ESD5200 Series
Speed Control Unit

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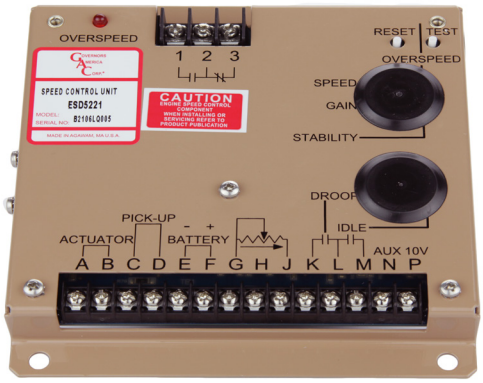
1 INTRODUCTION

The ESD5200 Series speed control unit is designed to precisely control engine speed with rapid responses to transient load changes. The ESD5221 is compatible with all GAC proportional actuators except the ACB2001 electric actuator.

Ruggedly built to withstand all engine environments, the ESD can control a wide variety of engines in an isochronous or droop mode. Capabilities include:

- Overspeed Switch and LED Indicator
- Selectable Droop Operation
- Adjustable Idle Current
- Auxiliary Accessory Input
- Reverse Voltage Protection
- Single Element Speed Switch
- Speed Anticipation

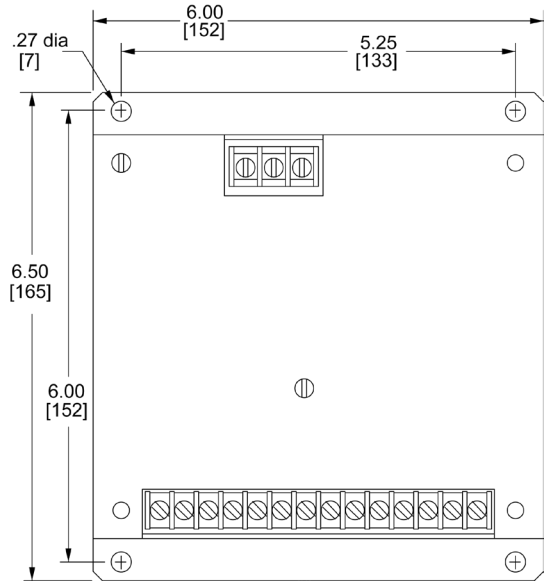


2 SPECIFICATIONS

PERFORMANCE	
Isochronous Operation	± 0.25 % or better
Speed Range / Governor	1 - 7.5 kHz continuous
Speed Drift with Temperature	±1 % MAX
Idle Adjust Clockwise	Minimum 1200 Hz below set speed
Idle Adjust Counterclockwise	Minimum 4100 Hz below set speed
Droop Range	1 - 5 % regulation
Droop Adj. Maximum (K-L Jumpered)	875 Hz., ±75 Hz per 1.0 A change
Droop Adj. Minimum (K-L Jumpered)	15 Hz., ±6 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 @ 5.0 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
INPUT / OUTPUT	
DC Supply	12 V DC and 24 V DC Battery Systems Transient and Reverse Voltage Protected
Polarity	Negative Ground (Case Isolated)
Power Consumption	50 mA (Continuous plus actuator current)
Actuator Current Range @ 77°F (25°C)	10 A Continuous
Speed Sensor Signal	1.0 - 120.0 V AC
Speed Switch Relay Contacts	MAX 10 A (N.O. and N.C.)
Speed Switch Adjustment Range	1000 - 10000 Hz

RELIABILITY	
Vibration	5 g @ 20 -500 Hz
Testing	100% Functional Testing
ENVIRONMENTAL	
Operating Temperature Range	-40° to 85 °C [-40° to 185 °F]
Relative Humidity	up to 95 %
Vibration	5 g @ 20-500 Hz
All Surface Finishes	Fungus Proof, Corrosion Resistant
COMPLIANCE / STANDARDS	
Agency	CE and RoHS Requirements
PHYSICAL	
Dimension	See Outline Diagram
Weight	1.8 lbf [0.82 kgf]
Mounting	Any position, vertical preferred

3 INSTALLATION



Read this entire guide before performing an installation.

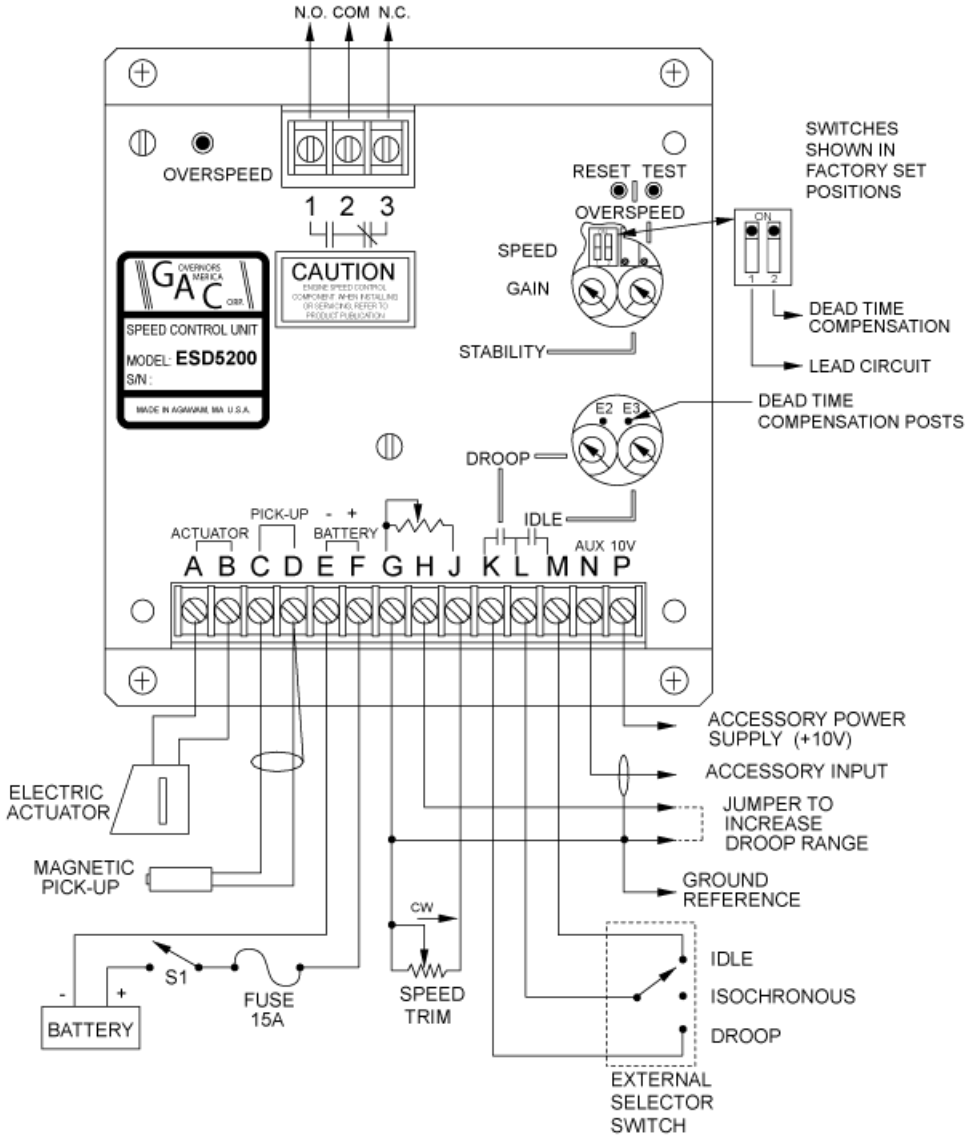
Vertical orientation allows fluids to drain in moist environments.

Avoid extreme heat

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

Dimensions in [mm]

4 WIRING



4 WIRING - CONTINUED

TERMINAL	DEFINITION	NOTES
A & B	Actuator (+/-)	Use 16 AWG [1.3 mm²] 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. [.5 mm] • Speed sensor voltage should be at least 1 V AC RMS during crank
E & F	Battery Power (-/+)	• 16 AWG [1.3 mm²] or larger wire • Install a 15 A fuse in the positive battery lead to protect against reverse voltage • Battery positive (+) input is Terminal F
G	Ground Signal	
H & G		Jumper to increase Droop range
J	Variable Speed Input	0 - 5 V DC
K & L	Droop Select	Active When Closed
M & L	Idle Select	
N	Accessory Input	Load Sharing / Synchronizing,
P	Accessory Power Supply	Supplies +10 V 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.

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.

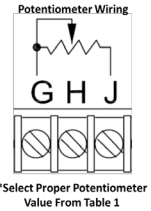
When wiring the ESD5200 series controller:

1. **Use shielded cable for all external connections** to the ESD5221 control unit.
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 or larger. Long cables require increased wire size to minimize voltage drops.
4. Battery positive (+) Terminal F should be fused for 15 A.
5. Magnetic speed sensors Terminals C and D must be twisted and or shielded for the entire length.
6. The gap between the speed sensor and the ring gear teeth should be smaller than 0.20 in [0.45 mm] usually obtained by backing out 3/4 turn after touching ring gear teeth. Speed sensor voltage should be at lease 1 V AC RMS during cranking.
7. If auto synchronization is used alone, not with a load sharing module, use a 3 Ω resistor between Terminal N and P to match the voltage between the speed control unit and the synchronizer.
8. When operating at the upper end of the control unit frequency range, add a jumper wire between Terminal G and J to increase the frequency range of the control unit over 7000 Hz.
9. **Do not over-tighten terminals**. Torque to no greater than 9.0 in-lb ±2.5 [1.01 ±0.28 N·m].

ADDING A POTENTIOMETER

Use a single remote speed adjustment potentiometer to adjust engine speed. Select the desired speed range and the corresponding potentiometer value.

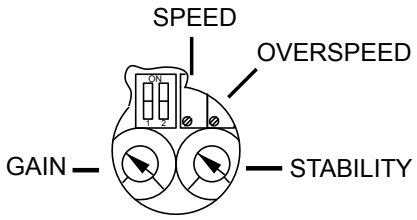
If the exact range is not found select the next higher range potentiometer. Connect the potentiometer as shown in the wiring diagram.



5 ADJUSTMENTS BEFORE ENGINE STARTUP

Make sure the following adjustments are set before starting the engine.

SETTING	POSITION
GAIN	Middle Position
STABILITY	Middle Position
SPEED TRIM CONTROL	Middle Position



6 START THE ENGINE

The factory set SPEED setting is set to approximately engine idle speed, 1000 Hz., Speed sensor signal or 600 RPM.

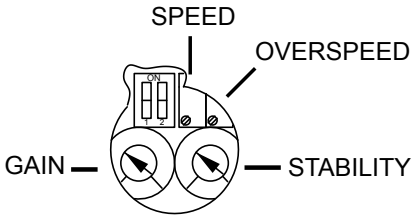
Crank the engine with DC power applied to the governor system. The actuator will energize to the maximum fuel position until the engine starts. The governor system should control the engine at a low idle speed.

If the engine is unstable after starting, refer to section 8, ADJUSTING FOR STABILITY.

7 GOVERNOR SPEED SETTING

To increase the speed control unit speed set point, turn SPEED adjustment control clockwise. This is a 25-turn potentiometer and may require several turns to reach required adjustment.

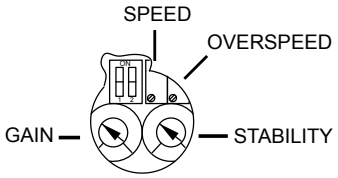
Remote speed adjustment can be obtained with the optional 5kΩ Speed Trim Control potentiometer.



8 ADJUSTING FOR STABILITY

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

STABILITY ADJUSTMENT	
PARAMETER	**PROCEDURE**
GAIN	1. Rotate the GAIN adjustment clockwise until instability develops. 2. 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.
STABILITY	Follow the same adjustment procedure, steps 1 - 3, as the GAIN parameter.

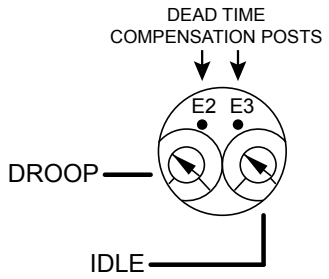


NOTE Normally, adjustments made at no load achieve satisfactory performance. If further performance improvements are required, refer to section 10, SYSTEM TROUBLESHOOTING.

9 ADDITIONAL FEATURES & OPTIONAL WIRING

IDLE SPEED SETTING

1. Adjust the SPEED setting.
2. After the control units speed setting had been adjusted, place the optional external selector switch in the IDLE position.
3. Increase the idle speed set point is increased by the clockwise rotation of the IDLE adjustment control.
4. When the engine is at idle speed, the speed control unit applies droop to the governor system to ensure stable operation.



DROOP OPERATION

Droop is typically used for the 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.

1. Place the optional external selector switch in the DROOP position. DROOP is increased by clockwise rotation of the DROOP adjustment control.

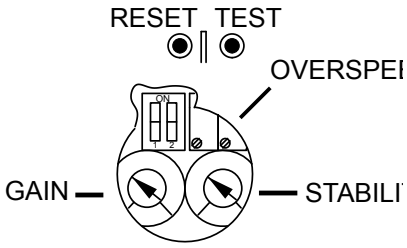
2. After the droop level has been adjusted, the rated engine speed setting may need to be reset. Check the engines speed and adjust that speed setting accordingly.

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

INTERNAL SPEED SWITCH

To set the overspeed function to approximately 10% above the requested speed. This is a 25-turn potentiometer and may require several turns to reach required adjustment.

1. When the engine is running at the desired speed, push and hold the TEST button.
2. While holding the TEST button, rotate the OVERSPEED adjustment counterclockwise until the LED lights and the relay re-energizes
3. Release the TEST button. Current to the actuator will be removed and the engine will shut off.
4. After the engine stops, press the RESET button or remove battery power.
5. Restart the engine. It will return to the original speed setting.



NOTE Always use the relay contacts provided to shut down the system by a means other than the governor or actuator. The overspeed protection system should be tested and verified during scheduled service of equipment.

ACCESSORY INPUT

Auxiliary Terminal N accepts input signals from load sharing units, auto synchronizers, and other governor system accessories. GAC accessories are directly connected to this terminal. Terminal N connections must be shielded.

When an accessory is connected to Terminal N, the speed will decrease and the speed adjustment must be reset.

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).

NOTE If the auto synchronizer is used alone, not in conjunction with a load sharing module, a 3 Ω resister should be connected between Terminals N and P. This is required to match the voltage levels between the speed control unit and the synchronizer.

ACCESSORY SUPPLY

Terminal P supplies +10 volt regulated supply 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.

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

9 ADDITIONAL FEATURES & OPTIONAL WIRING (CONTINUED)

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 as shown in Speed Range table. If the exact range cannot be found, select the next higher range potentiometer.

An additional fixed resistor may be placed across the potentiometer to obtain the exact desired range. Connect the speed range potentiometer as shown in section 4, Wiring.

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.

Contact GAC for assistance if difficulty is experienced in obtaining the desired variable speed governing performance.

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

NOTE RPM values shown are for 100 teeth flywheel

Conversion Formulas:

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

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

10 SYSTEM TROUBLESHOOTING

INSUFFICIENT MAGNETIC SPEED SIGNAL

A speed sensor signal of 3 volts RMS or greater at governed speed is recommended. Measurement of the signal is made at Terminals C and D.

A strong magnetic speed sensor signal eliminates the possibility of missed or extra pulses. The speed control unit governs well with 0.5 volts RMS speed sensor signal.

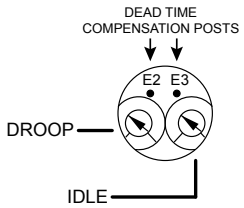
The amplitude of the speed sensor signal can be raised by reducing the gap between the speed sensor tip and the engine ring gear. The gap should not be any smaller than 0.020 in [0.5 mm]. When the engine is stopped, back the speed sensor out by 3/4 turn after touching the ring gear tooth to achieve a satisfactory air gap.

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 your actuator publication for troubleshooting and testing.

STEP	WIRES	CHECK	PROBABLE CAUSE
1	F(+) & E(-)	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
2	C(+) & D(-)	1.0 V AC RMS minimum 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 D and C should be 160 to 1200 Ω. See specific mag pickup data for resistance. 3. Defective speed sensor.
3	P(+) & G(-)	10 V DC, Internal Supply	1. Short on Terminal P. 2. Defective speed control unit.
4	F(+) & A(-)	1.0 - 2.0 V DC while cranking	1. SPEED parameter set too low 2. Short/open in actuator wiring 3. Defective speed control 4. Defective actuator, see your actuator's Troubleshooting guide.

INSTABILITY

INSTABILITY	SYMPTOM	PROBABLE CAUSE
Fast Periodic	The engine seems to jitter with a 3Hz or faster irregularity of speed.	1. Readjust the GAIN and STABILITY for optimum control. 2. Turn off other electrical equipment that may be causing interference. 3. Make sure LEAD switch SW1 is set to OFF 4. If system is still unstable, set DTC switch SW2 to OFF
Slow Periodic	An irregularity of speed below 3Hz. (Sometimes severe)	Readjust the GAIN and STABILITY 5. Set DIP switches 1 and 2 to ON in the following order: First SW1, Second SW2, and Third SW1 & SW2. 6. Check fuel system linkage during engine operation for: • binding • high friction • poor linkage 7. Adjust DEAD TIME COMPENSATION by adding a capacitor from posts E2 to E3 (negative on E2). Start with 10 mF and increase until instability is eliminated. 
Non-Periodic	Erratic Engine Behavior	1. Increasing the GAIN 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: • engine mis-firings • an erratic fuel system • load changes on the generator set voltage regulator. 3. If throttle is slightly erratic, but performance is fast, then move switch SW1 to the OFF position.

UNSATISFACTORY PERFORMANCE

SYMPTOM		NORMAL READING	PROBABLE CAUSE
Engine Overspeeds	1.	Do Not Crank. Apply DC power to the governor system.	After the actuator goes to full fuel, disconnect the speed sensor at Terminal C & D. If the actuator is still at full fuel-speed then the speed control unit is defective.
	2.	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 2.0 V DC: • SPEED adjustment is set above desired speed • Defective speed control unit If voltage reading is above 2.0 V DC then check for: • actuator binding • linkage binding If the voltage reading is below 1.0 V DC it may be a defective speed control unit
Overspeed Shuts Down Engine After Running Speed is Reached			• Speed adjustment set too high. • OVERSPEED set to close to running speed. • Actuator or linkage binding. • Speed control unit defective.
Overspeed Shuts Down Engine Before Running Speed is Reached		Check impedance between Terminals C & D. Should be 160 to 1200 Ω	OVERSPEED set too low. Adjust 5-6 turns CW. Erroneous speed sensor signal. Check wiring.
Actuator does not energize fully	1.	Measure the voltage at the battery while cranking.	Replace the battery if weak or undersized
	2.	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 • Fuse opens. Check for short in actuator or harness.
Engine remains below desired governed speed	1.	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.