ESD5500-II Fusion Series
Speed Control Unit

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1 OVERVIEW

The ESD5500-II speed control unit is designed to precisely control engine speed with rapid responses to transient load changes. The ESD5500-II speed control is compatible with all GAC proportional actuators except the ACB2001 electric actuator since this high torque actuator also requires current limiting available in the ESD5300 Series.

Ruggedly built to withstand all engine environments, the ESD5500-II has all the same well known features of the ESD5500 and also incorporates selectable light-force for low current actuators, dither for difficult engines with respect to stability and integrated anti-windup for both diesel and gaseous application.

- Variable Speed Operation
- Adjustable Droop and Idle
- Reverse Battery Voltage Protection
- Selectable light-force and Dither
- Soft Couple and Lead Circuit Options

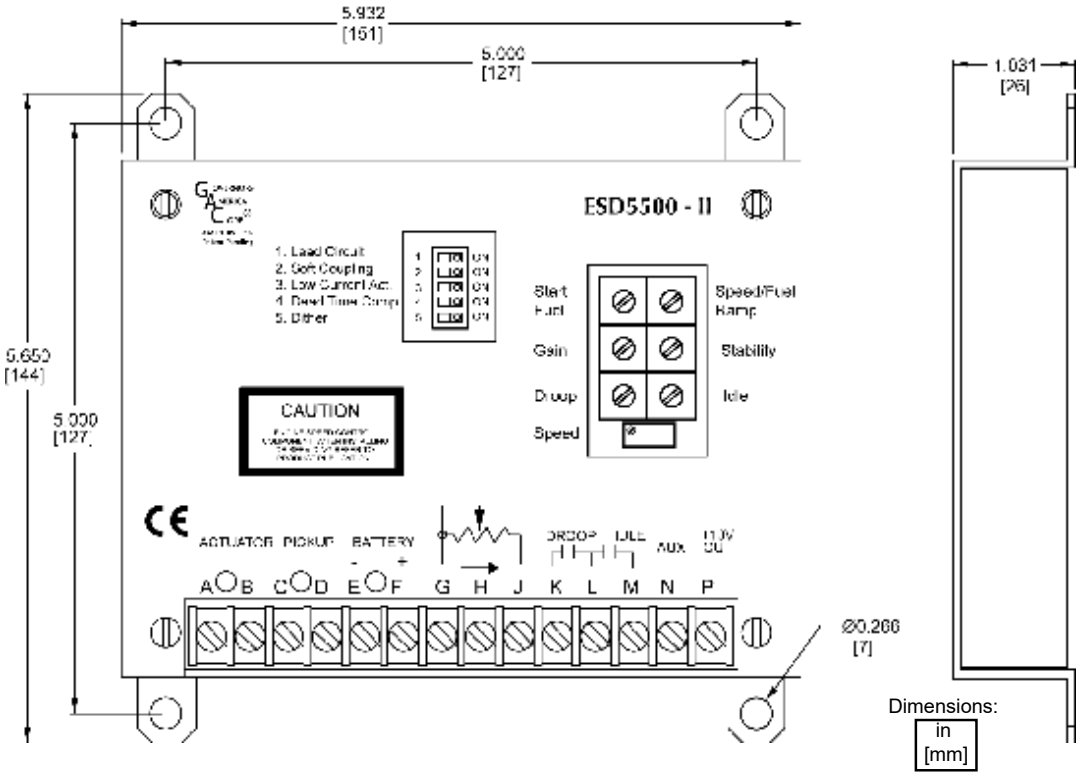
2 SPECIFICATIONS

PERFORMANCE	
Isochronous Operation	± 0.25 % or better
Speed Range / Governor	1 - 7.5 KHz Continuous
Speed Drift with Temperature	±1 % MAX
Idle Adjust CW	60 % of Set Speed
Idle Adjust CCW	Less than 1200 Hz
Droop Range	1 - 5 % regulation
Droop Adj. Max. (K-L Jumpered)	400 Hz., ±75 Hz per 1.0 A change
Droop Adj. Min. (K-L Jumpered)	15 Hz., ±75 Hz per 1.0 A change
Speed Trim Range	± 200 Hz
Remote Variable Speed Range	500 - 7.5 KHz
Terminal Sensitivity J L N P	 100 Hz, ±15 Hz/V @ 5 KΩ Impedance 735 Hz, ±60 Hz/V @ 65 KΩ Impedance 148 Hz., ±10 Hz/V @ 1 MΩ Impedance 10 V DC Supply @ 20 mA MAX
Reverse Power Protection	Yes
Transient Voltage Protection	60 V
RELIABILITY	
Vibration	1 g @ 20-100 Hz
Testing	100 % Functionally Tested

INPUT / OUTPUT	
DC Supply	12 - 24 V DC Battery Systems Transient and Reverse Voltage Protected
Polarity	Negative Ground (Case Isolated)
Power Consumption	50mA continuous plus actuator current
Speed Signal Range	1.0 - 50.0 V AC
Actuator Current @ 77°F [25°C]	8 A MAX Continuous
Speed Sensor Signal	1.0 - 120 V RMS
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	1.8 lbf [820 gf]
Mounting	Any position, vertical preferred
COMPLIANCE / STANDARDS	
Agency	CE and RoHS Requirements

3 INSTALLATION

READ THIS ENTIRE GUIDE BEFORE PERFORMING AN INSTALLATION.



Preferred vertical orientation allows for the draining of fluids in moist environments.

Mount in a cabinet, engine enclosure, or sealed metal box.

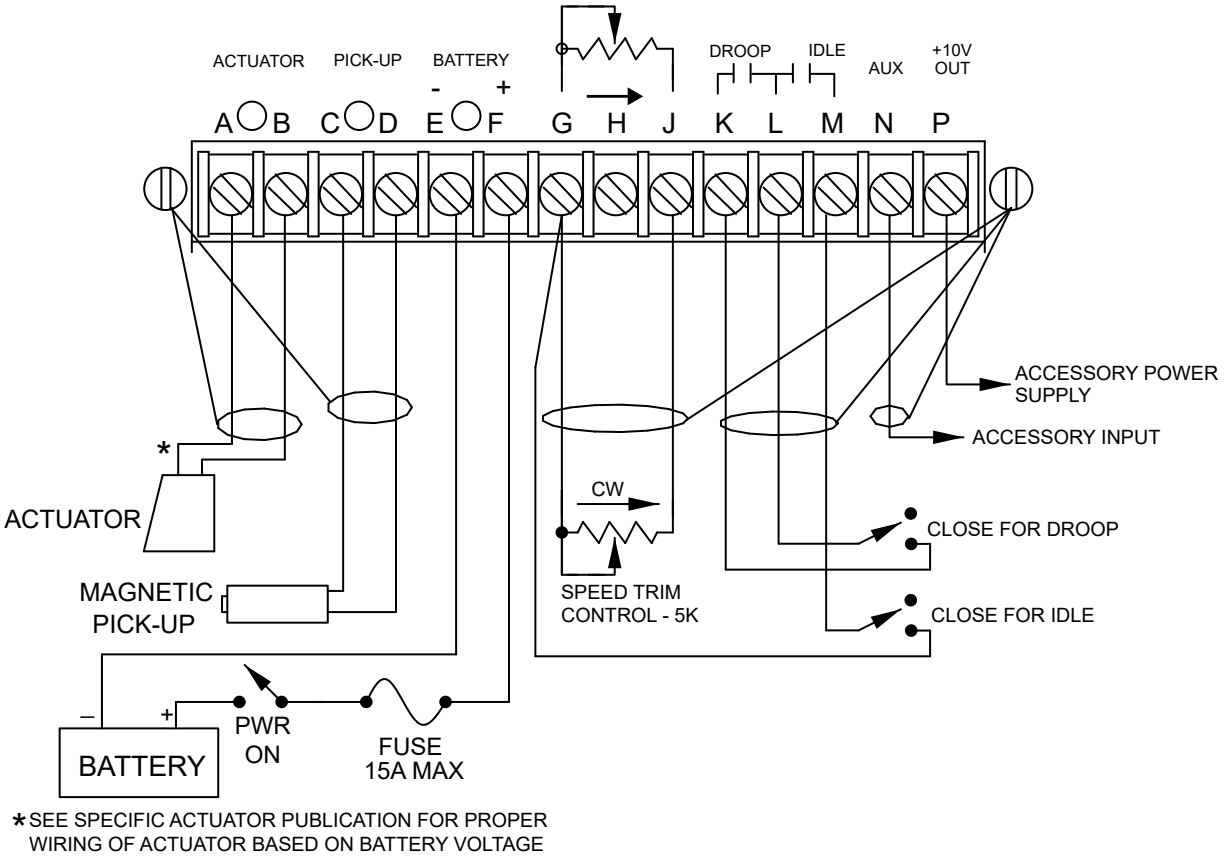
Avoid Extreme Heat

- An overspeed shutdown device, independent of the governor system, should be used 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.

When wiring ESD5500-II Series controllers:

1. **Use shielded cable for all external connections to the ESD controller**.
2. One end of each shield, including the speed sensor shield, should be grounded to a single point on the ESD case.
3. Terminal A, B, E,and F should be 16 AWG or larger. Long cables require increased wire size to minimize voltage drops.
4. Magnetic speed sensors Terminals C and D must be twisted and or shielded for the entire length.
5. The gap between the speed sensor and the ring gear teeth should be smaller than 0.02 in [0.5 mm] usually backing out 3/4 turn after touching ring gear teeth. Speed sensor voltage should be at lease 1 V AC RMS during cranking.
6. Terminal P is used to supply +10 V DC regulated supply to accessories. No more than 20 mA of current can be drawn from this supply. Ground reference is Terminal G. A short circuit in this terminal can damage the speed control unit.
7. **Do not over-tighten terminals**. Torque to no greater than 9.0 in-lb ±2.5 [1.01 ±0.28 N·m].

4 WIRING

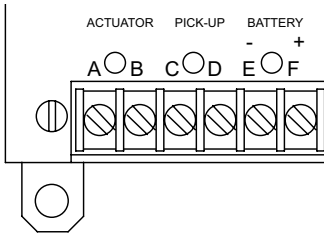


TERMINAL	DEFINITION	NOTES
A & B	ACTUATOR (+/-)	Use #16 (1.3mm sq) or larger wire
C & D	MAGNETIC SPEED PICKUP (D is ground)	• Wires must be twisted and/or shielded for their entire length • Gap between speed sensor and gear teeth should not be smaller than 0.02 in. [.51mm] • Speed sensor voltage should be at least 1 V AC RMS during crank
E & F	BATTERY POWER (-/+)	• Use #16 (1.3 mm sq) or larger wire • A 15 A fuse must be installed in the positive battery lead to protect against reverse voltage (2) • Battery positive (+) input is Terminal F
G	GROUND SIGNAL	Low current for switches & potentiometers
H	JUMPER INPUT	In some cases a jumper between Terminals H and G can be added for 12V systems with actuator currents above 5 A.
J	VARIABLE SPEED/ TRIM INPUT	0 - 5 k Ω Input
K & L	DROOP SELECT	Active when closed
M	IDLE SELECT	Close for Idle
N	ACCESSORY INPUT (1)	Load Sharing / Synchronizing Input 0 - 10 V Reverse Polarity
P	ACCESSORY POWER SUPPLY	10 V Output, 20 mA MAX

RECOMMENDATIONS

1. Use shielded cable for all external connections to the ESD controller. One end of each shield, including the speed sensor shield, should be grounded to a single point on the ESD case.
2. A 15 amp fuse must be installed in the positive battery lead. Protected against short circuit to actuator (shuts off current to actuator), unit automatically turns back on when short is removed.

NOTE 3 LEDs indicate actuator voltage output, magnetic speed pickup input signal, and battery. The Pickup LED illuminates solid when more than 2 V AC is going to the terminal.

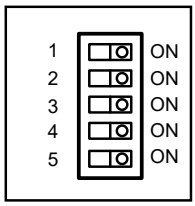


5 OTHER SETTINGS

DIP switches allow you to set the following settings on or off as required. These must be set prior to startup. These include [Factory setting]:

- 1 – Lead / Lag Circuit, adjusts for fast instability in the system [ON]
- 2 – Soft Coupling, eliminates fast erratic governor behavior caused by very soft or worn couplings in the drive train between the engine and generator. [OFF]
- 3 – Low Current Actuator, for use with light force/low current actuators including T1 ATB, ALR/ALN, 100-, 103-, and 104-Series actuators. [OFF]
- 4 – Dead Time Compensation, adjusts for irregularity in engine speed above and below 3Hz. [ON]
- 5 - Dither, reduces actuator sticking or increase stability in contaminated/ dirty environments. [OFF]

1. Lead Circuit
2. Soft Coupling
3. Low Current Act.
4. Dead Time Comp.
5. Dither



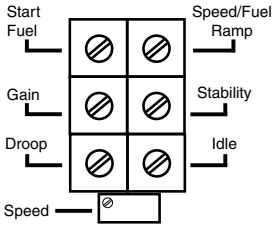
Contact GAC with any questions on these settings. [Factory setting]

6 ADJUSTMENTS BEFORE ENGINE STARTUP

Set the following adjustments before starting the engine.

Gain	Middle Position [50%]
Stability	Middle Position [50%]
Speed	Middle Position [50%]
Start Fuel	Full CW (Maximum Fuel) [100%]
Speed/Fuel Ramp	Full CCW (Fastest) [100%]

[Factory setting]



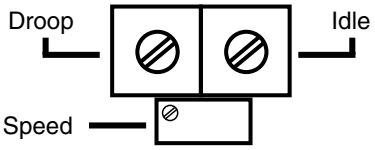
7 START THE ENGINE

The speed control unit governed speed setting is factory set at approximately engine idle speed. (1000 Hz., Speed sensor signal or 600 RPM)

Crank the engine with DC power applied to the governor system. The actuator will energize to the maximum fuel position until the engine starts. The governor system should control the engine at a low idle speed.

8 SPEED SETTING

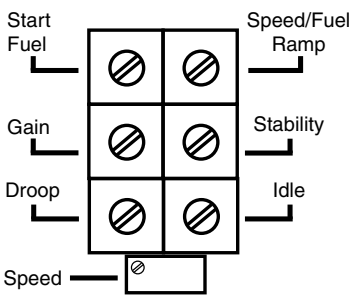
The speed set point is increased by clockwise rotation of the Speed adjustment control. Remote speed adjustment can be obtained with an optional 5K Speed Trim Control.



NOTE The Speed potentiometer is a 25 turn potentiometer

9 START FUEL & IDLE ADJUSTMENT

START FUEL ADJUSTMENT	
1.	Place the engine in idle by connecting Terminals M & G and placing the external selector switch in the Idle position.
2.	Adjust the Idle or operating speed for as low a speed setting as the application allows. (CCW turn to lower speed)
3.	Adjust the Start Fuel CCW until engine speed begins to fall. Increase the Start Fuel slightly so that the idle speed is returned to the desired level.
4.	Stop the engine.
IDLE SPEED SETTING	
5.	If idle is not set using the external selector switch as described in **START FUEL ADJUSTMENT**, place the optional external selector switch in the Idle position.
6.	The idle speed set point is increased by the clockwise rotation of the Idle adjustment control. When the engine is at idle speed, the speed control unit applies droop to the speed controller to ensure stable operation.



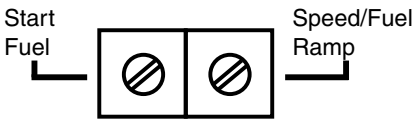
10 OPERATION

One of two methods of operation for the ESD5500-II may be now selected.

- Method 1: Start the engine and accelerate directly to the operating speed (Generator Sets, etc.).
- Method 2: Start the engine and maintain at an idle speed for a period of time prior to accelerating to the operating speed. This method separates the starting process so that each may be optimized for the lowest smoke emissions.

METHOD 1 Start the engine and accelerate directly to the operating speed

PROCEDURE	
1.	Remove the connection between Terminals M and G.
2.	Start the engine and adjust the Speed/Fuel Ramp for the least smoke during acceleration to rated speed and to prevent overshoot
3.	If the starting smoke is excessive, adjust the Start Fuel slightly CCW.
4.	If the starting time is too long, adjust the Start Fuel slightly CW.



METHOD 2 Start the engine and maintain at an idle speed for a period of time prior to accelerating to the operating speed.

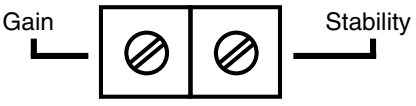
PROCEDURE	
1.	Replace the connection between Terminals M and G with a switch, usually an oil pressure switch or toggle switch.
2.	Start the engine.
3.	If the starting smoke is excessive, the Start Fuel may need to be adjusted slightly CCW.
4.	If the starting time is too long, the Starting Fuel may need to be adjusted slightly CW.
5.	When the switch opens, adjust the Speed Ramping for the least amount of smoke when accelerating from idle speed to rated speed or to prevent overshoot.

NOTE Idle speed must be set below operating speed.

11 ADJUSTING FOR GAIN AND STABILITY

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

STABILITY ADJUSTMENT		
PARAMETER		**PROCEDURE**
A.	Gain	1. Rotate the Gain adjustment clockwise until instability develops. 2. Then, gradually move the adjustment counterclockwise until stability returns. 3. Move the adjustment one division further counterclockwise to ensure stable performance (270° potentiometer). 4. If instability persists, adjust the next parameter.
B.	Stability	Follow the same adjustment procedure, steps 1 - 3, as the Gain parameter.

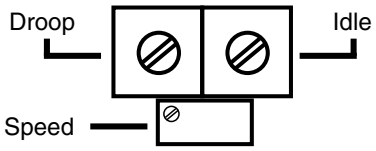


NOTE Normally, adjustments made at no load achieve satisfactory performance. If further performance improvements are required, refer to Section 11, SYSTEM TROUBLESHOOTING.

12 ADDITIONAL FEATURES & OPTIONAL WIRING

SPEED DROOP OPERATION

Droop is typically used for paralleling engine-driven generators. When in droop operation, the engine speed will decrease as engine load increases. The percentage of droop is based on the actuator current change from no engine load to full load. Factory setting for Droop is 0%.



To set droop:

1. Place the optional external selector switch in the Droop position. Droop is increased by clockwise rotation of the Droop adjustment control.
2. After the droop level has been adjusted, the rated engine speed setting may need to be reset. Check the engines speed and adjust that speed setting accordingly.

Droop is based on a speed sensor frequency of 4000 Hz. and an actuator current change of 1 amp from no load to full load. Applications with higher speed sensor signals will experience less percentage of droop. Applications with more actuator currant change will experience higher percentages of droop.

Though a wide range of droop is available with internal control, droop level requirements of 10% are unusual. If droop levels experienced are higher or lower than those required, contact GAC for assistance.

ACCESSORY INPUT

The AUX Terminal N accepts input signals from load sharing units, auto synchronizers, and other governor system accessories, GAC accessories are directly connected to this terminal.

The following apply when using the accessory input:

1. Terminal N is sensitive. Accessory connections must be shielded.
2. When an accessory is connected to Terminal N, speed will decrease and speed adjustment must be reset.
3. When operating in the upper end of the control unit frequency range, a jumper wire or frequency trim control may be required between Terminals G and J. This increases the frequency range of the speed control to over 7000 Hz (4200 RPM).
4. If the auto synchronizer is used alone, not in conjunction with a load sharing module, a 3 ohm resistor should be connected between Terminals N and P. This is required to match the voltage levels between the speed control unit and the synchronizer.

A short circuit on Terminal N can damage the speed control unit.

Never jumper Terminal P directly to Terminal N.

ACCESSORY SUPPLY

The +10 volt regulated supply, Terminal P, can be utilized to provide power to GAC governor system accessories. Up to 20 mA of current can be drawn from this supply. Ground reference is Terminal G.

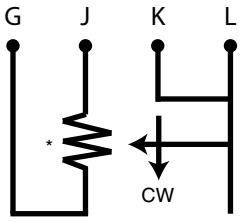
WIDE RANGE REMOTE VARIABLE SPEED OPERATION

A single remote speed adjustment potentiometer can be used to adjust the engine speed continuously over a specific speed range. Select the desired speed range and corresponding potentiometer value. (TABLE 1) If the exact range cannot be found, select the next higher range potentiometer.

Place an additional fixed resistor across the potentiometer to obtain the exact desired range. Connect the speed range potentiometer using Terminals G and J.

To maintain engine stability at the minimum speed setting, a small amount of droop can be added using the DROOP adjustment. At the maximum speed setting the governor performance will be near isochronous, regardless of the droop adjustment setting.

POTENTIOMETER WIRING



* Select proper potentiometer value from Table 1

TABLE 1

SPEED RANGE		POTENTIOMETER VALUE
900 Hz	540 RPM	1 K
2400 Hz	1440 RPM	5 K
3000 Hz	1800 RPM	10 K
3500 Hz	2100 RPM	25 K
3700 Hz	2220 RPM	50 K

NOTE RPM values shown are for 100 teeth flywheel

MPU Signal (Hz) = $\frac{\text{RPM x Flywheel Teeth}}{60\ \text{s}}$

13 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 4. Positive (+) and negative (-) refer to meter polarity. Should normal values be indicated during troubleshooting steps, and 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.

SYSTEM INOPERATIVE

STEP	WIRES	NORMAL READING	PROBABLE CAUSE OF ABNORMAL READING
1	F(+) & E(-)	Battery Supply Voltage (12 or 24 V DC)	• DC battery power not connected. Check for blown fuse, switch off power. • Low battery voltage • Wiring error
2	C(+) & D(-)	1.0 V AC RMS min. while cranking	• Gap between speed sensor and gear teeth too great. Check Gap. • Improper or defective wiring to the speed sensor. Resistance between Terminals D & C should be 160 to 1200 Ω. See specific mag pickup data for resistance. • Defective speed sensor.
3	P(+) & G(-)	10 V DC, Internal Supply	• Short on Terminal P • Defective speed control unit
4	F(+) & A(-)	1.0 - 2.0 V DC while cranking	• Speed parameter set too low • Short/open in actuator wiring • Defective speed control • Defective actuator, see Actuator Troubleshooting

INSTABILITY

INSTABILITY	SYMPTOM	PROBABLE CAUSE OF ABNORMAL READING
Fast Periodic	The engine seems to jitter with a 3Hz or faster irregularity of speed	• Make sure switch 1 Lead Circuit is set OFF. • Readjust the Gain and Stability for optimum control. • Turn off other electrical equipment that may be causing interference. • Turn switch 5 Dither on/off.

Slow Periodic	An irregularity of speed below 3 Hz	• Readjust the Gain and Stability
		• Adjust the Dead Time Comp by setting switch 4 to ON.
		• Check fuel system linkage during engine operation for:
		  • binding
		  • high friction
		  • poor linkage
		• Turn switch 5 Dither on/off.

Non-Periodic	Erratic engine behavior	• Increasing the Gain should reduce the instability but not totally correct it.
		• If this is the case, there is most likely a problem with the engine itself.
		• Check for:
		  • engine mis-firings
		  • erratic fuel system
		  • load changes on the generator set
		  • voltage regulator
		• If throttle is slightly erratic, but performance is fast, then move switch 1 Lead Circuit to the OFF position.
		• Turn switch 5 Dither on/off.

13 SYSTEM TROUBLESHOOTING - CONTINUED

UNSATISFACTORY PERFORMANCE

SYMPTOM	NORMAL READING	PROBABLE CAUSE OF ABNORMAL READING
Engine Overspeeds	Do Not Crank. Apply DC power to the governor system.	• After the actuator goes to full fuel, disconnect the speed sensor at Terminals C and D. • If the actuator is still at full fuel-speed then speed control unit is defective. • If the actuator is at minimum fuel position and there exists an erroneous position signal, then check speed sensor cable.
	Manually hold the engine at the desired running speed. Measure the DC voltage between Terminals A(-) & F(+) on the speed control unit.	If the voltage reading is 1.0 to 1.5 V DC: a. Speed adjustment is set above desired speed b. Defective speed control unit If voltage reading is above 1.5 V DC then check for: a. actuator binding b. linkage binding If the voltage reading is below 0.8 V DC: a. Defective speed control unit
Actuator does not energize fully	Measure the voltage at the battery while cranking.	If the voltage is less than: a. 7 V for a 12 V DC system, or b. 14 V for a 24 V DC system, Then: Check or replace battery.
	Momentarily connect Terminals A and F. The actuator should move to the full fuel position.	Actuator or battery wiring in error Actuator or linkage binding Defective actuator
Engine remains below desired governed speed	Measure the actuator output, Terminals A and B, while running under governor control.	If voltage measurement is within 2 V DC of the battery supply voltage level, then fuel control is restricted from reaching full fuel position, possibly due to mechanical governor, carburetor spring, or linkage interference. Speed parameter set too low

INSUFFICIENT MAGNETIC SPEED SIGNAL

A strong magnetic speed sensor signal will eliminate the possibility of missed or extra pulses. The speed control unit will govern well with 1.0 V RMS speed sensor signal. A speed sensor signal of 3 V AC or greater at governed speed is recommended. Measurement of the signal is made at Terminals C and D.

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.