SDG 725 Series
Smart Digital Governor

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1 OVERVIEW

The SDG725 (Smart Digital Governor) is a solid state, microprocessor based speed governor providing precise (+/- 0.25%) isochronous speed control. The non-volatile memory ensures settings are saved even if the power disconnects.

The SDG offers:

- State of the art surface mount technology (SMT) for greater reliability
- 12-24 VDC power range allows the SDG to be used in a wide range of applications
- Password protection to ensure security and system integrity
- Integrated heat sink for efficient heat transfer
- Programming and diagnostic port allows for reprogramming, configuration and display changes.
- LEDs provide real-time status and code display information
- Keypad for standalone configuration, no laptop required
- Rugged powder coated die cast aluminum case with hard potting stands up to virtually any environment
- Discrete output (Overspeed) capability

Programmable settings include:

- PID parameters for optimized performance
- 3 fixed-speed and 1 variable-speed settings or 4 fixed-speed settings
- On demand droop per speed setting
- Acceleration and deceleration speed ramps
- Starting fuel schedule to support minimized smoke and fuel economy

2 SPECIFICATIONS

PERFORMANCE	
Isochronous Operation/Steady State Stability	± 0.25%
Speed Range/Governor	400 - 10 KHz
Idle Adjust	Full Range
Speed Drift w/ Temp	± 0.25% MAX
Droop Range	1-17% Regulation
Trim Range	± 5% of Rated Speed
INPUT/OUTPUT PARAMETERS	
Supply	12 - 24 V DC Battery Systems (6.5 V DC to 33 V DC)
Polarity	Negative Ground (Case Isolated)
Ground Power Consumption	70 mA MAX continuous plus actuator current
Actuator Current @25°C (77°F) Inductive	Max 10 Amp cont
Speed Sensor Signal	0.5 - 120 V RMS
Load Share/Synchronizer Input	0 - 10VDC
Discrete Output (Terminal L SDG725)	Sinks to 25 m, Rated 20 mA @12V, 600Ω
Auxiliary Input Terminal L SDG735)	5 V DC Synch and Load Sharing Approx 100 Hz/V

PHYSICAL DIMENSIONS	
Dimensions	9.6 x 14.1 x 3.7cm (3.765 x 5.55 x 1.44 in)
Weight	≈ 0.64 Kg (1.4 lbs)
Mounting	Direct engine mount, vertical preferred
RELIABILITY	
Vibration	7 g @ 20-100 Hz
Testing	100% Functionally Tested
CONFIGURATION PARAMETERS	
Flywheel Teeth	50 - 250 teeth
Range (Gain/Stability multiplier)	1-10
Fixed Speed Settings*	400 - 8000 Hz
Variable Speed Settings* .	400 - 8000 Hz
Overspeed Setting* .	400 - 10000 Hz
Crank Termination	50 - 1000 Hz

ENVIRONMENTAL	
Ambient Operating Temperature Range	-40° to +85°C (-40° to +180°F)
Relative Humidity	Up to 95%

* Speed values in RPM are base on the number of flywheel teeth. RPM= pickup frequency / flywheel teeth

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3 INSTALLATION AND WIRING

INSTALLATION

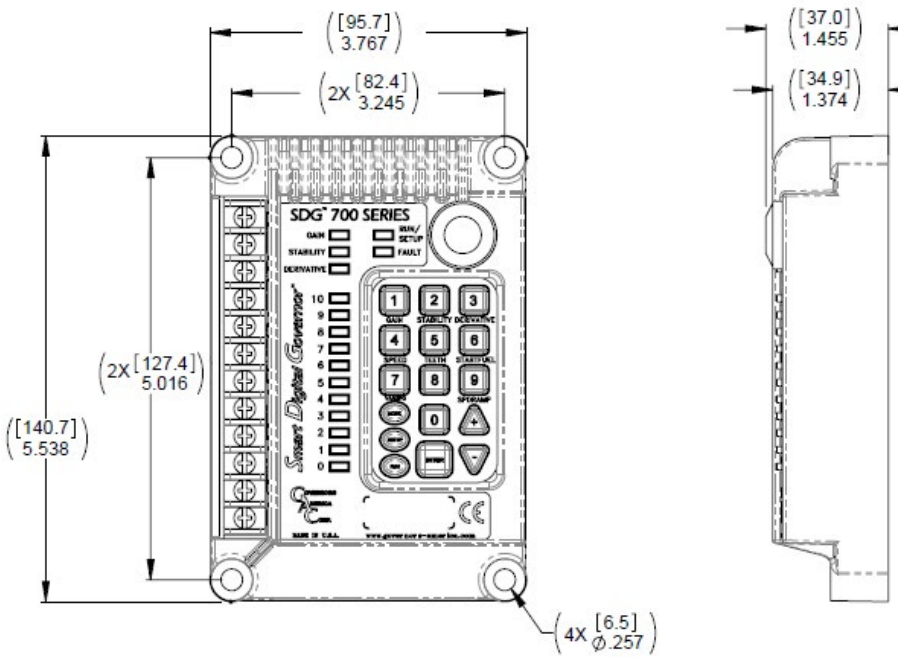
The following are required, but not included, for installation:

- Four M6 Screws
- Screwdriver and Drill
- #16 and #22 Wire
- Wire Termination Tools

When determining mounting location, the governor should be mounted isolated from engine ground.

To mount the SDG to a panel:

- Drill 4 (6.5 mm dia / Ø.257 drill size) holes for mounting screws.
- Place module in front of the panel aligning with the pre-drilled holes.
- Secure the module in place with four M6 screws.



BASIC WIRING

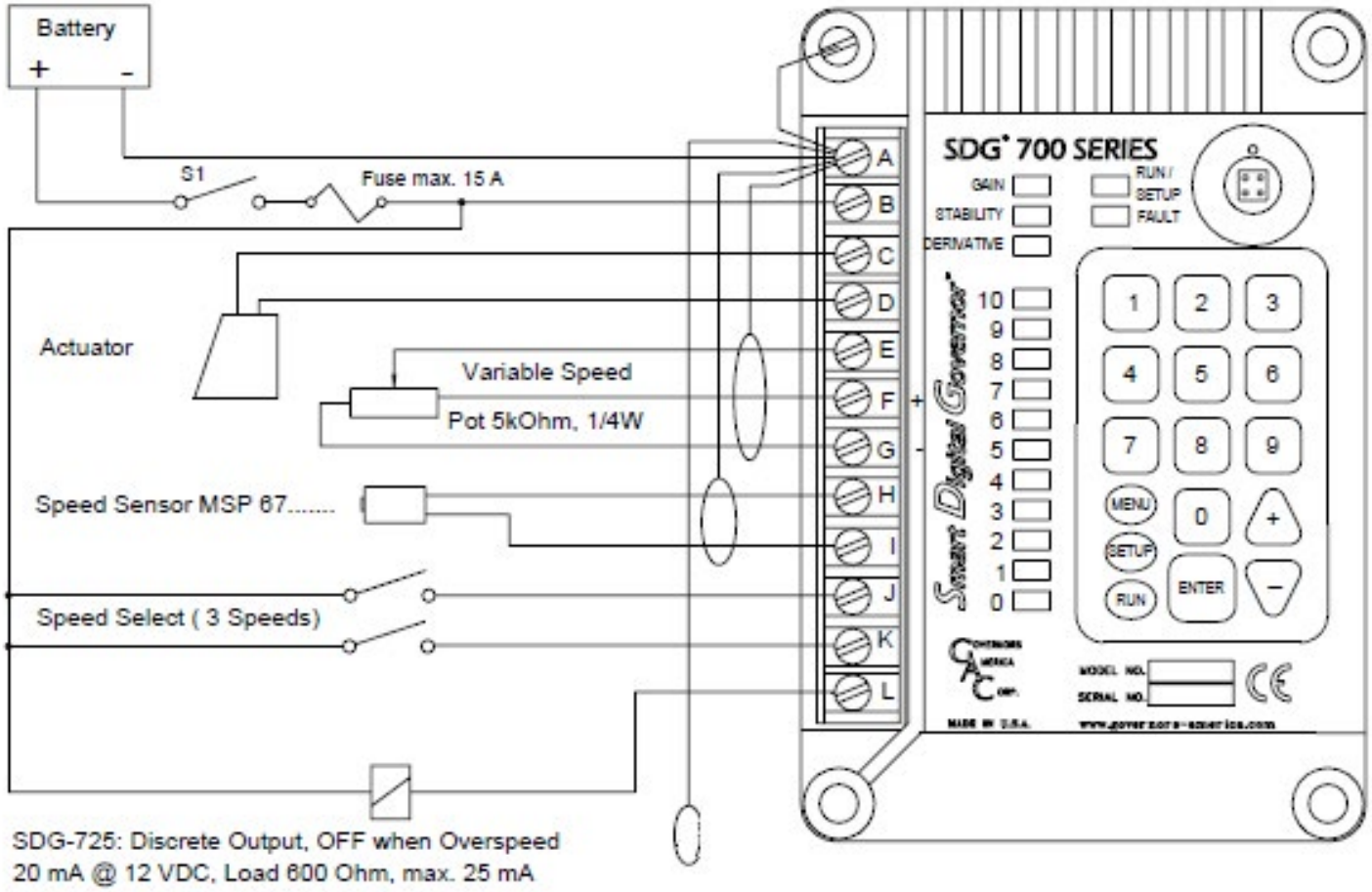
The following basic wiring is required. Reference section 4, Wiring Diagram for locations.

- The actuator cable MUST BE SHIELDED for its entire length.
- Terminals A thru D should be connected using #16 wire.
- Terminals E thru L should be connected using #22 wire.
- Battery and actuator connections to Terminals A,B,C, and D should be: 1.5 mm^2 for 24 V DC or 2.5 mm^2 for 12 V DC .
- Long cables (>5m (15 ft)) require an increased wire size to minimize voltage drops.
- Battery positive (+) input, Terminal B should be fused for 15 Amps.
- 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 5 m a shielded cable is required.
  - » Shields should only be connected to Terminal A
  - » Shields should be insulated to ensure no part of wiring comes in contact with engine ground.
- Specific speed configurations for Terminals J and K are shown in SPEED CONFIGURATION table.
- Terminal L is used for discrete output. Standard application is normally ON, OFF when overspeed tripped, latching, reset by cycling power. Depending on software version this output may be assign to crank termination or define function and latching. The discrete output is designed as a current sink and is capable of sinking 20 mA typically at 12 VDC through a 600 Ω load.

SPEED CONFIGURATION

Terminal J	Terminal K	Selected Speed	Selected Droop
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

4 WIRING DIAGRAM



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 relay exclusively on the governor system electric actuator to prevent overspeed. A secondary shutoff device, such as a fuel solenoid must be used.

POTENTIOMETER WIRING

Cables to the trim potentiometers can be up to 5 m (15 ft). Over this length use shielded cable. Connect the shield to Terminal A, case ground.

MAGNETIC PICKUP INSTALLATION

With engines stopped, adjust the gap between the mag speed pickup and the ring gear tooth. The gap should not be smaller than 0.45 mm (0.020 in). Follow the manufacturers instructions when installing. Verify proper installation by measuring voltage output of the pickup while cranking the engine. Output should be a minimum of 0.5 V AC.

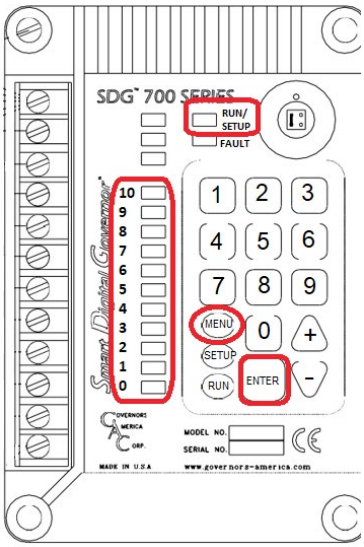
5 MENU FUNCTIONS AND ACTIVATION

GETTING STARTED

Before starting the engine safely, the SDG must be configured. To access configuration parameters:

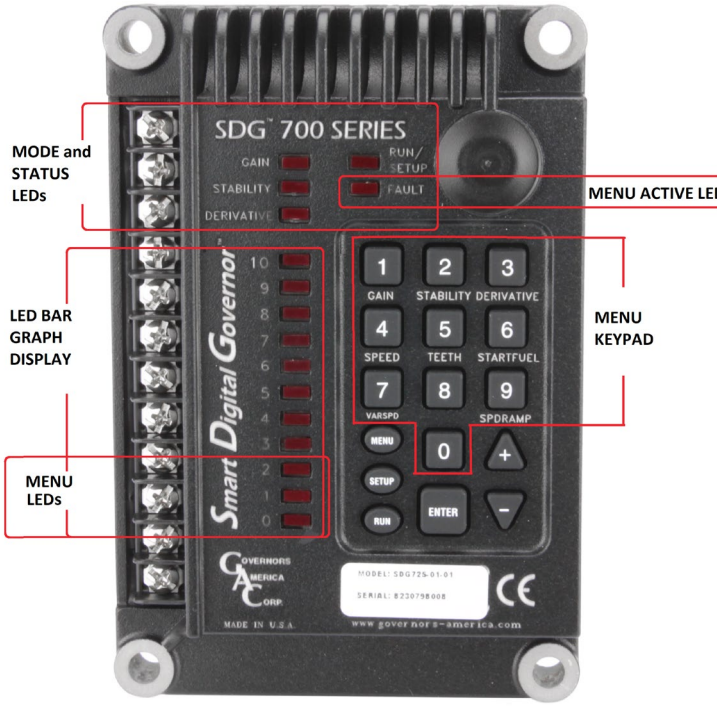
1. Apply power to the SDG without starting the engine.
2. Access SETUP mode:
   a. Press and hold the SETUP button until RUN/SETUP LED begins to flash.
   b. Enter the 4-digit security code using the followed by the ENTER key. Note: Each time a key is pressed the Bar Graph display LEDs flash.
   c. If the proper security code has been entered, the Bar Graph LEDs will flash the 4-digit software version number. If not, repeat step b.
   d. The RUN/SETUP LED flashes while the SDG is in SETUP mode.
   e. Make sure RUN/SET LED is flashing indicating you are in SETUP mode.

NOTE: You must be out of setup mode to start the engine. Press and hold the RUN button to save settings and exit setup mode.



SETUP FUNCTIONS

1. Once in SETUP mode, the parameters listed under each menu key can be accessed using the MENU button and that number key. Multiple parameters are aligned with the keypad number and combined with an active menu level.
2. Each time the MENU button is pressed, the next menu becomes active. Press until the desired menu level is active.
3. The MENU LEDs (0, 1, 2 of the LED Bar Graph display) indicate which menu is active (0, 1 or 2). The Fault LED (MENU Active LED) is always on when a menu is active.
4. The LED Bar Graph displays the value of a function settings.
5. The numeric keys are used to access and set values for menu functions as described in the following section, Setting Parameters. For example, press [MENU] [5] to access TEETH.



BASIC LED DISPLAY

LED	RUN Mode	SETUP Mode
RUN/ SETUP	Steady On (Defaults to this mode after reset)	Flashes to indicate setup enabled
FAULT	Steady On	Menu button pressed.
GAIN	Engine Running	Gain parameter is accessed.
STABILITY		Stability parameter is accessed.
DERIVATIVE	Engine Cranking	Derivative parameter is accessed
LEDs 0-10		Either 4-code flash or bar graph 0-100%

SETTING PARAMETERS

Use the following steps to change Parameters values:

1. Access menu level:
   - Menu 0 - Press Menu button once
   - Menu 1 - Press Menu button twice
   - Menu 2 - Press Menu button three times
2. Press keypad number that corresponds to parameter
3. Enter desired setting number on keypad or with arrow keys
4. Press Enter key (except for PID settings as detailed in the following table)
5. View LED Bar Graph display to confirm setting

To **save the setting**(s), 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.

NOTE: All setting modifications will be lost if not saved before the SDG is turned off. If power is cycled before values are saved, the SDG will return to previous or default settings.

PARAMETER	MENU	KEYPAD #	REQUIRED SETTING	DESCRIPTION
GAIN	0	1	YES	GAIN LED lights and Bar Graph displays percent setting. Use the [–] or [+] arrow keys to modify settings. Do not press [ENTER] after making a change.
STABILITY	0	2	YES	STABILITY LED lights and Bar Graph displays percent setting. Use the [–] or [+] arrow keys to modify settings. Do not press [ENTER] after making a change.
DERIVATIVE	0	3	YES	DERIVATIVE LED lights and Bar Graph displays percent setting. Use the [–] or [+] arrow keys to modify settings. Do not press [ENTER] after making a change.
FIXED SPEED	0	4	YES	Three fixed speed settings and one variable speed setting are available. Corresponding connections must be made on Terminals J and/or K to set this parameter. Settings can be made with the [–] or [+] arrow keys or by manually entering values with the keypad. 0 - Max RPM
VARIABLE SPEED HI	0	7	NO	A potentiometer must be connected to Terminal E, F, G to set this parameter. See SETTING VARIABLE SPEED in the following section for details. 0 - Max RPM
VARIABLE SPEED LOW	1	7	NO	A potentiometer is required to set this parameter.
DROOP	1	4	NO	Four droop settings correspond to the speed settings. Corresponding connections must be made on Terminals J and/or K to set this parameter. Use the [–] or [+] arrow keys to modify settings. **1 - 17%** regulation
TEETH	0	5	YES	Sets value for precise engine speed as related to number of Flywheel Teeth
OVERSPEED	1	5	YES	Sets overspeed value. 0 - Max RPM
START FUEL RAMP	0	6	NO	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. **0-100%**
START FUEL PRESET	1	6	NO	Determines how much fuel to begin with before fuel ramping engages. Minimum fuel required for engine starting. Retards black smoke. **0-100% (max fuel)**
CRANK TERMINATION	2	7	YES	Value must be at least 10% higher than the maximum cranking speed (RPM). Crank termination is used to determine if the ending is cranking or running. Without cranking termination set the SDG uses the PID algorithm instead of the cranking algorithm during the starting cycle. The LED labeled Derivative indicates SDG is in crank cycle. Once the engine is running the SDG invokes PID algorithm and Gain LED lights. If you are attempting to start the ending and GAIN lights, you may need to increase the Crank Termination value.
SPEED RAMP ACCELERATION	0	9	NO	Acceleration ramping during RPM input changes. **0-100%**
SPEED RAMP DECELERATION	1	9	NO	Deceleration ramping during RPM input changes. **0-100%**
RANGE	2	1	NO	Doubles or triples the GAIN and STABILITY parameter values. Normal setting is 0001. Use the [–] or [+] arrow keys to increase to 0002 or 0003.

When setting a parameter value:

- Parameters are added as a 4-digit number, entered through the keypad followed by pressing the enter key. The value entered then displays on the LED Bar Graph.
- If setting 1-3 digits, enter leading zeros: a 3-digit number is entered as [0] [1] [2] [5] = 125.
- Parameters defined as %-values are modified using the up and down 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 %
- Press and hold the RUN key until the RUN/SETUP LED stops blinking to save settings. The SDG will now be in RUN mode verified by a steady RUN/SETUP LED. Unsaved settings will be lost when power is removed from the system.

6 SETUP DETAILS

SETTING VARIABLE SPEED WITH A POTENTIOMETER

To set variable speed:

1. Turn the potentiometer to set maximum voltage on terminal E. (Voltage can be measured between Terminals E and G)
2. Access menu 0, key 7.
3. Maximum voltage is displayed on the bar graph display. This state also is recognized by the SDG as the potentiometers maximum position.
4. Typing in the 4-digit number followed by pressing the enter key assigns the maximum speed value (high idle) to this highest potentiometer position.
5. This maximum value is now flashed out with the Bar Graph LEDs.
6. Turn the potentiometer to the minimum voltage for Terminal E.
7. Access menu 1, key 7 (press MENU-MENU-[7]). The current minimum voltage is displayed on the Bar Graph LEDs. This state also is recognized by the SDG as the potentiometers minimum position.
8. Enter the 4-digit number and press the enter key to assign the min. speed value (low idle) to this lowest potentiometer position.
9. This minimum value is now displayed on the Bar Graph LEDs.

LED BAR GRAPH VALUE DISPLAY

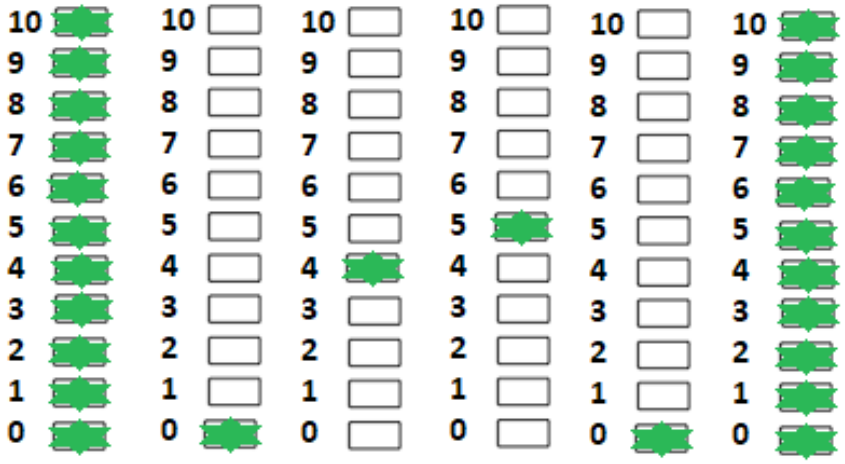
The LED Bar Graph display shows both parameter value settings and values set as approximate percentages.

PARAMETER SETTING VALUE

Once a value is entered and the enter key is pressed, the LED Bar Graph displays the value:

1. The LED Bar Graph blinks all LEDs
2. The first number of the value then lights
3. The second number lights
4. Followed by the third, then forth
5. The full column of LEDs again blinks, completing the display.
6. The sample parameter value shown here is [0] [4] [5] [0] - 450.

- Available values are between 0 and 9999.
- Values must be entered in as 4 digits. The value 23 is entered as [0][0][2][3].



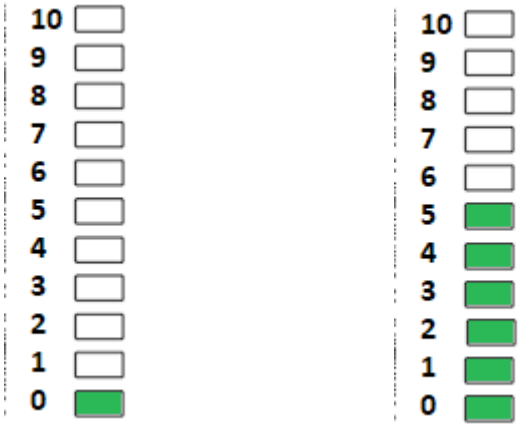
PARAMETER PERCENT VALUE

A percent value displays the approximate value, with each LED registering between 0 and 9%.

Percentages are set using the [+] and [-] arrow keys, with each click incrementing a percent.

The left hand example indicates the percent is between 1& and 9%.

The right hand example indicates between 50& and 59%.



7 STARTING THE ENGINE

Before starting the engine with the SDG connected, follow these steps:

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. You can do this by pressing the related buttons and reviewing the Bar Graph LED display.
3. When you are satisfied with the settings, cycle power to exit Setup Mode.
4. If you had to modify any settings, press and hold the [RUN] key to return to RUN Mode.
5. You are ready to start the engine.

STARTING THE ENGINE

1. On customized SDG versions 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.
2. On a new unit shipped from the factory the following initial setting are recommended:
   - GAIN: 30 %,
   - STABILITY: 10 %
   - DERIVATIVE: 10 %
3. These settings are made using the [+] [-] arrow keys.
4. Activate starter. Engine should run at low speed. If unstable, reduce GAIN and STABILITY.

SAVING PARAMETER 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

OPTIMIZATION OF DYNAMIC ADJUSTMENT (TUNING)

1. Increase the GAIN slowly by typing the [+] arrow until the engine hunts, then decrease using the [–] arrow until the engine runs stable. From this point decrease another 2-3 [-] arrows.
2. Adjust the STABILITY using same steps as GAIN.
3. Push the actuator lever momentarily and re-adjust GAIN and STABILITY for fastest recovery.
4. In some cases it may be necessary to change the DERIVATIVE (Dead time compensation) too.
5. If engine hunts rapidly even when GAIN is low, reduce DERIVATIVE by typing the [–] arrow. If engine hunts very slowly increase DERIVATIVE by pressing the [+] arrow.

8 TROUBLESHOOTING

ISSUE	POSSIBLE ISSUE	CHECK	REMEDY
ENGINE DOES NOT START			
Voltage failure?	Low Voltage Fuse Battery or 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 gauge or weak battery. If not, replace SDG.
LED FAULT on?	SDG in FAULT condition	Overspeed limit was exceeded?	Press and hold RUN button to exit setup mode. Recheck flywheel teeth and overspeed settings. Cycle power OFF-ON. Try to restart
LED RUN/SETUP blinking?	SDG in SETUP mode		Press and hold RUN button to exit setup mode. Cycle power OFF-ON. Try to restart.
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.
LED GAIN and DERIVATIVE off?	No speed signal from magnetic speed sensor.	Measure voltage on terminals H and I	Actuator failure.
	Actuator failure.	1. Check wiring. 2. Measure voltage on Terminals C & D 3. Measure actuator current.	1. See sections 3 and 4, for details on Wiring. 2. Compare with actuator specifications. **DO NOT DISCONNECT ACTUATOR WHILE ENERGIZED!**
Bar Graph flashing when power applied to SDG	1. SDG configuration corrupt. 2. Fuel supply failure	1. Check configuration 2. Check Fuel system	Reload software or reconfigure the unit.
ENGINE NOT RUNNING AT CORRECT FIXED SPEED			
Configuration, Wiring	1. Terminals J & K not properly configured. 2. Incorrect flywheel teeth number. 3. Incorrect fixed speed settings.	Check wiring. Settings have to be made with the corresponding connections on J and K	1. If nothing is connected to J & K the SDG is configured for variable speed. 2. Reconfigure flywheel setting
ENGINE NOT RUNNING AT CORRECT VARIABLE SPEED			
Pot-meter wiring	Terminals E,F,G not properly connected	Check wiring	
Configuration	Incorrect variable speed configuration		Reconfigure the variable speed pot-meter
OVERSPEED DURING STARTING, LOAD TRANSIENT OR SPEED CHANGES			
LED FAULT on?	1. Overspeed setting too low 2. Tuning not optimal 3. Crank termination setting too high		1. Check overspeed setting 2. Adjust GAIN, STABILITY and speed ramp ACCELERATE. 3. Check crank termination setting
UNSTABLE ENGINE BEHAVIOR			
Slow periodic instability	1. Friction in linkage or fuel rack 2. Low battery voltage 3. Actuator force insufficient 4. Insufficient dead time compensation	Check mechanical parts for friction. Check battery and wiring should be min. 20 V with 24 V systems.	1. Eliminate all friction in linkage and fuel rack. 2. Replace battery. 3. Use appropriate wiring. 4. Use stronger actuator 5. Increase DERIVATIVE
Fast periodic instability	1. GAIN too high 2. Too much dead time compensation 3. Fault in fuel injection system 4. Soft or worn coupling		1. Reduce GAIN 2. Reduce DERIVATIVE 3. Eliminate fault in fuel injection system 4. Correct fault
Governor performance good but actuator lever and fuel pump rack are shaking (dither) approx. 1 mm	1. Torsional vibrations caused by soft coupling or excessive play in coupling 2. Misfiring of one cylinder		Correct fault Correct fault in engine