ESD2400 Series
Speed Control Unit

1 SPECIFICATIONS

PERFORMANCE	
Isochronous Operation/Steady State Stability	± 0.25% or Better
Speed Range/Governor	1kHz - 7.5KHz
Continuous Speed Drift with Temperature	Typically < +0.5%
Speed Trim Range	± 250 Hz Typical
Idle Range	500-5000 Hz with Trim Pot Installed
ELECTRICAL POWER INPUT	
Operating Voltage (Transient and Reverse Voltage Protected)*	12 = 8-20VDC 24 = 16-32VDC
Polarity	Negative Ground (Case Isolated)
Power Consumption	60mA Continuous plus actuator current
Max. Actuator Current at 77° F (25°C)	10 Amps Continuous
Speed Sensor Signal	1.0 VAC to 50.0 VAC
ENVIRONMENTAL	
Ambient Operating Temperature	-40 to 180°F (-40 to 85°C)
Relative Humidity	Up to 100%
All Surface Finishes	Fungus Proof and Corrosion Resistant
PHYSICAL	
Dimensions	See Section 6
Weight	12oz (347g)
Mounting	Any Position (Vertical Preferred)
COMPLIANCE / STANDARDS	
Agency	CE (EN55011, EN50081-2, EN50082-2) RoHS, Lloyds Register, DNV/GL, Bureau Veritas

* Reverse voltage is protected against by a parallel diode in 12V units and a series diode in 24V units.
A 15A fuse must be installed in the positive battery lead. See Diagram 1.

2 INTRODUCTION

The ESD2400 Series are all-electronic devices designed to control engine speed quickly and precisely in response to transient load changes. The ESD2400 will control a wide variety of engines in an isochronous mode when connected to a proportional electric actuator and magnetic speed sensor. The ruggedly built ESD2400 is designed to withstand the engine environment. Light-Force variations are available which are optimized for low current actuators.

MODELS

PRODUCT NO.	System Voltage 12	System Voltage 24	Idle Control	Anti-Wind-up Circuit	Light Force	Standard Force
ESD2401-12	▪		▪	▪		▪
ESD2401-24		▪	▪	▪		▪
ESD2402-12	▪		▪	▪	▪	
ESD2402-24		▪	▪	▪	▪	

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.

3 INSTALLATION

The ESD2400 Series speed control unit is hard potted and 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.

4 WIRING

Basic electrical connections are illustrated in Diagram 1. Actuator and battery connections to Terminals F, G, H, and J 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 in Diagram 1.

Magnetic speed sensor wires connected to Terminals D and E 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 1/4 turn after touching the ring gear teeth will achieve a satisfactory air gap. The magnetic speed sensor voltage should be at least 1.0VAC RMS during cranking.

5 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.

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 (25 turn 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.

If instability cannot be corrected or further performance improvements are required, refer to the SYSTEM TROUBLESHOOTING section.

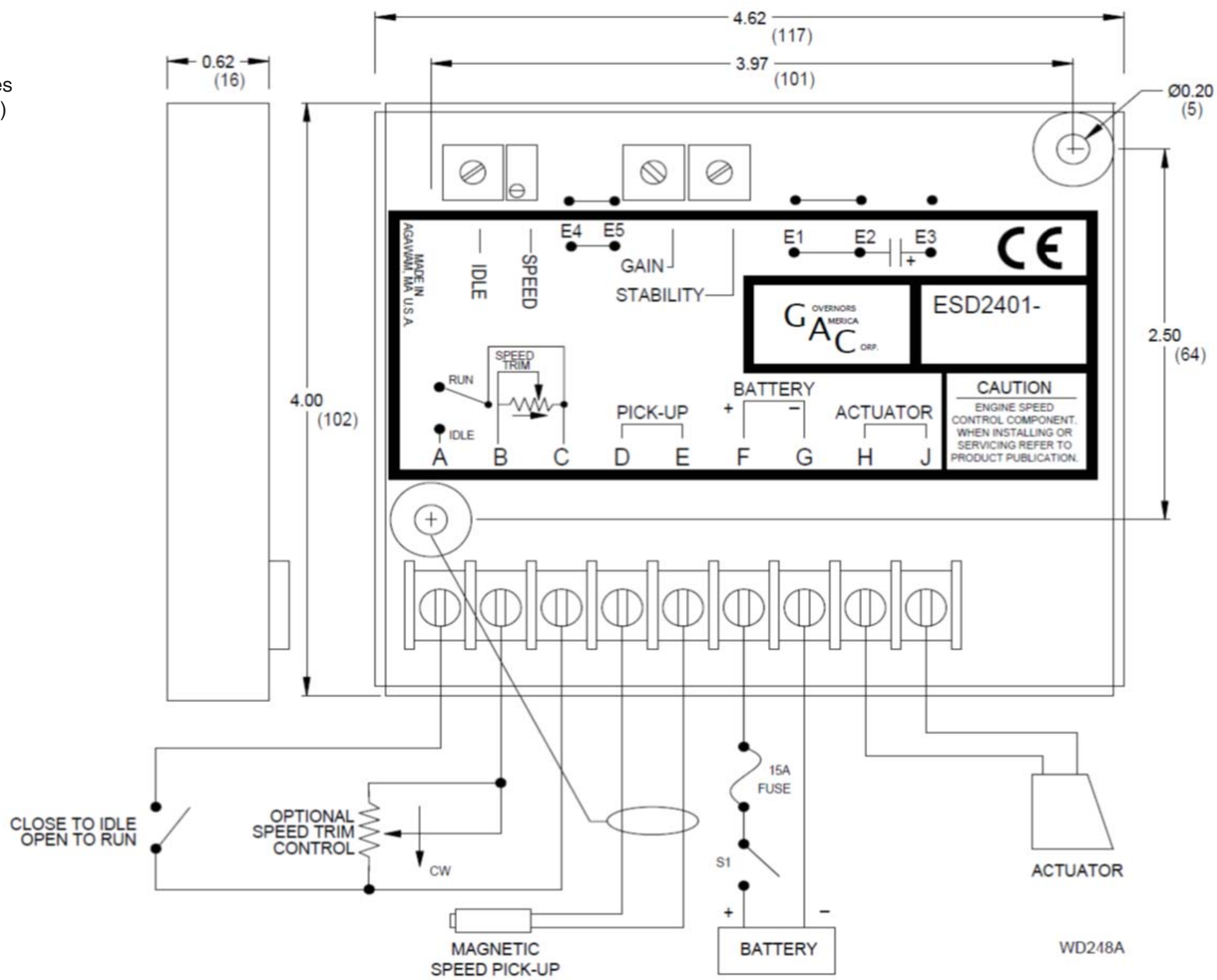
Idle Speed Setting

After the governor speed setting has 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 (270° pot). When the engine is at idle speed, the speed control unit applies droop to the governor system to insure stable operation.

6 SYSTEM WIRING / OUTLINE

DIAGRAM 1.

xx.x-----inches
(xx.x)---(mm)



7 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, 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	Terminals	Normal Reading	Probable Cause of Abnormal Reading
1.	F(+) & G(-)	Battery Supply Voltage (12, 24, or 32 VDC)	1. DC battery power not connected. Check for blown fuse 2. Low battery voltage. 3. Wiring error.
2.	B(+) & C(-)	0-2.7 with speed trim 4.8-5.4 without speed trim	1. Speed trim shorted or mis-wired. 2. Defective unit.
3.	D(+) & E(-)	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 should be between 30 to 1200 ohms. 3. Defective speed sensor.
4.	J(-) & F(+)	0.5 - 1.5VDC while cranking	1. Wiring error to actuator. 2. Defective speed control unit. 3. Defective actuator.

Unsatisfactory Performance

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

Symptom		Test		Probable Fault
Engine overspeed	1.	Do Not Crank. Apply DC power to the governor system.	1.	Actuator goes to full fuel. Then disconnect the speed sensor wires. If the actuator is still at full fuel, the speed control unit is defective. If actuator at minimum fuel position erroneous speed signals may be received. Check speed sensor cable.
	2.	Manually hold the engine at the desired running speed. Measure the DC voltage between Terminal J(-) & F(+) on the speed control unit.	1. 2. 3. 4.	If the voltage reading is 0.5 to 1.5 V DC, a) SPEED adjustment set above desired speed. b) Defective speed control unit. If the voltage reading is above 1.5 V DC, actuator or linkage binding. Set point of overspeed shutdown set too low. If the voltage reading is below 0.5 V DC, defective speed control unit.
Actuator does not energize fully while cranking.	1.	Measure the DC voltage between Terminals J(-) & F(+) on the speed control unit. Should be 0.8 to 1.5V DC. If not:	1. 2. 3.	Replace the battery if weak or undersized. Actuator wiring incorrect. If voltage is less than 1.5V, SPEED set too low
	2.	Momentarily connect Terminal F and J. The actuator should move to the full fuel position.	1. 2. 3.	Actuator or battery wiring in error. Actuator or linkage binding. Defective actuator.
Engine remains below desired governed speed	1.	Measure the actuator output, Terminals H & J, while running under governor control.	1. 2.	If voltage measurement is within 1.5V 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. If not, increase speed setting.

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 VAC RMS speed sensor signal. A speed sensor signal of 3.0 VAC RMS or greater at governed speed is recommended. Measurement of the signal is made at Terminals D and E.

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). With the engine is stopped, back the speed sensor out by 1/4 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 GAC application engineering 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 3Hz., 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, cutting the jumper from E1 to E2 will reduce this tendency. In extreme cases, the removal of the E1 to E2 jumper may not take all the jitter out of the system. A second jumper, E4 to E5, may be removed to further stabilize the system. Post locations are illustrated in Diagram 1. 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.

Slow instability can have many causes. Adjustment of the **GAIN** and **STABILITY** usually cures most situations by matching the speed control unit dynamics. If this is unsuccessful, the dead time compensation can be modified. Add a capacitor from posts E2 to E3 (negative on E2). Post locations are illustrated in Diagram 1. Start with 10mfds and increase until instability is eliminated. 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.

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 misfiring, an erratic fuel system, or load changes on the engine generator set voltage regulator. If the throttle is slightly erratic, but performance is fast, removing the jumper from E4 to E5 will tend to steady the system.

If unsuccessful in solving instability, contact GAC for assistance.