GAC GOVERNORS AMERICA CORP.®

ESD5330 Speed Control Unit

EGSA Electrical Generating Systems Association — ISO 9001 CERTIFIED

1 INSTALLATION

The ESD5330 speed control unit is rugged enough to be placed in a control cabinet or engine mounted enclosure with other dedicated control equipment. The circuit board is conformally coated to seal out moisture and resist vibration. If water, mist or condensation can come in contact with the controller, it should be mounted vertically. This will allow any accumulated fluids to drain away from the speed control unit.

2 WIRING

See the back of this document for the wiring diagram.

TERMINAL	DEFINITION	NOTES
A & B	Actuator (+/-)	#14 AWG wire
C & D	Battery Power (-/+)	#14 AWG wire A 20 amp fuse must be installed in the positive battery lead to protect against any overload or short circuit Battery positive (+) input is Terminal D
E & F	Magnetic Pickup (- is ground)	Wires must be twisted and/or shielded for their entire length Gap between speed sensor and gear teeth should not be smaller than 0.02 in. (45mm) Speed sensor voltage should be at least 0.51VAC RMS during crank
G	Ground Signal	
H	Frequency Trim	Shielded cable required for lengths over 15 ft (5 m) & connected to Terminal G
J & K	Droop	Active when closed
L & R	Gain 1 & Gain 2	Gain 1 when open / Gain 2 when closed
M	Aux Input	Load Sharing / Synchronizing, Ground at Terminal G
N & P	Idle	Active when closed

RECOMMENDATIONS

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

3 PRE-START SETUP

Preset the adjustments. Check to see that the GAIN, STABILITY, and External Frequency Trim (if used) are set to their mid positions. Also check to see that the STARTING FUEL adjustment is set to “100” initially.

CAUTION Dip Switches SW2-5, SW2-6, and SW2-7 must be set in their proper position before starting the engine. See the following table for normal switch position.

DIP SWITCHES			
ROW	SWITCH	FUNCTION	NORMAL POSITION
SW1	C1	Lead Lag Circuit	OFF
	C2	Standard Drive Train	OFF
NOTE	When switch C2 is ON, Resonant Drive Train is enabled.		

ROW	SWITCH	FUNCTION	NORMAL POSITION	
SW2	1	DTC 8X	OFF	
	2	DTC 4X	OFF	
	3	DTC 2X	OFF	
	4	DTC 1X	OFF	
	5 (adjust with engine stopped)	Speed Loop Gain 4X	For Actuator Series	120, 225, 275 = ON
				2001 = OFF
	6	Act Loop Gain (7AMax) (15A MAX)	For Actuator Series	120, 225, 275 = ON
				2001 = OFF
	7	Act Loop Gain (7A Max) (15A MAX)	For Actuator Series	120, 225, 275 = OFF
				2001 = ON
	8	Added DTC 11 mSec 65 mSec	For Actuator Series	120, 225, 275 = OFF
				2001 = ON

All other Dip SW2 switches (1-4) should be set for optimum engine performance as per instructions provided. The factory speed setting for the controller is 1400 Hz or approximately at idle speed. The crank termination is set very low initially.

WARNING ⚠ An overspeed shut down device, independent of the governor system, should be provided to prevent loss of engine control, which may cause personal injury or equipment damage.

4 STARTING THE ENGINE

If the cranking termination occurs too quickly, preventing the engine from starting, turn the crank termination adjustment CW. The actuator should snap to full fuel until the engine starts and runs at a low idle setting. Adjust the SPEED setting CW for the desired operating speed.

CAUTION If the IDLE speed adjustment is set too low, the engine may never exceed the crank termination point, possibly causing starter damage.

Should the engine be unstable, turn the GAIN and STABILITY adjustments CCW until the engine is stable. If the system remains unstable or not operating properly, refer to the SECTION 8 SYSTEM TROUBLESHOOTING.

5 GOVERNOR SPEED SETTING

The governed speed set point is increased by clockwise rotation of the SPEED adjustment pot. Remote speed adjustment can be obtained with an optional 5K Frequency Trim Control. (See Section 10 WIRING DIAGRAM)

6 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.

PARAMETER	ADJUSTMENT PROCEDURE
P (GAIN)	1. Rotate the GAIN adjustments CW until instability develops. 2. Then, gradually move the adjustment CCW until stability returns. 3. Finally, Move the adjustment one division further CCW to insure stable performance. 4. If instability persists, adjust the next parameter.
I (STABILITY)	1. Follow the same adjustment procedure as the P parameter using the Stability potentiometer. 2. If instability persists, adjust the next parameter.
D (DEADTIME)	1. Follow the instability procedure in Section (8) SYSTEM TROUBLE SHOOTING.
NOTE	A strip chart recorder can be used to further optimize the adjustments. If further performance improvements are required, refer to Section (8) SYSTEM TROUBLESHOOTING.

7 ADDITIONAL FEATURES

RESONANT DRIVE TRAINS

Many applications require a flexible coupling between the engine and its load. This can take the form of a soft rubber segmented coupling or a drive shaft which behaves as a natural spring. The reasons such couplings are used is for alignment purposes, torsional considerations, or because of the excess length of the drive shaft has a natural spring effect. In any case, the drive train can act as a resonant device causing variable loads at a cylindrical rate to be impressed on the engine and its flywheel. Such variations sometimes occur at a frequency that the governor responds to very well.

This can cause excessive throttle movement at the same frequency as the resonance. The ESD5300 speed control unit has a special circuit that minimizes the offset on the resonances on the governor.

RESONANT DRIVE TRAINS (CONT’D)

If the system exhibits these characteristics, turn ON SW1, C2 to institute this feature. Readjust the control system per the above procedure and the result should be a significant reduction in throttle dither. Because the governor does not respond to the resonance any longer does not mean the resonance is not still present in the drive train.

IDLE AND RAMP SETTING

Close the IDLE switch connecting Terminals N and P. This will cause the engine to slow to an idle speed. Adjust the IDLE setting for desired idle speed.

Open the IDLE switch between Terminals N and P. The engine will start accelerating toward rated speed. Adjustment of the ACCEL control will allow the engine to accelerate with just enough fuel to bring the system to operating speed with lowest emissions. The desired acceleration and deceleration rates can be achieved by manipulating the ACCEL and DECEL adjustments. Cycle the IDLE switch after each ACCEL or DECEL adjustment change until the desired results are achieved. It is suggested to use an oil pressure switch to operate these contacts. Open N and P and the engine speed will decelerate at a rate set by the DECEL control CW is faster for both ACCEL and DECEL functions.

SPEED DROOP OPERATION

If droop operation is desired (speed setting reduces with increased engine load), close the switch contact across Terminals J and K. Rotate the DROOP adjustment CW to increase the droop percentage “0” setting (Full CCW) = Zero droop. 100 = maximum droop.

STARTING FUEL ADJUSTMENT

Turn the STARTING FUEL RAMPING to minimum CCW position (0). Crank the engine and quickly rotate the starting fuel adjustment to CW until the engine starts without excess smoke. Repeat several times to find the best setting. Some engines require large amounts of fuel to start but most modern engines respond to limiting fuel during cranking. Once the engine starts repeatedly in a satisfactory manner, adjust the Fuel Ramping adjustment CW so the engine accelerates to rated speed quickly, without excess smoke.

The acceleration adjustment may be set to the fastest positions if start fuel ramping is not desired.

INTERNAL SPEED RAMPING FUNCTION

Each time the ESD5330 is started the speed ramping function operates by taking control of the engine at near idle position and automatically raises the engine speed until the speed set point is reached. The acceleration time is controlled by the acceleration control. If the idle switch is then closed, the speed will decelerate at the rate set by the deceleration adjustment control.

During these ramping periods, the speed control has a small amount of droop added to attain stability at low engine speeds. The droop is eliminated once rated speed is reached unless droop is added by closing the switch at J and K terminals.

The internal ramp generator can also be used for wide range variable speed applications. Connecting a 0-10 VDC variable voltage to terminal “N” with respect to terminal “G” will provide a means to achieve variable speed governing. To calibrate the speed range, either limit the voltage to a level which provides the desired range with an external potentiometer or add resistance in series with terminal N as shown in the diagram.

DUAL GAIN FEATURE

The ESD5330 can operate with two distinct gain settings. The two gain adjustments, Gain 1 and Gain 2 are independent adjustments. With the connection from R and L “Open,” the Gain 1 adjustment is in operation. With a connection from R to L “Closed”, Gain 2 is in operation. Switching between the two gain settings should have an imperceptible difference in speed change. The dual gain function is especially useful for engines, which exhibit different characteristics under different situations. An engine may run very stable at high speeds and less stable at lower speeds. Setting a single gain control for the lower speeds then yields less than an optimum setting at the higher speeds. A simple switch can be toggled for low or high speed operation. Additionally in gaseous fuel engine applications where the quality or type of gas is changed, the two gain settings can be used to idealize the governor for each type of fuel.

For cold engine instability, a temperature-sensing switch can reset the governor’s gain once the engine has reached a normal operating temperature.

These are some examples where the ESD5330 can be used to provide more optimum control of dynamic engine characteristics while providing the best of governing control.

OVERSPEED MONITOR

The overspeed monitor circuit trip point is set by the multi-turn potentiometer. This is normally set by raising the engine speed to the specific trip point speed and turning the adjustment CCW until the O.S. circuit turns ON (Red LED). This will also turn off the actuator output circuit and change the state of the internal relay contacts at terminals 1, 2, 3. To reset the O.S. circuit, push the “Reset” switch through the hole provided or recycle the DC power to the unit. The “Test” switch will reduce the O.S. setting about 20%. If the engine is running at rated speed and the test button is pushed the O.S. monitor circuit should trip.

The relay contacts at terminals 1, 2, 3 should be used to turn OFF the engine, either fuel or air. Do not rely on time control to turn “OFF” the actuator as a means of shutting off the engine. A fault could have occurred in the actuator, linkage, cables, etc. which the ESD5330 has control over.

ADJUSTABLE CHOPPING FREQUENCY

The actuator chopping frequency can be varied by adjusting P13. This allows for a wider RPM adjustment range.

CRANK TERMINATION

When no power is applied to the ESD5330, the crank relay contacts Terminals 5 and 6 are normally closed. As the speed increases, the internal relay will change state and the green LED will light. The speed setting at which this occurs is determined by the multi turn speed setting potentiometer. CW adjustment will increase the speed at which this transition takes place. Once the circuit has tripped, the crank termination circuit will remain tripped until DC power is removed from the unit. This will reset the function.

ACCESSORY INPUT

The AUXiliary input, Terminal M. directly accepts output signals from GAC Load Sharing units, Auto Synchronizers and other governor system accessories. Consult the applicable GAC publications for details. It is recommended that this connection from accessories be a shielded cable as it is a sensitive input terminal.

NOTE If the GAC Auto Synchronizer is used alone, not in conjunction with a Load Sharing Module, a resistor must be installed between Terminals M and L. If a frequency trim potentiometer is also used, the resistor should be 910K ohms. If no frequency trim is used, the resistor should be 1.2M ohms. This is required to match the voltage levels between the ESD5330 speed controller and the synchronizer.

ACCESSORY SUPPLY

The +10 Volt regulated supply, Terminal L, can be utilized to provide power to GAC governor system accessories. Up to 40 mA of current can be drawn from this supply. The ground reference for this supply is Terminal G.

FINAL SPEED SETTING

After the Droop, Frequency Trim, and/or accessory inputs have been connected, readjust the operating SPEED and IDLE.

8 TROUBLESHOOTING

System Inoperative

If the engine governing system does not function, the fault may be determined by performing the voltage tests described in Steps 1 through 3. 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 OF ABNORMAL READING
1	D(+) & C(-)	Battery Supply Voltage	1. DC battery power not connected. Check for blown fuse 2. Low battery voltage 3. Wiring error
2	E & F	1.0 VAC RMS min. while cranking	1. Gap between speed sensor and gear teeth too great. Check Gap 2. Improper or defective wiring to the speed sensor. Resistance between 3 and Ground should be 160 to 1200 ohms. **See specific mag pickup data for resistance.** 3. Defective speed sensor.
3	L(+) & G(-)	10 VDC, Internal Supply	1. Short on Terminal P. (This will cause a defective unit) 2. Defective speed control unit
4	A(+) & C(-)	2.0 V less than bettery voltage while cranking	1. Starting FUEL LIMIT set too low. 2. IDLE set too low. 3. SPEED adjustment set too low. 4. Wiring error to the actuator. 5. Defective speed control. 6. Defective actuator.

Instability

INSTABILITY	SYMPTOM	PROBABLE CAUSE OF ABNORMAL READING
Fast Instability	An irregularity of speed above 3Hz. (Perceived as a jitter)	1. Set SW1 C1 to OFF (Lead/Lag) **and/or** set SW2 switches 1,2, and 3 to ON (DTC). If instability continues then: 2. Set SW1 C2 (Soft Coupling Filter) to ON. If instability continues then: 3. Turn off battery changers or other electrical equipment to see if the symptom disappears.
Slow Periodic	An irregularity of speed below 3Hz. (Sometimes severe)	1. Set SW1 C1 (Lead/Lag) to ON. If instability continues then: 2. Set SW2 switches (DTC) to the ON/OFF positions in the sequential order described in the next table.

For slow instability use the SLOW INSTABILITY SEQUENCE and for fast instability use the FAST INSTABILITY SEQUENCE. Start by setting the switches to reflect Sequence 1. If instability persists, adjust the switches to reflect Sequence 2. Continue through each sequence until instability stops.

SW2 SWITCH SETTINGS FOR INSTABILITY

SLOW INSTABILITY SEQUENCE	SW2-1	SW2-2	SW2-3	SW2-4	FAST INSTABILITY SEQUENCE
1	**ON**	**ON**	**ON**	**ON**	16
2	**ON**	**ON**	**ON**	OFF	15
3	**ON**	**ON**	OFF	**ON**	14
4	**ON**	**ON**	OFF	OFF	13
5	**ON**	OFF	**ON**	**ON**	12
6	**ON**	OFF	**ON**	OFF	11
7	**ON**	OFF	OFF	**ON**	10
8	**ON**	OFF	OFF	OFF	9
9	OFF	**ON**	**ON**	**ON**	8
10	OFF	**ON**	**ON**	OFF	7
11	OFF	**ON**	OFF	**ON**	6
12	OFF	**ON**	OFF	OFF	5
13	OFF	OFF	**ON**	**ON**	4
14	OFF	OFF	**ON**	OFF	3
15	OFF	OFF	OFF	**ON**	2
16	OFF	OFF	OFF	OFF	1

Slow Periodic (continued)	An irregularity of speed below 3Hz. (Sometimes severe)	3.	If slow stability is unaffected by the explained procedure above, add a small amount of droop.
		4.	Additional Dead Time Control can be added by connecting a capacitor across the two posts below the ACCEL/DECEL adjustments. The postitive side (+) of the cap is to be connected to E3. 20 MFD and above should be used.

Non-Periodic	Erratic Engine Behavior	1.	Increasing the GAIN should reduce the instability but not totaly correct it. If increasing the gain reduces the irregularity, the problem is probably with the engine. Higher gain allows the governor to respond faster and correct for the disturbance. Look for engine misfirings, erratic fuel system, load changes on the engine generator set, or voltage regulator irregularities.

If unsuccessful in solving instability, contact GAC for assistance.
info@governors-america.com 413-786-5600

Insufficient Magnetic Speed Signal

The speed control unit will govern well with 1.0 VAC RMS speed sensor signal. A speed sensor signal of 3 volts RMS or greater at governed speed is recommended. A strong magnetic speed sensor signal will eliminate the possibility of missed or extra pulses. The amplitude of the speed sensor signal can be raised by reducing the gap between the speed sensor tip and the engine ring gear. The gap should not be any smaller than 0.020 in (0.45 mm). When the engine is stopped, back the speed sensor out by 3/4 turn after touching the ring gear tooth to achieve a satisfactory air gap.

Electromagnetic Compatibility (EMC)

EMI SUSCEPTIBILITY - The governor system can be adversely affected by large interfering signals that are conducted through the cabling or through direct radiation into the control circuits.

All GAC speed control sensors contain filters and shielding designed to protect the units sensitive circuits from moderate external interfering sources.

Although it is difficult to predict levels of interference, applications that include magnets, solid sate ignition systems, radio transmitters, voltage regulators or battery chargers should be considered suspect as possible interfering sources.

If it is suspected that external fields, either those that are radiated or conducted, are or will affect the governor systems operation, it is recommended to use shielded cable for all external connections. Be sure that only one end of the shields, including the speed sensor shield, is connected to a single point on the case of the speed control unit. Mount the speed control to a grounded metal back plate or place it in a sealed metal box.

Radiation is when the interfering signal is radiated directly through space to the governing system. To isolate the governor system electronics from this type of interference source, a metal shield or a solid metal container is usually effective.

Conduction is when the interfering signal is conducted through the interconnecting wiring to the governor system electronics. Shielded cables and installing filters are common remedies.
In severe high-energy interference locations such as when the governor system is directly in the field of a powerful transmitting source, the shielding may require to be a special EMI class shielding. For these conditions, contact GAC application engineering for specific recommendations.

9 SPECIFICATIONS

RoHS CE

PERFORMANCE	
Isochronous Operation	± 0.25%
Speed Range / Governor	1.0 - 7.5 KHz Continuous
Speed Drift with Temperature	± 1% Maximum
Idle Speed Adjust Range	25 - 85% of rated speed
Droop Range	0 - 5% for a 1.5 A actuator current change
Speed Trim Range	± 200 Hz
Remote Variable Speed Range	Accel. Adjustment 266 Hz/sec - 1300 Hz/sec Decel. Adjustment 250 Hz/sec - 1000 Hz/sec
Starting Fuel Adjustment 0.0 - 1.5 A 0.3 - 5.0 A	 120, 175, 225, 275 Actuators / SW2-7 "OFF" (24 Volt Only) 2000 Actuator / SW2-7 "ON"
Overspeed Set Point	2330 Hz - 8500 Hz
Crank Termination Set Point	200 Hz - 2050 Hz
Terminal Sensitivity H M K N	 105 Hz, ±15 Hz/Volt @ 5 K Impedance 130 Hz, ±15 Hz/Volt @ 1 M Impedance 685 Hz, ±40 Hz/Volt @ 326 K Impedance 1000 Hz, ±50 Hz/Volt @ 8 K Impedance
INPUT / OUTPUT	
Supply	24 VDC Battery Systems (Transient and Reverse Voltage Protected)
Maximum Continuous Supply	32 Volts
Polarity	Negative Ground (Case Isolated)
Power Consumption	100 mA (no actuator current)
Speed Signal Range	1.0 - 50 VAC
Maximum Actuator Current	Internally Limited to 9 A Continuous
Maximum Current, Relay Contact (Terminals 1 - 6) Rating	6 A
Chopping Frequency Range	60 - 380 Hz
ENVIRONMENTAL	
Ambient Temperature	-40° to 85°C (-40 to 185°F)
Relative Humidity	up to 95%
All Surface Finishes	Fungus Proof and Corrosion Resistant
COMPLIANCE / STANDARDS	
Agency	CE and RoHS Requirements
Communications	RS-232-C, IEEE J1939
PHYSICAL	
Dimension	See Section 1 "Installation"
Weight	6oz
Mounting	Any position, Vertical Preferred
RELIABILITY	
Vibration	1G, 20-100 Hz
Shock	10 G (11ms)
Testing	100% Functional Testing

10 WIRING DIAGRAM