# APECS 1000 & 2000 Electronic Controllers

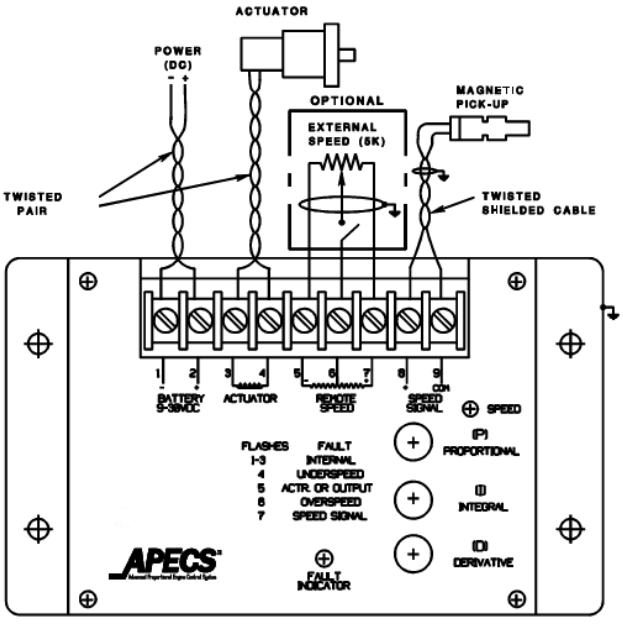
## Installation and Calibration Instructions

## *Controller Installation Guidelines*

Refer to the wiring diagram below.

1. Power leads are to be connected directly to the SWITCHED POWER SOURCE (i.e. battery).
2. Use proper gauges of insulated wire as shown in the Actuator Wiring table below.
3. Use shielded cable for external speed potentiometer and speed signal source. Shields should be connected to case ground (example one of the mounting screws).
4. Mount the unit in a location where effects of vibration and temperature are within specified ranges.
5. Four mounting holes are provided on the APECS case. Use 10-32 or M6 screws to mount the unit to an electrically grounded mounting plate. Use star washers for good electrical connection of the case to ground. If the case is mounted on an insulated surface, connect terminal pin 1 to one of the four screws on the case cover.
6. Install the magnetic pickup using the guidelines below.
7. Mount and adjust the actuator using the guidelines below.

## *Wiring Diagram*




**WARNING**

**The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.**

**The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.**

# Controller Calibration Guidelines

**NOTICE** **During calibration, be prepared to manually shut down the engine.**

1. Calculate the frequency for the input signal in Hertz (Hz) as follows:
    a) Magnetic Pickup: Engine Speed (rpm) x number of teeth on flywheel / 60 seconds
    b) Mini-Gen™ Signal Generator: Engine speed (rpm) at Mini-Gen Signal Generator / 2
2. Connect tachometer or frequency counter to the speed source to monitor engine speed (the tachometer or the frequency counter can be connected to terminals 8 and 9 of the APECS controller).
3. Select proper frequency range by cutting jumper wires according to the following table ("X" indicates wires to be cut). The jumper wires are located under the top cover. Be sure to cut jumper wires so they cannot short to the cover or to any other wiring.

| Input Speed Signal Frequency (Hz) | Red | Yellow | Green | Blue |
|---|---|---|---|---|
| 200 to 650 | | | | |
| 400 to 1300 | | | | X |
| 600 to 1950 | | | X | |
| 800 to 2600 | | | X | X |
| 1000 to 3250 | | X | | |
| 1200 to 3900 | | X | | X |
| 1400 to 4550 | | X | X | |
| 1600 to 5200 | | X | X | X |
| 1800 to 5850 | X | | | |
| 2000 to 6500 | X | | | X |
| 2200 to 7150 | X | | X | |
| 2400 to 7800 | X | | X | X |
| 2600 to 8450 | X | X | | |
| 2800 to 9100 | X | X | | X |
| 3000 to 9750 | X | X | X | |
| 3200 to 10400 | X | X | X | X |

4. Set initial proportional gain setting to 3. Adjust integral gain to 1. If using PID controller, set derivative gain to 4. All three gains turn clockwise to increase.
5. Select speed control mode:
    a) White jumper intact (+/- 10% mode). Both internal and external speed pots are active. The internal pot can adjust the speed setting within the range selected by the speed jumpers above.

    If the remote speed pot is connected to terminals 5, 6 and 7, it can adjust the speed to +/- 10% of the internal speed setting. Adjust the remote pot to mid-range before adjusting the internal speed pot.

    If the remote speed pot is disconnected, the internal pot is the default speed setting.

    b) White jumper cut (2 speed mode). Only one pot is active and the two speed pots operate independently. The active pot can adjust the speed setting from 0 rpm to the highest speed in the range selected by the speed jumpers.

    If the remote speed pot is connected, it is active and sets the desired speed.

    If the remote speed pot is disconnected, the internal pot is active and sets the desired speed.
6. Start the engine with no load. Magnetic pickup and actuator must be connected.
7. Adjust active speed pot (dependent on the mode, step 5 above). The internal speed pot may need to be turned 6 to 12 turns clockwise for engine to run after starting (maximum turns 25).

8. Proportional gain is used to improve response time. A maximum amount of proportional gain should be used while still maintaining stability. Increase proportional gain until speed begins to oscillate, then decrease until oscillation stops. If oscillations do not occur, bump actuator lever, then decrease proportional gain until oscillation stops.
9. Integral gain is used to remove steady state errors. Increase integral gain until speed begins to oscillate, then decrease until oscillation stops. If oscillations do not occur, bump actuator lever, then decrease integral gain until oscillation stops.
10. Derivative gain is used to improve stability. This feature is only available in Model 2000 (PID controller). Increase derivative gain until response has a slight overshoot on load transients. If derivative gain is too high, response may exhibit high frequency oscillation. If derivative gain is too low, response will have a large overshoot, and the settling time may be too long.
11. Apply a variety of loads on and off (up to 100%) to check performance and stability.
12. Repeat steps 8, 9, & 11 (8, 9, 10, & 11 for Model 2000 PID controller) until response has a fast rise time with a minimum overshoot, and settling time. In multiple speed systems, response should be optimized for all speed settings.
13. Test for overshoot by turning controller off, letting speed drop to about 50%, then turning controller back on. If overshoot exceeds 4%, decrease integral gain slightly and try again.
14. Test for cold start stability by turning engine off and waiting until engine is cold. Start the engine. If engine speed oscillates, decrease proportional and integral gains slightly until oscillation stops.

## *Magnetic Pickup Installation Guidelines*

**NOTICE** **The magnetic pickup must provide at least 2 Vrms or 5.7 Vpp during cranking.**

1. The mounting of the pickup unit must be rigid. Excessive vibration relative to the sensed gear causes spurious signals and may cause unacceptable performance of the system. The sensed gear must have evenly spaced teeth (missing tooth or extra tooth gears are not acceptable).
2. Air gap between the pickup and the sensed gear must be sufficient to prevent pole piece damage. Gear tooth run-out (eccentricity) and bearing wear must be considered. The gap should be as small as practical to obtain a reliable, high level signal at low speed.
3. Generally, 0.015" to 0.020" (0.38mm to 0.5mm) gap is satisfactory. If the gap cannot be measured directly, turn the pickup in until it touches the gear O.D. Screw out between 95° and 130° to obtain a 0.015" to 0.020" (0.38mm to 0.5mm) gap. It is imperative that the pickup be installed at the correct gap and correct mounting orientation.
4. Use proper mating connectors or shielded cable assembly as specified.

## *Actuator Installation Guidelines*

1. Remove pre-existing linkage from fuel control lever. On **diesel engines with two levers,** attach actuator linkage to the shutdown lever if possible.
2. Mount actuator bracket securely to the engine block on two axes. The bracket should be made of 1/4" (5mm) minimum cold rolled steel.
3. Select either 12V or 24V actuator. Mount actuator on mounting bracket using all bracket holes.
4. Attach actuator's plunger to fuel control lever using necessary linkages. Heavy duty spherical rod-end bearings are recommended.

**NOTICE** **If engine is equipped with a mechanical governor, the governor should be adjusted to a speed setting 10% higher than the APECS speed setting.**

## ACTUATOR WIRING

The table below shows the maximum length of connecting wires that amount to 5% force reduction at room temperature. Wire length is the total length (to and from) used to connect actuator to controller and controller to system power.

| ACTUATOR | RESISTANCE (NOMINAL) 12 Vdc | RESISTANCE (NOMINAL) 24 Vdc | AWG 14 2.50mm$^2$ | AWG 16 1.50mm$^2$ | AWG 18 1.00mm$^2$ |
|---|---|---|---|---|---|
| **175** | 2.8 Ohm | 10.63 Ohm | 66 ft (20m) | 33 ft (10m) | 22 ft (6.7m) |
| **250** | 1.76 Ohm | 6.84 Ohm | 46 ft (14m) | 23 ft (7m) | 15 ft (4.6m) |
| **300** | 1.72 Ohm | 6.57 Ohm | 46 ft (14m) | 23 ft (7m) | 15 ft (4.6m) |

## ACTUATOR ADJUSTMENT

1. Adjust linkage to position the fuel control lever to shut down the engine with actuator fully de-energized.
2. Manually move linkage from shutdown to maximum fuel, ensuring actuator will return linkage to shutdown position and full travel of linkage is smooth and uninhibited, and does not exceed specified stroke.
3. Tighten all nuts and bolts of the linkage and actuator mounting flange.
4. Use a tachometer or frequency meter connected to the signal source to measure engine speed.
5. Start the engine. On a **diesel engine,** manually hold the linkage at maximum fuel position until engine starts.
6. On a **spark ignition engine,** hold the linkage at near-full throttle, taking care not to overspeed.
7. Move the linkage from low idle to desired maximum speed to check the range of motion. Adjust linkage accordingly.
8. Release the actuator and ensure the linkage returns to shutdown position.
9. Repeat previous steps to ensure desired operation.

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