ESD 2100 SERIES SPEED CONTROL UNIT

PRODUCT TECHNICAL INFORMATION

PTI 1020

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MPC

INTRODUCTION

The ESD 2100 SERIES speed control unit is an all electronic device designed to control engine speed with fast and precise response to transient load changes. This closed loop control, when connected to a proportional electric actuator and supplied with a magnetic speed sensor signal, will control a wide variety of engines in an isochronous mode. It is designed for high reliability and built ruggedly to withstand the engine environment.

Simplicity of installation and adjustment was foremost in the design. Two non interacting performance controls allow near optimum response to be easily obtained.

Other features include; protection against reverse battery voltage and transient voltages, fail-safe design in the event of loss of speed sensor signal or battery supply.

DESCRIPTION

Engine speed information for the speed control unit is usually received from a magnetic speed sensor. Any other signal generating device may be used, provided the generated frequency is proportional to engine s,d and meets the voltage input and frequency range specification. The speed sensor is typically mounted in close proximity to an engine driven ferrous gear, usually the engine ring gear. As the teeth of the gear pass the magnetic sensor, a signal is generated which is proportional to engine speed.

Signal strength must be within the range of the input amplifier. An amplitude of 0.5 to 120 volts RMS is required to allow the unit to function within its design specifications. The speed signal is applied to Terminals 3 and 4 of the speed control unit. Between these terminals there is an input impedance of over 33,000 ohms. Terminal 4 is internally connected to Terminal 5, battery negative. Termination of the speed sensor shield should be made at Terminal 4. Only one end of the cable shield should be connected.

When a speed sensor signal is received by the controller, the signal is amplified and shaped by an internal circuit to provide an analog speed signal. If the speed sensor monitor does not detect a speed sensor signal, the output circuit of the speed control unit will turn off all current to the actuator. A summing circuit receives the speed sensor signal along with the speed adjust set point input. The speed range has a ratio of 7:1 and is adjusted with a 25 turn potentiometer. The output from the summing circuit is the input to the dynamic control section of the speed control unit. The dynamic control circuit, of which the gain and stability adjustments are part, has a control function that will provide iso chronous and stable performance for most engine fuel systems.

The speed control unit output circuit is influenced by the integral gain and stability performance adjustments. The governor system sensitivity is increased with clockwise rotation of the gain adjustment. The gain adjustment has a non-linear range of 33:1. The stability adjustment, when advanced clockwise, increases the time rate of response of the governor system in order to match various time constants of a wide variety of engines. Since the speed control unit is a P I D device, the "D", derivative portion can be varied when required (See Instability section).

During engine cranking, the actuator is fully energized and will move to the maximum fuel position. The actuator will remain in that state during engine cranking and acceleration. While the engine is at steady load, the actuator will be energized with sufficient current to maintain the governor speed setpoint.

The output circuit provides switching current at a frequency of about 500 Hz. to drive the actuator. The switching frequency is well beyond the natural frequency of the actuator, thus there is no visible motion of the actuator output shaft. Switching of the output transistor reduces its internal power dissipation for efficient power control. The output circuit can provide current of up to 10 amps continuous at 25°C. at battery voltages up to 40 VDC to drive an actuator. The actuator responds to the average current to position the engine fuel control lever.

The speed control unit has several performance and protection features which enhance the governor system. A speed anticipation circuit will minimize speed overshoot on engine start-up or when large increments of load are applied to the engine.

The ESD 2100 Series speed control units are compatible with Governors America Corp. proportional actuators (except the ACB2000) as well as those of other manufacturers.

ESD 2110. . . . . Standard Unit
ESD 2112. . . . Variable Speed Operation
ESD 2112-150 . . . . .Variable Speed With Added Dead Time

SPECIFICATIONS

PERFORMANCE

Isochronous Operation / Steady State Stability	± 0.25% or better
Speed Range/Governor	1K – 7.5K Hz continuous
Speed Drift With Temperature	±1% maximum
Speed Trim Range	±450 Hz Typical
Remote Variable Speed Range	500 – 6K Hz. or any part thereof
Terminal 9 Sensitivity	120 Hz., ± 15 Hz. / Volt @ 250K impedance

ENVIRONMENTAL

Ambient Operating Temperature Range	−40° to +180°F (−40° to +85°C)
Relative Humidity	up to 95%
All Surface Finishes	Fungus proof & corrosion resistant

INPUT POWER

Supply	10-40VDC (transient & reverse voltage protected)*
Polarity	Negative ground (case isolated)
Power Consumption	60 ma continuous plus actuator current
Maximum Actuator Current at 25°C (77°F)	10 Amps continuous
Speed Sensor Signal	0.5-120 Volts RMS

RELIABILITY

Vibration	5 G @ 20-500 Hz.
Testing	Functionally tested.

PHYSICAL

Dimensions	See outline (Diagram 1)
Weight	1.2 lbs. (545 grams)
Mounting	Any position, vertical preferred

*Reverse voltage is protected against by a parallel diode. A 15 amp fuse must be installed in the positive battery lead. See Diagram 1.

APPLICATION AND INSTALLATION INFORMATION

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 is to come in contact with the controller, the controller should be mounted vertically. This will allow the fluid to drain away from the speed control unit. Extreme heat should be avoided.

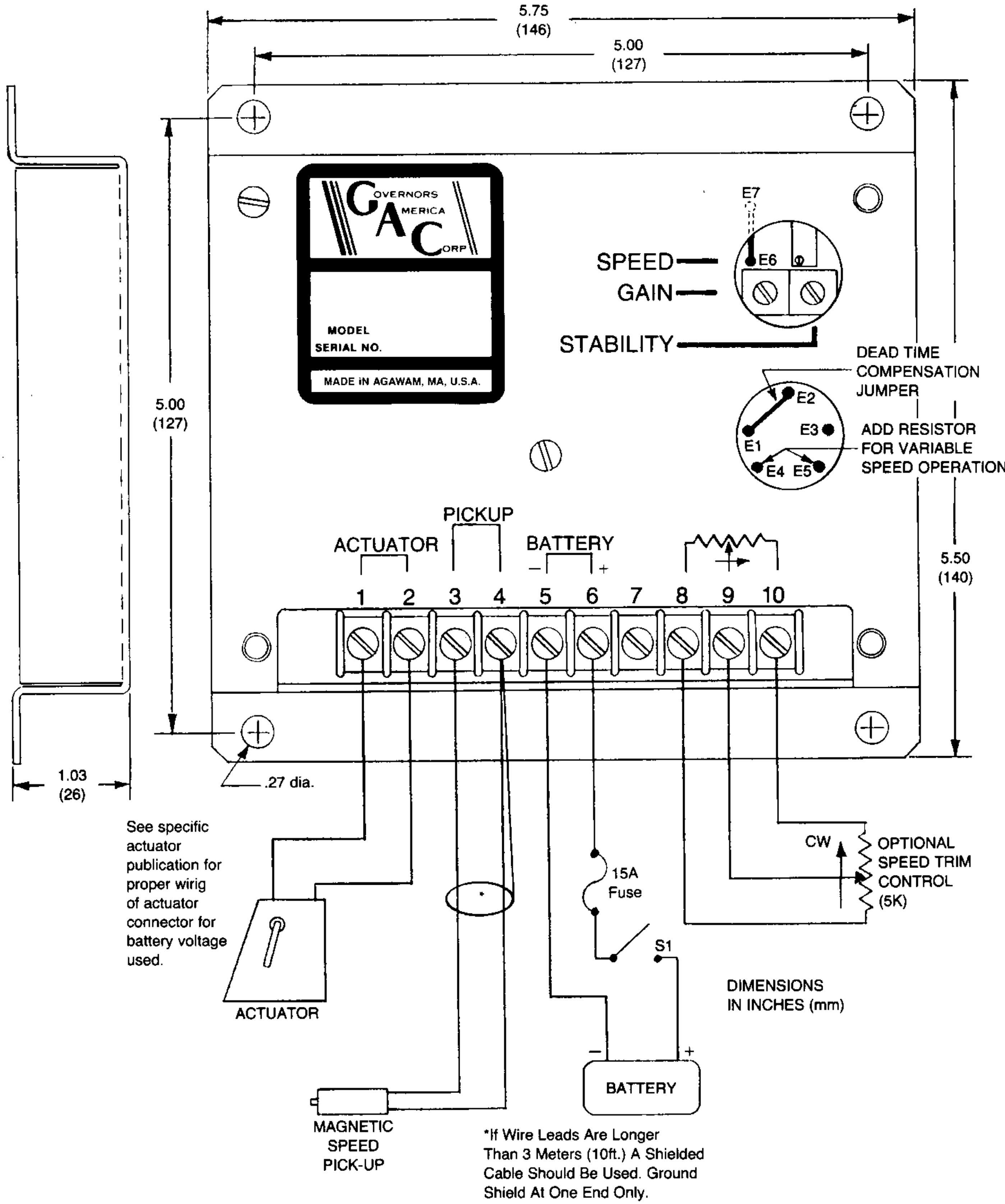
WARNING
An overspeed shutdown device, independent of the governor system, should be provided to prevent loss of engine control which may cause personal injury or equipment damage.

WIRING

Basic electrical connections are illustrated in Diagram 2. Actuator and battery connections to Terminals 1, 2, 5, and 6 should be # 16 AWG (1.3 mm sq.) or larger. Long cables require an increase in the wire size to minimize voltage drops. The battery positive (+) input, Terminal 6, should be fused for 15 amps as illustrated in Diagram 1.

Magnetic speed sensor connections to Terminals 3 and 4 **MUST BE TWISTED AND/OR SHIELDED** for their entire length. The speed sensor cable shield should only be connected to Terminal 4. The shield should be insulated to insure no other part of it comes in contact with engine ground, otherwise stray 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 tooth will achieve a satisfactory air gap. The magnetic speed sensor voltage should be at least 1 VAC RMS during cranking.

DIAGRAM 1
SYSTEM WIRING/OUTLINE



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 controller is factory set to operate at approximately engine idle speed. (1000 HZ. speed sensor signal)

Crank the engine with D.C. power applied to the governor system. The actuator will energize to the maximum fuel position until the engine starts. The governor system should be controlling 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 control. Remote speed adjustment can be obtained with an optional Speed Trim Control. (See Diagram 1)

Governor Performance

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

A. Rotate the **GAIN** adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment 1/8 of a turn further counterclockwise to insure stable performance.

B. Rotate the **STABILITY** adjustment clockwise until instability develops. Gradually move the adjustment counterclockwise until stability returns. Move the adjustment 1/8 of a turn further counterclockwise to insure stable performance.

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 optimize the adjustments further.

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

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 thru 6. (+) and (−) refer to meter polarity. Should normal values be indicated during the troubleshooting steps, then the fault may be with the actuator or the wiring to the actuator. See actuator publication for testing details.

Step	Terminals	Normal Reading	Probable Cause of Abnormal Reading
1	5(−) & 6(+)	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	8(+) & 10(−	6.5-7.1 with speed trim 7.1-7.9 without speed trim	1. Speed trim shorted or miswired 2. Defective unit.
3	7(+) & 10 (−	1.8-2.6V	1. Low battery voltage. 2. Defective unit.
4.	3(+) & 4(−	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 3 and 4 should be 30 to 300 ohms. 3. Defective speed sensor.
5	7(+) & 10(−) while cranking	8.4-9.4V	1. **SPEED** adjustment set too low. 2. Wiring error to actuator. 3. Defective speed control unit. 4. Defective actuator.
6	2(−) & 6(+)	0.8-1.5V 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 speed sensor at Terminals 3 and 4. If actuator still at full fuel - speed control unit defective. If actuator at minimum fuel position - erroneous speed signal. Check speed sensor cable.
	2. Manually hold the engine at the desired running speed. Measure the DC voltage between Terminals 2 (–) and 6 (+).	1. If the voltage reading is 0.8 to 1.5 VDC, a) **SPEED** adjustment set above desired speed. b) Defective speed control unit. 2. If the voltage reading is above 1.5 VDC, actuator or linkage binding 3. Set point of overspeed shutdown device set too low. 4. If the voltage reading is below 0.8 VDC, defective speed control unit
Actuator does not energize fully while cranking.	1. Measure the DC voltage between Terminals 2 (–) & 6 (+) on the speed control unit. Should be 0.8 to 1.5 volts; if not:	1. Replace the battery if weak or undersized. 2. Actuator wiring incorrect.
	2. Momentarily connect Terminal 2 to 6. The actuator should move to the full fuel position.	1. Actuator or battery wiring in error. 2. Actuator or linkage binding. 3. Defective actuator.
Engine remains below desired governed speed	Measure the actuator output, Terminals 1 & 2 while running under governor control.	1. If voltage measurement is within 1.5 volts or less 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. If not, increase speed setting.

SYSTEM TROUBLESHOOTING

Insufficient Magnetic Speed Sensor 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. Measurement of the signal is made at Terminals 3 and 4.

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 ¾ 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 units contain filters and shielding designed to protect the units 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 unit 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.

As an aid to help reduce the levels of EMI of a conductive nature, a battery line filter and shielded cables is conveniently supplied by GAC in KT310. To reduce the levels of EMI of a radiated nature, a shielded container P/N CA114 can be sourced from GAC and its distributors.

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 a 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. If this is the 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, E6 to E7, 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 symptom 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 10 mfds. 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 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 even 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 the 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, removing the jumper from E6 to E7 will tend to steady the system.

If unsuccessful in solving instability, contact the factory for assistance.