ESD5300 Series
Speed Control Unit

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1 OVERVIEW

The ESD5300 Series Speed Control units are designed to precisely control engine speed and provide fast, precise response to transient engine loads. The ESD5330 and 5340 speed control can be used with all GAC Actuators, including the ACB2001. A complete, closed-loop control system is formed with the addition of a magnetic pickup signal sensing engine speed and 24 V DC power.

- ◊ Two-element speed switch
- ◊ Speed ramping idle to operating speed
- ◊ Starting fuel control for lower engine exhaust emissions
- ◊ Unique actuator power drive circuit
- ◊ Accessory inputs for load sharing
- ◊ Variable speed governing
- ◊ Protection against reverse battery and transient voltage
- ◊ Advanced startup circuit for large-bore engines (ESD5340)

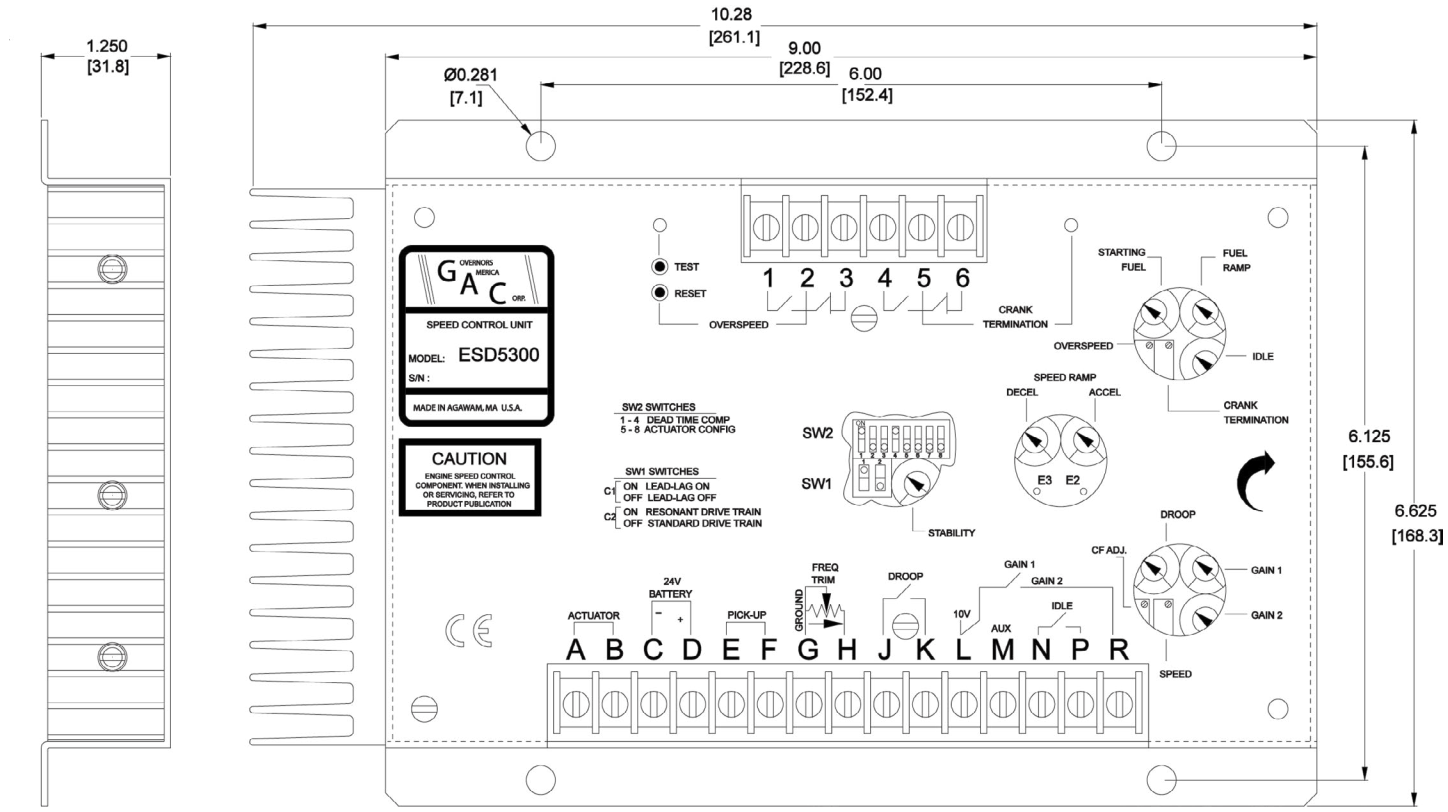
2 SPECIFICATIONS

PERFORMANCE	
Isochronous Operation	± 0.25 %
Speed Range / Governor	1.0 - 7.5 KHz Continuous
Speed Drift with Temperature	± 1% MAX
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: 266 Hz/s - 1300 Hz/s DECEL: 250 Hz/s - 1000 Hz/s
Starting Fuel Adjustment 0.0 - 1.5 A 0.3 - 5.0 A	 120, 175, 225, 275 Actuators / SW2-7 OFF (24 V DC Only) 2001 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/V @ 5 kΩ Impedance 130 Hz, ±15 Hz/V @ 1 MΩ Impedance 685 Hz, ±40 Hz/V @ 326 kΩ Impedance 1000 Hz, ±50 Hz/V @ 8 k Ω Impedance
RELIABILITY	
Vibration	1 G, 20 - 100 Hz
Shock	10 G (11 ms)
Testing	100 % Functional Testing

INPUT / OUTPUT	
Supply	24 V DC Battery Systems (Transient and Reverse Voltage Protected)
Maximum Continuous Supply	32 V DC
Polarity	Negative Ground (Case Isolated)
Power Consumption	100 mA (no actuator current)
Speed Signal Range	1.0 - 50 V AC
MAX Actuator Peak Current	15 A
MAX 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
PHYSICAL	
Dimension	See Section 4, Installation
Weight	3 lbf (1.36 kgf)
Mounting	Any position, vertical preferred

3 INSTALLATION

The ESD5300 speed controller can be placed in a control cabinet or engine mounted enclosure with other control equipment. If water, mist, or condensation can come in contact with the controller, it should be mounted vertically, to allow any accumulated fluids to drain away from the unit.



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

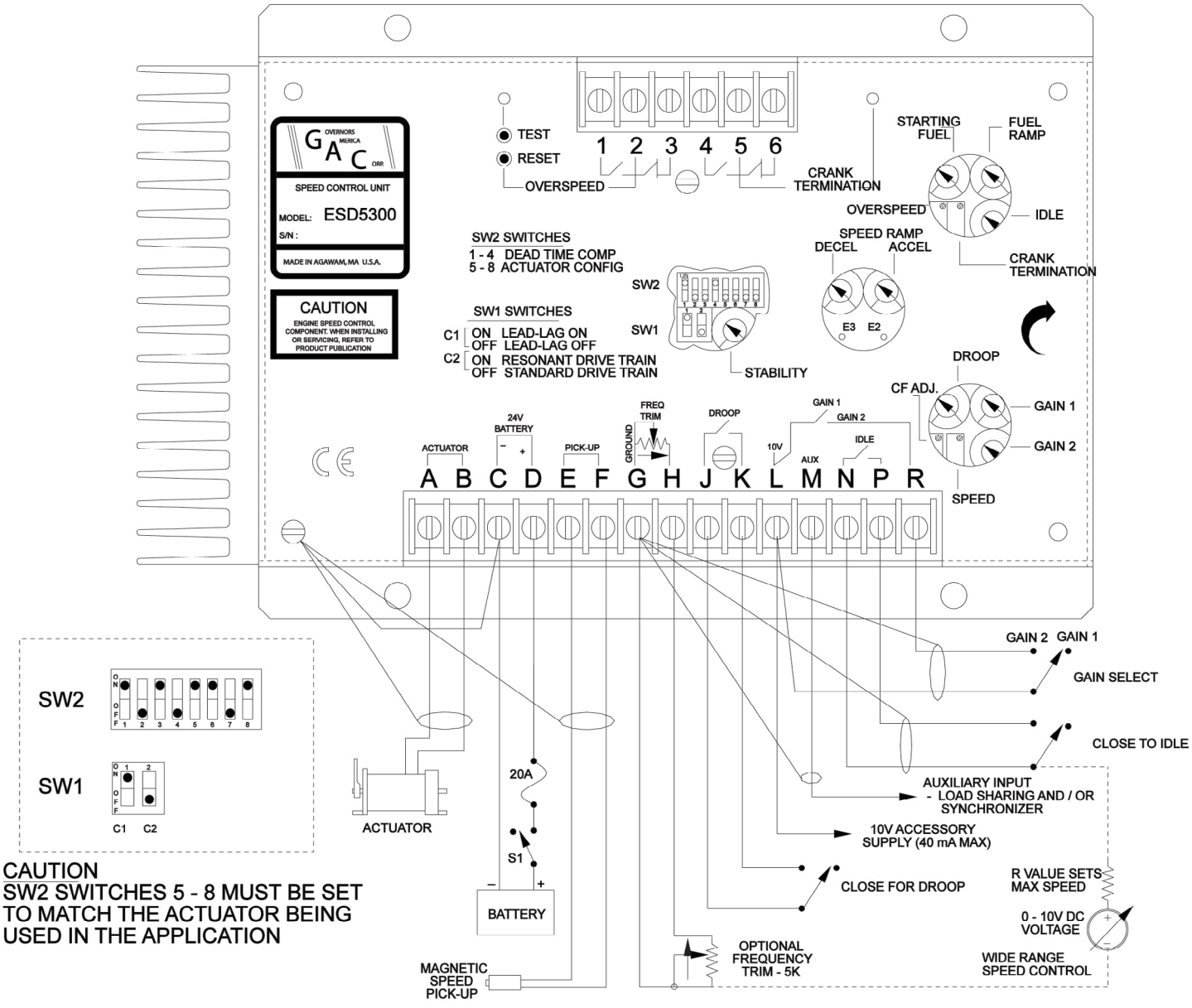
4 WIRING

TERMINAL	DEFINITION	NOTES
A & B	Actuator (+/-)	14 AWG wire
C & D	Battery Power (-/+)	• 14 AWG wire • 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. (0.45mm) • Speed sensor voltage should be at least 1.0 V AC RMS during crank
G	Ground Signal	
H	Frequency Trim	Shielded cable required for lengths over 15 ft (5 m) and 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
1 - 6	Overspeed Relay Contacts	
5 - 6	Crank Relay Contacts	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.

4 WIRING (CONTINUED)



CAUTION
SW2 SWITCHES 5 - 8 MUST BE SET TO MATCH THE ACTUATOR BEING USED IN THE APPLICATION

5 PRE-START SETUP

Before starting the engine, preset at minimum the following adjustments.

1. Set GAIN, STABILITY, and External Frequency Trim (if used) are set to their mid point (50) positions.
2. Set STARTING FUEL is set to 100 initially.
3. Ensure Dip Switches SW2-5, SW2-6, and SW2-7 are set in their normal positions before starting the engine as shown in the DIP SWITCHES table below.
4. Set all other Dip SW2 switches (1 - 4) for optimum engine performance per the DIP SWITCHES table. Take into account the factory speed setting for the controller is 1400 Hz, or approximately set to idle speed. The crank termination is set very low initially.

Failure to set these dip switches may cause startup engine trouble. See Section 10, System Troubleshooting, SW2 SWITCH SETTINGS FOR INSTABILITY table for additional information.

DIP SWITCHES

ROW	SWITCH	FUNCTION	NORMAL POSITION	
SW1	1	Lead Lag Circuit	OFF	
	2	Soft Coupling	OFF	
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, 175, 275 = ON
				335, 2001 = OFF
	6**	Act Loop Gain (7 A MAX) (15 A Peak)	**For Actuator Series**	120, 225, 175, 275 = ON
				335, 2001 = OFF
	7**	Act Loop Gain (7 A MAX) (15 A Peak)	**For Actuator Series**	120, 225, 175, 275 = OFF
				335, 2001 = ON
	8**	Added DTC 11 ms 65 ms	**For Actuator Series**	120, 225, 175, 275 = OFF
				335, 2001 = ON

* When switch C2 is ON, the Soft Coupling feature is enabled.
** SW2 Switches 5-8 must be set to match the actuator being used in the application. Contact GAC for questions.

6 START THE ENGINE

If crank termination occurs too quickly preventing the engine from starting, turn the crank termination adjustment clockwise (CW). The actuator should snap to full fuel until the engine starts and run at a low idle setting. Adjust the SPEED setting CW for the desired operating speed. If the engine is still unstable, turn the GAIN and STABILITY adjustments CCW until the engine is stable.

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

If the system remains unstable or not operating properly, see SECTION 10, System Troubleshooting.

Read this entire document before starting your engine.

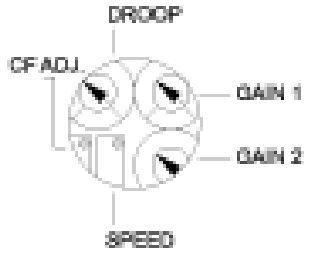
7 GOVERNOR SPEED SETTING

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 4, WIRING for more information.

8 INITIAL ADJUSTMENTS

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.	Gradually move the adjustment CCW until stability returns.
	3.	Move the adjustment one division further CCW to ensure 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 10, System Troubleshooting.

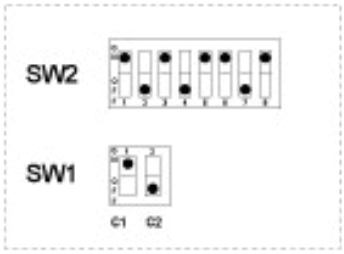


NOTE A strip chart recorder can be used to further optimize the adjustments. If further performance improvements are required, See Section 10, System Troubleshooting, for more information.

9 ADDITIONAL FEATURES

SOFT COUPLING / 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. These couplings are used for alignment purposes, torsional considerations, or due to excess length of the drive shaft. When a drive train produces a resonant device causing variable loads at a cylindrical rate to be placed on the engine and its flywheel, this can cause excessive throttle movement at the same frequency as the resonance. The ESD5300 speed control unit has a special circuit, SOFT COUPLING, that minimizes the offset on the resonances on the governor.



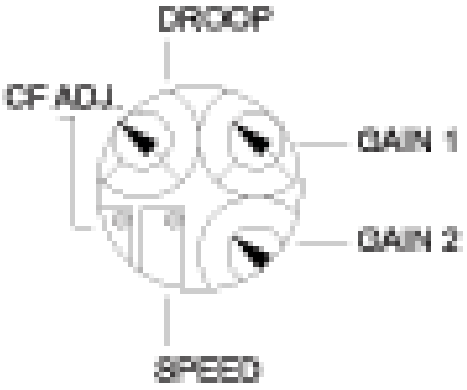
NOTE If the system exhibits these resonance characteristics, set dip switch SW1, C2 to ON to activate soft coupling. Readjust the control system per the procedure in Section 8, Adjustments, and the result should be a significant reduction in throttle dither.

Although the governor does not respond to the resonance any longer does not mean the resonance is not still present in the drive train.

SPEED DROOP OPERATION

If droop operation is desired (speed setting reduces with increased engine load), close the switch contact across Terminals J and K.

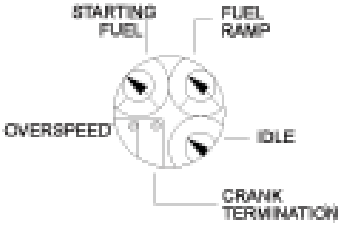
Rotate the DROOP adjustment CW to increase the droop percentage 0 setting (Full CCW) = Zero droop. 100 = maximum droop.



9 ADDITIONAL FEATURES (CONTINUED)

STARTING FUEL AND FUEL RAMPING ADJUSTMENT

Turn the STARTING FUEL to minimum CCW position (0).



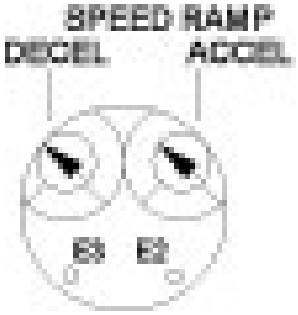
Crank the engine and quickly rotate the STARTING FUEL adjustment CW until the engine starts without excess smoke. Repeat several times to find the best setting. Some engines require large amounts of fuel to start but most modern engines respond to limited fuel during cranking.

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.

The ESD5340 has an advanced startup circuit that adjusts cranking fuel for faster startups.

IDLE AND RAMP SETTING

To set idle and ramp speeds:



- 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.
- Adjust the ACCEL control to 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. Use an oil pressure switch to operate these contacts.
- Open Terminals 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.

INTERNAL SPEED RAMPING FUNCTION

Each time the ESD5300 Series controller 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 (DECEL) 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 Terminals J and K.

The internal ramp generator can also be used for a wide range variable speed applications.

- To add variable speeds, connecting a 0-10 V DC variable voltage to Terminal N with respect to Terminal G.
- 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 Section 4 Wiring.

DUAL GAIN

The ESD5300 can operate with two distinct gain settings. The two gain adjustments, Gain 1 and Gain 2 are independent adjustments.

- With the connection from Terminals R and L set Open, the Gain 1 adjustment is in operation.
- With a connection from R to L set 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.

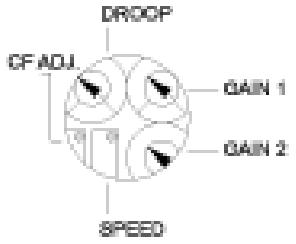
A simple switch can be toggled for low or high speed operation. Additionally in gaseous fuel engine applications where the quality or type of gas is changed, the two gain settings can be used to idealize the governor for each type of fuel.

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

9 ADDITIONAL FEATURES (CONTINUED)

ADJUSTABLE CHOPPING FREQUENCY

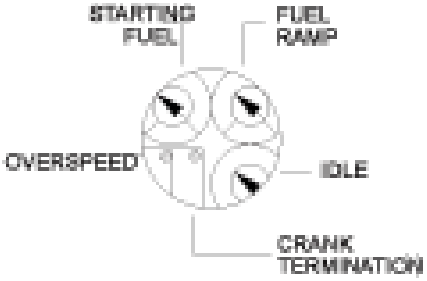
The actuator chopping frequency can be varied using the potentiometer labeled CF ADJ. This chopping frequency applied to the actuator provides an additional stability enhancement as the dither shakes the actuator to overcome static friction and ensure its immediate response.



OVERSPEED MONITOR

The overspeed monitor circuit trip point is set by the multi-turn potentiometer.

- Set overspeed by raising the engine speed to the specific trip point speed and turning the OVERSPEED adjustment CCW until the overspeed 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 overspeed circuit, push the RESET switch through the hole provided or cycle the DC power to the unit. The Test switch will reduce the overspeed setting about 20%. If the engine is running at rated speed and the Test button is pushed the overspeed 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 ESD5300 does not control.

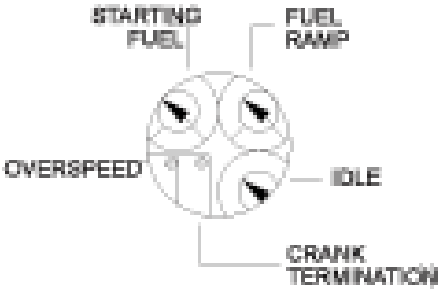
CRANK TERMINATION

When no power is applied to the ESD5300, 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 the LED lights is determined by the multi-turn CRANK TERMINATION speed setting potentiometer.

Adjust CRANK TERMINATION CW to 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.



FINAL SPEED SETTING

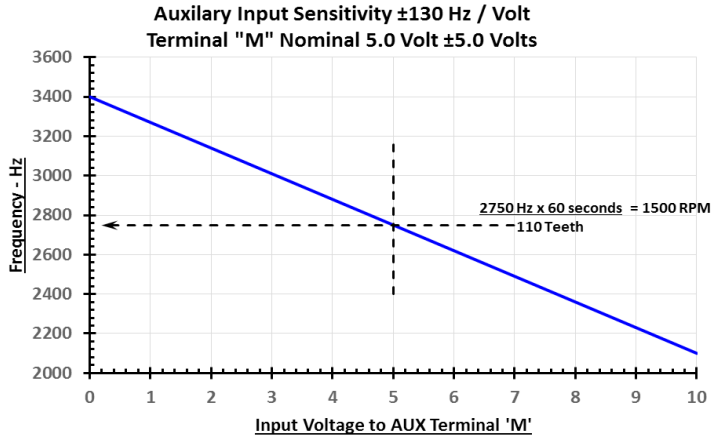
After the Droop, Frequency Trim, and/or accessory inputs have been connected, readjust the operating SPEED and IDLE.

9 ADDITIONAL FEATURES (CONTINUED)

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 910 K Ω. If no frequency trim is used, the resistor should be 1.2M Ω. This is required to match the voltage levels between the ESD5300 speed controller and the synchronizer.



Conversion Formulas

$$Hertz_{MAG\ PICKUP} = \frac{(RPM \times \#Teeth)}{60sec}$$

$$RPM = \frac{(Hertz_{MAG\ PICKUP} \times 60sec)}{\#Teeth}$$

ACCESSORY SUPPLY

The +10 V 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.

10 SYSTEM 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 your actuator publication for the testing procedure for that 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 V AC 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 your specific magnetic 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 battery 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.

10 SYSTEM TROUBLESHOOTING (CONTINUED)

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). 2. If instability continues set SW1 C2 (Soft Coupling Filter) to ON. 3. If instability continues 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. 2. If instability continues set SW2 switches (DTC) to the ON/OFF positions in the sequential order described in the SW2 SWITCH SETTINGS FOR INSTABILITY table.
Slow Periodic (continued)	An irregularity of speed below 3Hz. (Sometimes severe)	1. If slow stability is unaffected by the explained procedure above, add a small amount of droop. Additional Dead Time Control can be added by connecting a capacitor across the two posts below the ACCEL/DECEL adjustments. The positive side (+) of the cap is to be connected to E3. 20 MFD and above should be used.

For slow instability use the table below to set 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

INSUFFICIENT MAGNETIC SPEED SIGNAL

The speed control unit will govern well with 1.0 V AC RMS speed sensor signal. A speed sensor signal of 3 V 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.

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.

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.