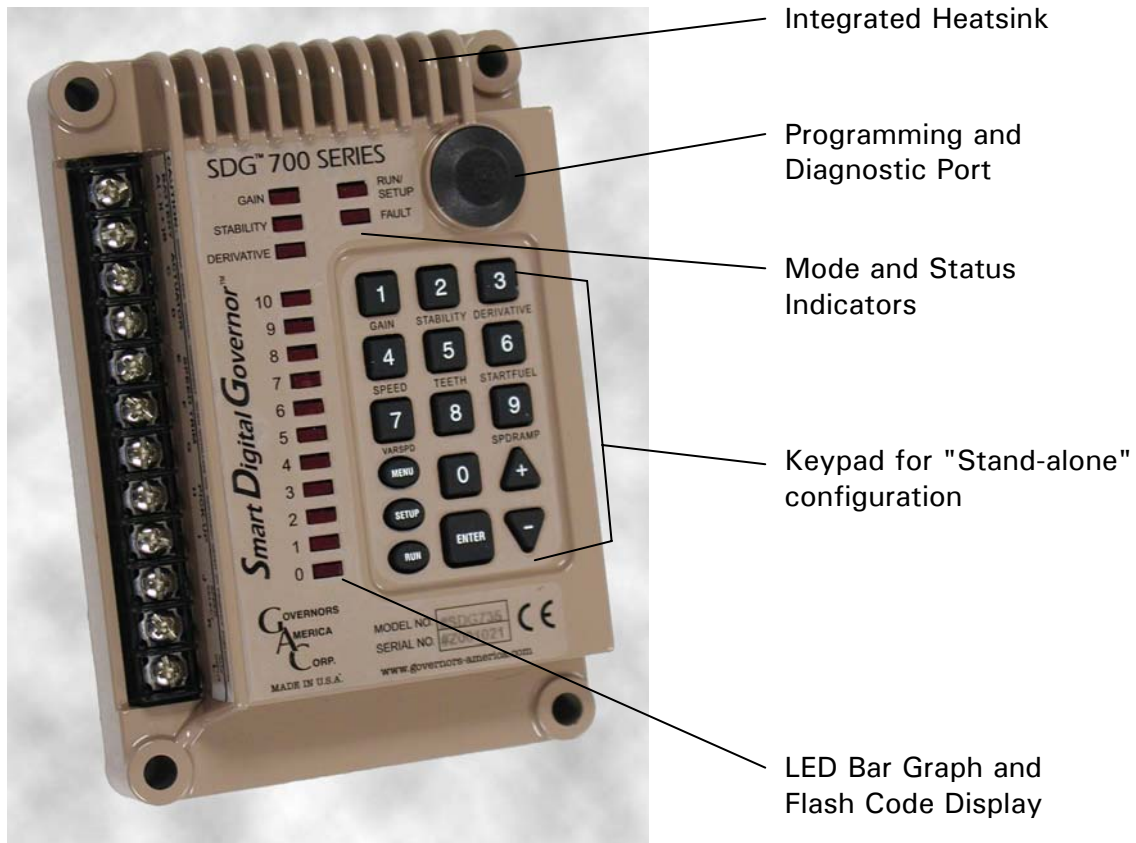




## Digital Speed Governor Versions

- SDG-725**     with discrete output (Overspeed)
- SDG-735**     with auxiliary input (Synchronizer and Load Sharing)



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## 1 Introduction

The SDG (Smart Digital Governor) is an all electric device designed to control engine speed with fast and precise response to transient load changes. This closed loop control unit, when connected to a GAC proportional electric actuator and supplied with a magnetic speed sensor signal, will control a wide variety of engines in isochronous or droop mode. It is designed for high reliability and built ruggedly to withstand the engine environment.

The microprocessor-based design allows for a precise customized performance and increased functionality. The SDG offers precise ( $< \pm 0.25\%$ ) Isochronous speed control. The Non-volatile memory ensures that settings will be saved even if power is disconnected. The 12-24 VDC power range allows the SDG to be used on a wide range of applications. The SDG offers password protection to ensure security and system integrity.

Customer configurable settings included in the SDG:

- PID parameters for optimized performance
- Three fixed and one variable speed settings or four fixed settings
- On demand droop for each individual speed setting
- Acceleration and deceleration speed ramps for smooth speed changes
- Starting fuel schedule, allows for minimized smoke as well as fuel economy.

## 2 Safety Instructions and Warnings

Please read this manual before installing and commissioning the system. It contains important information about safety, use and maintenance of the system.

For damage, which is caused by neglecting instructions, misuse or wrong operation, all warranty will be rejected.

### OVERSPEED PROTECTION

An overspeed shutdown device, independent of the governor system, should be provided to prevent loss of engine control which may cause personal injury or equipment damage. Do not rely exclusively on the governor system electric actuator to prevent overspeed. A secondary shutoff device, such as a fuel solenoid must be used.





## 3 Warranty Conditions

The system is intended exclusively for the purpose and under conditions mentioned in chapter "Technical Data". Other purposes are possibly dangerous. Huegli-Tech AG is not responsible for losses which are caused by misuse or operation beyond specifications.

Use of accessories.

Accessories may be used only if they are approved by Huegli-Tech AG. If other parts are applied, warranty claims will be rejected.

The Huegli-Tech Ltd. "Standard Warranty Terms" are applied.

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## 4 Technical Data

### Physical:

Dimensions	96 x 141 x 37 mm
Weight	0.64kg
Mounting	Direct engine frame mounting, isolated via rubber elements, vertical preferred, or in panel.

### Performance:

Isochronous Operation / Steady State Stability	±0.25% or better
Speed Range of Governor	400 – 8000 Hz
Speed Drift with Temperature	±0.25% maximum

### Environmental:

Ambient Operating Temperature Range	-40° to 85 °C
Relative Humidity	up to 95%

### Input / Output Parameters:

Supply	12 or 24 VDC battery systems
Polarity	Negative Ground (case isolated)
Power Consumption	70 mA max. continuous plus actuator current
Actuator Current Max	10 A continuous
Speed Sensor Signal	1 to 120 V RMS
Discrete Output (terminal L on SDG-725) *	Sinks up to 25 mA, Rated 20 mA @ 12V,600Ω
Auxiliary Input (terminal L on SDG-735) *	5 VDC, for GAC/ComAp Synchr. & Load Sharer
	Sensibility: approx. 100 Hz/V

### Configuration Parameters :

Flywheel Teeth Range	50 – 250 teeth
Overspeed Setting	400 – 10000 Hz **
Crank termination	50 – 1000 Hz **
Fixed Speed settings (all 3 speeds)	400 – 8000 Hz **
Variable Speed settings	400 – 8000 Hz **
Start Fuel Ramp	0 – 100%
Start Fuel Preset	0 – 100% (max fuel)
Droop Range	0 – 10% regulation
Speed Ramp up	0 – 100%
Speed Ramp down	0 – 100%

### Reliability:

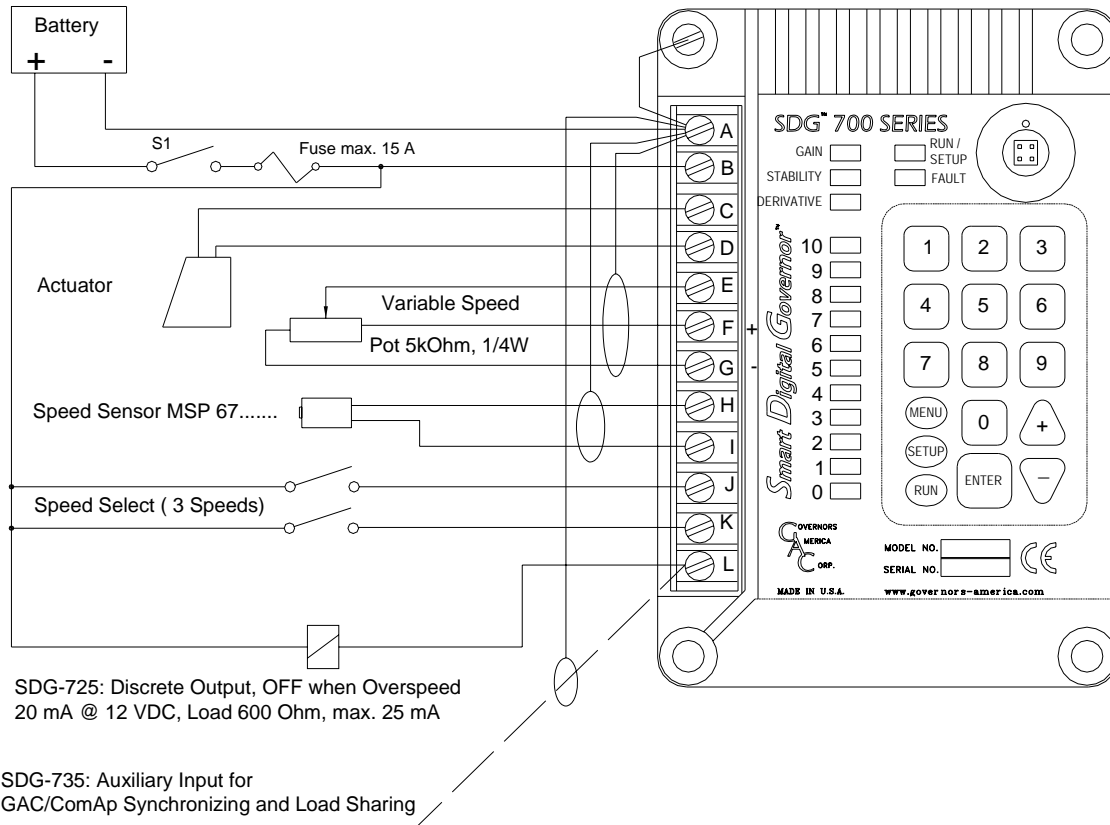
Vibration	7G @ 20-100Hz.
Testing	(100%) Functionally tested

### Password Protection:

Password	4-digit number
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- Notes:** \*) Terminal L used as:  
in SDG-725 as output, normally ON, OFF when overspeed tripped,  
latching, reset by cycling power  
in SDG-735 as auxiliary input for synchronizing and load sharing.
- \*\* \*) Speed values in RPM are based on the number of flywheel teeth.  
RPM = Pickup frequency x 60 / flywheel teeth. (Max. frequency is 10'000 Hz.)

## 5 Installation and Wiring



- Battery and actuator connections to terminals A,B,C,and D should be:  
1,5 mm<sup>2</sup> for 24 VDC    or    2.5 mm<sup>2</sup> for 12 VDC  
Long cables (>5m) require an increased wire size to minimize voltage drops.
- Battery positive (+) input, Terminal B should be fused for 15 Amps as illustrated in the diagram.
- The governor should be mounted isolated from engine ground.
- The Actuator cable **MUST BE SHIELDED** for its entire length.
- The Magnetic Speed Sensor connections to terminals H and I **MUST BE SHIELDED** for their entire length.
- The cables to the Variable Speed Potentiometer can be of any reasonable length up to 5 m. Over this length, a shielded cable is required.
- The shields should only be connected to Terminal A.
- The shields should be insulated to insure that no part of it comes in contact with engine ground, otherwise, stray signals may be introduced into the SDG causing erratic operation.
- For specific speed configuration using terminals J and K, please see table 1 below.

Table 1: Speed Configuration		Selected Speed	Selected Droop
Terminal J	Terminal K		
Open	Open	Variable Speed	Droop
Open	Battery +	Fixed Speed 1	Droop 1
Battery +	Open	Fixed Speed 2	Droop 2
Battery +	Battery +	Fixed Speed 3	Droop 3

## 5.1 Discrete Output / Auxiliary Input

Terminal L is used for two different features:

The **SDG-725** series uses Terminal L for a discrete output. Standard application is normally ON, OFF when overspeed tripped, latching, reset by cycling power.

Special software versions assign this output to crank termination. Function and latching are defined with the particular software version.

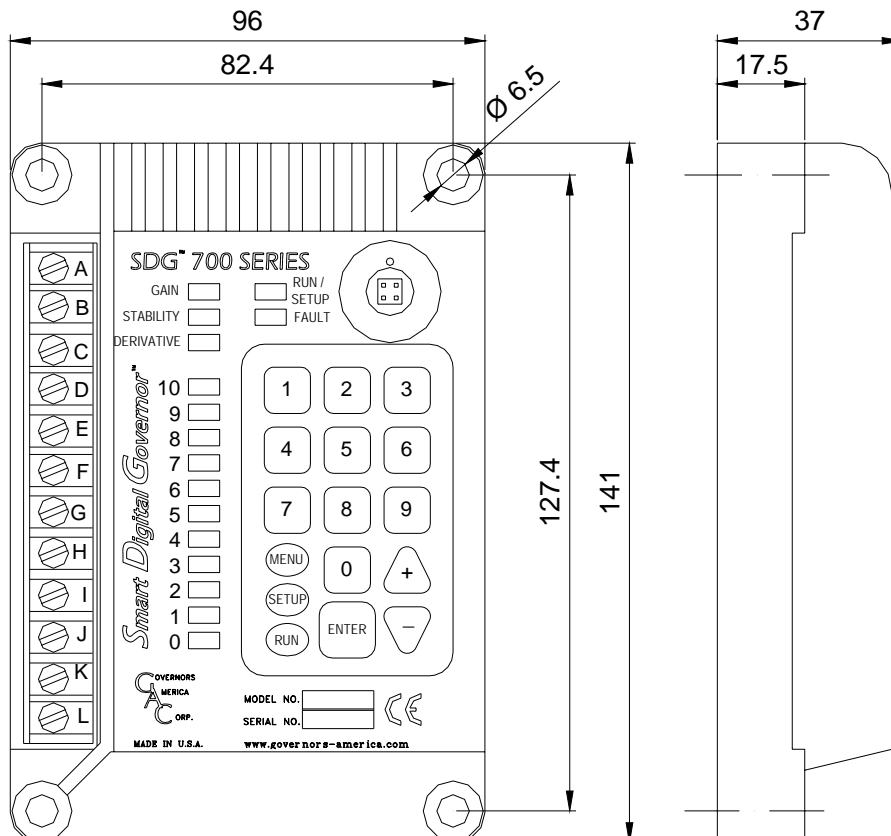
The discrete output is designed as a current sink and is capable of sinking 20 mA typically at 12 VDC through a 600 Ohm load.

The **SDG-735** series utilizes Terminal L as an auxiliary input for synchronizer and load sharer input.

## 5.2 Magnetic Pick-Up Installation

With the engine stopped, adjust the gap between the magnetic speed sensor and the ring gear tooth. The gap should be between 0.5 and 0.8 mm. Please follow the manufacturers instructions when installing. Verify proper installation by measuring the AC voltage output of the pick-up while cranking the engine. The output should be minimum **1.0 VAC**.

## 6 Dimensions



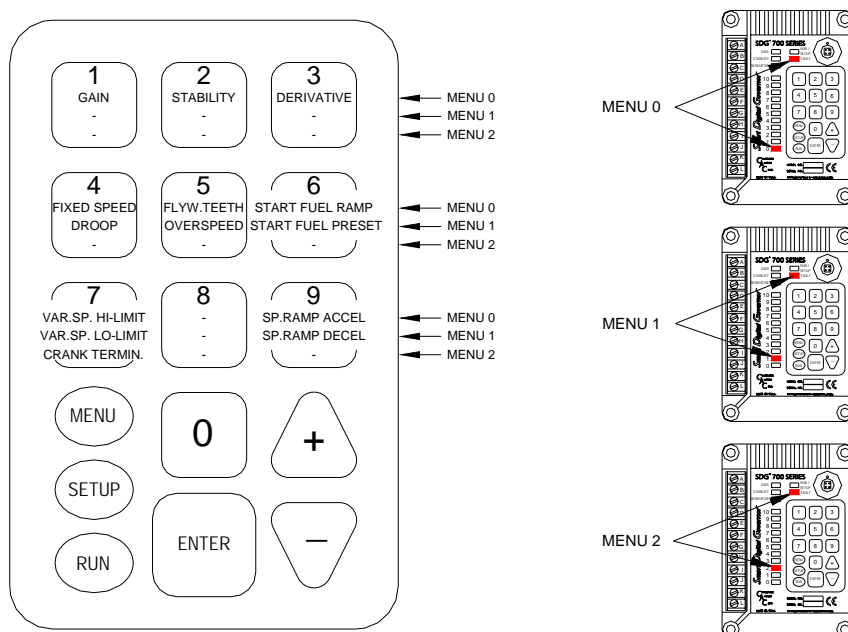
## 7 Keypad Functions

### 7.1 Accessing SETUP mode:

- a) To access the SETUP mode press and hold the SETUP button until RUN/SETUP LED begins to flash.
- b) Now enter the 4-digit security code followed by the ENTER key.  
Note: Each time a key is pressed the Bar Graph LEDs will flash.
- c) If the proper security code has been entered, the Bar Graph LEDs will begin to flash out the 4-digit software version number. If not, repeat step b.
- d) The RUN/SETUP LED will always be flashing while the SDG is in the SETUP mode. If you have problems during the configuration always check to make sure this LED is flashing indicating you are in SETUP mode.

### 7.2 Accessing Functions:



- e) Once in the SETUP mode, the functions listed under each key can be accessed by using the MENU button.  
Each time the MENU button is pressed, the next menu will become active.  
Press until the desired menu is active.  
The Bar Graph display will indicate which menu is active (0, 1 or 2).  
Additional to the Bar Graph display the Fault LED is always on when a menu is active.
- f) Next press the particular key to access its function.  
For example, press [MENU] [MENU] [5] to access overspeed.



Settings defined as 4-digit numbers are modified by typing in a 4-digit number followed by the enter key. These values are flashed out by the four digits on the bar graph. Note: a 3-digit number has to be typed in with a 0 (125 = [0] [1] [2] [5]).

Setting defined as %-values are modified by pressing the arrow keys [+ ] or [-]. You may have to press the arrow key several times to illuminate the next LED. To set a defined value of for example 30% press the [+ ] key until the LED 3 is on.

If only LED 0 is on, this indicates the value is between 0 and 9 %.

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## 8 Setting of Adjustable Parameters

**Before starting the engine the SDG must be configured with the necessary basic parameters:** Factory set default values have to be verified.

### 8.1 Flywheel Teeth:



With this number the SDG calculates RPM Speed and Overspeed.

Entering menu 0, key 5, the set value is being flashed out. Typing in a 4-digit number followed by pressing the enter key will change the setting. Now the new value is being flashed out.

### 8.2 Overspeed:



The overspeed set point is used for engine protection.

Entering menu 1, key 5, the set value is being flashed out. Typing in a 4-digit number followed by pressing the enter key will change the setting. Now the new value is being flashed out.

### 8.3 Crank Termination Setting:



This set point helps the SDG determine if the engine is cranking or running. When engine speed exceeds the crank termination setting the governor switches from start up procedure to PID loop control.

Entering menu 2, key 7, the set value is being flashed out. Typing in a 4-digit number followed by pressing the enter key will change the setting. Now the new value is being flashed out.

### 8.4 Speed Settings:

The SDG offers a variety of speed settings to the user. The user can select from three fixed speed settings and one variable speed setting. (see table 1 on page 4).

The variable speed input can be used as if it were a fixed speed. Any speed inbetween low and high idle adjusted on the pot-meter is reflecting a PID controlled speed.

### 8.5 Fixed Speed Operation:



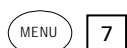
Speed settings have to be made with the corresponding connections to terminal K or/and J, wired up and switched before configuration.

Entering Menu 0, Key 4 the set value assigned to the particular speed is being flashed out. Typing in a 4-digit number followed by pressing the enter key will change the setting. Now the new value is being flashed out.





Droop settings for the particular fixed speed are made similarly but here the values are modified by using the arrow keys.

### 8.6 Variable Speed Operation:



Make sure the potentiometer is attached on terminal E, F(+), G(-) as shown on the wiring diagram.

The setting procedure also serves as alignment of the potentiometer. Proceed as follows:

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- a) Turn the potentiometer such that maximum voltage is present on terminal E. (Voltage can be measured between E and G)
- b) Access menu 0, key 7. The max. voltage is verified by the bar graph display. This state also is recognized by the SDG as the potetiometers maximum position.
- c) Typing in the 4-digit number followed by pressing the enter key will assign the max. speed value (high idle) to this highest potentiometer position.
- d) This max. value is now flashed out with the bar graph LEDs.
- e) Turn the potentiometer such that minimum voltage is present on terminal E.
- f) Access menu 1, key 7. The min. voltage is verified by the bar graph display. This state also is recognized by the SDG as the potetiometers minimum position.
- g) Typing in the 4-digit number followed by pressing the enter key will assign the min. speed value (low idle) to this lowest potentiometer position.
- h) This min. value is now flashed out with the bar graph LEDs.



Drop setting for variable speed is made with no connections on terminals J and K, the values are modified by using the arrow keys.

### 8.7 PID Parameters: GAIN, STABILITY, DERIVATIVE

On customized SDG versions all PID parameters are factory set for best engine performance and stability. However, individual engine dynamics or changed operating conditions may require readjustments of these settings.

In new applications these parameters have to be preset before starting. Adjustment and tuning procedure see point 9.2.

**Additionally, there is a group of parameters that do not necessarily need to be preset for basic engine operation:**

### 8.8 Starting Fuel Ramp Control:



This parameter gradually increases the amount of fuel during the engine start cycle, which eliminates unnecessary smoke. The higher the setting the longer it takes to reach full fuel delivery.

### 8.9 Starting Fuel Preset Point:



Determines how much fuel to begin with before fuel ramping engages.



### 8.10 Speed Ramping Control:



**UP:** Provides acceleration ramping during RPM input changes.



**DOWN:** Provides deceleration ramping during RPM input changes.

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### 8.11 Droop Setting:



Each of the three fixed speed settings as well as the variable speed setting has a corresponding droop setting.

The settings have to be made with corresponding connections on terminals J and/or K (see table on page 4).

### 8.12 Saving the SDG Settings:

Press and hold the RUN key until the RUN/SETUP LED stops blinking. This causes the SDG to save all settings into permanent memory. The SDG will now be in RUN mode verified by a steady RUN/SETUP LED.

Without doing this all setting modifications will be lost when the SDG is turned off. When cycling power without saving the SDG will return to the previous or default settings.

## 9 Engine Tuning

### 9.1 Verify Settings:

Before starting the engine with the SDG connected, follow the steps listed below:

1. Apply power but do not start engine.
2. Enter Setup Mode and verify all settings are what you expect for:  
Flywheel Teeth, Overspeed, Speed Configuration and Crank Termination.
3. When you are satisfied without having modified the settings, cycle power to exit Setup Mode.  
If you had to modify any settings, press and hold the [RUN] key to return to RUN Mode.
4. Now you are ready to start the engine.

### 9.2 Starting the Engine:



On customized SDG versions all PID parameters are factory set for best engine performance and stability. However, individual engine dynamics or changed operating conditions may require readjustments of these settings.

On a new unit shipped from the factory the following initial setting are recommended:

(MENU)	1	GAIN:	30 %	
(MENU)	2	STABILITY:	10 %	
(MENU)	3	DERIVATIVE:	10 %	

These settings are made using the arrow keys.

Activate starter. Engine should run at low speed. If unstable, reduce GAIN and STABILITY.

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### 9.3 Optimization of Dynamic Adjustment (Tuning):

Increase the GAIN slowly by typing the + key until the engine hunts, then decrease typing the – key until the engine runs stable. From this point decrease another 2-3 counts.

Adjust the STABILITY in the same manner.

Poke the actuator lever momentarily and re-adjust GAIN and STABILITY for fastest recovery.

In some cases it may be necessary to change the DERIVATIVE (Dead time compensation) too.



If engine hunts rapidly even when GAIN is low, reduce DERIVATIVE by typing the – key. If engine hunts very slowly increase DERIVATIVE by typing the + key.

### 9.4 Unstable Engine Behavior:

See Chapter Trouble Shooting

### 9.5 Saving Values (While Engine is Running)

When all tuning and engine configuration is complete, press and hold the RUN button to save all settings. You may notice a slight engine stutter when saving the settings. This is normal and only occurs during the saving process.

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## 10 Trouble Shooting





### WARNING



Do not disconnect the actuator while energized. This may cause high voltage peaks that can damage the control unit.

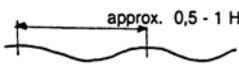
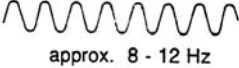
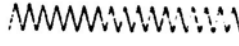
### Trouble Shooting Check List

No	Fault, LED signal	Possible Cause	Check	Requirements, Remedy
<b>1</b>	<b>Engine will not start</b>			
1.1	Voltage failure?  Are any LEDs on?	Low voltage Fuse  Battery and wiring	Measure voltage across terminals A(-) and B(+).  Check battery voltage while cranking. Check wiring.	Verify voltage and polarity (12 V or 24 V).  Too much voltage drop due to too small wiring or weak battery.  If not, replace SDG.
1.2	LED FAULT on?	SDG in FAULT condition	Overspeed limit was exceeded?	Recheck flywheel teeth and overspeed settings. Cycle power OFF-ON. Try to restart
1.3	LED RUN/SETUP blinking?	SDG in SETUP mode		Cycle power OFF-ON. Try to restart.
1.4	LED GAIN on?	Crank termination setting too low.	Crank termination setting should be min. 50 RPM above firing speed.	Cycle power OFF-ON Try to restart. Readjust setting if needed
1.5		Start fuel preset too low. Start fuel ramp too high.		Cycle power OFF-ON. Try to restart. Readjust setting if needed
1.6	both LED GAIN and DERIVATIVE off?	No speed signal from magnetic speed sensor.	Measure voltage on terminals H and I	Should be min. 1.0 VRMS during cranking
1.7		Actuator failure.	Check wiring. Measure voltage on terminals C and D. Measure actuator current.	See wiring diagram. Compare with actuator specifications. Do not disconnect actuator while energized!
1.8	Bar Graph flashing when power applied to SDG	SDG configuration corrupt.	Check configuration.	Reload software or reconfigure the unit.
1.9		Fuel supply failure	Check fuel system	

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No	Fault, LED signal	Possible Cause	Check	Requirements, Remedy
<b>2 Engine not running at correct fixed speed</b>				
2.1	Configuration, Wiring	Terminals J and K not properly configured.	Check wiring. See table 1, page 4.	If nothing is connected to J and K the SDG is configured for variable speed.
2.2		Incorrect flywheel teeth number.		Reconfigure
2.3		Incorrect fixed speed settings.	Settings have to be made with the corresponding connections on J and K	
<b>3 Engine not running at correct variable speed</b>				
3.1	Pot-meter wiring	Terminals E,F,G not properly connected	Check wiring. See table 1, page 4.	
3.2	Configuration	Incorrect variable speed configuration		Reconfigure the variable speed pot-meter
		Refer to chapter 8, pt. 8.6 for proper variable speed setting		
<b>4 Overspeed during starting, load transient or speed changes</b>				
4.1	LED FAULT on?	Overspeed setting too low		Check overspeed setting
		Tuning not optimal		Adjust GAIN, STABILITY. eventually speed ramp ACCEL.
		Crank termination setting too high		Check crank termination setting
<b>5 SETUP mode is not accessible</b>				
	Refer to chapter 7, pt. 7.1: Accessing SETUP mode			

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No	Fault, LED signal	Possible Cause	Check	Requirements, Remedy
<b>6</b>	<b>Unstable Engine Behavior</b>			
6.1		Friction in linkage or fuel rack	Check mechanical parts for friction.	Eliminate all friction in linkage and fuel rack.
6.2		Low battery voltage	Check battery and wiring should be min. 20 V with 24 V systems.	Replace battery. Use appropriate wiring.
6.3		Actuator force insufficient		Use stronger actuator
6.4		Insufficient dead time compensation		Increase DERIVATIVE
6.5		GAIN too high		Reduce GAIN
6.6		Too much dead time compensation		Reduce DERIVATIVE
6.7		Fault in fuel injection system		Eliminate fault in fuel injection system
6.8		Soft or worn coupling	Check play in coupling	Correct fault
6.9	Governor performance O.K. but actuator lever and fuel pump rack are shaking (dither) approx. 1 mm 	Torsional vibrations caused by soft coupling or excessive play in coupling		Correct fault
6.10		Misfiring of one cylinder		Correct fault in engine

For consulting the GAC distributor please provide all information filling in the following Test Protocol form.

## 11 Test Protocol

Customer..... Date.....

Contact person..... Phone / Fax.....

Engine make ..... Model.....

Max. output (kW) ..... Nominal speed (RPM).....

Ring gear teeth ..... Pick up frequency (Hz).....

GAC Control Unit SDG ..... S/N.....

Software version.....

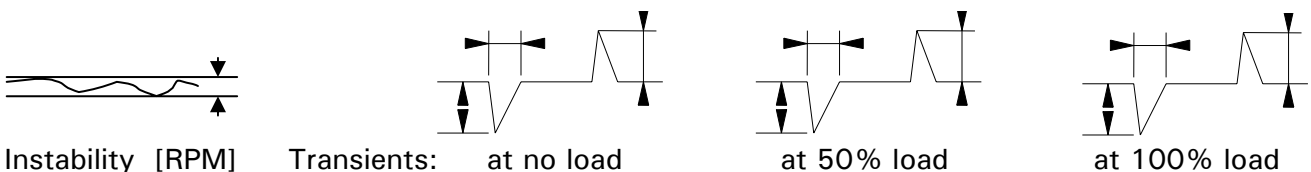
GAC Actuator ..... S/N.....

Pick-up:.....

Kind of load: Generator, Pump, Transmission, etc. ....

Generator model:.....

Settings	1	2	3
Menu 0	GAIN	STABILITY	DERIVATIVE
Menu 1			(FUEL LIMIT)
Menu 2			
	<b>4</b>	<b>5</b>	<b>6</b>
Menu 0	FIXED SPEED 1 FIXED SPEED 2 FIXED SPEED 3	FLYW.TEETH	START FUEL RAMP
Menu 1	DROOP 1 DROOP 2 DROOP 3 DROOP VAR.SP.	OVERSPEED	START FUEL PRESET
Menu 2			
	<b>7</b>	<b>8</b>	<b>9</b>
Menu 0	VAR. SPEED HIGH LIMIT		SPEED RAMP ACCELERATION
Menu 1	VAR. SPEED LOW LIMIT		SPEED RAMP DECELERATION
Menu 2	CRANK TERMINATION		



Comments: .....

## 12 Configuration and Settings (Factory Settings):

SDG \_ \_ \_ - \_ \_ - \_ \_ PASSWORD :

Software version (flashed out after entering password) :

### Safety and Setup Parameters:

Flywheel Teeth :  
  Overspeed [RPM] :

### Starting parameters:

Crank Termination [RPM] :  
  Start Fuel Ramp % :  
  Start Fuel Preset % :

### Fixed Speed parameters:

Fixed Speed 1 (Battery + to K) [RPM] :  
  Fixed Speed 2 (Battery + to J) [RPM] :  
  Fixed Speed 3 (Battery + to J and K) [RPM] :  
  Droop for Fixed Speed 1 (Bat. + to K) % :  
  Droop for Fixed Speed 2 (Bat. + to J) % :  
  Droop for Fixed Speed 3 (Bat. + to K and J) % :

### Variable Speed parameters:

Variable Speed High Limit [RPM] :  
  Variable Speed Low Limit [RPM] :  
  Droop for Var. Speed (J and K not conn.) % :

### Engine Tuning:

Gain (P) % :  
  Stability (I) % :  
  Derivative (D) % :

### Speed Ramping

Speed Ramp Acceleration % :  
  Speed Ramp Deceleration % :