracy (@ 25 degrees C)	S&C SCADA-Mate: +/-0.25% of full scale
	Yaskawa LFG: +/- 0.2% of full scale
power system configuration	grounded wye
power frequency	50 Hz/60 Hz
overload rating	S&C SCADA-Mate: 200% of nominal
	Yaskawa LFG: 110% of nominal

5.2 Current Inputs

input	S&C SCADA-Mate: from S&C 14.4K or 25KV current sensors; 5AAC RMS nominal/12.5 AAC RMS full scale Yaskawa LFG: from Yaskawa-supplied current sensors; 5AAC RMS nominal/12.5 AAC RMS full scale
burden	less than 0.03 VA
magnitude measuring range	1.6% to 100% of full scale
accuracy (@ 25 degrees C)	+/- 0.2% of full scale
power system configuration	grounded wye
power frequency	50 Hz/60 Hz
overload rating	400% of nominal for 4 seconds

5.3 Calculated Data

Calculated data is a function of the IED. Consult IED specifications fo the type of data available

5.4 Status Inputs

number of inputs	three; switch open, switch close, auxilliary
input wetting	27.6VDC nominal; 23 to 34 VDC range
thresholds (@ 25 deg. C)	on at greater than 20VDC, off at less than 11 VDC

5.5 Control Outputs

number of outputs	two; switch open, switch close
rating	20 Amps resistive for 4 seconds
control source	7.6VDC nominal; 23 to 34VDC range

5.6 Internal Indications

over and low voltage	issued on a per charger basis; high and low voltage alarms are issued to the host as a single status point
loss of AC	issued on a per charger basis
switch status	open, close and travel
control mode	local or remote
pseudo status points	consult IED literature

5.7 Battery Protection

low voltage load disconnect	on a per charger basis
over voltage disconnect	on a per charger basis

Consult the DART charger documentation for more information.

5.8 Local Display & Indicators

power supply system	seven states are visually alarmed; consult the DART charger documentation
control	switch open, switch close, auxiliary
data display panel	optional; consult the data display panel

5.9 Local Controls

local/remote	local/remote switch on IED and switch control
indicator test	test switch allows user to test the health of the control’s indicators
switch operation	large diameter, momentary on push buttons

5.10 Power Supply

input voltage	108 to 132VAC or 198 to 242 VAC, 50Hz/60Hz
input power (maximum) option	110VA for high power option; 55VA for low power
internal protection	6.3A fast blow fuse
battery back-up time	See discussion in earlier section

5.11 Com. Link Accessories

frequency range	125 MHz to 1 GHz
insertion loss	0.4 dB over the frequency range
surge withstand	50KA, 8/20us waveform with an energy content of 500 Joules as defined in IEC 801-5
turn on time	2.5 nsec.
surge let-through voltage	600V+/- 20%

5.12 Physical

size	for DART IED – 30”L X 18”W X 8.5”D
	for SCD IED – 26”L X 16”W X 12”D
weight	approximately 90 lbs.
enclosure	aluminum, painted, NEMA 3R with 3-point latch and 0.50” diameter padlock hasp, integrated pole-mounting bracket for lag or band mounting, integrated ground studs, varmint-proof vents, equipment mounting panels and 150 degrees door open latch
terminations	S&C SCADA-Mate: Harting connector
term	Yaskawa LFG: Nanaboshi Electric WT-304-P11 plug
	120V or 220V power through a user drilled hole

5.13 Environmental

operating ambient temperature	-40 degrees C to +80 degrees C
humidity	< 95% non condensing

5.14 Standards & Protection

ANSI/IEEE C37.90.1-1989 oscillatory waveform on all power, analog, status, and control field connections – 2.5KV applied for 2 seconds, 6 repetitions with 10 second wait time between repetitions; line-to-line and line-to-ground without upset or damage. ANSI/IEEE C37.90.1-1989 fast transient waveform on all power, analog, status, and control field connections – 4KV @ 60Hz applied for 2 seconds, 6 repetitions with 10 second wait time between repetitions; positive and negative polarity line-to-line and line-to ground without upset or damage. Ontario Hydro A-28M-82 oscillatory waveforms on all power, analog, status and control field connections – from 130 KHz to 1.6 MHz, 2.5KV applied for 2 seconds, 6 repetitions with 10 second wait time between repetitions; applied line-to-line and line to-ground without upset or damage. ANSI/IEEE C37.90.2 basic radiation and keying tests - 10V/m without upset or damage IEC 801-2 (EN 61000-4-2) ESD - 8KV contact discharge applied to any point on the exterior of the enclosure without upset or damage.

5.15 Product Documentation

standard	Product Description, Information & Specification, assembly and schematic drawings

Quantity of product documentation is defined on a per contract basis. Documentation for additional contract deliverables is arranged on a per contract basis.