DPG101
Electronic Digital Governor

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1 INTRODUCTION

The DPG101-FR is a microprocessor based digital governing system integrated with an electro-mechanical actuator in a single pump-mountable housing, designed for BQ-series in-line fuel injection pumps.

The fixed speed DPG has two connectors: power and speed. Using a magnetic speed sensor positioned in close proximity to the engine's ring gear the DPG compares actual speed with the desired speed and the DPG's digital electronics adjusts the position of the rack to command the proper amount of fuel. Changes in engine speed are processed using GAC's highly developed EDGE™ PID algorithm for closed loop speed control. The DPG solution provides:

- Wide Operating Temperature Range
- Immune to Analog Drift
- IP67 Sealed Case and Connector
- 2 Selectable Speeds: Rated and Idle
- User Tamper Resistant - no External Adjustable Pots or Switches
- LED Power Notification

The DPG is controlled using either software or a handheld device:

1. Pairing GAC's SmartVU software running with the EAM211 (sold separately) to interface the DPG with a USB connection on a computer. See section 5, SETTING DPG PARAMETERS WITH SMARTVU.
2. Using the DPI100, a hand held unit with physical buttons (sold separately). The DPI100 includes the required serial connector. See section 6, SETTING DPG PARAMETERS WITH DPI100.

EAM211

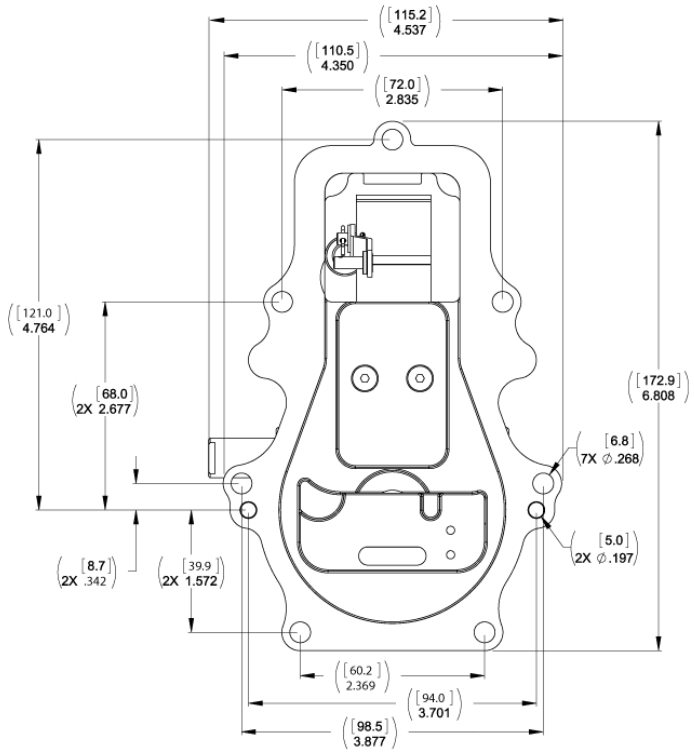
DPI100

2 SPECIFICATIONS

PERFORMANCE	
Isochronous Operation	± 0.25 %
Speed Range / Governor	400 - 10 KHz
Droop Range	1 - 5% regulation
INPUT / OUTPUT	
Supply	12-24 V DC Battery Systems (7.0 to 33 V DC)
Polarity	Negative Ground (Case Isolated)
Power Consumption (12 V DC)	40 mA MAX (no load) 6 A MAX (full load) 2.7 - 3.3 A Typical Range 2.0 - 4.0 A Operating Range
Power Consumption (24 V DC)	40 mA MAX (no load) 3 A MAX (full load) 1.3 - 1.7 A Typical Range 1.0 - 2.0 A Operating Range
Speed Sensor Signal	1.0 - 120 V RMS
Mechanical Shutdown Lever Force Required	20 lb-in (2.3 N m)
Mechanical Max Fuel Rack Stop Screw Range	12 mm

ENVIRONMENTAL	
Ambient Temperature	-40° to 85°C [-40 to 180°F]
Relative Humidity	up to 95%
All Surface Finishes	Fungus Proof and Corrosion Resistant
PHYSICAL	
Dimension	See Section 3, INSTALLATION
Weight	3.1 lbf [1.41 kgf]
RELIABILITY	
Vibration	4 g, 20 - 500 Hz
Shock	20 g Peak
Testing	100% Functional Testing
COMPLIANCE / STANDARDS	
Agency	CE and RoHS Requirements
Communications	RS-232-C, IEEEE J1939

3 INSTALLATION



Dimensions:
[mm]
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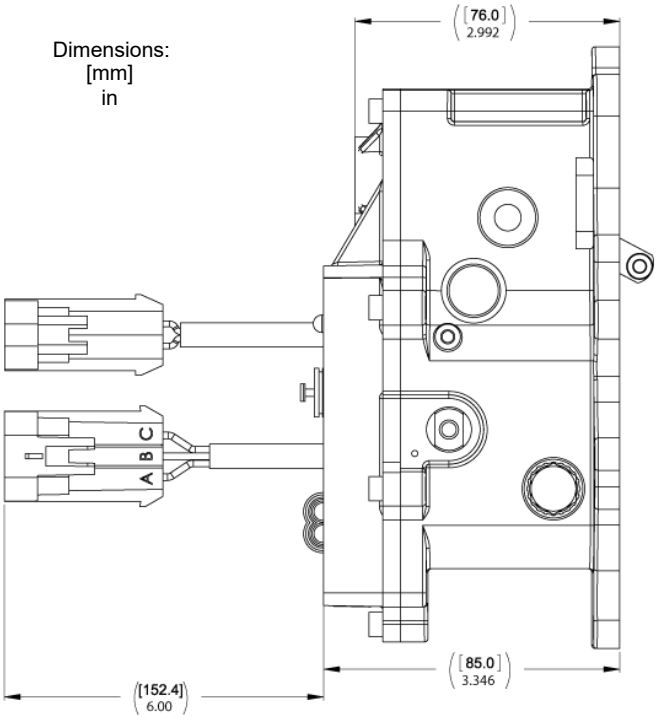
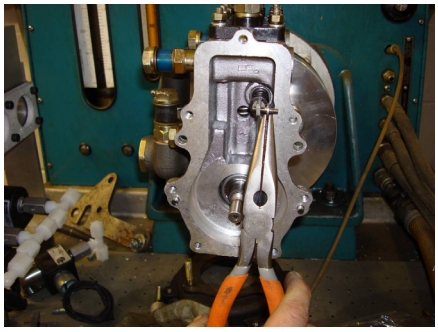
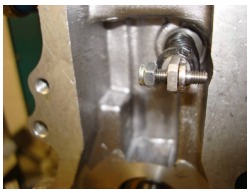
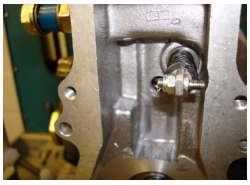


CONNECTING THE DPG TO THE PUMP

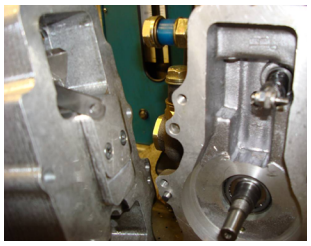
1. Remove pin from DPG
2. Install pin and nut on pump rack

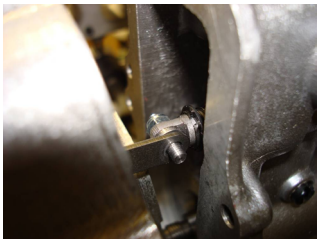


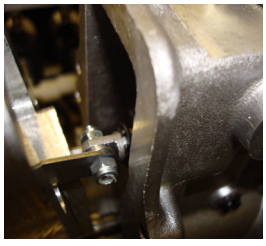




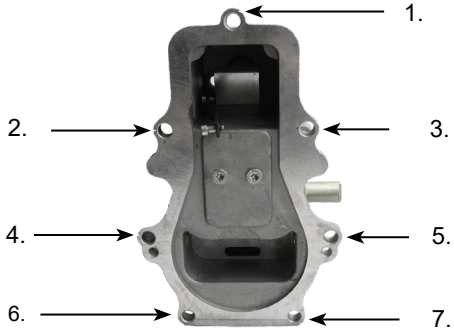
3. Move DPG close to the pump.
4. Connect the DPG link to the pin on the rack and secure it with the second nut.







5. Fasten the DPG to the pump by tightening bolts in the order numbered 1-7.



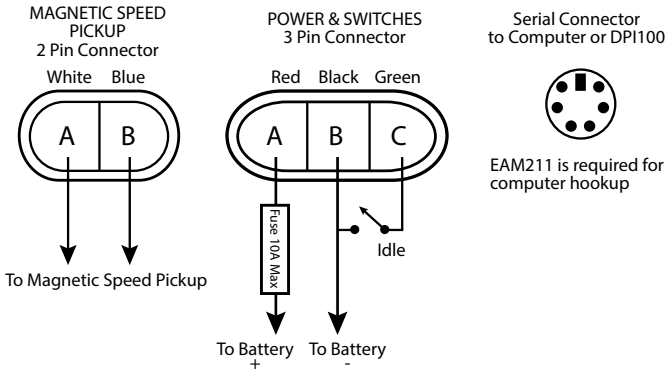
4 WIRING

There are two ways to control the DPG and therefore wiring is related to your control choice.

1. Use GAC's SmartVU software: Requires the GAC EAM211 (sold separately) which provides a USB interface between the DPG and your computer. Further details on using SmartVu with the DPG are found in section 5, SETTING DPG PARAMETERS WITH SMARTVU.

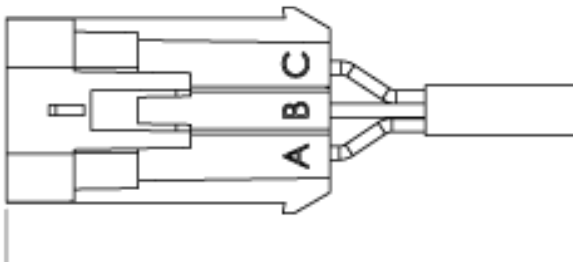
2. Use the DPI100 a hand held unit with physical buttons (sold separately) using the serial connector which is included with the DPI100. Further details on using the DPI with the DPG are found in section 6 SETTING DPG PARAMETERS WITH DPI100.

3. Magnetic pickups and battery connections are also required for either control systems.



POWER BUNDLE			
MATING CONNECTOR	**FUNCTION**	**PIN**	**COLOR**
EC1523 (3 Pin)	Battery +	A	Red
	Battery -	B	Black
	Idle	C	Green
MAGNETIC SPEED PICKUP BUNDLE			
MATING CONNECTOR	**FUNCTION**	**PIN**	**COLOR**
EC1360 (2 Pin)	Mag Pickup 1	A	White
	Mag Pickup 2	B	Blue

RECOMMENDATIONS	
1.	Use shielded cable for all external connections to the DPG control.
2.	One end of each shield, including the speed sensor shield, should be grounded to a single point on the DPG case.



If the DPG detects no input from the magnetic pickup, the DPG will set the actuator to 0 V and set the speed to 0 RPM.

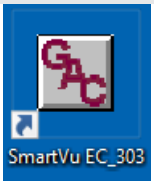
After the DPG has detected loss of magnetic pickup, the system must be reset. To reset the DPG, DC power must be cycled.

5 SETTING DPG PARAMETERS WITH SMARTVU

The DPG100 and DPG101 can be programmed using GAC's SmartVU software. Instructions for SmartVU using the DPG101 can be found at https://www.governors-america.com/ in Software Downloads. Contact your GAC representative for help as required.

INSTALL GAC SMARTVU

Once downloaded to your computer, follow the installation steps for SmartVU.

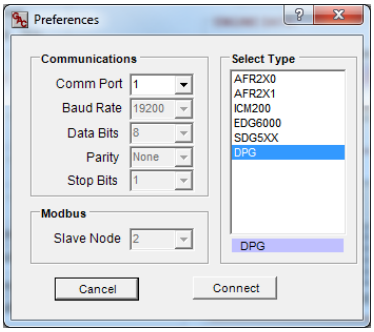


Open the application from the desktop icon.

The DPG must be installed and connected to the PC for SmartVU to see the hardware in the application screen.

SETUP CONNECTION

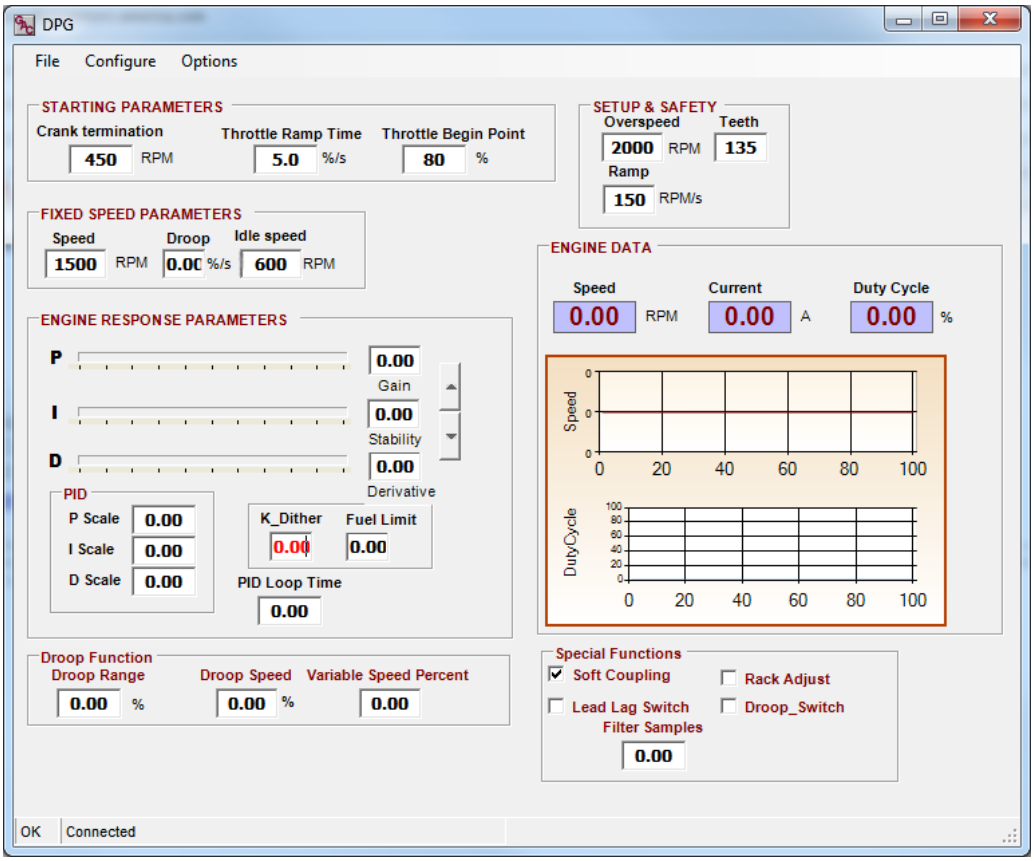
1. Select DPG from the Select Types on the Preferences menu located under the Main menu → Configure.
2. SmartVU recognizes the device and allows you to set parameters from the Main menu.



NOTE The engine will maintain current operation while adjusting parameters. (i.e. NO CHANGES) Since the scaling will be made to the Gain, Stability, and Derivative parameters automatically, go back and readjust these parameters to the desired levels.

MAIN MENU

Adjust all the settings from the main menu of SmartVU.



5 SETTING DPG PARAMETERS WITH SMARTVU (CONTINUED)

STARTING PARAMETERS			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
CRANK TERMINATION	Crank termination is the RPM at which the DPG switches from starting to governing.	100 - 500 RPM	250 RPM
THROTTLE RAMP TIME	Throttle position's rate of change. From the throttle begin point to 100%, during the start/crank cycle.	0-100	2
THROTTLE BEGIN POINT	Starting position of the actuator during the start/crank cycle.	0-100%	100%

SETUP & SAFETY			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
OVERSPEED	RPM at which to automatically shut off the actuator.	0 - 3800 RPM	2220 RPM
TEETH	Number of teeth on the flywheel for engine speed calculation.	50-250	108
RAMP	Allows for rapid engine speed response with minimal overshoot during engine start acceleration and deceleration.	0 - 9999 RPM/s	150 RPM/s
FIXED SPEED PARAMETERS			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
SPEED	Fixed speed setpoint for operating.	0 - 3800 RPM	1500 RPM
DROOP	Droop to apply under maximum load.	0 - 5%	0%
IDLE SPEED	Idle speed setting. Must be lower than operating speed.	0 - 3800 RPM	850 RPM

ENGINE RESPONSE PARAMETERS			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
P	Proportional (P) set point. [GAIN]	0 -100, 100 = Max Gain	10
I	Integral (I) set point. [STABILITY]	0 -100, 100 = Longest Time	35
D	Derivative (D) set point. [DEADTIME]	0 -100	25

UPDATE & PID			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
PID Loop Time	Changes the rate at which the PID routine is called.(in ms)	4 - 250 ms	4 ms
P Scale	If a PID Scale multiplier is changed (e.g. P Scale), the corresponding parameter (e.g. P) will be affected in two ways: • If the multiplier is decreased by 1, the corresponding parameter will double. • If the multiplier is increased by 1, the corresponding parameter will halve.	0 - 20	**17**
I Scale		0 - 20	**17**
D Scale		0 - 20	**8**

ENGINE RESPONSE PARAMETERS			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
DITHER	Adds a high-frequency, low amplitude signal to the actuator to prevent the from sticking in harsh environment.	0 - 100%	0% (no dither)
FUEL LIMIT	Maximum allowable actuator % the system can command fuel	0 - 100%	99%

SPECIAL FUNCTIONS			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
Soft Coupling	Slows down engine response and improves steady state performance.	Off, On	Off
Rack Adjust	Not Available	-	-
Filter Samples	Changes the cutoff frequency for soft coupling when soft coupling is enabled. Lower numbers filter out higher frequency noise.	1 - 63	40
Droop Switch	Sets the droop mode (On = Auto offset, Off = Manual).	Off, On	On
Lead / Lag	Lead Circuit in PID - response increase.	Off, On	Off

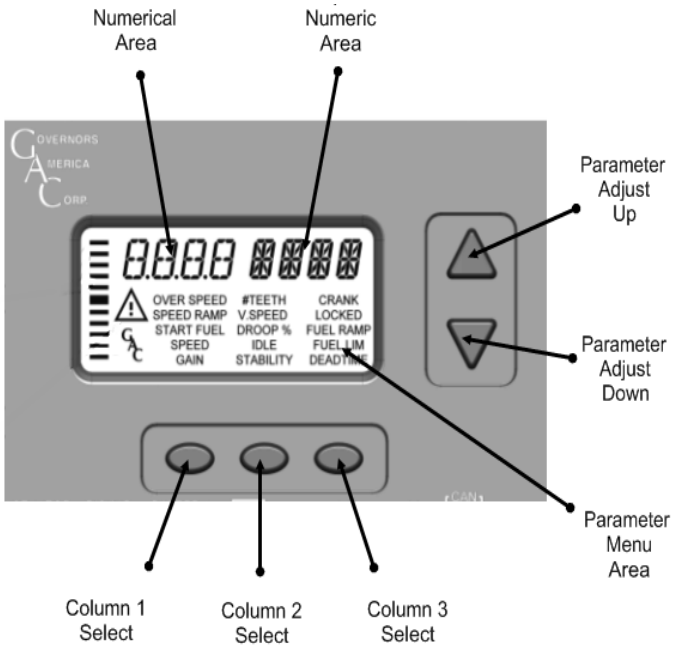
6 SETTING DPG PARAMETERS WITH DPI100

The parameters found in SmartVU are also found on the DPI100.

The DPI100 is the user interface for configuring the either the DPG.

All adjustments are made using the LCD and five buttons – 3 COLUMN select buttons, 1 UP ARROW, 1 DOWN ARROW.

- Three configuration menus: Main, Special, and Advanced
- **Main** display consists of most frequently adjusted parameters.
- **Special** is used to view and change lesser used parameters.
- **Advanced** Configuration is used to manipulate the operating characteristics of the PID control. These parameters include PID update rate, Filter, Gain, Stability, and Deadtime Compensation scale adjustments.
- There are 5 rows with 3 parameters in each row



MENU CONTROL BUTTONS

MAIN MENU CONTROLS	
ACTION	**BUTTONS**
Lock the Display	Press and hold both Parameter Adjust Up and Parameter Adjust Down buttons for 2 seconds.
Unlock the Display	Press and hold both Parameter Adjust Up and Parameter Adjust Down buttons for 2 seconds.
Change Display Mode	Tap Parameter Adjust Up or Down buttons. The display will toggle between showing engine RPM, duty cycle, and actuator current.
Change Parameter Row	Press any Column button.
View Parameter	Press and hold Column button under desired parameter.
Change Parameter Value	Press and hold Column button under desired parameter while tapping the Parameter Adjust Up button or Parameter Adjust Down button (holding the Adjust buttons will scroll the values).
SPECIAL MENU CONTROLS	
ACTION	**BUTTONS**
Special Menu	Hold all 3 Column buttons until “AUX” appears in the display (approximately 2 seconds).
Next Parameter	Press Column button 3.
Previous Parameter	Press Column button 1.
Change Parameter Value	Tap or hold down the Parameter Adjust Up or Down button.
Return to Main Menu	Press and hold all 3 Column buttons for 2 seconds.
ADVANCED MENU CONTROLS	
ACTION	**BUTTONS**
Advanced Menu	Press and hold all 3 Column buttons until “RATE” appears in the display (approximately 10 seconds).
Next Parameter	Press Column button 3.
Previous Parameter	Press Column button 1.
Change Parameter Value	Tap or hold down the Parameter Adjust Up or Down button.
Return to Main Menu	Press and hold Column button 1 and Column button 3.

PARAMETER SETTINGS

ADJUSTABLE MAIN MENU PARAMETERS		
OVERSPEED	**#TEETH**	**CRANK**
RPM to automatically shutoff the actuator	Number of teeth on flywheel	RPM DPG switches from starting to governing
Range: 500 - 9999 RPM Default: 2200 RPM	Range: 50 - 255 Default: 108	Range: 0 - 9999 RPM Default: 250 RPM
SPEED RAMP	**V.SPEED**	**LOCKED**
Rate at which speed changes from idle to speed and back	Not available	DPI will lock after 5 minutes of non-use
Range: 0 - 9999 Default: 150 RPM/sec	Range: NA Default: NA	Range: OFF, ON Default: OFF
START FUEL	**DROOP%**	**FUEL RAMP**
Percent of fuel to apply to actuator first upon cranking.	Droop to apply under maximum load (based on current of actuator)	Percent per second to apply fuel as engine starts
Range: 0 - 100% Default: 100%	Range: 0 - 25.0% Default: 0.0%	Range: 0 - 100% Default: 2%
SPEED	**IDLE**	**FUEL LIMIT**
Operating speed of engine.	Engine speed when IDLE input closed	Maximum actuator percentage allowed
Range: 0 - 9999 RPM Default: 1500 RPM	Range: 0 - 9999 RPM Default: 850 RPM	Range: 0 - 100% Default: 100%
GAIN	**STABILITY**	**DEADTIME**
Proportional (P) set point of the PID control.	Integral (I) set point of PID control.	Derivative (D) set point of the PID control.
Range: 0 - 100, 100 = Max Gain Default: 10	Range: 0 - 100, 100 = fastest response Default: 35	Range: 0 - 100 Default: 25

SPECIAL MENU PARAMETERS

PARAMETER	DEFINITION	RANGE	DEFAULT
SOFT	Soft Coupling - dampening of system (slow down response).	Off, On	Off
LEAD	Lead Circuit - response increase.	Off, On	Off
RADG	Rack adjust not used.	Off, On	Off
D SW	Sets the droop mode (On=Auto Offset, Off = Manual Offset)	Off, On	On
DITH	Dither - adds white noise to actuator to prevent sticking in the fuel rack. (%)	0 - 10	0
DRNG	System current to the actuator that represents full load. Units in (A).	0.0 - 10.0	3.9
DSPD	Droop offset when D SW is set to Off (RPM)	0 - 9999	1500

NOTE The engine will maintain current operation while adjusting parameters. (i.e. NO CHANGES)
Since the scaling is made to the Gain, Stability, and Derivative parameters automatically, go back and readjust these parameters to the desired levels.

6 SETTING DPG PARAMETERS WITH DPI100 (CONTINUED)

ADVANCED SETTINGS

Advanced menu parameters are used to manipulate the operating characteristics of the PID control. These parameters include PID update rate, Filter, Gain, Stability, and Deadtime Compensation scale adjustments.

Modifying these advanced parameters without thorough knowledge of their use can damage the engine or cause injury. Contact your GAC representative with questions.

ADVANCED MENU PARAMETERS			
PARAMETER	**DEFINITION**	**RANGE**	**DEFAULT**
RATE	The time (mS) between calls to the PID control loop.	4 - 250 mS	8
FLTR	Number of speed samples in frequency calculation. Filter is active when soft coupling (**SOFT**) is set to ON. Lower numbers filter high frequency noise.	1 - 62 samples	10
GMUL *	If the **GAIN** parameter is at maximum and more **GAIN** is required, increase **GMUL**. **GAIN** will be more responsive. If small changes in the **GAIN** parameter are over responsive, decrease **GMUL.**	1 - 20	16
SMUL *	If the **STABILITY** parameter is at maximum and more **STABILITY** is required, increase **SMUL**. **STABILITY** will be more responsive. If small changes in **STABILITY** parameter are over responsive, decrease **SMUL.**	1 - 20	16
DMUL *	If **DEADTIME** value is at maximum and more **DEADTIME** is required, increase **DMUL**. **DEADTIME** will be more responsive. If small changes in **DEADTIME** parameter are over responsive, decrease **DMUL.**	1 - 20	10

*Multiplier changes can make drastic changes. Changing a multiplier (e.g. GMUL) will affect the corresponding Main Menu parameter (e.g. GAIN) in two ways:

1. If the multiplier is decreased by 1, corresponding P,I, or D value will double.
2. If the multiplier is increased by 1, corresponding P,I, or D value will halve.

7 PRE-START SETUP

The following parameters must be set before starting the engine:

SETUP & SAFETY PARAMETERS		STARTING PARAMETERS	
OVERSPEED	TEETH	CRANK TERMINATION	THROTTLE RAMP TIME
RAMP		THROTTLE BEGIN POINT	
FIXED SPEED PARAMETERS			
SPEED		IDLE SPEED	

8 ADJUSTING FOR STABILITY

Once the engine is running at operating speed and at no load, the following governor performance adjustment can be made to increase engine stability.

MAIN MENU	
PARAMETER	**ADJUSTMENT**
P (GAIN)	1. Increase this parameter until instability develops. 2. Then, gradually decrease this parameter until stability returns. 3. Finally, decrease this parameter one increment further to insure stable performance. 4. If instability persists, adjust the next parameter.
I (STABILITY)	Follow the same adjustment procedure as the P parameter. If instability persists, adjust the next parameter.
D (DEADTIME)	Follow the same adjustment procedure as the P parameter.

NOTE P, I, & D parameter adjustments may require minor changes after engine load is applied. Normally, adjustments made at no load achieve satisfactory performance. If further performance improvements are required, refer to Advanced Menu Parameters and SYSTEM TROUBLESHOOTING in Section 11.

9 OTHER FEATURES

OVERSPEED

If the DPG101 detects the engine speed has reached the value specified by OVERSPEED parameter (Main Menu), the DPG101 will command the engine speed to 0 RPM and the actuator output to 0 V.

NOTE After the DPG has detected an overspeed, the system must be reset. To reset the DPG, DC power must be cycled.

SPEED DROOP OPERATION

Droop replicates a mechanical governor's response to a load change. In Droop Operation, the engine speed will decrease as engine load increases. DROOP (Main Screen: Fixed Speed Parameters & Variable Speed Parameters) is based on the Droop Function System Range found in the Governor Advanced Settings.

10 DPG VERSIONS

PRODUCT NO.	DEFINITION
DPG100	Basic unit
DPG101	Basic unit plus power LED & extended travel
PRODUCT NO.	**DEFINITION**
F	Fixed Speed
R	Right-Hand Rack
L	Left-Hand Rack
12	12 Volt version
24	24 Volt version
	EXAMPLE
DPG101-FR-12	Basic 12 volt unit with power LED, fixed speed, and right rack.

11 SYSTEM TROUBLESHOOTING

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in the following table. Positive (+) and negative (-) refer to meter polarity. Should normal values be indicated during troubleshooting steps, then the fault may be with the actuator or the wiring to the actuator.

Tests are performed with battery power on and the engine off, except where noted. See actuator publication for testing procedure on the actuator.

STEP	WIRES	NORMAL READING	PROBABLE CAUSE
1	Power Bundle Wires Red & Black	Battery Supply Voltage (12 or 24 V DC)	1. DC battery power not connected. Check for blown fuse 2. Low battery voltage 3. Wiring error 4. LED ON
2	Mag Pickup Bundle Blue Wire & Mag Pickup Bundle Black wire (Ground)	1.0 - 2.0 V AC RMS min. while cranking	1. Gap between speed sensor and gear teeth too great 2. Check Gap 3. Improper or defective wiring to the speed sensor 4. Resistance between the Mag Pickup Bundle Blue wire and the Mag Pickup Bundle Black wire (Ground) should be 30 to 1200Ω. See specific Mag Pickup data for resistance. Defective speed sensor.

11 SYSTEM TROUBLESHOOTING (CONTINUED)

INSTABILITY	SYMPTOM		PROBABLE CAUSE
Slow Periodic	An irregularity of speed below 3Hz. (Sometimes severe)	1.	Verify the SOFT COUPLING Governor Advanced Setting parameter is disabled.
		2.	Decrease the update rate of the controller by decreasing the UPDATE Advanced parameter. (Each time UPDATE is changed, P, I, and D must be re-adjusted.
		3.	Check fuel system linkage during engine operation for: a. binding b. high friction c. poor linkage
		4.	Add a small amount of droop.
Non-Periodic	Erratic Engine Behavior	1.	Increasing the P parameter should reduce the instability but not totally correct it.
		2.	If this is the case, there is most likely a problem with the engine itself. Check for: a. engine mis-firings b. an erratic fuel system c. load changes on the generator set voltage regulator.
		3.	Excessively high deadtime/derivative term.

UNSATISFACTORY PERFORMANCE

SYMPTOM	NORMAL READING		PROBABLE CAUSE
Engine Overspeed	Do Not Crank. Apply DC power to the governor system.	1.	After the actuator goes to full fuel, disconnect the speed sensor at the Mag Pickup Bundle Blue wire. If the actuator is still at full fuel-speed then the control unit is defective.
		2.	If the actuator is at minimum fuel position and there exists an erroneous speed signal, then check speed sensor
	Check #TEETH parameter.	1.	Incorrect tooth count entered.
Overspeed shuts down engine after running speed is reached	Examine the SPEED and OVERSPEED operating parameters for the engine	1.	SPEED parameter set too high.
		2.	OVERSPEED set too close to SPEED.
		3.	GAIN set to low.
		4.	Actuator or linkage binding.
		5.	Speed Control unit defective.
Overspeed shuts down engine before running speed is reached	Check impedance between the Mag Pickup Bundle Blue wire & the Mag Pickup Bundle Black wire (Ground). Should be 30 to 1200 ohms. See your specific Magnetic Pick-up data for resistance.	1.	OVERSPEED set too low
		2.	If the speed sensor signal is erroneous, then check the wiring.
Actuator does not energize fully	Measure the voltage at the battery while cranking.	1.	If the voltage is less than: a. 10 V DC for a 12 V system, or b. 20 V DC for a 24 V system, Then: Check or replace battery.
Engine does not get to correct speed		1.	Idle set above operating speed
		2.	Fixed speed set above overspeed
		3.	Set crank cutoff speed above idle or fixed speed