

ESD-5400 Series - Speed Control Unit

INSTALLATION

The speed control unit is rugged enough to be placed in a control cabinet or engine mounted enclosure with other dedicated control equipment. If water, mist, or condensation may come in contact with the controller, it should be mounted vertically. This will allow the fluid to drain away from the speed control unit. Extreme heat should be avoided.



WARNING

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

WIRING

Basic electrical connections are illustrated in Diagram 1. Actuator and battery connections to Terminals A, B, C, and D should be #16 AWG (1.3 mm sq.) or larger. Long cables require an increased wire size to minimize voltage drops. The battery positive (+) input, Terminal F, should be fused for 15 amps as illustrated.

Magnetic speed sensor wires connected to Terminals C and D **MUST BE TWISTED AND/OR SHIELDED** for their entire length. The speed sensor cable shield should ideally be connected as shown in Diagram 1. The shield should be insulated to insure no other part of the shield comes in contact with engine ground, otherwise stray speed signals may be introduced into the speed control unit. With the engine stopped, adjust the gap between the magnetic speed sensor and the ring gear teeth. The gap should not be any smaller than 0.020 in. (0.45 mm). Usually, backing out the speed sensor 3/4 turn after touching the ring gear teeth will achieve a satisfactory air gap. The magnetic speed sensor voltage should be at least 1 VAC RMS during cranking.

ADJUSTMENTS

Before Starting Engine

Check to insure the **GAIN** and **STABILITY** adjustments, and if applied, the external **SPEED TRIM CONTROL** are set to mid position.

*Solutions for combustion engines,
that work right from the beginning.*

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Start Engine

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

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, turn the **GAIN** and **STABILITY** adjustments counterclockwise until the engine is stable.

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 Speed Trim Control. (See Diagram 1.)

Governor Performance

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

- A. Rotate the **GAIN** adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further counterclockwise to insure stable performance (270° pot).
- B. Rotate the **STABILITY** adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment one division further to insure stable performance (270° pot).
- C. Gain and stability adjustments may require minor changes after engine load is applied. Normally, adjustments made at no load achieve satisfactory performance. A strip chart recorder can be used to further optimize the adjustments.

The four-position OPTIONS switch adjusts the derivative function of the ESD-5401. Position 1 controls the Lead/Lag circuit. Turn the switch ON if there is slow instability. OFF if there is fast instability. Position 2, 3, and 4 should be switched in combination based on frequency of instability that results when the GAIN is turned too far CW.

TABLE 1

	POSITION			
	2	3	4	
FAST 	OFF	OFF	OFF	 SLOW
	ON	OFF	OFF	
	OFF	ON	OFF	
	ON	ON	OFF	
	OFF	ON	ON	
	ON	ON	ON	
	ON	ON	ON	

If instability cannot be corrected or further performance improvements are required, refer to the **SYSTEM TROUBLESHOOTING** section for instructions on changing the Dead Time Compensation and/or Lead Lag DIP switches.



Idle Speed Setting

After the governor speed setting had been adjusted, place the optional external selector switch in the IDLE position. The idle speed set point is increased by clockwise rotation of the IDLE adjustment control. When the engine is at idle speed, the speed control unit applies droop to the governor system to insure stable operation.

Speed Droop Operation

Droop is typically used for the paralleling of engine driven generators.

Place the optional external selector switch in the DROOP position. DROOP is increased by clockwise rotation of the DROOP adjustment control. 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 engine no load to full load. A wide range droop is available with the internal control. Droop level requirements above 10% are unusual.

If droop levels experienced are higher or lower than these required, contact Huegli Tech for assistance.

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

Accessory Input

The **AUX**iliary Terminal U accepts input signals from load sharing units, auto synchronizers, and other governor system accessories. GAC accessories are directly connected to this terminal. It is recommended that this connection from accessories be shielded, as it is a sensitive input terminal.

If the auto synchronizer is used alone, not in conjunction with a load-sharing module, a 3 M ohm resistor should be connected between Terminals U and P. This is required to match the voltage levels between the speed control unit and the synchronizer.

When an accessory is connected to Terminal U, 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.

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 W.

Internal Speed Switch

When the engine is running at the desired speed, push and hold the TEST button. Rotate the OVERSPEED adjustment counterclockwise until the LED lights and the relay reenergizes. Current to the actuator will be removed and the engine will shut off.

Release the TEST button. After the engine stops, press the RESET button or remove the battery power. Restart the engine and it will return to the original speed setting.



The overspeed function is now set to approximately 10% above the requested speed. If a different value for overspeed is required, standard procedure for adjustment should be used.

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

Wide Range Remote Variable Speed Operation

Simple and effective remote variable speed can be obtained with the ESD-5400 Series speed control unit. A single remote speed adjustment potentiometer can be used to adjust the engine speed continuously over a specific speed range.

Actuator Loop Gain Adjustment

The actuator control loop sensitivity can be adjusted using the single turn adjustment located below the relay Terminals 2 and 3. The advancement of this control CW will stiffen the actuators response.

In applications such as carbureted systems or high friction systems advancement of the actuator loop gain setting will likely improve the governing. However, any advancement may require a reduction of the speed gain setting to balance the overall governor loop gain. It is therefore recommended that the two gain adjustments be changed in opposition. Then the overall governing should be evaluated to determine the best setting.

Caution must be exercised in the optimization process as the actuator loop can become unstable as well as or in addition to the speed loop. Reducing the actuator loop gain and increasing the speed loop gain will likely make the speed loop gain unstable. Reducing the speed gain loop to zero and increasing the actuator loop gain can make the actuator loop unstable especially if the actuator is disturbed.

Dual Gain Switch

The ESD-5400 Series speed control units have a dual gain capability. When Terminal R is connected to Terminal W (ground), the governor will have a standard gain setting. In this condition the system has the highest performance and is typically set with the internal gain control.

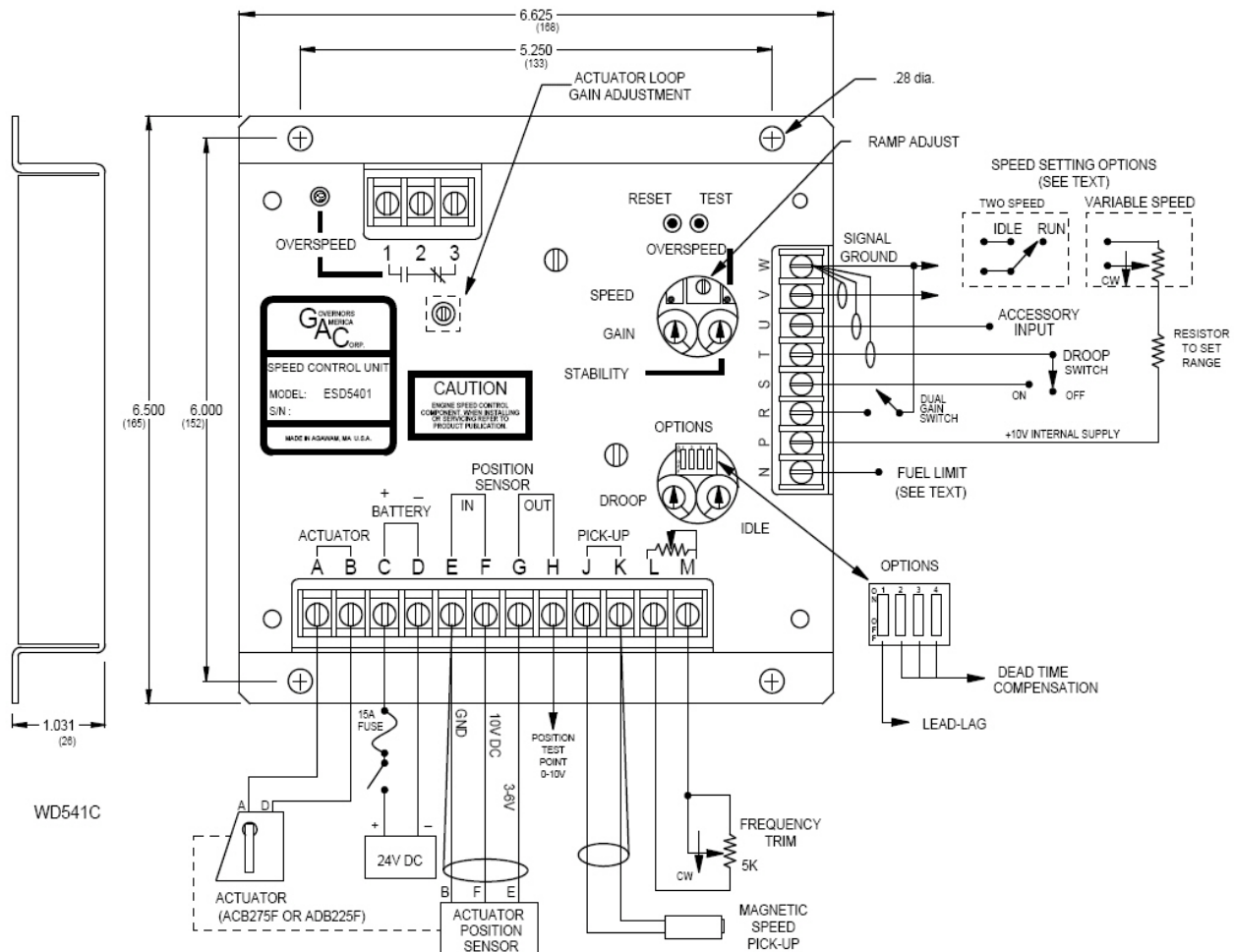
If a situation arises where the gain is required to be lower such as when changing fuels to the engine (natural gas to bio gas), the connection between R-W can be opened to reduce the governors gain to 1/2 of the standard setting made by the gain control.

A resistor may be inserted in series with Terminal R to lessen the gain change if necessary.

Fuel Limiting

Terminal N of the ESD-5401 can be used to externally limit the maximum position of the actuator. The range of the voltages is between 1 and 5 Volts DC. With a voltage above 5 Volts applied to Terminals N with respect to Terminal W, no fuel limiting will occur. As this voltage is reduced, it will limit the maximum travel of the actuator. Since the position loop is still and accurate, the limit is as hard as the electro-magnetics and the internal spring can possess. Continued reduction of the voltages at Terminal N will limit the travel to the point of zero actuator travel.

DIAGRAM 1. SYSTEM WIRING/OUTLINE



SPECIFICATIONS

PERFORMANCE

Isochronous Operation/Steady State Stability	0.25% or better
Speed Range/Governor	1K-7.0K Hz continuous
Speed Drift with Temperature	±1% Maximum
Idle Adjust CW	Min. 300 Hz. Below set speed
Idle Adjust CCW	Min. 4100 Hz. Below set speed
Gain Range	1 - 5% non-linear
Droop Range	1 - 5% regulation*
Droop Adj. Max. (S-T Jumpered)	1500 Hz., ± 75 Hz. per 50% change
Droop Adj. Min	6 Hz., ± 6 Hz. per 50% change
Speed Trim Range	± 200 Hz.
Remote Variable Speed Range	500 - 7.0 Hz. or any part thereof
Terminal Sensitivity	
M	100 Hz., ± 15 Hz / Volt @ 5.0 K Impedance
T	735 Hz., ± 60 Hz / Volt @ 65 K Impedance
U	148 Hz., ± 10 Hz / Volt @ 1 Meg. Impedance
P	10 VDC Supply @ 20 ma Max.
Speed Switch Adjustment Range	1000 - 10000 Hz.

**ENVIRONMENTAL**

Ambient Operating Temperature Range	-40 to +180°F (-40° to +85°C)
Relative Humidity	up to 95%
All Surface Finishes	Fungus Proof and Corrosion Resistant

INPUT POWER

Supply	12 (ESD5401-12) or 24 VDC 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 Amps continuous***
Speed Sensor Signal	0.5-50 Volts RMS
Speed Switch Relay Contacts (N.O. and N. C.)	10 Amps

RELIABILITY

Vibration	±0.7G up to 100 Hz.
Testing	100% Functionally Tested

PHYSICAL

Dimensions	See Outline (DIAGRAM 1)
Weight	1.8 lbs. (820 grams)
Mounting	Any Position, Vertical Preferred

- * 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 current change will experience higher percentages of droop. See droop description for specific details on operation of droop ranges. When used with the ADC-100 actuator the droop percentage will be less due to the actuators low current consumption.
- ** Protected against reverse voltage by a series diode. A 15 amp fuse must be installed in the positive battery lead. For 32V systems, contact Huegli Tech.
- *** Protected against short circuit to actuator (shuts off current to actuator), unit automatically turns back on when short is removed.

SYSTEM TROUBLESHOOTING**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 0.5 volts RMS speed sensor signal. A speed sensor signal of 3 volts RMS or greater at governed speed is recommended.

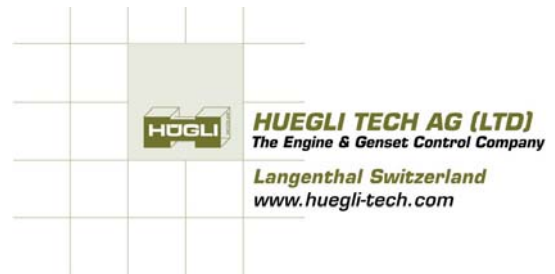
The amplitude of the speed sensor signal can be raised by reducing the gap between the speed sensor tip and the engine ring gear. The gap should not be any smaller than 0.020 in (0.45 mm). When the engine is stopped, back the speed sensor out by 3/4 turn after touching the ring gear tooth to achieve 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 unit's sensitive circuits from moderate external interfering sources.

Although it is difficult to predict levels of interference, applications that include magnetos, solid state 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 Huegli Tech for specific recommendations.

Instability

Instability in a closed loop speed control system can be categorized into two general types.

PERIODIC appears to be sinusoidal and at a regular rate. **NON-PERIODIC** is a random wandering or an occasional deviation from a steady state band for no apparent reason.

The **PERIODIC** type can be further classified as fast or slow instability. Fast instability is a 3 Hz. or faster irregularity of the speed and is usually a jitter. Slow periodic instability is below 3 Hz., can be very slow, and is sometimes violent.

If fast instability occurs, this is typically the governor responding to engine firings. Raising the engine speed increases the frequency of instability and vice versa. In this case, placing the LEAD switch (SW1) in the "OFF" position will reduce this tendency. In extreme cases, this may not take all the jitter out of the system. In this case, turn the adjustment DTC switches to "OFF" to further stabilize the system.

To resolve instability, DIP switches 2, 3, and 4 should be switched in combination based on the frequency of instability that results when the GAIN is turned too far CW as seen in Table 1.

Readjust the GAIN and STABILITY 1 after each change of the DIP switch position. The control system can also be optimized for best performance by following this procedure.

If slow instability is unaffected by this procedure, evaluate the fuel system and engine performance. Check the fuel system linkage for binding, high friction, or poor linkage. Be sure to check linkage during engine operation. Also look at the engine fuel system. Irregularities with carburetion or fuel injection systems can change engine power with a constant throttle setting. This can result in speed deviations beyond the control of the governor system. Adding a small amount of droop can help stabilize the system for troubleshooting. Interference from powerful electrical signals can also be the cause. Turn off the battery chargers or other electrical equipment to see if the system instability disappears.

NON-PERIODIC instability should respond to the **GAIN** control. If increasing the gain reduces the instability, then the problem is probably with the engine. Higher gain allows the governor to respond faster and correct for disturbance. Look for engine misfirings, an erratic fuel system, or load changes on the engine generator set voltage regulator. If the throttle is slightly erratic, but performance is fast, move switch C1 to the "OFF" position. This will tend to steady the system.

If unsuccessful in solving instability, contact Huegli Tech for assistance.

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 6. 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.

Step	Wires	Normal Reading	Probable Cause of Abnormal Reading
1	C(+) & D(-)	Battery Supply Voltage (12 or 24 VDC)	1. DC battery power not connected. Check for blown fuse 2. Low battery voltage. 3. Wiring error.
2	J & K	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 J and K should be 30 to 1200 ohms. 3. Defective speed sensor.
3	P(+) & W(-)	10 VDC, Internal Supply	1. Short on Terminal P. (This will cause a defective unit.) 2. Defective speed control unit.
4	N(+) & W(-)	10 VDC	1. Low voltage applied at fuel limiting terminal.
5	H(+) & E(-)	Position sensing - 0.5-9.5 VDC, while manually moving the actuator through its strokes	1. Wiring Error 2. Actuator Defective
6	C(+) & A(-)	1.0 - 2.0 VDC while cranking	1. SPEED adjustment set too low. 2. Short/open in actuator wiring. 3. Defective speed control. 4. Defective actuator. See Actuator Troubleshooting.

Unsatisfactory Performance

If the governing system functions poorly, perform the following tests.

Symptom	Test	Probable Fault
Engine overspeeds	1. Do Not Crank. Apply DC power to the governor system. 2. Manually hold the engine at the desired running speed. Measure the DC voltage between Terminals A(-) & C(+) on the speed control unit.	1. Actuator goes to full fuel. Then disconnect speed sensor at Terminal J & K. If actuator still at full fuel-speed control unit defective. If actuator at minimum fuel position erroneous speed signal. Check speed sensor cable. 2. If the voltage reading is 1.0 to 2.0 VDC: a) SPEED adjustment set above desired speed. b) Defective speed control unit. 3. If the voltage reading is above 2.0 VDC, actuator or linkage binding. 4. Set point of overspeed shutdown device set too low 5. If the voltage reading is below 1.0 VDC, defective speed control unit.
Overspeed shuts down engine after running speed is reached.		1. Speed adjust set too high. 2. OVERSPEED set to close to running speed. 3. Actuator or linkage binding. 4. Speed control unit defective.
Overspeed shuts down engine before running speed is reached	1. Check impedance between Terminals J & K. Should be 30 to 1200 ohms.	1. OVERSPEED set too low. Adjust 5-6 turns CW. 2. Erroneous speed sensor signal. Check wiring.
Actuator does not energize fully	1. Measure the voltage at the battery while cranking. 2. Momentarily connect Terminals A and C. The actuator should move to the full fuel position.	1. If the voltage is less than 7V for a 12V system, or 14V for a 24V system, check or replace the battery. 1. Actuator or battery wiring in error. 2. Actuator or linkage binding. 3. Defective actuator. 4. Fuse opens. Check for short in actuator or harness.
Engine remains below desired governed speed	1. Measure the actuator output, Terminals A & B, while running under governor control.	1. If voltage measurement is with 2 volts or more of the battery supply voltage level, then fuel control restricted from reaching full fuel position. Possibly due to mechanical governor, carburetor spring, or linkage interference. 2. Speed setting too low.