



Conforms to EC Directive on
Electromagnetic Compatibility

ISO 9001



AMBAC
INTERNATIONAL
ADVANTAGE SERIES

Model EC5000 Speed Controller

- Wide Application Range
- Fuel Limiting
- Speed Ramping

Features

- Both Isochronous and Droop governing
- Smoke reduction at start/speed ramping
- Direct compatibility with Cummins EFC valve
- Remote variable speed capability
- Controls 12 and 24 volt systems
- Output short circuit protected
- Reverse polarity protected
- Load sharing capability

AMBAC's EC5000 was specifically designed as a multifunction engine speed governor, capable of driving proportional solenoid actuators including the Cummins EFC valve, with steady continuous current up to 8 Amps. The controller has the capability to limit starting fuel and ramp speed on start-up and thus provide smoke reduction. An AUX input can be utilized as either an external trim control input or a load sharing control input. Controls are provided to set RUN and IDLE speeds, DROOP, RAMP time, and START FUEL quantity in addition to the normal GAIN, STABILITY, and DEAD TIME settings for this controller. The starting current, output current and DROOP are switch selectable in two ranges for small or large actuators. DROOP OFFSET adjustment is provided for independent speed setting in droop mode. Protection against a jammed actuator or shorted output is also incorporated.

These units are packaged in a rugged case which provides excellent environmental protection. Every unit is fully electrically tested and meets AMBAC's traditional high standards for quality and long-term reliability.

NOTES:

- FOR TWO WIRE POTENTIOMETERS
USE CONNECTIONS: 1 & 4 100K
2 & 4 5K/10K
- FOR THREE WIRE POTENTIOMETERS
USE CONNECTIONS: 2, 3 & 4 5K/10K
- IF POTENTIOMETER DOES NOT FUNCTION,
ADJUST RUN

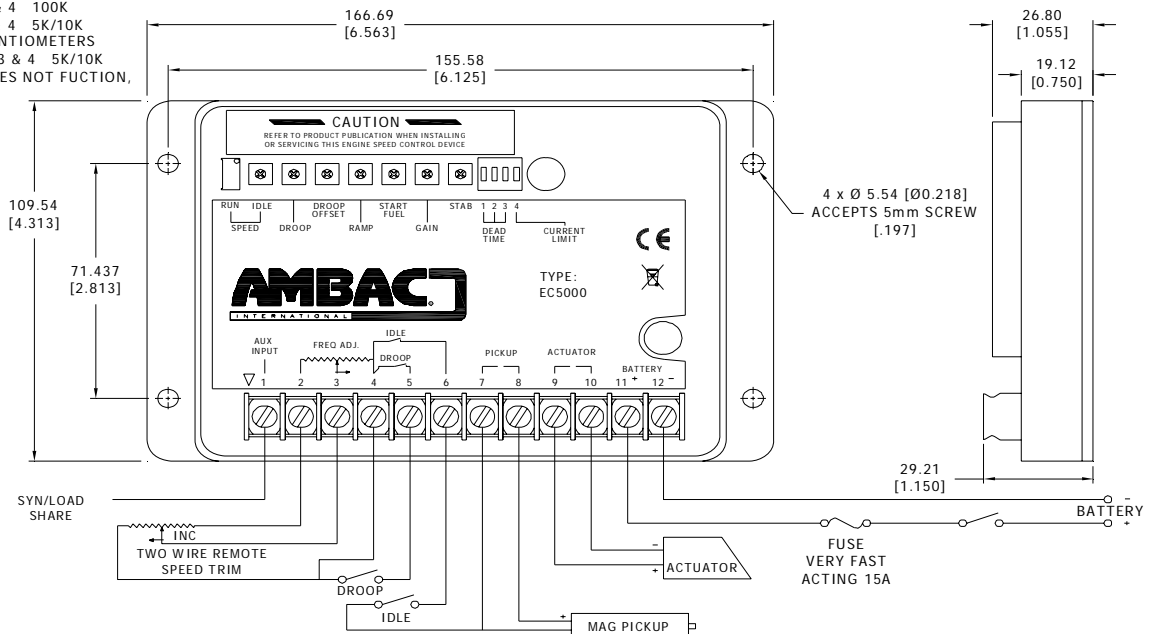


Figure 1. Outline Dimensions

Description

The EC5000 operates directly from a battery system, measures the speed of an engine and supplies a control signal to the actuator which controls engine fuel supply.

The engine speed signal is typically taken from a magnetic sensor mounted in proximity to the flywheel teeth. The control unit will accept any signal if the frequency is proportional to engine speed and of the correct amplitude and frequency. This speed input is compared to an internal SPEED setting and the difference is amplified to drive the actuator to supply more or less fuel, thus controlling engine speed. A safety feature is provided to turn off the actuator and prevent engine runaway if the speed input signal fails for more than 0.1 seconds. Speed is controlled isochronously or in droop mode (when the DROOP control is moved from its full CCW position; the further CW, the more droop). Terminal 5 is grounded (to terminal 4) for DROOP operation or left open for ISOCHRONOUS mode. During cranking, the actuator is commanded to the START FUEL current setting to eliminate smoke from excess starting fuel. When starting in RUN mode or when transitioning from IDLE to RUN, a built-in RAMP generator provides a smoothly controlled and adjustable rate -

Performance Specifications

<u>Outputs</u>		
Actuator output current, continuous	max	up to 4.0A (8.0 A ²)
Actuator output current, peak transient	nom	4.0 A ¹ (10A ²)
Isochronous/steady state SPEED stability	max	± 0.25%
SPEED drift with temperature	max	± 1.0%
DROOP range ³	nom	600 Hz/A ¹ (250 Hz/A) ²
RAMP time		0-20 sec
<u>Inputs</u>		
Magnetic speed sensor voltage (PICKUP)		1 < V < 30 Vrms
Internal RUN SPEED control range		1 kHz - 7.5 kHz ^{4,5}
Internal IDLE SPEED control range ⁶	min	500 Hz - 4 kHz ^{4,5}
AUX INPUT sensitivity	typ	-180 Hz/V ^{4,5}
FREQ ADJ sensitivity	typ	-900 Hz/V ^{4,5}
ISO/DROOP		Ground for DROOP
IDLE		Ground for IDLE
Supply voltage (BATTERY) ⁷		+7 < V < +32 Vdc, negative ground
Supply current	typ	60 mA ⁸
<u>Environmental</u>		
Temperature range		-40°C < T < +65°C (-40°F < T < +150°F)
Humidity		0 to 95%, Test Method 103
Vibration		15g, 10-2000Hz, Test Method 204

Notes

1. Switch S4 in OFF position
2. Switch S4 in ON position
3. Switch S4 Selectable
4. Mag sensor frequency in Hz = (engine RPM) x (number of teeth on flywheel) / 60
5. With internal SPEED Control set to 4000 Hz, AUX and FREQ ADJ inputs open
6. Max. IDLE speed is always less than RUN
7. Reverse polarity and transient protected
8. Actuator current must be added

of speed change which also prevents excess smoke. Ramp Adjustments are made by moving controls CCW for slow response or CW for faster response time.

Adjustment for GAIN, STABILITY and DEAD TIME allow simple field optimization for a wide range of engine/generator or pump combinations. See "Installation Instructions".

This unit may be operated with a remote speed control on the FREQ TRIM input and in conjunction with Synchronizer and a Load Sharing Unit.



ADVANTAGE SERIES

INSTALLATION INSTRUCTIONS SPEED CONTROL UNITS

INTRODUCTION

All AMBAC Speed Control Units use solid state electronics to sense engine speed from a magnetic speed sensor or other suitable signal source and, in turn, provides a controlled output current to a proportional electric actuator for throttle control.

The desired engine speed is adjustable via a SPEED adjust control. A GAIN control adjusts the speed of response. STABILITY CONTROL and DEAD TIME compensation switches (or capacitors) are used to match the time constant of the engine governing system to the engine for optimum control.

OPERATION

The Speed Control Units are designed to be powered directly from engine battery systems (12, 24 or 32 Vdc). The engine speed signal is usually obtained from a magnetic speed sensor mounted in close proximity to the teeth of a ferrous gear that is driven by the engine. The frequency of the speed sensor signal is therefore proportional to the engine speed. The flywheel ring gear (typically around 120 teeth and rotating at engine speed) is normally used. The typical speed input frequency would therefore be equal to 120 x RPM/60 in Hertz. The speed control unit will accept any signal if the frequency is proportional to engine speed and in the frequency range of the speed control unit (see individual controller data sheet). The signal strength must also be within the range of the input amplifier (1.0 volts rms to 30 volts rms for approximately sinusoidal signals).

A monitoring circuit detects if the speed sensor signal disappears for longer than 0.1 second and, if so, the speed control unit will turn off the actuator and the malfunction must then be corrected.

The output circuit provides a pulse width modulated current to drive the actuator. The actuator responds to the average current to position the engine throttle for the desired SPEED setting. During cranking, the actuator will move to the full fuel position and remain there during starting and acceleration of the engine (except on units which have a START FUEL adjustment).

INSTALLATION

The genset speed control unit is rugged enough for mounting in the control cabinet or other engine mounted enclosure. Do not subject the speed control unit to extreme heat. If it is expected that water or mist will come in contact with the speed control unit, mount it vertically so that condensation will not accumulate on the unit.

Leads to the battery and the actuator from the speed control unit should be no smaller than 16 AWG and no smaller than 14 AWG if over 10 feet (3 meters) long. Refer to the Speed Control Unit data sheet for detailed wiring information. A fast

acting external fuse must be in series with the positive (+) battery input terminal. The magnetic speed sensor leads must be twisted and/or shielded for their entire length. If shielded, connect the shield in accordance with the data sheet at the control unit end only. Do not connect the shield at the magnetic speed sensor end. If optional SPEED TRIM control is used, connect it, as shown on the Speed Control Unit data sheet, using shielded wire. The mechanical governor speed setting must be adjusted at least 5% above the desired governed speed for all load conditions.

CAUTION:
THE ENGINE SHOULD BE EQUIPPED WITH AN INDEPENDENT OVERSPEED SHUTDOWN MECHANISM TO PREVENT RUNAWAY WHICH CAN CAUSE DAMAGE OR PERSONAL INJURY.

ADJUSTMENTS

INITIAL SETTING

Units with switches for DEAD TIME compensation (EC5000, EC5010, EC5100 or EC5111) Initially set dip switches as shown in Table 1 below:

Table 1

Actuator	Initial Setting
AGL100, AGS50	S4* - ON
AGB130, AGD130, AGK130, AGL202, AGL301, AL3000	S3* - ON
AGB200, AGD200, AGK200, AGK270, AGK280	S2* - ON
AGK505, AGK525, AGK1600	S1* - ON

*All other switches OFF

Maximum DEAD TIME compensation (D.T.) is achieved with all four switches ON. The relative amount of the maximum D.T. compensation provided by switches S1 - S4 is:

- S1 - 50%
- S2 - 25%
- S3 - 16%
- S4 - 8%

When optimizing the D.T. setting with the engine running these switches may be adjusted on or off to vary the total compensation. For example, setting S1, S4 - ON, S2, S3 - OFF corresponds to 58% of total possible compensation.

Units with internal dead time compensation capacitors (ECD67-2110, ECD67-2112, ECD67-5111, ECD 67-5221, CU671, CW 673) Verify that an appropriate capacitor is installed before starting the engine. Refer to the Speed Control Unit data sheet. Typical capacitor values are shown in Table 2:

ADJUSTMENTS (Continued)

Units with external pins for DEAD TIME COMPENSATION capacitors (EC60) Solder an appropriate capacitor on the pins provided before starting the engine. Typical capacitor values are shown in Table 2:

Table 2

Actuator	Approximate Capacitance (μ F)
AGL100, AGS50	0 - 10
AGB130, AGD130, AGK130, AGL202, AGL301, AL3000	10 - 22
AGB200, AGD200, AGK200, AGK270, AGK280	10 - 22
AGK505, AGK525, AGK1600, AGK2200	32 - 68

Tantalum electrolytic capacitors are recommended provided their working voltage is 10 WVDC or better. Observe polarity as shown in the Speed Control Unit data sheet when connecting. Capacitive values can be added by soldering additional capacitors in parallel. Larger actuators which are fitted to larger engines have slower response time and need more compensation (more capacitance).

INITIAL ENGINE START

- A. Preset the GAIN/STABILITY and, if used, the optional external SPEED TRIM control to mid position. The SPEED control pot should remain in the factory set idle position (1000 Hz speed sensor signal).
- B. Apply DC power to the engine governing system. The actuator may momentarily move but should remain in the no fuel position. (If actuator is not in the no fuel position, proceed to troubleshooting and DO NOT START the engine).
- C. Crank the engine. The actuator will move to the maximum fuel position (or to a start fuel position on some units). Once started, the engine will be controlled at a low idle by the engine governing system.
- D. If the engine is unstable after starting, turn the GAIN and STABILITY controls CCW until the engine is stable.

GOVERNOR SPEED SETTINGS

Increase the engine speed to the desired governed speed by rotating the external SPEED control CW. If at any time the engine governing system becomes unstable, turn the GAIN and STABILITY controls CCW until the engine is stable.

PERFORMANCE ADJUSTMENT

Once the engine is at the desired governed speed and at no load, the following performance adjustments can be made:

- A. Rotate the GAIN control CW until instability results. Slowly move GAIN CCW until stability returns. Rotate CCW another 1/8 turn (or 1 division) to insure stable performance.
- B. Rotate the STABILITY control CW until instability results. Slowly move STABILITY CCW until stability returns. Rotate CCW another 1/8 turn (or 1 division) to insure stable performance.
- C. If low frequency (.5 to 3Hz) instability or surge is encountered, increase the DEAD TIME COMPENSATION. If high frequency instability is encountered, decrease the compensation.
- D. Load may now be applied to the engine. If necessary, repeat A and B above until optimum performance is obtained. Normally, the critical condition for GAIN and STABILITY adjustment is at no load.

NOTE: Optimum adjustment of both controls is in the furthest CW position that will result in the best response and stability under ALL operating conditions. Backing off slightly from the best position achieved during adjustment will allow for changing conditions that may affect the dynamic response of the engine. If a load bank and a strip chart recorder are available, use them to evaluate and optimize the performance using Figure 2 as a guide. If a stable system cannot be obtained, refer to the section on Troubleshooting.

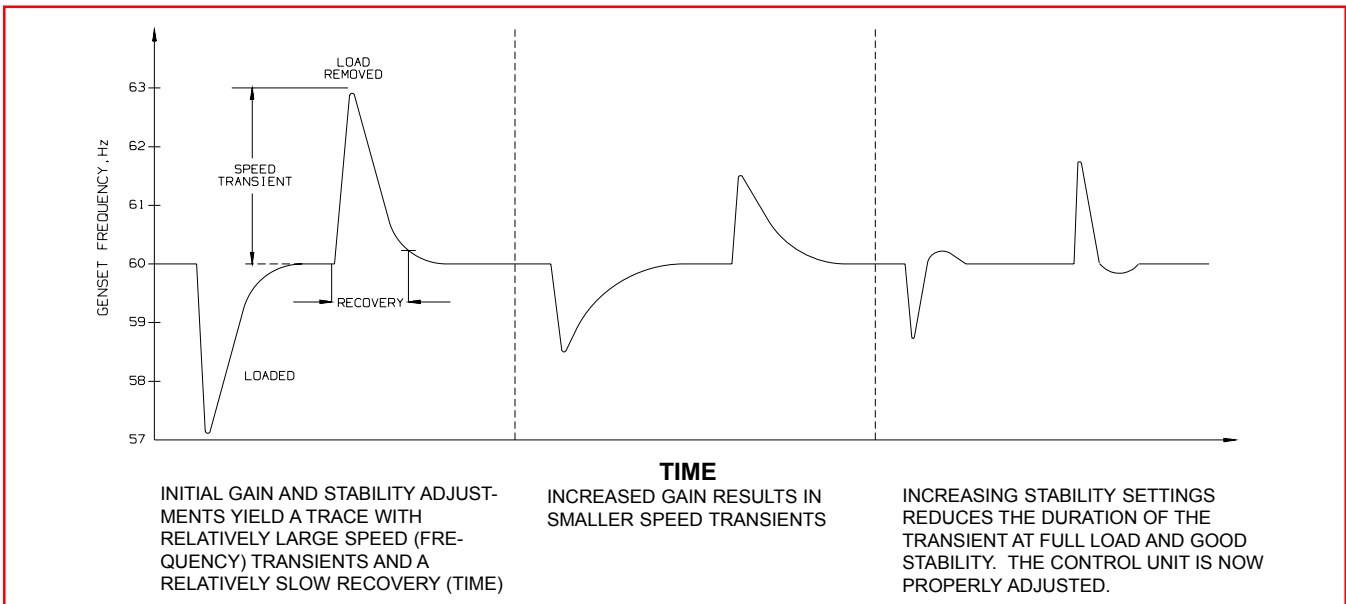


Figure 2. Typical Strip Chart Performance vs. Load Changes (Isochronous Operation Shown)

TROUBLESHOOTING

Governor is Inoperative or Throttle Does Not Move

If the engine governing system does not function properly, use the following steps to determine the cause. Use a standard VOM and observe proper polarity.

STEP	CONTROL UNIT TERMINALS	NORMAL READING	POSSIBLE CAUSE OF ABNORMAL READING
1	Mag Pickup	1.0 Vrms minimum while cranking	<ol style="list-style-type: none"> 1. Gap between magnetic speed sensor and gear teeth too large. Readjust closer to gear if possible. 2. Shorted or improper wiring to magnetic speed sensor. Resistance of sensor should be 30 to 1200 ohms. 3. Defective magnetic speed sensor or sensor gain is too low
2	BAT (+), BAT (-)	Battery Supply Voltage (12Vdc, 24Vdc nominal)	<ol style="list-style-type: none"> 1. Improper wiring of battery circuit. 2. Blown fuse. 3. Low battery voltage. (Refer to Speed Control Unit data sheet)
3	Internal Regulated Voltage*	+5.0 Vdc (-10.0 on some units*), for TRIM or REMOTE SPEED controls	<ol style="list-style-type: none"> 1. Inadequate battery voltage. 2. Short across trim control circuit. 3. Defective Speed Control Unit.
4	Actuator (+), Actuator (-)	Zero volts when not cranking, 1-3 Vdc when cranking	<ol style="list-style-type: none"> 1. SPEED setting lower than cranking speed. 2. Defective Control Unit. 3. Short/open in Actuator wiring. 4. Defective Actuator (see Actuator Troubleshooting).

*Refer to schematic on data sheet

Unsatisfactory Performance

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

SYMPTOM	TEST	PROBABLE FAULT
Engine overspeeds	<ol style="list-style-type: none"> 1. Do not crank. Apply DC power to the governor system. 2. Manually hold the engine at the desired running speed. Measure the Actuator DC voltage. 	<ol style="list-style-type: none"> 1. If Actuator commands full fuel, disconnect speed sensor. If Actuator still commands full fuel - Speed Control Unit defective. If Actuator commands minimum fuel position, check speed sensor voltage, frequency. (Refer to Speed Control Unit data sheet). 1. If the voltage reading is 1.0 to 3.0 VDC, <ol style="list-style-type: none"> a) SPEED adjustment set above desired speed. b) Defective Speed Control Unit. 2. If the voltage reading is above 3.0 VDC, <ol style="list-style-type: none"> a) Actuator or linkage binding. 3. If the voltage reading is below 1.0 VDC, <ol style="list-style-type: none"> a) Defective Speed Control Unit. 4. GAIN set too low.
Actuator does not energize fully	<ol style="list-style-type: none"> 1. Measure the voltage at the battery while cranking. 2. Momentarily connect Actuator terminals. The actuator should move to the full fuel position. 	<ol style="list-style-type: none"> 1. If the voltage is less than 7V for a 12V system, or 14V for a 24V system, replace the battery. It is weak or undersized. 1. Actuator or battery wiring in error. 2. Actuator or linkage binding. 3. Defective Actuator. See Actuator Troubleshooting. 4. Fuse opens. Check for short in Actuator or Actuator wiring harness.
Engine remains below desired governed speed.	<ol style="list-style-type: none"> 1. Measure the Actuator DC voltage. 	<ol style="list-style-type: none"> 1. If voltage measurement is within approximately 2 volts of the battery supply voltage, then fuel control restricted from reaching full fuel position. Possibly due to interference from the mechanical governor, carburetor, spring or linkage alignment. 2. SPEED setting too low.

Electromagnetic Compatibility (EMC)

Most AMBAC Electric Governor products are designed to be insensitive to Electromagnetic Interference (EMI); but for excessive levels of interference some installation considerations are still necessary.

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. Applications that include magnetos, solid state ignition systems, radio transmitters, voltage regulators or battery chargers should be considered suspect as possible interfering sources.

It is recommended to use shielded cable for all external connections. Always use twisted leads for the Magnetic Pickup. Be sure that only one end of the shields, including the speed sensor shield, is connected to a single point at the speed control unit. Mount the

Speed Control Unit to a grounded metal back plate or place it in a sealed and grounded 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 grounded metal shield or a grounded solid metal container is usually effective.

Conduction is when the interfering signal is conducted through the interconnecting wiring to the governing system electronics. Shielded cables and noise 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, a special class of EMI shielding may be required. Contact AMBAC application engineering for specific recommendations.