SGC

operational & installation manual

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VR Avionics
www.vravionics.com

Contents

Introduction and Preparation

Thank you for considering our SGC to control the starter-generator on your aircraft. We believe you'll find the SGC fit and flexible to meet your specific application requirements.

Recommended Steps

This manual describes the preparation, operation, installation, configuration, and maintenance of the SGC line-replaceable unit. We recommended the following sequence of actions:

1. Decide on which model of SGC to use while taking into consideration the starter-generator, the batteries, the engine, as well as any other requirements for your application.
2. Order the SGC (or any MCU which uses the SGC) and other parts and perform the installation.
3. Update the SGC unit's firmware to the latest version (or at least version 3.6).
4. Familiarize yourself with and adjust the Configuration settings of your SGC as your specific application requires. If unsure email us your configuration file and we'll help you get it set up.
5. Perform the post-installation checks listed under Maintenance and Diagnostic Checks.
6. Perform a motor/vent cycle to verify the working of the starter while making a recording via SetView to confirm correct operation and maybe email to us.
7. Perform an engine start and if possible cycle the generator while again doing a live recording of everything. Afterwards inspect the graphs yourself, and maybe email it to us.
8. Based on the recorded graphs if required make new adjustments to configuration settings and repeat step 7 and 8 until satisfied with all aspects of operation.

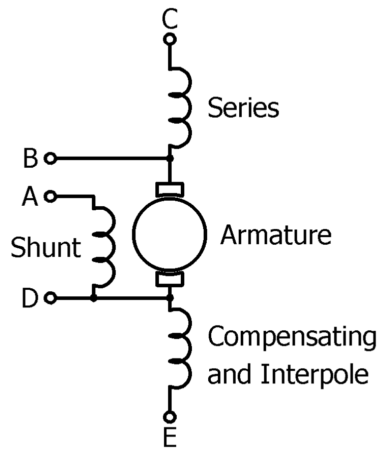
Model Functionality Matrix

Functionality	**SGC-1**	**SGC-2**	**SGC-3**	**SGC-4**
Generator Control	X	X	X	X
Battery Recharge Control	X	X	X	X
Starter Shunt Field Weakening	X	X		X
Auto-Start Starter Control		X	X	X
Auto-Start Ignition Control				X
Auto-Start Parallel-Series Battery Control			X	
Tachometer-Generator Speed Sensing		X	X	X

Starter-Generator Considerations

The SGC works with 28 VDC generators and starter-generators of various sizes, makes and models.

To the right is a schematic showing the internals of a typical starter-generator with the armature enclosed in brushes connected to four types of field windings (series, shunt, compensating and interpole) and terminals showing typical markings A through E.



Though this represents a starter-generator one would typically find, there are shunt-only ones that have no series winding (no C terminal). There are further also mostly older units that not only have non-standard (A, B, C, etc.) terminal markings than shown here, but do not have the D terminal (or interpole terminal) accessible.

The interpole terminal D provides feedback as to the load current on the starter-generator, whether as starter or as generator. For starter-generators without the interpole terminal, the SGC can, by use of an external shunt, still sense (and control) the load current during generation.

Starter-generators act as starter motors when you apply a positive voltage to terminal C with terminal E grounded. The series winding utilized provides a consistent torque versus speed curve, which is well-suited for starting gas-turbine engines. The magnetic field will automatically weaken as the motor speed increases.

As technology advanced, it became possible to accomplish field weakening via only the shunt winding, making the series winding redundant. Aircraft are increasingly utilizing starter-generators without the series winding (and without the C terminal) for the benefits they provide. The SGC supports both types.

The table below lists some important specifics that can be found on the nameplate and/or from the manufacturer.

Generator current rating (amps)	Normally on the nameplate, this indicates the rated continuous current (amps) it can deliver to the aircraft electrical bus as a generator.
Series field winding (yes/no)	Does the starter-generator have a series field winding traditionally used for starting, and normally marked as terminal C.
Shunt field resistance (ohms)	The resistance of the shunt field in ohms. For starter-generators or generators with typical markings it is measured between terminals A and E on a disconnected unit.
Interpole or “D” terminal (yes/no)	Does the starter-generator have an interpole (D terminal) accessible that can provide feedback as to the current through the starter-generator.
Interpole or “D” terminal voltage at generator rating	The voltage on the D terminal relative to the E terminal when the rated generator current flows through the starter-generator. This can be obtained from the manufacturer or measured during operation with a current clamp and a voltmeter.

Battery Considerations

Aircraft batteries not only serve as a power source to start an engine or multiple engines, whether on the ground or in the air, but function as reliable essential power in the event of a generator failure.

Whether using lead-acid, lithium, or any other type of battery, it is worthwhile to take good care of them, whether discharging, recharging or storing them by understanding and complying with the specifications from the battery manufacturer. Here are some key specifications to look out for:

Battery type	Lead acid, lithium iron phosphate, etc.
Voltage	The voltage to be expected on a fully charged battery – nominal voltage.
Capacity	The amp-hours a fully charged battery should last. Note that capacity changes significantly with temperature – lower temperatures, less capacity.
Self-discharge rate	The rate at which a stored battery looses charge over time.
Pulse crank amps (PCA)	The current a battery can provide typically for 3 seconds at 25°C.
Cold crank amps (CCA)	The current a battery can provide at 0°F (-18°C) typically for 30 seconds.
Continuous discharge current	The current a battery can continuously provide.
Maximum charge current	The maximum current a battery can accept to charge it.
Recommended charge current	Recommended maximum charging current for longer battery life.
Maximum charge voltage	The maximum voltage a battery can accept when charging it.

Engine Considerations

Some engine applications may require the incorporation of parallel-to-series switched starting for the added starter power it delivers. It is particularly useful for single shaft engines, like the Garrett TPE-331, where the starter must turn not only more mass and inertia but the propeller's drag.

The SGC-3 model will provide manual or completely automated parallel-to-series switched starting for applications that require this particular power versus speed curve. It does so by driving various contactors, taking care when making the switch-overs to open certain ones before closing others to prevent, even momentarily, the short circuiting of the batteries.

In this scheme, when starting, two batteries will be first run in parallel, until either reaching a certain speed or manually triggered, then switched in series to apply twice the voltage, until finally when reaching turbine idle speed switching back to parallel and disengaging the starter.

Parallel-to-series switched starting using the SGC-3 is only available for use with starter-generators with a series field winding, as described under starter-generator considerations.

Operation

System Parameters

The SGC gathers and maintains a series of parameters by sensing mainly voltages and frequencies at its pins, detailing what it's currently doing. Via Maintenance Support one can view these parameters in real-time and record them. This manual references them to describe how the SGC functions.

Parameter	Description	
BUS	BUS is the aircraft electrical bus voltage sensed at the BUS-PWR input (pin 1).	
POR	POR is the point-of-regulation voltage sensed at the POR input (pin 24). Also referred to as voltage sense, it typically senses generator voltage to regulate it.	
FVR	FVR is the field-volt ratio measured in one-thousandths. It gives the FIELD (pin 12) voltage to POR (pin 24) voltage ratio, which is very useful to track.	
LOAD	LOAD is the starter-generator load current in percentage of rated generator current via the D-SENSE (pin 11). It can go negative, which would indicate operation as a starter. Positive means generator.	
SHUNT	SHUNT is the current (in amps) flowing through an external current measurement shunt sensed via the SHUNT inputs (pins 5 and 6). It typically reads battery recharge current (to limit it).	
TACH	TACH is the speed (in percentage) of an external tachometer-generator measured via the TACH input (pin 17). It typically reads gas-generator/engine speed (to track starter-generator speed).	
GEN ON	Indicates generator activation/engagement.	
STARTER	Indicates starter activation/engagement.	
IGNITION	Indicates ignition activation/engagement (only SGC-4 has this capability).	
CAN BUS	Indicates when the SGC is receiving Supervisory Control command messages via CAN bus.	
CODE	NO FAULT	See explanations for each fault under Primary Fault Protection.
	INTERNAL	
	OVER-VOLT	
	OVER-LOAD	
	OVER-SHUNT	
	NEG-CURR	
	LINE-CON	
SGC	INIT	SGC is initializing. Usually for 1 second after power-up (master on).
	STANDBY	SGC is standing by (ready for action).
	STBY-START	SGC is standing by with START-PWR applied.
	STBY-GEN	SGC is standing by with GEN-PWR applied.
	START-FW	SGC is doing a start cycle and field weakening is deployed.
	START-NF	SGC is doing a start cycle and no field weakening is deployed.
	START-HI	SGC is doing a start cycle and batteries are currently switched in series.
	MOTOR-FW	SGC is doing a motor/vent cycle and field weakening is deployed.
	MOTOR-NF	SGC is doing a motor/vent cycle and no field weakening is deployed.
	GEN-RAMP	SGC is ramping the generator voltage (bulk phase).
	GEN-LOAD	SGC is limiting the generator load current (LOAD parameter).
	GEN-SHUNT	SGC is limiting the shunt (recharge) current (SHUNT parameter).
	GEN-ABSORB	SGC is generating battery absorption phase voltage.
	GEN-FLOAT	SGC is generating battery float phase voltage.
	GEN-EQU	SGC is generating an equalizing voltage to share the load with a second SGC.
	FAULT	SGC is in fault mode. Primary protection was activated.

Generator Control

All SGC models provide the generator control functions described in this section.

Voltage Build-Up

A properly polarized generator running at engine idle speed or higher produces a small voltage on its B terminal because of residual magnetism in its shunt field. The SGC will switch this voltage if applied to the GEN-PWR input to its FIELD output connected to the A terminal of the generator to excite the shunt field further and bring about voltage build-up.

The unit does not require voltage on any pin other than on the GEN-PWR input as stated to achieve build-up, nor does it need an electromagnetic relay externally (or employ one internally).

After enough build-up, the SGC uses pulse width modulation to control its FIELD output to regulate the generator's B terminal voltage as sensed on the POR input to equal that on the BUS-PWR input unless lower than 22 volts. If lower, the SGC regulates the POR input to 27 volts instead.

Line Contactor Control

After voltage build-up with the POR parameter stable at the described regulation target, the SGC will switch the voltage on the GEN-PWR input to the GEN-C output to energize the line contactor, which engages the generator to the bus. The SGC will, however, delay the engagement if the FVR parameter reads above the "Generator Engagement Field-Volt Ratio" or if "Generator Allow With START-PWR Powered" equals No and the START-PWR input gets power (bus/positive voltage). The Field-Volt Ratio measure prevents generator engagement at too low an engine speed, such as after an incomplete start.

When the generator current reverses to where the LOAD parameter reads below -10% with the Field-Volt Ratio (FVR) above "Generator Engagement Field-Volt Ratio", the SGC will de-energize the line contactor. This measure will ensure the generator disengages from the electrical bus if its speed drops below what the regulator needs to maintain voltage, such as during engine shutdown.

Phased Voltage Regulation

After energizing the line contactor bringing the generator online, the SGC sequences through three phases of voltage regulation that allows for improved battery management.

Bulk Phase

In this first phase, the aim is gradually to increase the generator voltage to maintain a constant recharge current for the batteries while fully servicing other loads until the "Generator Absorb Voltage" gets reached. Then it transitions to the absorb phase.

The SGC executes the bulk phase by slowly increasing the generator voltage (POR parameter) at the rate specified by "Generator Ramp Voltage Rise-Rate" unless one of two things. First, if the LOAD parameter does not meet the "Generator Ramp Load Current Minimum", the SGC augments the POR voltage slowly upwards. Secondly, if the SHUNT parameter exceeds the "Generator Shunt Recharge Current Limit", the SGC will lower the POR voltage as described further under Generator Limiting.

The SGC parameter will indicate GEN-RAMP in this phase unless the SHUNT parameter is actively limited, as explained, in which case it will show GEN-SHUNT instead.

Absorb Phase

This second phase keeps the generator voltage (POR parameter) constant at the "Generator Absorb Voltage" for a duration defined by the "Generator Absorb Duration" setting. The SGC parameter will indicate GEN-ABSORB in this phase. The SGC then transitions to the final float phase.

Float Phase

This final phase keeps the generator voltage constant at the "Generator Float Voltage".

The SGC parameter will indicate GEN-FLOAT in this phase.

Generator Limiting

The SGC will lower the generator voltage as sensed on the POR input to limit the LOAD parameter at the "Generator Load Current Limit" and the SHUNT parameter at the "Generator Shunt Recharge Current Limit", should either one exceed. The voltage will lower until both parameters meet their respective limits, but only to as low as 22 volts unless the generator is cross-start assisting, then as low as 12 volts. Should one of the parameters at this point still exceed its limit, the SGC will activate a fault. See also Generator Cross-Start Assist and Primary Fault Protection.

The SGC parameter will indicate GEN-LOAD if limiting the LOAD parameter, and GEN-SHUNT if limiting the SHUNT parameter.

Generator Disable

When the SGC senses the starter is active, it disables the generator by de-energizing the line contactor and performing Shunt Field Weakening if able to. See Simple Start Control and Automatic Start Control for how the SGC senses the starter is active.

Generator Reset

Grounding the TRIG input for 2 seconds while the generator is engaged, will reset it. The SGC will first de-energize the line contactor for 2 seconds, then equalize the generator voltage with the bus voltage (as described in Voltage Build-Up), before energizing the line contactor again (as described in Line Contactor Control). Phased Voltage Regulation will then start anew.

Generator Annunciation – Off/Fault

The SGC will ground its GEN-LT output to turn on an external GEN-OFF annunciation light. It indicates when the generator is offline (disengaged) and, should Primary Fault Protection have activated, as follows:

GEN-OFF	Explanation
Off	Generator Engaged
On (solid)	Generator Offline / Disengaged
Flashing (toggles every second)	Primary Fault Protection Activated (can be reset)

Residual Magnetism

Generator Control Units (GCUs) require a level of residual magnetism in the shunt field of the generator (starter-generator) to bring about effective voltage build-up.

A generator will lose its residual magnetism over time from inactivity (such as years in storage) or improper use. One can, however, restore the residual magnetism, also called "flashing the field", by applying a positive voltage, typically 24 volts, to the shunt field winding (terminal A) for 3 to 5 seconds.

Shunt-only starter-generators automatically receive "a flash" during an engine start, as their shunt fields are then subject to field weakening. The SGC, unlike other GCUs, can provide similar "flashing" for series-shunt starter-generators when performing a startup with the GEN switch On. The Shunt Field Weakening that will be active can thus restore the residual magnetism should it have dropped below an operative level.

Start Control

Simple Start Control

The most basic engine start setup is where an external circuit or device (such as a TSLM) controls starter activation. Though all SGC models support it, you can only use the -1 in this setup. The SGC is not in charge of starter engagement but must get notified of it. While bus/positive voltage is present on the START-PWR input, the SGC will disable the generator, turn on the external start annunciator, and perform shunt field weakening as required. You must configure "Start Engagement Require Momentary Powered TRIG" and "Generator Allow With START-PWR Powered" to No when using this setup.

Automatic Start Control

More advanced engine start setups supported by the -2, -3, and -4 models let the SGC control start and motor/vent cycles, beginning with starter engagement and ending with starter disengagement. During these cycles, the -3 model can perform parallel-series battery control and the -4 model ignition control. The -4 also distinguishes between start and motor/vent cycles.

Cycle Safeguarding

The -2, -3, and -4 models have speed safeguards where a start or motor/vent cycle will not initiate if the TACH parameter reads above the "Start Termination TACH Speed", an engaged generator produces proper voltage, or a disengaged generator produces bus voltage at a Field-Volt Ratio (FVR) lower than the "Generator Engagement Field-Volt Ratio".

Cycle Selection/Initiation

The "Start Engagement Require Momentary Powered TRIG" setting determines whether the SGC initiates a cycle immediately upon START-PWR or waits for an additional signal or command. With it set to No, the SGC will immediately commence a start or motor/vent cycle when bus/positive voltage gets applied to the START-PWR input. With it set to Yes, the SGC waits for an additional momentary bus/positive voltage on the TRIG or MOTOR inputs or an appropriate Supervisory Control command. The MOTOR input is only available on the -4 model.

For the -4 model, a start cycle gets selected differently from a motor/vent cycle. The status of the MOTOR input at cycle initiation determines which one. A start cycle if the MOTOR input is open-circuit, and a motor/vent cycle if it gets bus/positive voltage.

The -4 model with "Start Engagement Require Momentary Powered TRIG" set to Yes, will transition from start to motor/vent cycle if bus/positive voltage gets momentarily applied to the MOTOR input and from a motor/vent to a start cycle if bus/positive voltage gets momentarily applied to the TRIG input. If bus/positive voltage gets applied to both these inputs simultaneously, the SGC disregards the TRIG input signal and interprets it as a motor/vent cycle selection.

Cycle Starter Control

When the -2, -3, and -4 models must crank the engine during a start or motor/vent cycle, they will switch the bus/positive voltage on the START-PWR input to the START-C output to energize the contactor that engages the starter motor.

Parallel-Series Battery Control

The -3 model will switch a two battery arrangement from parallel to series during a start or motor/vent cycle if all the following criteria are valid. 1) 3 seconds have passed since cycle initiation, 2) the TACH speed has reached "Start Parallel-to-Series Transition TACH Speed", 3) the GEN-PWR input has no applied voltage, and 4) either bus/positive voltage gets applied to the TRIG input or the "Start Parallel-to-Series Transition Require Powered TRIG" setting equals No.

To engage the batteries in series, the -3 model first switches the bus voltage on the BUS-PWR input to the PAR2-C output to energize the (normally-closed) contactor that grounds the second battery, which ungrounds it. Simultaneously the -3 disrupts the voltage on the BUS-PWR input going to the BAT2-C output to de-energize the contactor that ties the second battery to the bus, which completes the parallel disconnection. After a 60ms delay, the -3 switches bus/positive voltage on the START-PWR input to the SER2-C output to energize the contactor that connects the two batteries in series, which raises the voltage to the starter motor to boost torque.

Cycle Ignition Control

When the -4 model must activate the ignition within the engine, it will switch the bus/positive voltage on the START-PWR input to the IGN-OUT output to energize the exciter(s) that engages the ignitor(s). The -4 model activates the ignition during a start cycle and withholds it during a motor/vent cycle.

Start Lead-In Ignition Check

The -4 model can insert an audible ignition check after initiating a start cycle before it engages the starter.

With "Start Lead-in Ignition Check Duration" set to a non-zero value, the -4 will activate the ignition but hold off on the starter until this configured time expires. The starter then activates to continue the start cycle.

Cycle Termination

All models will immediately terminate start or motor/vent cycles upon removing bus/positive voltage from the START-PWR input.

The -2, -3, and -4 models will furthermore terminate a start or motor/vent cycle if the TACH speed reaches the "Start Termination TACH Speed", the LOAD parameter rises above "Start Termination Under Current", the FVR parameter drops below "Start Termination Field-Volt Ratio", the TRIG input is momentarily grounded, or the SGC receives the appropriate supervisory control command.

In addition to the above, the -4 model, if "Start Engagement Require Momentary Powered TRIG" is Yes, will terminate an active start cycle if bus/positive voltage gets momentarily applied to the TRIG input and likewise terminate a motor/vent cycle if bus/positive voltage gets momentarily applied to the MOTOR input. If bus/positive voltage gets applied to both the TRIG and MOTOR inputs simultaneously, the SGC disregards the TRIG input signal.

Shunt Field Weakening

All SGC models will provide shunt field weakening when they sense the starter is active, as during a start or motor/vent cycle. It includes field ramp-up for the first second into a start to limit starter torque and reduce stress on the engine gearbox.

The SGC switches voltage on the GEN-PWR input to the FIELD output using pulse width modulation to excite the shunt field of the starter-generator via its A terminal to regulate the LOAD parameter to the value set by "Start Field Weakening Control".

The LOAD parameter represents the starter current as sensed by the SGC via its D-SENSE input, which connects to the D terminal of the starter-generator. A negative LOAD parameter indicates operation as a starter and a positive value operation as a generator.

Shunt-only starter-generators (no C terminal) require shunt field weakening to control the starter current. Series-shunt starter-generators powered through their C terminals have inherent starter current control, which field weakening will only slightly augment during the initial acceleration, but otherwise not affect.

Start Annunciation – On/Primed

The SGC will ground the START-LT output to turn on an external START annunciator/light. The SGC turns this annunciator on when it senses the starter is engaged to indicate that either a start or a motor/vent cycle is underway. Furthermore, the -2, -3, and -4 models will flash this annunciator if "Start Light Blinking Advisory" equals Enable and the start is primed (START-PWR gets bus/positive voltage), but a start or a motor/vent cycle is not yet engaged (START-C outputs no voltage).

START	Explanation
Off	Start or Motor/Vent Cycle Disengaged
On (solid)	Start or Motor/Vent Cycle Engaged (In progress)
Flashing (toggles every second)	Start or Motor/Vent Cycle Primed (Ready for Activation)

Fault Protection

To safeguard a stable and fail-safe system that prevents damage to components on the electrical bus, including the starter-generator, the SGC incorporates both primary and backup protection.

Independent from each other, primary protection acts with less delay to handle faults before backup protection will trigger. Backup protection acts as a second line of defense should primary protection fail.

The SGC microprocessor implements primary protection, covering a wide range of faults. Dedicated backup protection circuits, however, keep the system safe should the microprocessor malfunction or break down.

Primary Fault Protection

If the SGC detects any fault specified below, its primary protection will turn off all controlled contactor and ignition outputs GEN-C, START-C, PAR2-C, SER2-C, and IGN-OUT except for BAT2-C. In addition, the GEN-OFF annunciator will start flashing, the SGC parameter will indicate FAULT, and the CODE parameter and "Fault during Last Cycle" configuration property will update according to CODE and ID below.

CODE	ID	Fault Explanation
INTERNAL	IF	Internal fault. Internal reference voltage out of acceptable range.
OVER-VOLT	OV	Over-voltage during generator operation.
OVER-LOAD	OL	Load current limiting unsuccessful during generator operation.
OVER-SHUNT	OS	Shunt current limiting unsuccessful during generator operation.
NEG-CURR	NC	Negative current during generator operation.
LINE-CON	LC	Line contactor failure to close during generator operation.

An activated primary protection fault may be reset in the following ways:

- The positive voltage on the GEN-PWR input can be removed and re-applied (via GEN switch),
- The TRIG input can be momentarily grounded for at least half a second, or
- A supervisory computer can send a reset command (see Supervisory Control).

Backup Malfunction Protection

The SGC incorporates circuits that ensure the electrical system reverts to a safe condition should the SGC's microprocessor malfunction or break down.

One circuit prevents the SGC from switching bus/positive voltage on the GEN-PWR input to the GEN-C output that could have energized the line contactor should the microprocessor break down or malfunction.

Another circuit prevents the SGC-3 model from switching bus/positive voltage on the START-PWR input to the SER2-C output that could have energized the contactor that engages the batteries in series during a parallel-series start cycle should the microprocessor break down or malfunction.

Backup Over-voltage Protection

The SGC has a redundant over-voltage protection circuit that triggers at a level inversely proportional to time above a steady state voltage of 32.8 ±0.5 VDC.

If the voltages on either the POR or GEN-PWR inputs exceed this trigger level relative to the SIG-GND pin, the SGC will deploy an internal crowbar circuit to trip the field circuit-breaker by shorting pin 13 (GEN -PWR) to pin 11 (D-SENSE). This action will immediately remove voltage from the GEN-PWR input and as a result the FIELD and GEN-C outputs. It de-energizes both the shunt field of the generator and the line contactor.

If the circuit-breaker tripped, you can reset it by pushing it back in.

Supervisory Control

An external supervisory computer/device can monitor and control an SGC via CAN bus. In twin-engine applications, each SGC must be assigned a different "Unit Reference Number" for individual supervision.

Besides monitoring operating parameters, the supervisory computer can command an SGC into a particular mode should conditions permit the SGC. See Command Message for details.

CAN Bus Details

The SGC sends out information and can receive commands via its CAN bus interface.

Nominal bit time / rate	Determined by the setting "CAN Bus Interface Speed"
Frame format / identifier bit length	Base frame format / 11 identifier bits

Command Message

Command message Identifier	0x759 – if "Unit Reference Number" set to 1 0x75D – if "Unit Reference Number" set to 2
Command message length	1 (byte)
Command message recommended rate	10 messages per second
Command message timeout	1 second (if no message is received in this time, the SGC will act as though receiving a GENERATE command)

Command	*Value*	*Description*
STOP / INHIBIT	0x00	To inhibit Starter, Generator and Ignition
IGNITION CHECK	0x04	To engage only the Ignition if able *
MOTOR	0x01	To engage only the Starter (motor/vent cycle) if able *
START	0x05	To engage the Starter and Ignition (start cycle) if able *
GENERATE	0x02 **	To engage only the Generator if able *
GENERATE + IGNITION	0x06	To engage the Generator and Ignition if able *
RESET	0x08	To reset a triggered fault (only one message needed)

* Commanded actions are executed only if able to. For example, neither the starter nor the ignition will be engaged if power on the START-PWR pin is insufficient. Similarly the generator will not engage if power on the GEN-PWR pin is insufficient. If more than one action are commanded (such as GENERATE + IGNITION) only the actions able to be executed will be engaged.

** If a value other than listed in this table is commanded, it will be interpreted as a GENERATE command.

Information Message #1

Information message #1 identifier	0x75A – if "Unit Reference Number" set to 1 0x75E – if "Unit Reference Number" set to 2
Information message #1 length	8 (bytes)
Information message #1 send rate	10 messages per second

Parameter	*Bits*	*Offset*	*Details*
MODE	First 4	0	0 : INIT 1 : STANDBY 2 : STBY-START 3 : STBY-GEN 4 : START-FW 5 : START-NF

Parameter	Bits	Offset	Details
			6 : START-HI 7 : GEN-RAMP 8 : GEN-LOAD 9 : GEN-SHUNT 10 : GEN-ABSORB 11 : FAULT 12 : GEN-FLOAT 13 : MOTOR-FW 14 : MOTOR-NF 15 : GEN-EQU
CODE	Next 4	0	0 : NO FAULT 1 : INTERNAL 2 : OVER-VOLT 3 : OVER-LOAD 4 : OVER-SHUNT 5 : NEG-CURR 6 : LINE-CON
GEN ON	Next 1	0	ON/OFF indication of generator engagement
STARTER	Next 1	0	ON/OFF indication of starter engagement
IGNITION	Next 1	0	ON/OFF indication of ignition engagement (only SGC-4 has capability to control ignition)
CAN BUS	Next 1	0	ON/OFF indication of whether the SGC is receiving command messages via CAN bus
Not used	Next 4	0	Not used. Reserved.
BUS volt	Next 9	0	Voltage (V) from 0.0 to 51.1 (0.1 volt resolution)
POR volt	Next 9	0	Voltage (V) from 0.0 to 51.1 (0.1 volt resolution)
FVR	Next 10	0	Ratio from 0 to 1023
LOAD	Next 10	600	Percentage (%) from -600 to 423
SHUNT	Last 10	0	Amps (A) from 0 to 1023

Information Message #2

Information message #2 identifier	0x75B – if "Unit Reference Number" set to 1 0x75F – if "Unit Reference Number" set to 2
Information message #2 length	4 (bytes)
Information message #2 send rate	10 messages per second

Parameter	Bits	Offset	Details
TACH	First 16	0	Percentage (%) from 0.0 to 199.9 (0.1 % resolution)
NOT-USED	Last 16	0	Not used. Reserved.

Maintenance Support

You can access an SGC with a Windows laptop or tablet PC running our **SetView** application to perform maintenance and support tasks such as:

- Viewing system parameters in real-time (and recording them to file),
- Performing diagnostic tests to troubleshoot the system,
- Adjusting configuration settings, and
- Updating system firmware.

For installation options, see Maintenance Support Connection.

SetView Application

SetView is a free Windows application that you can download from our website. It comes bundled with the latest firmware for most VR Avionics LRUs, including the SGC, TSLM, PDC, FSM, and LSI.

Download it by the following direct link:

http://www.vravionics.com/support/how-to/#sv-install

Learn how to perform the various tasks SetView offers you from our **Support** web-page.

Twin-Engine Operation

Two SGC units can work together in twin-engine applications to provide the functions described in this section. For this, both units must be able to communicate with each other via the CAN bus.

To install, see CAN Bus Connections.

To configure, see the settings "Unit Reference Number" and "CAN Bus Interface Speed".

Generator Load Equalization

In twin-engine applications, one generator will get turned on before the other. The generator first engaged will function as it would in a single-engine application. The second generator, after it gets turned on, will slave onto the first. While the first SGC follows master generator modes GEN-RAMP, GEN-SHUNT, GEN-ABSORB, and GEN-FLOAT, the second will be in generator load equalization mode (GEN-EQU) as the slave.

In GEN-EQU mode, the slave generator takes on half the load of the first-engaged generator. The total electrical load will thus be split, each generator supplying half the load current. The LOAD parameters on both units should read equally to within a percent or two.

If one generator disengages, the remaining one will take up the total load if able to. Should the master generator disengage, the remaining slave generator will become the master, transitioning from generator load equalization mode (GEN-EQU) to one of the master generator modes (GEN-RAMP, GEN-SHUNT, GEN-ABSORB, and GEN-FLOAT).

Generator Cross-Start Assist

For twin-engine aircraft, after the first engine has started, its generator can assist the start of the second engine by supplying supplemental electrical power for the latter's starter.

The SGC with its generator engaged will allow for a lower-than-normal bus voltage when the other SGC signals it has its starter engaged. It enables the assisting generator to provide supplemental power to a greater degree throughout the start of the second engine. See also the section on Generator Limiting.

Installation

Mounting and Wiring

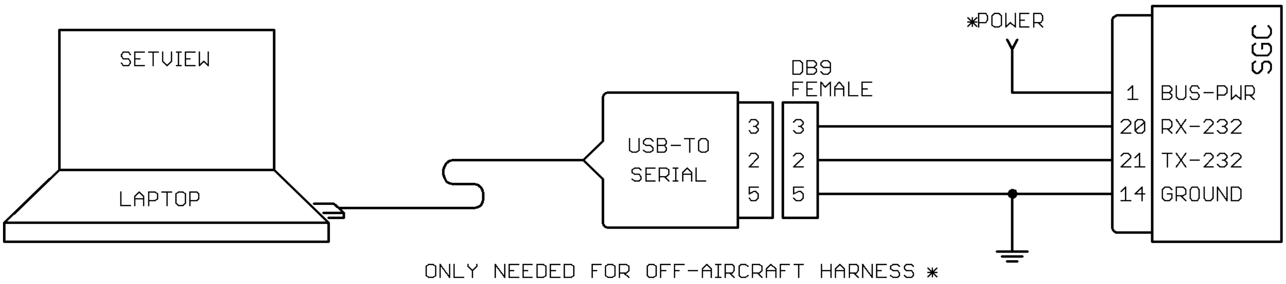
The SGC unit should be physically mounted as close to the starter-generator as possible without exposing it to excessive heat, and preferably within an MCU box. Wires that must carry substantial current should thus be shorter.

We recommend you use 20 gauge aircraft grade Teflon or Tefzel insulated wire for all wiring to and from the SGC unit or thicker (18, 16 gauge) wire if and where required. We also recommend you use machined contacts (such as 205090-1) with a crimp connector housing (such as 5205207-1) and a connector hood (such as 5207908-7). To crimp these machined contacts, you can use the AFM8 crimp tool and K13-1 positioner from DMC, alternatively, the PA1440 crimp tool from Paladin.

Ensure you use the correct splicing techniques to properly insulate any exposed wire, route and strain-relieve all wires so they will not chafe against any other object, and secure all connections. Since improper wiring may cause damage to the SGC or aircraft, we recommend you confirm all wire connections are correct before turning on any power.

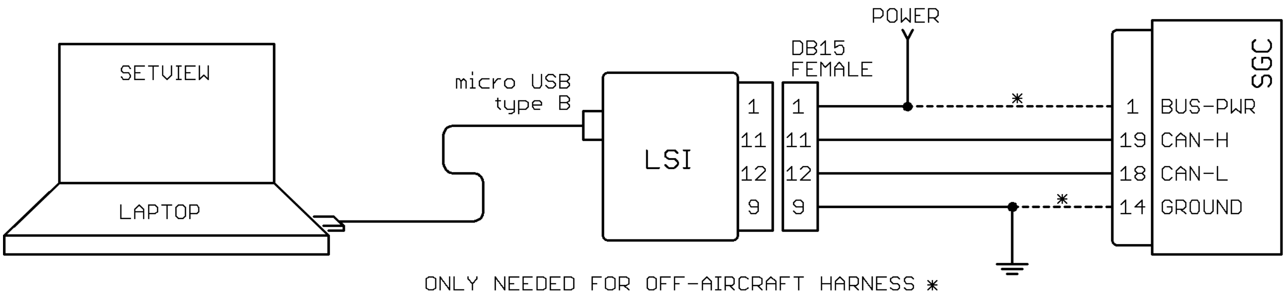
Maintenance Support Connection

There are two ways of getting Maintenance Support to allow you to view and record system parameters, perform diagnostic tests, adjust configuration, and update the firmware.



One way is shown above via the SGC serial interface. It exposes SGC serial communication pins via a 9-pin female d-sub connector. With a USB-to-serial converter, a laptop or tablet PC running our SetView application will give you the necessary access.

Another way is shown below via the SGC's CAN bus interface. It exposes the relevant pins via a 15-pin female d-sub connector. Plugging in an LSI (log sync interface) gives you the access. The LSI advantage is its convenience of logging operations onto a micro SD card instead of a laptop or tablet PC.

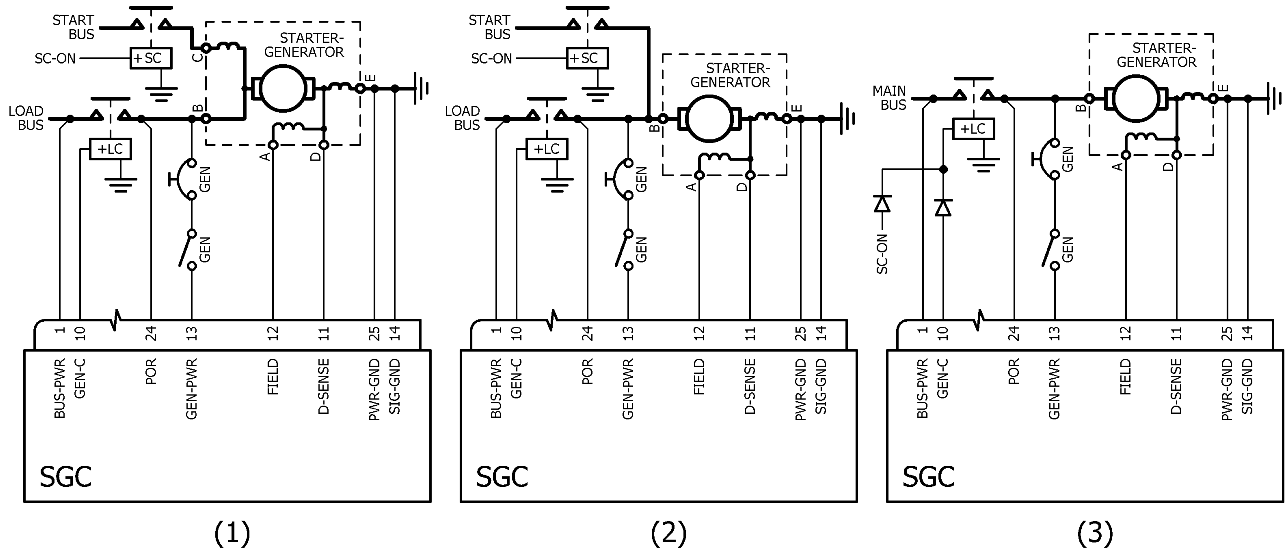


To download and learn more about SetView, see SetView Application.

You can find a USB-to-serial converter, a micro SD card, and a laptop or tablet PC at an online or local consumer electronics store.

Starter-Generator Connection

The circuits below show options to connect your starter-generator to the SGC and aircraft electrical system.



(1) (2) (3)

Circuit 1 above is for a series-shunt starter-generator, while 2 and 3 are for a shunt-only starter-generator. Though circuits 1 and 2 show separate start and load buses, they may be connected and form one main bus as in 3. Circuit 3 illustrates how one contactor can fulfill the roles of two in shunt-only starter-generator applications. The wires marked SC-ON, which engages the respective starters when powered, link up to circuits to be discussed in the next section, Starter Control Connection.

Contactors and cable/wire selected must be able to conduct the expected current with as little voltage drop as possible to and from starter-generator terminals B and C (if used) and between the starter-generator's ground terminal E and aircraft ground. See also Contactor Selection.

Connect the SGC to the ground via two separate wires. One for PWR-GND, which conducts the shunt-field return current, and one for SIG-GND. The closer the connections are to terminal E of the starter-generator, the better.

Connect the wires for BUS-PWR and POR close to the line contactor (LC) contacts, as shown, one on the load bus (or main bus) side and the other on the starter-generator side. You can add fuses close to where they connect to protect these wires should there be accidental shorting or arcing. These can be as low as 1 amp and as high as the wire specification. However, if using a -3, see Parallel-Series Battery Control Connection.

The wire that powers the GEN-PWR input from the B terminal of the starter-generator via the GEN circuit-breaker and switch may be fused close to where it connects to the B terminal to protect it should there be any accidental shorting or arcing. The GEN circuit-breaker trip rating must be lower than this fuse so that it trips before the fuse blows. The "Maximum Field Control Voltage" setting allows you to select from a range of circuit-breaker ratings, and more.

Backup Over-voltage Protection requires the GEN circuit-breaker and a D-SENSE connection to the D terminal of the starter-generator to function. If the latter doesn't have a D terminal, connect D-SENSE to the ground via a dedicated wire.

We recommended using a GEN switch, as shown, which one may combine with the START ENABLE function into a single double-pole selector, as discussed under Starter Control Connection. Though alternatives exist, the GEN switch enables one to force the generator offline and reset any activated Primary Protection Fault.

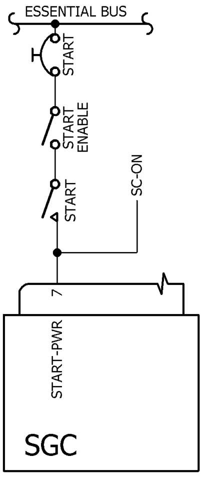
Check the "Starter-Generator Rated Current D Terminal Voltage" setting is accurate to ensure the SGC setup is correct for your starter-generator.

If considering circuit 3 above, see Diode Selection.

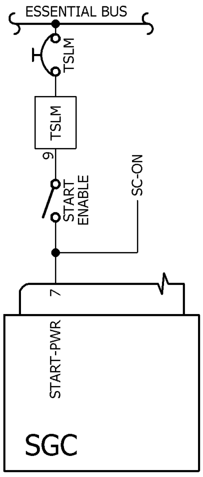
Starter Control Connection

Wires marked SC-ON below link to circuits in the previous section, Starter-Generator Connection.

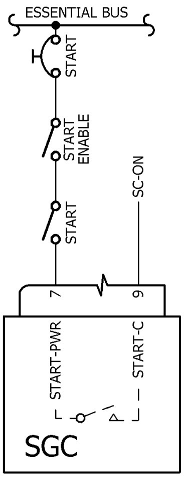
Circuits A and B below to the left give examples of Simple Start Control. In circuit A a momentary switch controls the starter, whereas, in circuit B a TSLM or similar device does the task.



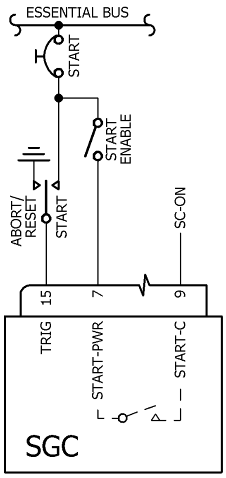
(A)



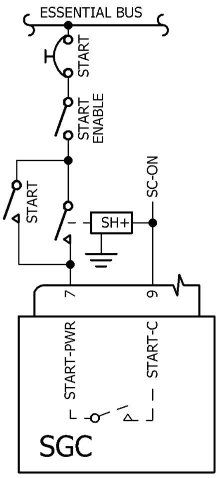
(B)



(C)



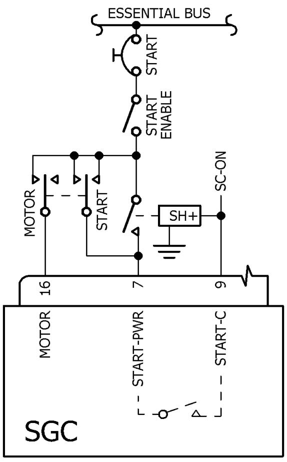
(D)



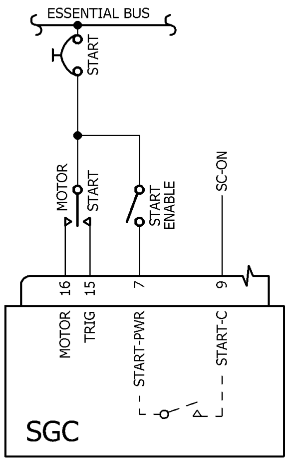
(E)

Circuits C thru E above to the right give options for Automatic Start Control of -2, -3, and -4 models that allow automatic starter disengagement as the START-C output now controls the SC-ON wire. You can configure the SGC to immediately engage the starter upon receiving power on the START-PWR input or require an additional momentary power application on the TRIG input, such as circuit D would need. See also Cycle Selection/Initiation.

Circuits F and G, shown to the right, provide options for Automatic Start Control available to the -4 model. It allows the operator to select between a start and a motor/vent cycle, as described under Cycle Selection/Initiation.



(F)



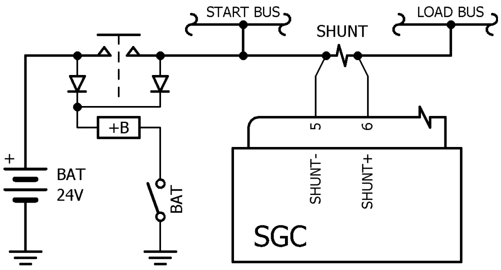
(G)

When specifying the **START circuit-breaker** or fuse shown in these circuits, consider the currents from START-C, IGN-OUT and SER2-C outputs, as START-PWR will source all of these.

Though more complex with the added **SH relay**, circuits E and F allow the automatic removal of power from the START-PWR input after the SGC de-energizes the START-C output. Two independent devices (the SGC and the relay) can thus prevent starter activation, which may be an application requirement. The start hold (SH) relay can be a single pole normally open relay however must be 24 volts and able to handle the current necessary to energize the start contactor (SC) for circuits 1 and 2 or the line contactor (LC) for circuit 3 discussed under Starter-Generator Connection.

For shunt-only starter-generator applications, we recommend you consolidate the **START ENABLE switch**, shown in circuits A thru F, and the GEN switch, discussed under Starter-Generator Connection, into one double-pole unit. The START ENABLE switch is typically redundant in series-shunt starter-generator applications as there are alternatives to override (abort) a start or motor/vent cycle.

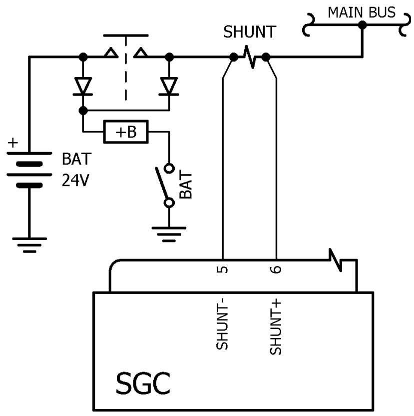
Shunt Recharge Current Sensing Connection



The SGC can measure the current flow through an external shunt (resistor) via its ±SHUNT pins. Typically this shunt senses battery recharge current, as shown to the left.

The SGC computes the SHUNT parameter from the differential voltage, which it can also use to execute Generator Limiting.

It allows the SGC to provide a precise bulk (constant charging current) phase if required. For more, see the section on Setting Up Battery Recharge Control.



A shunt can be inserted between the LOAD BUS and the START BUS or between the MAIN BUS and the battery contactor.

We don't recommend placing the shunt between the batteries and their contactor since this can cause slow battery drainage over time with the aircraft parked and not on a charger.

You may add fuses close to where SHUNT+ and SHUNT- connect to the shunt to protect their wires should there be any accidental shorting or arcing. These can be as low as 1 amp and as high as the wire specification.

To select a shunt, its resistance (R), power rating (P) and short-term overload (STO) are important parameters. The SGC can read differential voltages between the SHUNT± pin of up to 90mV.

As **an example**, if we consider the WSBS5216L1000JK battery shunt shown to the right made by Vishay Dale (which you can obtain from online stores like digikey.com), we get the following from its datasheet:

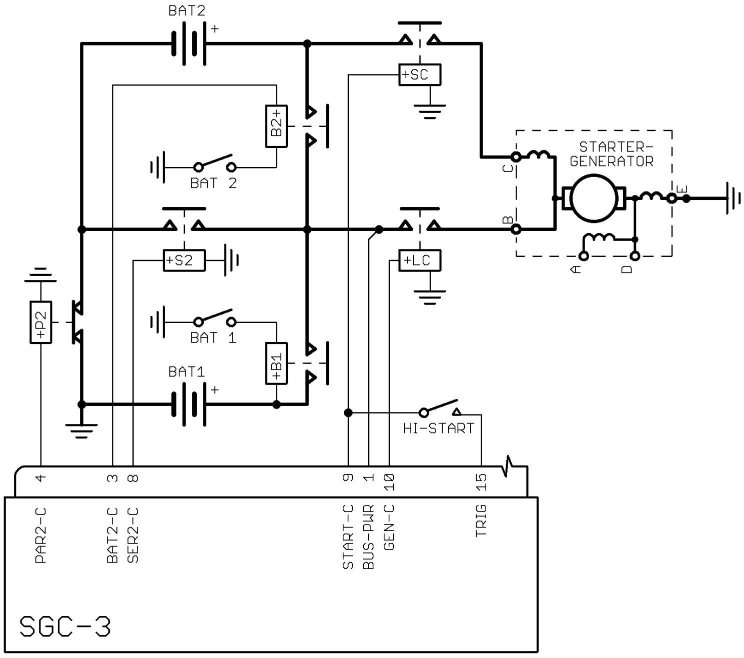
Parameter	**Value**
Resistance (R)	0.0001 Ohm
Power rating (P)	12 Watt
Short time overload (STO)	10 x rated power for 5 seconds

From this we can calculate the following:

Parameter	**Calculation**	**Result**
Max. continuous current rating (MCC)	√(P / R)	346 Amps
Short time current (STC)	10 x MCC	3460 Amps (for 5 seconds)
Max. measurable current (MMC)	0.09 / R	900 Amps
Measurable current resolution	MMC / 1000	0.9 Amps
Amps value at 50mV	0.05 / R	500 Amps

To set up the SGC for this example, you must adjust the "Shunt Recharge Current Sensing 50mV Current" setting to the last value in the table above, which is 500 amps.

Parallel-Series Battery Control Connection



The circuit to the right shows how to connect an SGC-3 model for parallel-series battery control.

It shows two battery master switches, BAT1 and BAT2, which control the two contactors, B1 and B2, one for each battery. The SGC shares control over the B2 via the BAT2-C output.

Also in the circuit are the start and line contactors, SC and LC. The SGC controls them via START-C and GEN-C, as on other models.

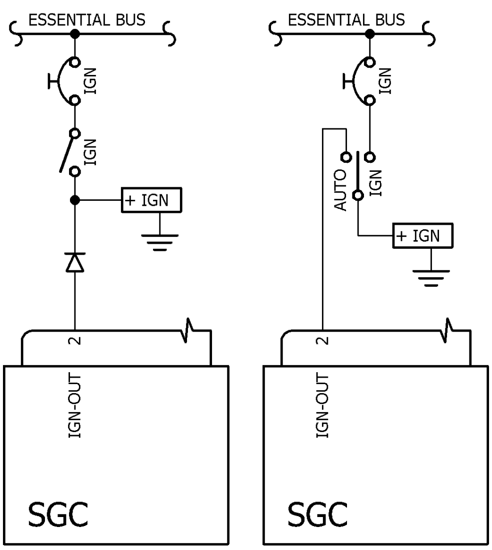
There are also two additional contactors, P2 and S2. Note that P2 is the only normally-closed contactor. The rest is all normally-open ones. The SGC controls P2 via the PAR2-C output and S2 via the SER2-C output.

The circuit also has a momentary switch between START-C and the TRIG input, which is optional. For more on this and how parallel-series battery control operates, see Parallel-Series Battery Control.

If employing this circuit with a fuse on the BUS-PWR wire where it connects to the bus, as discussed in Starter Control Connection, you must spec this fuse to include currents to energize the contactors, P2 and B2, as BUS-PWR will be sourcing these.

Similarly, if using a START circuit-breaker or fuse, also discussed in Starter Control Connection, you must specify its rating to include currents to energize the contactors, SC and S2, as START-PWR will source these.

Ignition Control Connection



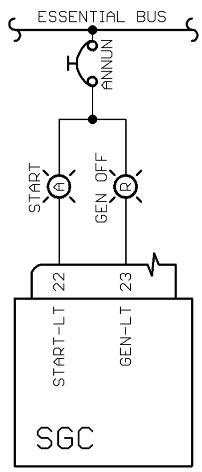
The circuits on the right show examples of how to connect the SGC-4 to activate the ignition.

One circuit to the right ensures the ignition gets powered during a start via a diode, and the other circuit uses the IGN switch to select between On, Off and Auto, with the latter ensuring automatic ignition activation. The diode is required in the first circuit to prevent power from feeding back into the IGN-OUT pin. See also Diode Selection.

The IGN-OUT output of the SGC can provide a continuous current of 6 amps to power the ignition exciter(s), which produces sparks at the ignitors.

For more on how it functions, see Cycle Ignition Control and Start Lead-In Ignition Check.

Annunciation Lights Connection



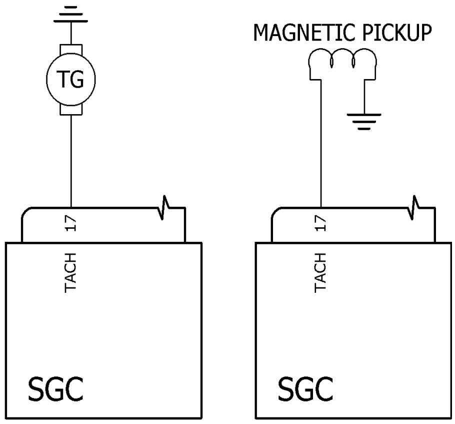
The SGC can connect to two external annunciation lights, one for START (or STARTER) advisory (or caution), and one for GEN OFF warning.

Each of these SGC outputs can ground up to one amp continuously to turn on their respective external lights.

For how these lights operate, see:

- Generator Annunciation – Off/Fault, and
- Start Annunciation – On/Primed.

TACH Speed Sensing Connection



The -2, -3, and -4 models can read the starter-generator speed from either a tachometer-generator (TG) or a magnetic pickup source, as shown to the right.

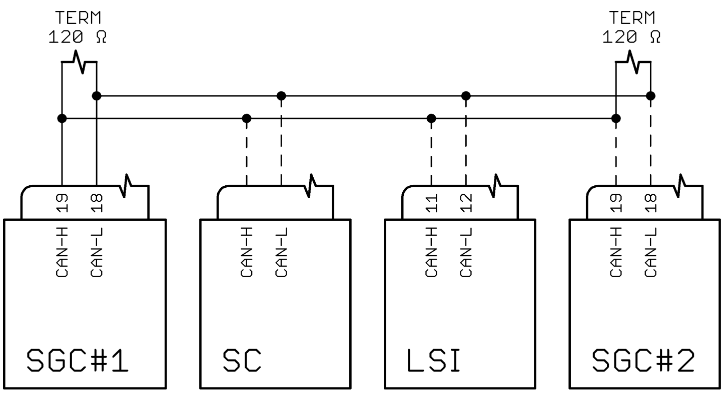
The sensor may be the N1 or N2 tachometer-generator that is coupled via a fixed gear ratio to the starter-generator shaft, or a separate sensor on the starter-generator itself.

Assign the "Tachometer-Generator Full Speed Frequency" setting correctly to enable the SGC to read the TACH speed.

The TACH speed can serve as a useful reference when analyzing system operation, but also facilitate other operations, such as:

- Cycle Termination, and
- Parallel-Series Battery Control.

CAN Bus Connections



The circuit to the right shows all available possibilities in terms of CAN bus connections.

To connect an SGC with another device or second SGC via CAN bus you need two termination resistors, one at each end of the bus as shown.

Other devices can be a second SGC, a third-party Supervisory Control (SC) device, and an LSI (log sync interface).

The devices that share the CAN bus must be grounded at a common grounding point.

We recommend using two core cable, one for CAN-H and one for CAN-L.

For more, see Supervisory Control, Maintenance Support and Twin-Engine Operation.

Diode Selection

Diodes, if required to be used with the SGC, should be able to block at least 50 volts and conduct the current for their purpose, such as energizing a contactor coil or powering an ignition exciter. Diodes like the SB560-E3/54 will block 60 volts and conduct a continuous current of 5 amps, which should be suitable in most instances.

Contactor Selection

SGC contactor outputs, including GEN-C, START-C, BAT2-C, PAR2-C, and SER2-C, can all provide a continuous coil energizing current of 2.5 amps and a 100ms inrush of 10 amps. Choose 24-volt contactors that meet these specifications and can make and break the necessary contact amps.

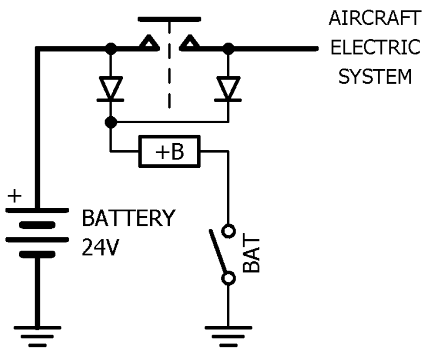
SGC contactor outputs also provide for fast demagnetization to improve switch-over speed, increase contactor life and reduce the risk of "sticking" between contacts. The latest SGC units will clamp coil demagnetization at ±70 volts. Do not add external demagnetization (also called coil suppression) for these SGC outputs.

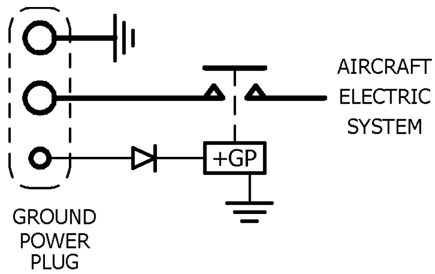
For contactors not controlled by the SGC, such as those connecting batteries and ground power to the electrical bus, you may need to add demagnetization. Check the specifications of your chosen contactor as many these days have built-in coil suppression.

Battery and GPU Polarity Protection

To protect your aircraft's electrical system from damage resulting from accidentally connecting batteries the wrong way around, possibly after a service, you may want to add one or two diodes to your battery contactor, as shown in the first circuit below. These diodes will prevent the energizing of the coil and the closing of its contacts should the polarity of the battery be incorrect.

Similarly, you can protect your electrical system from any incorrectly wired external ground power plug hooked up to your aircraft by incorporating the diode, as shown in the second circuit below.





Configuration

To set the SGC up for your application, we recommend the following:

- ✔ Get to know and understand all the configuration settings described in this chapter.
- ✔ Before doing an engine cycle, if you know any setting's value or can determine it as described here, do so, else leave it at its factory default as provided here.
- ✔ Do a recorded cycle, analyze the recording, make adjustments, and repeat until satisfied.
- ✔ Feel free to contact us for advice, suggestions or only for confirmation.

You can view and alter your SGC configuration settings by connecting Maintenance Support and employing our free SetView application.

Basic Operational Settings

#	Configuration Setting	Minimum	Maximum	Factory
1	Starter-Generator Rated Current D Terminal Voltage (V)	0.80	2.00	1.63
2	Shunt Recharge Current Sensing 50mV Current (A)	50	600	500
3	Maximum Field Control Voltage (V)	16.00	24.00	24.00
4	Tachometer-Generator Full Speed Frequency (Hz)	70.00	70.00	70.00
5	Unit Reference Number	1	2	1
6	CAN Bus Interface Speed	125K	1000K	142.8K
7	Fault during Last Cycle	-	-	--

Starter-Generator Rated Current D Terminal Voltage

This setting assigns what voltage on your starter-generator D terminal constitutes the rated starter-generator current. The D terminal connects to D-SENSE, and the SGC senses it to derive the LOAD parameter. You can find the rated current (in amps) given on the nameplate of your starter-generator, typically under Generator Rating.

In starter mode, a positive D terminal voltage (relative to the E terminal), and in generator mode, a negative one appears. The ratio of voltage to current stays the same independent of direction.

For many applications, this setting's value should be 1.63 V. Because it impacts how accurately the SGC derives the LOAD parameter, we recommend you confirm it.

This setting can be confirmed as correct when the starter-generator current as a percentage of the rated current equals the LOAD parameter (via SetView). You can measure the starter-generator current with a current clamp or current shunt. For example, if the generator current is 150 amps for a starter-generator rated at 250 amps, the LOAD should read 60%. If it does not, you can correct the Rated D Terminal Voltage setting by multiplying its current value by the actual LOAD % and dividing that by the expected LOAD %.

Shunt Recharge Current Sensing 50mV Current

This setting defines the resistance of the current sensing shunt connected to the ±SHUNT input pins, typically used for sensing battery recharge current. Though instead of Ohms, one specifies it in amps at 50mV. The SGC calculates the SHUNT parameter from it. Having a setting allows the SGC to sense a wide range of current sensing shunts.

Some datasheets state the 50mV current, while with others, you must calculate the value from the specified resistance using Ohm's law. For example, a 0.0001-ohm shunt will produce 50mV at 500 amps. For an specific example, see Shunt Recharge Current Sensing Connection.

Leave this setting at its default (500) should you not use a current-shunt.

Maximum Field Control Voltage

This setting defines the maximum voltage the SGC will apply to its FIELD output. It allows you to limit the excitation current to the shunt field of the starter-generator, as this has a resistance (typically ±2.2 ohms).

Limiting the shunt field current can have benefits, which include allowing an application to work with a lower GEN circuit-breaker rating without nuisance tripping. Thereby one can use 10, 7.5, and even 5-amp breakers.

Reducing this setting may also be used to lower the maximum power the generator will produce at low engine speeds, such as idle or below, should it be desired.

We recommend assigning the default (24 V) at first. Then if the need arises, such as if the circuit-breaker nuisance trips during operation, reduce this setting to remedy the situation.

See also the section on Starter-Generator Connection.

Tachometer-Generator Full Speed Frequency

This setting determines the frequency (in Hertz) on the TACH input that constitutes 100% starter-generator speed. It only allows for 70.00 Hz sensors, the most commonly used tachometer-generators setup on gas-turbine engines. We may broaden the selection in future.

Unit Reference Number

This setting enables the two SGC units to communicate with each other over a shared CAN bus for applications where more than one starter-generator connects to a shared electrical bus, such as with a twin-engine aircraft. It allows you to assign reference numbers that must be different (ideally, 1 for engine 1 and 2 for engine 2).

On twin-engine aircraft, you get Generator Load Equalization and Generator Cross-Start Assist.

CAN Bus Interface Speed

This sets the speed in bits per second (bps) of the unit's CAN bus interface. Options are as follows:

Setting	CAN Bus Speed (bps)
0	142.8K (default)
1	125K
2	250K
3	500K
4	1000K

You must configure all devices on the CAN bus to the same speed to allow them to communicate with each other.

Fault during Last Cycle

This configuration property reports the cause of any fault detected (and activated) by the unit's primary protection during the previous generator cycle. You can reset it manually via SetView, or it will auto-reset 10 seconds into a faultless generator cycle.

See the section on Primary Fault Protection for what each fault code represents.

Start Specific Settings

#	Configuration Setting	Minimum	Maximum	Factory
8*	Start Light Blinking Advisory	Disable	Enable	Disable
9*	Start Engagement Require Momentary Powered TRIG	No	Yes	Yes
10***	Start Lead-in Ignition Check Duration (0 to 2 sec)	0	2	0
11	Start Field Weakening Control (%)	100	250	120
12**	Start Parallel-to-Series Transition Require Powered TRIG	No	Yes	No
13**	Start Parallel-to-Series Transition TACH Speed (%)	20.0	40.0	30.0
14*	Start Termination TACH Speed (%)	40.0	80.0	55.0
15*	Start Termination Field-Volt Ratio (FVR)	0	300	0
16*	Start Termination Under Current (%)	0	80	0

* used only by SGC-2, SGC-3 and SGC-4

** used only by SGC-3

*** used only by SGC-4

Start Light Blinking Advisory

This setting defines how the start annunciator will behave when a start or motor/vent cycle is not active but primed, meaning bus/positive voltage gets applied to the START-PWR input, but the SGC is not switching it to the START-C output. If set to Enable, the start annunciator will flash, else it will remain off. For more, see the section on Start Annunciation – On/Primed.

Start Engagement Require Momentary Powered TRIG

This setting determines if the SGC should wait for momentary bus/positive voltage at the TRIG input or reception of a Supervisory Control start command before initiating a start or motor/vent cycle. For more, see the section on Cycle Selection/Initiation. Note that the -1 model will force this setting to No.

Start Lead-in Ignition Check Duration

Applicable only to the -4 model, this setting determines if the SGC must insert a short audible ignition check after start cycle initiation but before starter engagement, and if so, for what duration (2 seconds maximum). Set this to 0 to disable this feature. See also Start Lead-In Ignition Check.

This feature can be of use in two ways. First, it gives audible confirmation of start cycle selection, in contrast to a motor/vent cycle where ignition is distinctly absent. If the cycle type is not what you intended to initiate, you can quickly abort or select the correct one. Second, one can audibly verify the quality of ignition. If inadequate, the operator can abort the start cycle, ideally before the starter gets engaged. For more, see the section on Cycle Selection/Initiation and Cycle Termination.

Start Field Weakening Control

This setting sets the starter current to be regulated using shunt field weakening during an engine start. Its value is in percentage of the rated starter-generator current as indicated by the LOAD parameter (negative during starter activation). For more on how it works, see Shunt Field Weakening. To disable start field weakening altogether set this setting to its maximum (250).

A recommended point to start is 120, the default, meaning 120% of the rated starter-generator current. For many applications, this would be good enough. Also, as the LOAD parameter depends on it, ensure you verify "Starter-Generator Rated Current D Terminal Voltage" is assigned correctly.

In search of a more optimal value, you may want to reduce this setting a little at a time until you notice a drop-off in starter performance or the performance becomes unacceptable. When satisfied, dial it back a notch or two and leave it at that.

The general idea with a lower setting (and lower starter current) is to reduce strain on your batteries and gain more consistent starter performance across battery conditions, including state-of-discharge and age.

Start Parallel-to-Series Transition Require Powered TRIG

Applicable only to the SGC-3, this setting selects whether an SGC will require a trigger on the TRIG input, such as an SPR button push, in addition to the other criteria to perform the parallel-batteries to series-batteries switch-over during a start cycle.

For more, see Parallel-Series Battery Control.

Start Parallel-to-Series Transition TACH Speed

Applicable only to the SGC-3, this setting defines the minimum speed (in %) an SGC must read from the TACH parameter in addition to the other criteria to perform the parallel-batteries to series-batteries switch-over during a start cycle.

For more, see Parallel-Series Battery Control.

Start Termination TACH Speed

This setting defines the minimum speed (in %) an SGC must see the TACH parameter reach before it terminates a start cycle, which includes disengaging the starter.

For different options to set up an SGC to automatically terminate a start cycle after reaching a certain speed, see Setting Up Cycle Termination at Speed.

Start Termination Field-Volt Ratio

This setting defines the maximum Field-Volt Ratio (FVR) an SGC must see the FVR parameter drop below before it terminates a start cycle, which includes disengaging the starter.

For different options to set up an SGC to automatically terminate a start cycle after reaching a certain speed, see Setting Up Cycle Termination at Speed.

Start Termination Under Current

This setting defines the maximum current (in % of rated current) an SGC must see the LOAD parameter drop below before it terminates a start cycle, which includes disengaging the starter.

For different options to set up an SGC to automatically terminate a start cycle after reaching a certain speed, see Setting Up Cycle Termination at Speed.

Generator Specific Settings

#	Configuration Setting	Minimum	Maximum	Factory
17*	Generator Allow With START-PWR Powered	No	Yes	No
18	Generator Engagement Field-Volt Ratio (FVR)	100	500	300
19	Generator Load Current Limit (%)	10	100	100
20	Generator Shunt Recharge Current Limit (A)	20	600	40
21	Generator Ramp Load Current Minimum (%)	0	50	20
22	Generator Ramp Voltage Rise-Rate (seconds per volt)	0	6000	10
23	Generator Absorb Duration (minutes)	1	60	5
24	Generator Absorb Voltage (V)	27.00	29.00	28.80
25	Generator Float Voltage (V)	27.00	29.00	27.60

* used only by SGC-2, SGC-3 and SGC-4

Generator Allow With START-PWR Powered

This setting selects whether bus/positive voltage (power) on the START-PWR input will inhibit generator engagement. Set to No it will, to Yes it won't. Note that the -1 model will force this setting to No.

Generator Engagement Field-Volt Ratio

This setting defines the maximum Field-Volt Ratio an SGC must see the FVR parameter drop below in addition to the other criteria before it engages the generator. This setting will prevent (inhibit) the generator from engaging at too low a speed. The lower this value, the higher the engine speed must be before the SGC activates the generator. The best practice is to see what the FVR parameter reads at engine idle (via SetView) and adjust this setting accordingly.

For more, see Line Contactor Control.

Generator Load Current Limit

This setting defines the generator load current (in %) the SGC will attempt to limit the LOAD parameter at or below. The main purpose of this setting is to protect the generator from overloading and overheating.

For more, see Generator Limiting.

Generator Shunt Recharge Current Limit

This setting defines the battery shunt current (in amps) the SGC will attempt to limit the SHUNT parameter at or below. With a battery shunt installed, this setting sets the maximum battery recharge current.

See also the sections on Bulk Phase Voltage Regulation and Setting Up Battery Recharge Control.

Generator Ramp Load Current Minimum

This setting defines the minimum generator load current (in %) the SGC will increase the generator voltage to meet while in GEN-RAMP mode.

See also the sections on Bulk Phase Voltage Regulation and Setting Up Battery Recharge Control.

Generator Ramp Voltage Rise-Rate

This sets the rate of rise (in seconds per volt) the SGC will increase the POR (point-of-regulation) input to starting when the generator gets engaged and ending when the POR input reaches "Generator Absorb Voltage".

See also the sections on Bulk Phase Voltage Regulation and Setting Up Battery Recharge Control.

Generator Absorb Duration

This setting specifies the time in minutes the SGC will spend in absorption phase before switching to float phase. See also the sections on Absorb Phase Voltage Regulation and Setting Up Battery Recharge Control.

Generator Absorb Voltage

This sets the absorption phase voltage the SGC will regulate the POR (point-of-regulation) to when the generator is engaged after voltage ramp-up have completed and no battery recharge current limiting is being performed.

See also the sections on Absorb Phase Voltage Regulation and Setting Up Battery Recharge Control.

Generator Float Voltage

This sets the float phase voltage the SGC will regulate the POR (point-of-regulation) to when the generator is engaged after the absorption phase have completed and no load limiting or battery recharge current limiting is being performed. This setting must be lower than or equal to "Generator Absorb Voltage".

See also the sections on Float Phase Voltage Regulation and Setting Up Battery Recharge Control.

Factory Calibration Settings

Factory Calibration settings are particular to a specific SGC unit and were configured at the factory. As such they will seldom if ever need adjustment. They are however accessible should re-calibration be needed and you have the necessary equipment and time at hand.

#	Configuration Setting	Minimum	Maximum	Factory
26	Factory Calibration: POR Voltage	-1.00	1.00	Unit specific
27	Factory Calibration: BUS Voltage	-1.00	1.00	
28	Factory Calibration: D-SENSE Zero	500 (typ)	545 (typ)	
29	Factory Calibration: D-SENSE Span	143 (typ)	149 (typ)	
30	Factory Calibration: SHUNT Span	227 (typ)	247 (typ)	

Factory Calibration: POR Voltage

This setting calibrates the POR parameter reading which senses the voltage between the POR pin and the SIG-GND pin. For example, if the POR parameter indicates 0.25 volt lower than it should be, you can increase this value by 0.25 to correct it. This calibration should only be attempted with an accurate voltmeter.

Factory Calibration: BUS Voltage

This setting calibrates the BUS parameter reading which senses the voltage between the BUS-PWR pin and the SIG-GND pin. For example, if the BUS parameter indicates 0.25 volt lower than it should be, you can increase this value by 0.25 to correct it. This calibration should only be attempted with an accurate voltmeter.

Factory Calibration: D-SENSE Zero

This setting is the first of two that calibrates the LOAD parameter reading which senses the voltage between the D-SENSE pin and the SIG-GND pin. For example, if the LOAD parameter reads higher than 0% when D-SENSE is at zero volts, you can lower this setting to lower it to 0%. The latter must indicate 0% when the starter-generator is not engaged, which occurs when there is zero voltage difference between the D-SENSE and SIG-GND pins.

Factory Calibration: D-SENSE Span

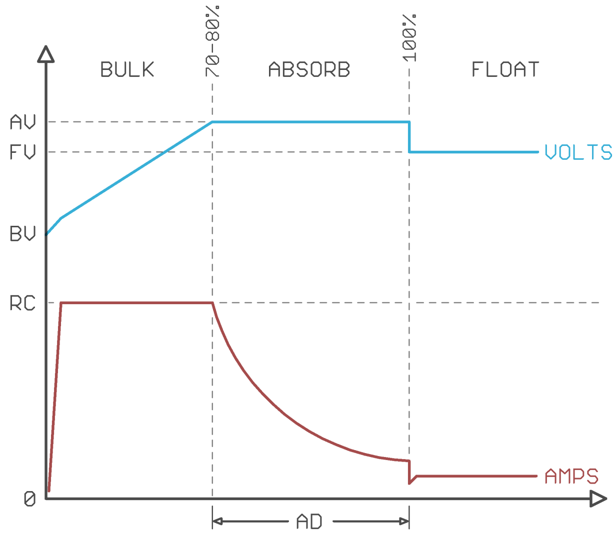
This setting is the second of two that calibrates the LOAD parameter reading which senses the voltage between the D-SENSE pin and the SIG-GND pin. Its calibration should only be attempted after successful completion of the "Factory Calibration: D-SENSE Zero" setting's calibration.

It requires you apply a precise voltage equal to "Starter-Generator Rated Current D Terminal Voltage" to D-SENSE relative to SIG-GND. The LOAD parameter should then read -100%. If not, you must adjust this setting up or down until it does. This calibration should only be attempted with an accurate voltmeter.

Factory Calibration: SHUNT Span

This setting calibrates the SHUNT parameter reading which senses the voltage between the SHUNT+ and SHUNT- pins. It requires you apply a precise voltage equal to 50mV to SHUNT+ relative to SHUNT-, but where the voltage from SHUNT+ to SIG-GND is at least 24 volts. The SHUNT parameter should then read a value equal to "Shunt Recharge Current Sensing 50mV Current". If not, you must adjust this setting up or down until it does. This calibration should only be attempted with an accurate voltmeter.

Setting Up Battery Recharge Control



The first thing to do is determine values for the four parameters below from specifics on your batteries, starter-generator, electrical system, and operator requirements.

1) Select a (bulk) **recharge current (RC)** between 20 amps and the maximum charge current specified for your batteries. The higher the amps, the faster batteries recharge after the usual discharge from engine startup. The lower the amps, the better for battery life span and their general health.

One approach would be to estimate the average state-of-discharge after an engine start (in amp-hours), select a recharge duration you are willing to live with, and work backwards to calculate a recharge current.

It may also be beneficial to know that by selecting a recharge current, you can free up generator power for other uses by capping it for battery recharging.

2) Select an **absorb voltage (AV)** between your battery's specified nominal and its maximum recharge voltage. The higher the voltage, the faster the recharge to 100%. Upon seeing this voltage reached, you will know you battery's state of charge will be at 70-80% of capacity. This setting is typically set to 28.8 volts.

3) Select an **absorb duration (AD)** that allows the charging current to drop to a level that signifies fully recharged batteries. The lower the recharge current or the absorb voltage, the longer the absorb duration must be. This setting is typically set to 5 minutes.

4) Select a **float voltage (FV)** between your battery's nominal voltage and the absorb voltage (AV) you chose that will keep your batteries fully charged. Also, a voltage drop to a known value can serve as a 100% battery indication in the cockpit. This setting is typically set to 27.6 volts.

After you have selected the above, you can transpose the last three parameters directly to configuration settings "Generator Absorb Voltage", "Generator Absorb Duration", and "Generator Float Voltage".

Bulk phase recharge current requires further consideration as there are several ways to implement it.

The **first method** calls for installing a battery current sensing shunt and you assigning "Generator Shunt Recharge Current Limit" with the recharge current you selected. You must also adjust "Generator Ramp Load Current Minimum" to 0% and "Generator Ramp Voltage Rise-Rate" according to the level of soft engagement you want. The larger the value, the slower the generator current will rise from zero to where it settles and deliver a smoother engagement.

The **second method** lets you do without the battery shunt. You assign "Generator Ramp Load Current Minimum" with the recharge current you selected though recalculated from amps to % of rated starter-generator current. You must also set "Generator Ramp Voltage Rise-Rate" to the rate of voltage increase corresponding to the recharge current you selected, which you obtain from the battery datasheet.

You may want to temporarily hook up a battery shunt to facilitate dialling in "Generator Ramp Load Current Minimum" and "Generator Ramp Voltage Rise-Rate", or confirm recharge current implementation.

The **third method** employs the battery shunt as in the first method, but with the second method as a backup should, for example, one of the wires for the shunt to the SGC break. For this setup, you set "Generator Shunt Recharge Current Limit" as described in the first method and "Generator Ramp Load Current Minimum" and "Generator Ramp Voltage Rise-Rate" as the second method describes.

Utilize SetView as a tool to set up battery recharge control, not only for adjusting configuration settings but for making recordings and analyzing them afterwards.

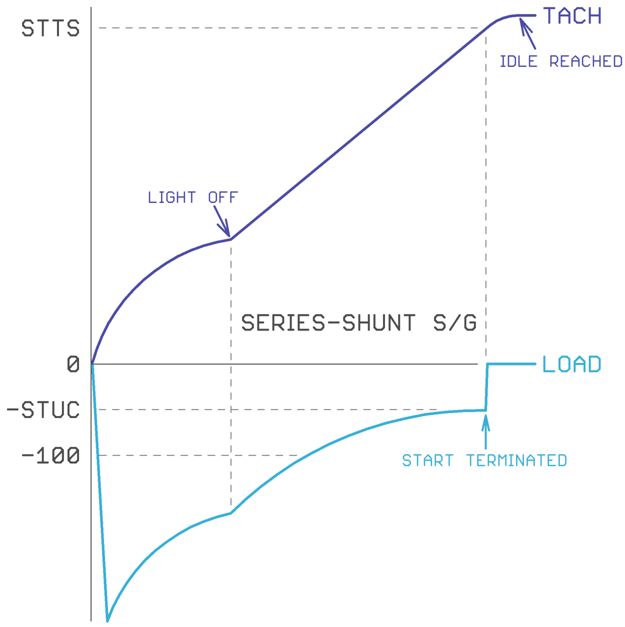
Setting Up Cycle Termination at Speed

There are three methods to implement start cycle termination at speed. The first method uses the TACH parameter, the second the LOAD parameter, and the third the FVR parameter. Note that the first method requires the installation of the TACH Speed Sensing Connection. The first and second work with series-shunt starter-generators, while the first and third are for shunt-only ones.

The procedure is to 1) perform a start while recording it via SetView, 2) analyze the recorded graph and make configuration adjustments, and then repeat steps 1 and 2 until satisfied.

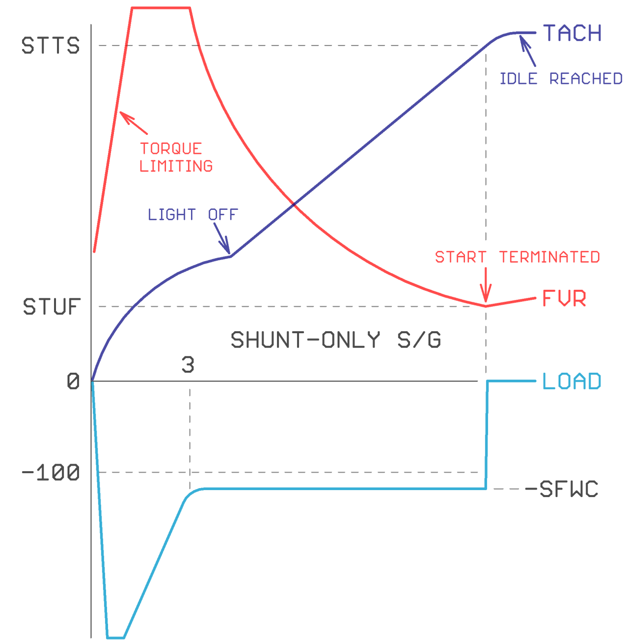
For a **series-shunt starter-generator**, assign as shown to the right "Start Termination TACH Speed", else "Start Termination Under Current", or both.

To disable any method, set the appropriate setting to its default.



For a **shunt-only starter-generator**, assign as shown to the right "Start Termination TACH Speed", else "Start Termination Field-Volt Ratio", or both.

To disable any method, set the appropriate setting to its default.



Note that if the TACH input is not connected (left open), the TACH parameter simply reads 0.

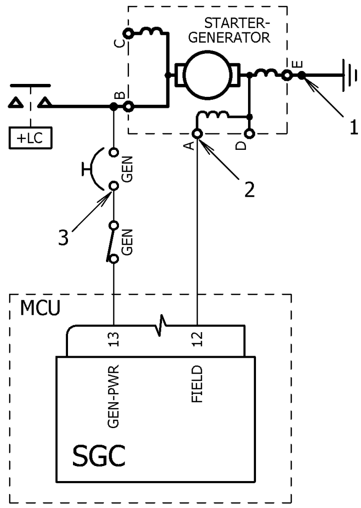
Utilize SetView as a tool to set up cycle termination at speed, not only for adjusting configuration settings but for making recordings and analyzing them afterwards.

Maintenance and Diagnostic Checks

In this section we describe some post installation checks that can be performed prior to starting, as well as other maintenance checks to be performed routinely or as the time arise to troubleshoot the system after commissioning.

Post Installation Shunt Field Circuit Checkout

This check confirms that the SGC would be able to energize the shunt field of the starter-generator for generator operation. It is also essential for shunt-only starter-generators to perform the required field weakening during starter operation.



1. Ensure all battery master switches are off and that the GEN circuit-breaker is open (pulled out) and that the GEN (or S/G) switch is closed as shown by the circuit to the right.
2. Measure with an ohm meter the resistance between the A terminal (arrow 2) of the starter-generator and its E terminal (arrow 1) which should be at ground. This resistance should be around 2.2 ohm for most starter-generators.
3. Measure with an ohm meter the resistance between the circuit-breaker terminal (arrow 3) and the E terminal of the starter-generator (arrow 1) which should be at aircraft ground. This resistance should be about 1.5 ohm more than the resistance measured in step 2.
4. Close the GEN circuit-breaker and again measure the resistance between arrow 3 and arrow 1 (ground). It should have dropped to below 1 ohm.

Trigger Input High Diagnostic Checkout

This check confirms the correct wiring and working of the circuit leading up to the SGC unit's TRIG input pin that applies bus/positive voltage to it and is only relevant to applications that employ the TRIG input.

1. Turn on power to the aircraft with SetView connected to your SGC.
2. On SetView select the TRIG HI - START (pin 15) diagnostic function (menu > system > diagnostic function).
3. Activate the switch that applies bus/positive voltage to the TRIG input to the SGC and confirm that the SetView window confirms receiving that signal via the SGC.
4. Exit the test by pressing escape or clicking with the mouse within the SetView window.

Trigger Input Grounded Diagnostic Checkout

This check confirms the correct wiring and working of the circuit leading up to the SGC unit's TRIG input pin that grounds it and is only relevant to applications that employ the TRIG input in this way.

1. Turn on power to the aircraft with SetView connected to your SGC.
2. On SetView select the TRIG LO – STOP/RESET (pin 15) diagnostic function (menu > system > diagnostic function).
3. Activate the switch(es) that applies ground to the TRIG input to the SGC and confirm that the SetView window confirms receiving that signal via the SGC.
4. Exit the test by pressing escape or clicking with the mouse within the SetView window.

START-PWR Input Diagnostic Checkout

This check confirms the correct wiring and working of the circuit leading up to the SGC unit's START-PWR input pin that applies power (bus/positive voltage) to it.

1. Turn on power to the aircraft with SetView connected to your SGC.
2. On SetView select the START-PWR - START ENABLE (pin 7) diagnostic function (menu > system > diagnostic function).
3. Activate the switch that applies bus/positive voltage to the START-PWR input to the SGC and confirm that the SetView window confirms receiving that signal via the SGC.
4. Exit the test by pressing escape or clicking with the mouse within the SetView window.

START Light Diagnostic Checkout

This check confirms the correct wiring and working of the external START light driven by the SGC.

1. Turn on power to the aircraft with SetView connected to your SGC.
2. On SetView select the START LIGHT (pin 22) diagnostic function (menu > system > diagnostic function).
3. Confirm that the START light slowly toggles on and off.
4. Exit the test by pressing escape or clicking with the mouse within the SetView window.

GEN-OFF Light Diagnostic Checkout

This check confirms the correct wiring and working of the external GEN-OFF light driven by the SGC.

1. Turn on power to the aircraft with SetView connected to your SGC.
2. On SetView select the GEN-OFF LIGHT (pin 23) diagnostic function (menu > system > diagnostic function).
3. Confirm that the GEN-OFF light slowly toggles on and off.
4. Exit the test by pressing escape or clicking with the mouse within the SetView window.

Generator Circuit-Breaker Trip Checkout

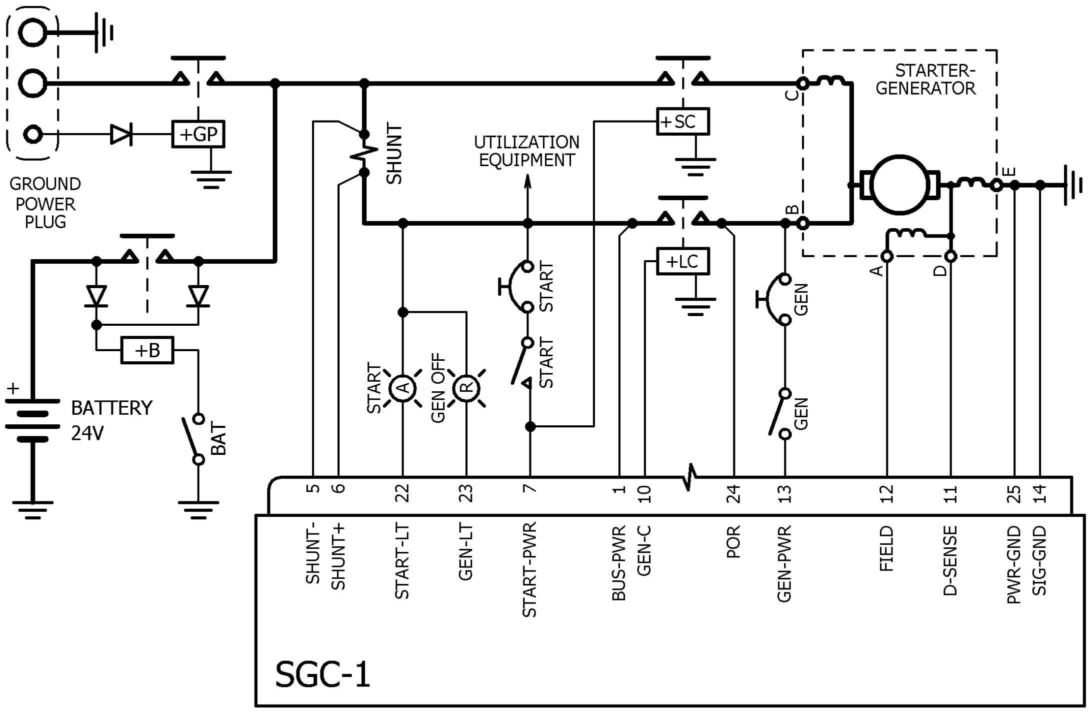
This check will confirm that the Backup Over-voltage Protection circuit of the SGC will trip the external generator circuit-breaker that secures power to the GEN-PWR input. This test can routinely be performed.

1. Start the aircraft engine with SetView connected to its SGC.
2. Ensure the generator is turned off / disengaged (open GEN switch).
3. On SetView select the GEN C/B POP diagnostic function (menu > system > diagnostic function).
4. On SetView click inside the diagnostic window box to continue the procedure.
5. If you wish to do a recording of the test, start it (menu > system > record parameter stream).
6. Engage / turn on the generator (close GEN switch).
7. Confirm that the GEN circuit-breaker pops (opens) within 10 seconds.
8. If recording the test, stop it (menu > system > stop recording).

Examples

We have selected the following examples to illustrate not only the different applications of the SGC models possible but the different optional features available on all the models. Do not construe these as the only way to apply any particular SGC.

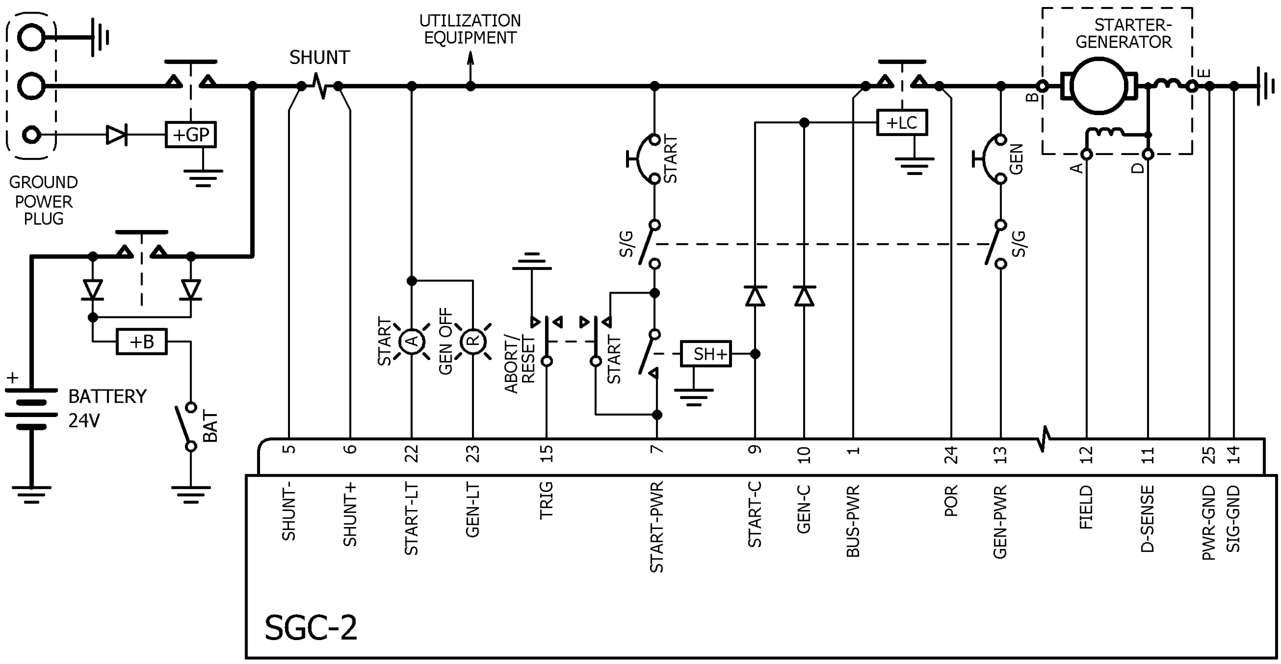
SGC-1 with Series-Shunt S/G



Notes:

- Before initiating a start or motor/vent cycle, select the GEN switch position. Closed (On) for one with Shunt Field Weakening, or open (Off) for one without it.
- Depress and hold the START switch to engage the starter. To abort the cycle, release the START switch, or wait until a start is complete. The START light will be on while the starter is engaged.
- If the GEN switch is on, the generator automatically engages, else it does so when you turn the GEN switch on. The GEN-OFF light will go out and stay off while the generator remains engaged.
- To disengage the generator, turn the GEN switch off. The GEN-OFF light will come on.
- Should a fault be detected, the generator will disengage, and the GEN-OFF light will flash. To reset it and re-engage the generator, cycle the GEN switch off and back on again.
- If the engine quits or you do a shutdown, the generator automatically disengages if engaged as its speed winds down and the generator current reverses.
- Should the START switch be depressed while the generator is engaged, the starter will not activate, but the generator will disengage and remain so while the START switch gets held in.

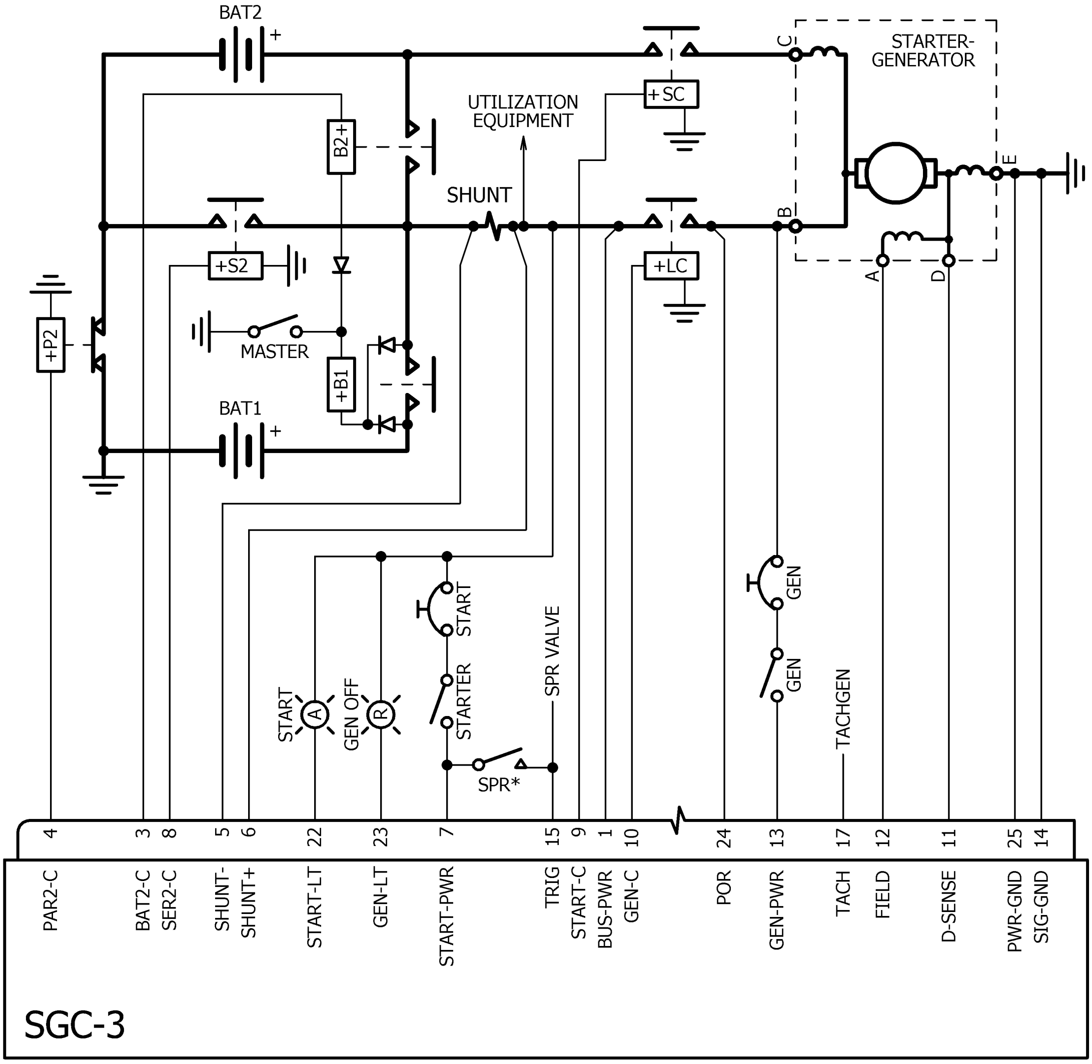
SGC-2 with Shunt-Only S/G



Notes:

- Before initiating a start or motor/vent cycle, turn the S/G switch On (closed).
- Depress the selector switch to START for a moment to engage the starter.
- To abort the cycle, shortly depress the selector switch to ABORT/RESET, or turn the S/G switch off.
- The starter automatically disengages after a successful start.
- The START light will be on while the starter is engaged.
- A short moment after the starter disengages, the generator automatically engages. The GEN-OFF light will go out and stay off while the generator remains engaged.
- To turn the generator off, open the S/G switch. The GEN-OFF light will come on.
- To reset the generator, depress the selector switch to ABORT/RESET for 2 seconds.
- Should a fault be detected, the generator will disengage, and the GEN-OFF light will flash. To reset the latter and re-engage the generator, cycle the S/G switch off and back on or depress the selector switch to ABORT/RESET for a moment.
- If the engine quits or you do a shutdown, the generator automatically disengages if engaged as its speed winds down and the generator current reverses.
- Should the selector switch be depressed to START while the generator is engaged, the starter will not activate, and the generator will remain engaged.

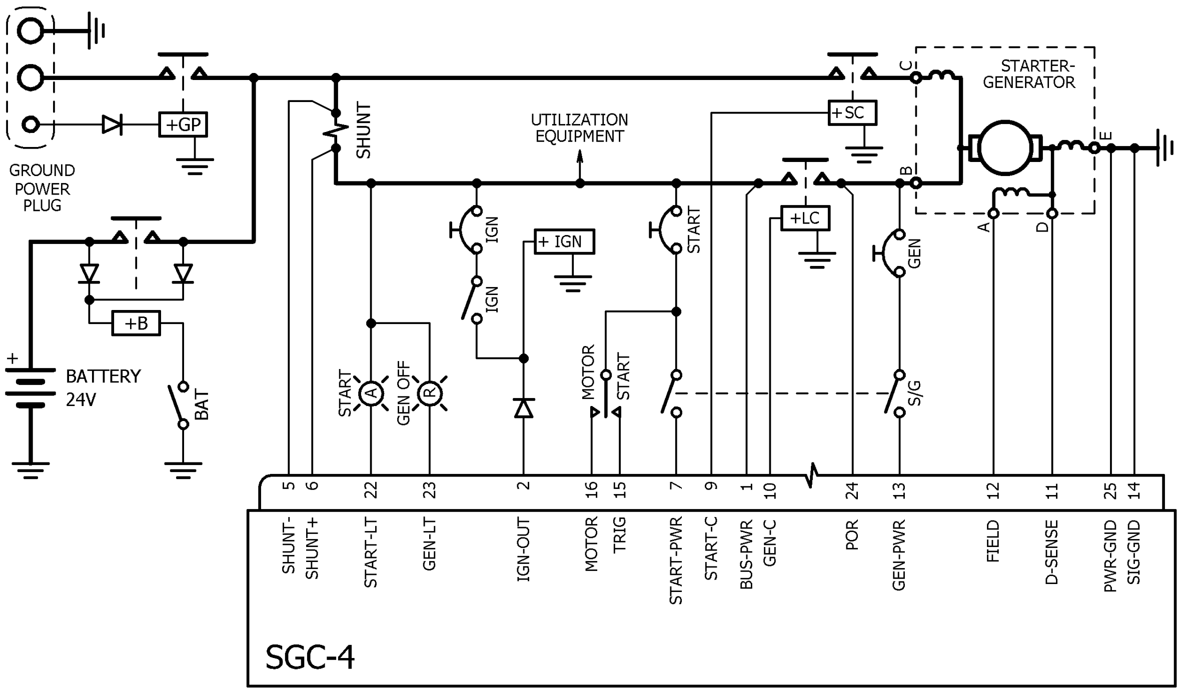
SGC-3 with Series-Shunt S/G



Notes:

- Before initiating a start or motor/vent cycle, select the GEN switch position. Closed (On) for a parallel-only cycle and open (Off) for a parallel-series one.
- Close the STARTER switch to engage the starter. To abort the start or motor/vent cycle, open the STARTER switch. The starter automatically disengages after a successful start. When all the conditions listed in Parallel-Series Battery Control get met, the batteries will automatically switch parallel to series to boost starter torque. The START light will be on while the starter is engaged. Afterwards, the "Start Light Blinking Advisory" setting determines if the light blinks to advise you to open the STARTER switch.
- If the GEN switch is on, the generator automatically engages, else it does so when you turn the GEN switch on. The GEN-OFF light will go out and stay off while the generator remains engaged. To disengage the generator, turn the GEN switch off. The GEN-OFF light will come on.
- Should the STARTER switch be closed while the generator is engaged, the starter will not activate. However, if the "Generator Allow With START-PWR Powered" is set to No, the generator will disengage and remain so while the STARTER switch is on, else it remains engaged.
- Should a fault be detected, the generator will disengage, and the GEN-OFF light will flash. To reset it and re-engage the generator, cycle the GEN switch off and back on again.
- If the engine quits or you do a shutdown, the generator automatically disengages if engaged as its speed winds down and the generator current reverses.

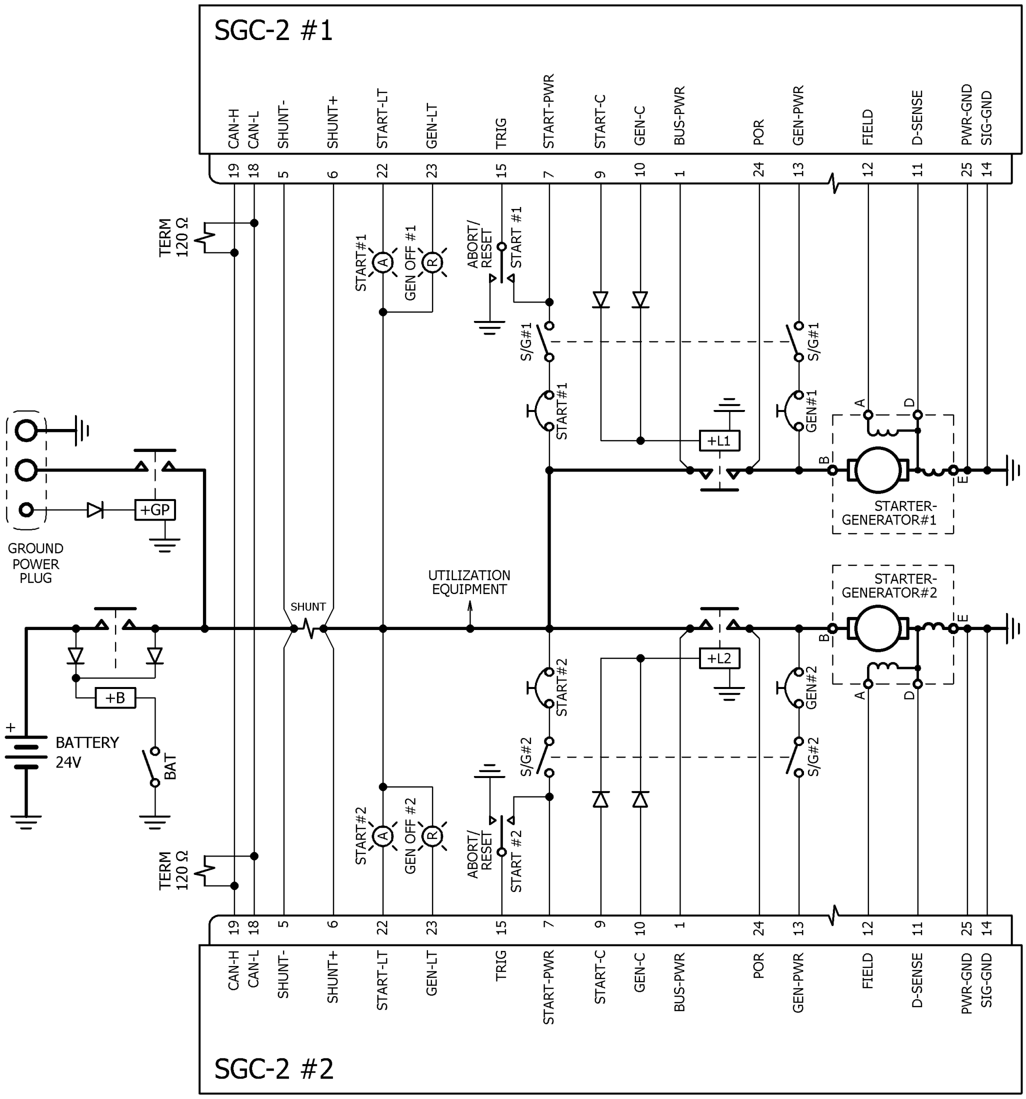
SGC-4 with Series-Shunt S/G



Notes:

- Before initiating a start or motor/vent cycle, turn the S/G switch On and the IGN switch Off.
- Momentarily depress START to engage a start cycle or MOTOR to engage a motor/vent cycle.
- In a start cycle, the starter and ignition engage. The ignition may activate up to 2 seconds before starter engagement, depending on the "Start Lead-in Ignition Check Duration" setting.
- In a motor/vent cycle, only the starter and not the ignition gets activated.
- The START light will be on while the starter is engaged.
- To abort a start cycle, shortly depress START. To abort a motor/vent cycle, shortly depress MOTOR.
- To alternatively abort either cycle, turn the S/G switch off.
- To change from a motor/vent to a start cycle, depress START.
- To change from a start to a motor/vent cycle, depress MOTOR.
- A start cycle automatically ends after a successful start. A moment later, the generator automatically engages. The GEN-OFF light will go out and stay off while the generator remains engaged.
- To disengage the generator, turn the S/G switch off. The GEN-OFF light will come on.
- Should a fault be detected, the generator will disengage, and the GEN-OFF light will flash. To reset it and re-engage the generator, cycle the S/G switch off and back on again.
- If the engine quits or you do a shutdown, the generator automatically disengages if engaged as its speed winds down and the generator current reverses.
- Should START or MOTOR be depressed while the generator is engaged, the starter and ignition will not activate, and the generator will remain engaged.

Dual SGC-2 for Twin Engine Shunt-Only S/G's



Notes:

- Before initiating a start or motor/vent cycle, turn the designated S/G switch On, then depress its selector switch to START to engage its starter. Its START light will be on while its starter is engaged.
- To abort a start or motor/vent cycle, depress its selector to ABORT/RESET or turn its S/G switch Off. The starter automatically disengages after a successful start. A moment later, the generator engages. The GEN-OFF light will go out and stay off while the generator remains engaged.
- To start the other engine with cross-start assistance, turn the running engine's S/G switch On, then perform the same procedure described with the first engine start.
- To disengage a generator, turn its S/G switch Off. Its GEN-OFF light will come on. To reset a generator, depress its selector switch to ABORT/RESET for 2 seconds.
- Should a fault be detected, the relevant generator will disengage, and its GEN-OFF light will flash. To reset the latter and re-engage the generator, cycle its S/G switch off and back on or depress its selector switch to ABORT/RESET for a moment.
- If an engine quits or you shut it down, its generator automatically disengages if engaged when its speed winds down and the generator current reverses.
- Should any selector switch be depressed to START while its generator is engaged, its starter will not activate, and its generator will remain engaged.