Released

Product Manual 36750
(Revision B, 07/2019)
Original Instructions

APECS 4800 Controller

Installation and Operation Manual

General Precautions	**Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.** **Practice all plant and safety instructions and precautions.** **Failure to follow instructions can cause personal injury and/or property damage.**

Revisions	**This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:** **www.woodward.com/publications** **The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.**

Proper Use	**Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.**

Translated Publications	**If the cover of this publication states "Translation of the Original Instructions" please note:** **The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.**

Revisions— A bold, black line alongside the text identifies changes in this publication since the last revision.

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Important Definitions

⚠ This is the safety alert symbol used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER** - Indicates a hazardous situation, which if not avoided, will result in death or serious injury.
- **WARNING** - Indicates a hazardous situation, which if not avoided, could result in death or serious injury.
- **CAUTION** - Indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.
- **NOTICE** - Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT** - Designates an operating tip or maintenance suggestion.

⚠WARNING

Lockout/Tagout

Ensure that personnel are fully trained on LOTO procedures prior to attempting to replace or service an APECS controller on a "live" running engine. All safety protective systems (overspeed, over temperature, overpressure, etc.) must be in proper operational condition prior to the start or operation of a running engine. Personnel should be equipped with appropriate personal protective equipment to minimize the potential for injury due to release of hot hydraulic fluids, exposure to hot surfaces and/or moving parts, or any moving parts that may be activated and are located in the area of control of the APECS controller.

⚠WARNING

Overspeed / Overtemperature / Overpressure

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.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

WARNING **Automotive Applications**	**On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.**

NOTICE **Battery Charging Device**	**To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.**

Electrostatic Discharge Awareness

NOTICE **Electrostatic Precautions**	**Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:** • **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).** • **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.** • **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.** **To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.**

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

IMPORTANT	**External wiring connections for reverse-acting controls are identical to those for direct-acting controls.**

Regulatory Compliance

European Compliance for CE Marking

These listings are limited only to those units bearing CE Marking

EMC Directive: 2014/30/EU COUNCIL DIRECTIVE of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility and all applicable amendments.

IMPORTANT	This unit is not qualified for use in residential installations due to EMC compliance. It is only allowed in non-residential applications.

Other European Compliance:

RoHS Directive: Restriction of Hazardous Substances 2011/65/EU:
This product is intended to be sold and used only as equipment which is specifically designed, and is to be installed, as part of another type of equipment that is excluded or does not fall within the scope of this Directive, which can fulfil its function only if it is part of that equipment, and which can be replaced only by the same specifically designed equipment and therefore fulfills the requirements stated in Art.2.4(c) and as such is excluded from the scope of the Directive

Restriction of Hazardous Substances 2011/65/EU:
This product is intended to be sold and used only as repair, updating or upgrading of EEE (as defined in Article 3(27) of the Directive) that either was excluded from the scope of the Directive at the time of placing on the market (as defined in Article 4.4(e)) or which benefited from an exemption and which was placed on the market before that exemption expired (per Article 4.4(f)).

General Compliance

⚠CAUTION	The APECS 4800 family of products is not intended for direct sale to general consumers. This product is intended for industrial fixed installations and direct sale to OEM system integrators, not general consumers.

Due to regulatory requirements listed in regulatory compliance section, these guidelines are necessary:

1. Wiring/cabling requirements must be followed.
2. Wiring/cabling should be grouped into bundles as possible or segregated by I/O type.
3. Wiring/cabling I/O types or bundles should be routed against chassis/frame ground potential (the engine) for the maximum length of the cable present, where possible. Cabling and wire routing should only allow small sections of wiring and cabling to be more than 5 cm (2 inches) from chassis/frame ground potential. Wires should preferably be routed directly against chassis/frame.
    a. Cabling may be more than 5cm (2 inches) from chassis/frame ground potential for items like strain relief and cable routing bends. The length of cabling allowed to be more than 5cm (2 inches) from chassis/frame ground potential, must be:
        i. Less than ~0.5m (~20 inch) sections at the cabling ends.
        - or -
        ii. Less than ~0.5m (~20 inch) sections at points along the cabling & wire routing where cabling or wiring greater than ~1.5m (~60 inch) of length on each side of it is less than ~5cm (~2inch) from chassis/frame ground potential.
        - or -
        iii. Cables shorter than ~3.0m (~120 inch) should have at least ~1.5m (~60 inch) of cable wiring less than ~5cm (~2inch) from chassis/frame ground potential. Route as much length as possible against chassis/frame ground potential.

IMPORTANT	**Serial communication port is intended as service and monitoring ports; no critical functions should be attributed to them. Data is sent in a free-run mode such that the port is serviced when the microprocessor has extra time.**

Chapter 1.
General Information

Scope of Manual

This manual provides the information necessary to apply the APECS 4800 control to diesel engines. Topics covered include mechanical installation, electrical wiring, software programming, and troubleshooting.

This manual does not contain instructions for operation of the complete engine system. For engine or plant operating instructions, contact the plant or equipment manufacturer.

APECS 4800 System Description

Woodward's APECS 4800 is a microprocessor-based engine control for diesel engine applications. The basic system components are:

- *Magnetic pickup* that sends engine speed signal to the controller.
- *APECS 4800 engine controller* that processes the signal received from a speed sensor and compares it to the desired speed setting.
- *Linear actuator* connected to the engine fuel control lever. The output of the controller is a pulse-width modulated (PWM) signal that is proportionally converted to an output shaft position. Position feedback is sent to the controller to provide black smoke control and load calculation for droop and torque limiting.
- *PC service tool* that allows configuration of controller's software programmable features as well as servicing the system.

The system may be further extended by utilizing the controller's other programmable features or by adding additional components.

Figure 1-1 below outlines the basic structure of the APECS 4800 engine control system.

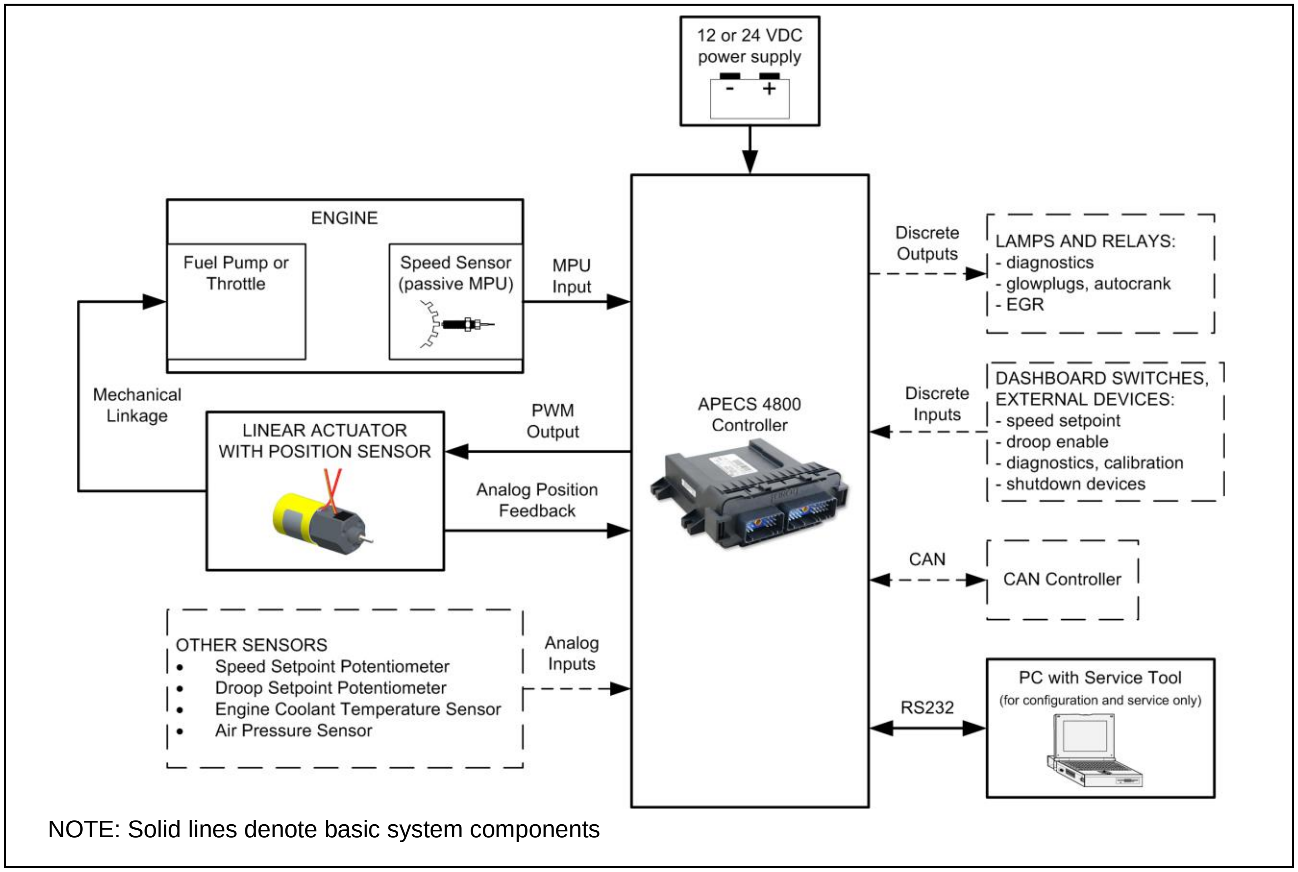


Figure 1-1. Basic APECS 4800 Control System Components

Programmable Features

The APECS 4800 controller is fully configurable through the PC service tool. The controller's programmable features are listed below. Certain features that require additional hardware apart from software configuration are discussed in **Chapter 3** (Installation) and **Chapter 4** (Operation).

APECS 4800 Programmable Features:

- *Engine Speed Governing*
  - Capable of both isochronous and droop operation
  - Flexible droop mode configuration, including droop potentiometer
  - Flexible fixed or variable speed setpoint configuration
  - Engine speed and coolant temperature controlled gains, dual proportional gain
- *Emissions Control*
  - Engine startup ramp
  - Fuel limit on startup, controlled with coolant temperature
  - Black smoke control using engine speed and air pressure as inputs
  - Capable of driving EGR (Exhaust Gas Recirculation) relay
- *Engine Torque Control*
  - Precise engine load estimation by use of the actuator position feedback and configurable no load and full load lines
  - Configurable engine torque limits

- *Autocrank and Glowplug Control*
- *Flexible Diagnostics System*
  - Diagnostic lamp with configurable fault codes
  - Up to four configurable warning lamp outputs
  - Limp home modes for selected faults
- *Additional Engine Monitoring Inputs and Outputs*
  - External shutdown device inputs including engine oil pressure
  - Speed trip outputs
  - System voltage monitoring
  - Speed sensor fault detection
  - Coolant temperature monitoring, fan control
- *CAN Communication using J1939 Protocol*
  - Monitoring of multiple values including diagnostics is available
  - Possibility of speed setpoint command through TSC1 (Torque/Speed Control 1) message
- *Password Controlled Access through Software Tool*
  - Three separate tool access levels, each with configurable passwords

Emissions Compliance Features

With the addition of an air pressure sensor, the APECS 4800 controller enables smoke limiting and altitude compensation emissions control on small diesel engines with mechanically controlled fuel systems. The 4800 controller and an actuator with position feedback act as a system to reduce black smoke from over fueling during acceleration or high altitude operations. The 4800 control system provides the optimal air fuel/air ratio for all operations at any altitude based on a closed loop control from an intake manifold air pressure sensor for turbocharged or naturally aspirated engines. This system can provide full authority control, or be a fuel limiter to a mechanical governed engine to reduce black smoke.

Black smoke or particulates are formed when excessive fuel or a rich fuel/air ratio is delivered to the engine. In typical mechanically controlled diesel fuel systems, the engine speed is limited at a maximum level by a flyweight governor, and acceleration and droop are fixed by mechanical means. The Woodward system provides a means to achieve optimal fuel delivery necessary for “Not to Exceed” particulate levels. This technology enables the OEM to certify the engine at regional “Not to Exceed” limits as part of their comprehensive emissions and operation strategy.

The APECS 4800 can also provide basic on/off EGR control based on temperature/speed/load that would need to be calibrated and qualified to each specific engine for NOx reduction. Contact your Woodward representative for more details on this feature and its limitations.

Overall, the APECS 4800 controller enables particulate (smoke) reduction, and can reduce NOx emissions on small diesel engines with mechanically controlled fuel systems.

A total system approach to the application, qualification, and certification of this technology will need to be considered before utilization of this product family. Woodward is capable of defining these steps and processes, and has production experience to accomplish this effort successfully. Contact your regional Woodward representative for more details on a total system approach.

Chapter 2. Specifications

Table 2-1. Physical Specifications

Height x Width x Depth	Approx. 2.3 x 6.0 x 5.8 in (58.4 x 153.2 x 148.6 mm)
Weight	Approx. 1.2 lb (0.54 kg)
Mounting	Off-engine and away from exhaust manifold and pipes

Table 2-2.Electrical Specifications

Power Supply	
Power Supply	9-32 Vdc (12 or 24 Vdc nominal) reverse polarity protection
Power Consumption	1.1 W maximum (not including driven loads)
Input Voltage Monitor	
Maximum Voltage Measured	40 Vdc
Resolution	10 bits
Accuracy	±5%
Speed Signal Input	
Sensors Supported	MPU – Magnetic Pickup (Passive Variable Reluctance)
Voltage Sensitivity at 180 Hz	3.0 Vpeak-to-peak
Voltage Sensitivity at 1530 Hz	4.0 Vpeak-to-peak
Maximum Input Voltage	60.0 Vpeak-to-peak
VR Input Frequency	25-6000 Hz
Switching Hysteresis	0.4 Vdc
Isolation Voltage	None
Input Common Mode Range	0 Vdc
Diagnostics	Detect loss of signal
Discrete Inputs (DI) (7 inputs)	
***Input Low and High Voltage Thresholds*:**	
Inputs Switched to Battery Voltage (DI2-DI5)	VIL (min) = 1.0 Vdc
	VIH (max) = 6.3 Vdc
Input Switched to Battery Voltage (DI1)	VIL (min) = 2.0 Vdc
	VIH (max) = 3.6 Vdc
Inputs Switched to Ground (DI6, DI7)	VIL (min) = 0.7 Vdc
	VIH (max) = 4.3 Vdc
Input Current (DI1-DI5)	(min) 0.4 mA @ 9 V Power Supply
	(max) 2.7 mA @ 32 V Power Supply

Table 2-2.Electrical Specifications (cont'd.)

Input Current (DI6, DI7)	(min) -0.8 mA @ 9 V Power Supply
	(max) -3.2 mA @ 32 V Power Supply
Anti-aliasing Filter	1 pole at 100 µs (fc = 1600 Hz)
Isolation Voltage	None
Diagnostics	None
Actuator Position Input	
Input Type	Analog Voltage Input
Typical Load	Woodward actuator position sensor
Sensor Power Supply	
Output Voltage	5.0 ± 0.5 Vdc
Output Current	15 mA maximum
Protection	Output is protected from short circuit
Analog Signal Input	
Input Voltage Range	0 - 5 Vdc full scale minimum and maximum valid signal value configurable by 0.01V
Isolation Voltage	None
Common Mode Rejection (DC)	None
Input Common Mode Range	0 Vdc, single-ended input
Anti-aliasing filter	1 pole at 100 µs (fc = 1600 Hz)
Resolution	10 bits
Accuracy	±3 % of input value (incl. temperature drift)
Diagnostics	Detect sensor power supply short circuit
	Detect broken signal wire, or signal wire is shorted to ground when input voltage below minimum (adjustable by 0.01 Vdc)
	Detect signal wire shorted to sensor power supply when input voltage above maximum (adjustable by 0.01 V(dc))
Manifold Air Pressure Input	
Input Type	Analog Voltage Input
Typical Load	Three terminal manifold air pressure sensor
Power Supply	
Output Voltage	5.0 ± 0.5 Vdc
Output Current	15 mA maximum
Protection	Output is protected from short circuit
Potentiometer Analog Inputs for Remote Speed Potentiometer (RSP) and Droop Setpoint Potentiometer (DSP)	
Input Voltage Range	0 - 5 Vdc full scale minimum and maximum valid signal value configurable by 0.01 V
Isolation Voltage	None
Common Mode Rejection (DC)	None
Input Common Mode Range	0 Vdc, single-ended input
Input Impedance	221 kΩ (±1 %) pull-down
Anti-aliasing filter	1 pole at 100 µs (fc = 1600 Hz)

Table 2-2.Electrical Specifications (cont'd.)

Resolution	10 bits
Accuracy	±2 % of input value (incl. temperature drift)
	Detect broken positive supply, broken signal wire, or signal wire is shorted to ground when input voltage below minimum (adjustable by 0.01 Vdc)
	Detect signal wire shorted to positive supply when input voltage above maximum (adjustable by 0.01 Vdc)
Resistor Analog Input for Engine Coolant Temperature (ECT)	
Input Voltage Range	0 - 5 Vdc full scale minimum and maximum valid signal value configurable by 0.01 V
Isolation Voltage	None
Common Mode Rejection (DC)	None
Input Common Mode Range	0 Vdc, single-ended input
Input Impedance	2.74 kΩ (±0.1 %) pull-up to 5 V
Anti-aliasing filter	1 pole at 100 µs (fc = 1600 Hz)
Resolution	10 bits
Accuracy	±1 % of input value (incl. temperature drift)
Diagnostics	Detect broken signal wire, or signal wire is shorted to ground when input voltage below minimum (adjustable by 0.01 Vdc)
	Detect signal wire shorted to positive supply when input voltage above maximum (adjustable by 0.01 Vdc)
Discrete Outputs (DO) (9 outputs)	
Output Type	Low side driver
Typical Load	3 W automotive lamp or relay
Control Type	On / Off
Maximum Output Current	250 mA
Leakage Current	170 µA in 12 V system / 315 µA in 24 V system
Diagnostics	Short circuit detection (350 mA max detection threshold) Open load detection
Actuator Output	
Output Type	Low side driver
Maximum Output Current	5 A
Control Type	PWM (Pulse Width Modulated) signal
PWM Frequency	200 Hz fixed
Duty Cycle Control Range	5-95% default, configurable up to 0 – 100%
Diagnostics	Short and open load detection
CAN Port	
Isolation Voltage	None
Channel Configuration	CAN 2.0B
Wiring	High, Low
Baud Rate	250 kBaud
Termination	Provided in the controller (120 Ω)
Protocols Supported	SAE J1939

Table 2-2.Electrical Specifications (cont'd.)

Diagnostics	Protocol specific
RS-232 Serial Communication Service Port	
Isolation	None
Baud Rate	38400 kBaud
Electrical Interface	External transceiver for conversion to RS-232 levels not required
Driver Diagnostics	Protocol specific
Protocols Supported	Woodward ServLink

Table 2-3. Environmental Specifications

Ambient Operating Temperature	–40 to +85 °C (–40 to +185 °F)
Storage Temperature	–40 to +105 °C (–40 to +221 °F)
Humidity	95% RH
Water Spray	JIS D 0203-1994 S1
Dust	JIS Z 8901 1995, Method F2
Random Vibration	0.04 G^2/Hz, 10-2000 Hz, 8.2 Grms
Drop	SAE J1455, paragraph 4.11.3.1
Thermal Shock	3 hours 125°C to 3 hours at -40°C, 200 cycles
Ingress Protection	IP67 per IEC 60529
EMC **Electro-Magnetic Compatibility has been tested and demonstrated to meet the following requirements:**	
ISO 13766:2006 ESA / CISPR 25:2002 ESA	30-1000 MHz radiated emissions limit -6 dB & 30-1000 Class 3, respectively
CISPR 25:2002, ESA Class 3 Conducted Emissions 0.15 to 108 MHz	~10% CAN bus utilization passed. ~60% CAN bus utilization 1.1 to 2.0 MHz and 5.9-6.2 MHz the class 3 limit was exceeded, Class 1 was met
ISO 7637-2 Pulse Conducted Emissions	Pulse emissions conducted back to the power source only, 28.6 V_{peak}
IEC 61000-4-2:2001, Operational ESD	±8 kV contact. ±15 kV air
ISO 10605:2001(E), Handling ESD	±8 kV contact to control pins. ±6 kV contact to actuator pins
SAE J1113-24:2000-5 section 5&6, G-TEM Radio Frequency Interference Immunity/Susceptibility	1 to 1000 MHz range: 150 V/m CW & 75 V/m 80% depth 1 kHz AM no degradation, 100 V/m 80% depth 1 kHz AM, self-recovery. Demonstrates will meet EN 61000-4-3 10V/m requirement
ISO 11452-2:2004 Radio Frequency Interference Immunity/Susceptibility	100 V_{RMS}/m (peak envelope), 200 MHz to 1000 MHz 80% depth 1 kHz AM. 30 V_{RMS}/m (peak envelope), 800 MHz to 2400 MHz pulse modulated 577 μs on time, 4600 μs period. Demonstrates will meet EN 61000-6-2 10 V/m requirement

Table 2-3. Environmental Specifications (cont'd.)

ISO 11452-4:2005 Bulk Current Injection (BCI)	1-200 MHz, 100 mA_{RMS} (peak envelop), No modulation and 80% AM at 1 kHz. Demonstrates will meet EN 61000-6-2 10 V_{RMS} requirement
IEC 61000-4-4:2004 Electrical Fast Transients (EFT)	±2.2 kV to power inputs, cables are <3m long
ISO 7637-3:1995 Pulse a & b Electrical Fast Transients (EFT)	±400 V common mode to all I/O cable types
ISO 7637-2:2004 Pulse 3a & 3b Electrical Fast Transients (EFT)	±600 V differential mode to power input
ISO 7637-2:2004 Pulse 1	-600 V to power input
JASO D001-94 Pulse E & B-2	-250/-320V to power input
JASO D001-94 Pulse A-2 & D-2	+110 / +170 V to power input
JASO D001-94 Pulse A-1 & D-1, ISO 7637-2 Pulse 5a	+70 & +105 V / +130 & +165 V to power input
ISO 7637-2:2004 Battery Droop During Engine Start	12 V & 24 V profiles
JASO D001 94 Section 5.2	12 V & 24 V profiles
EN 61000-6-2:2005	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments
EN 61000-6-4:2010	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

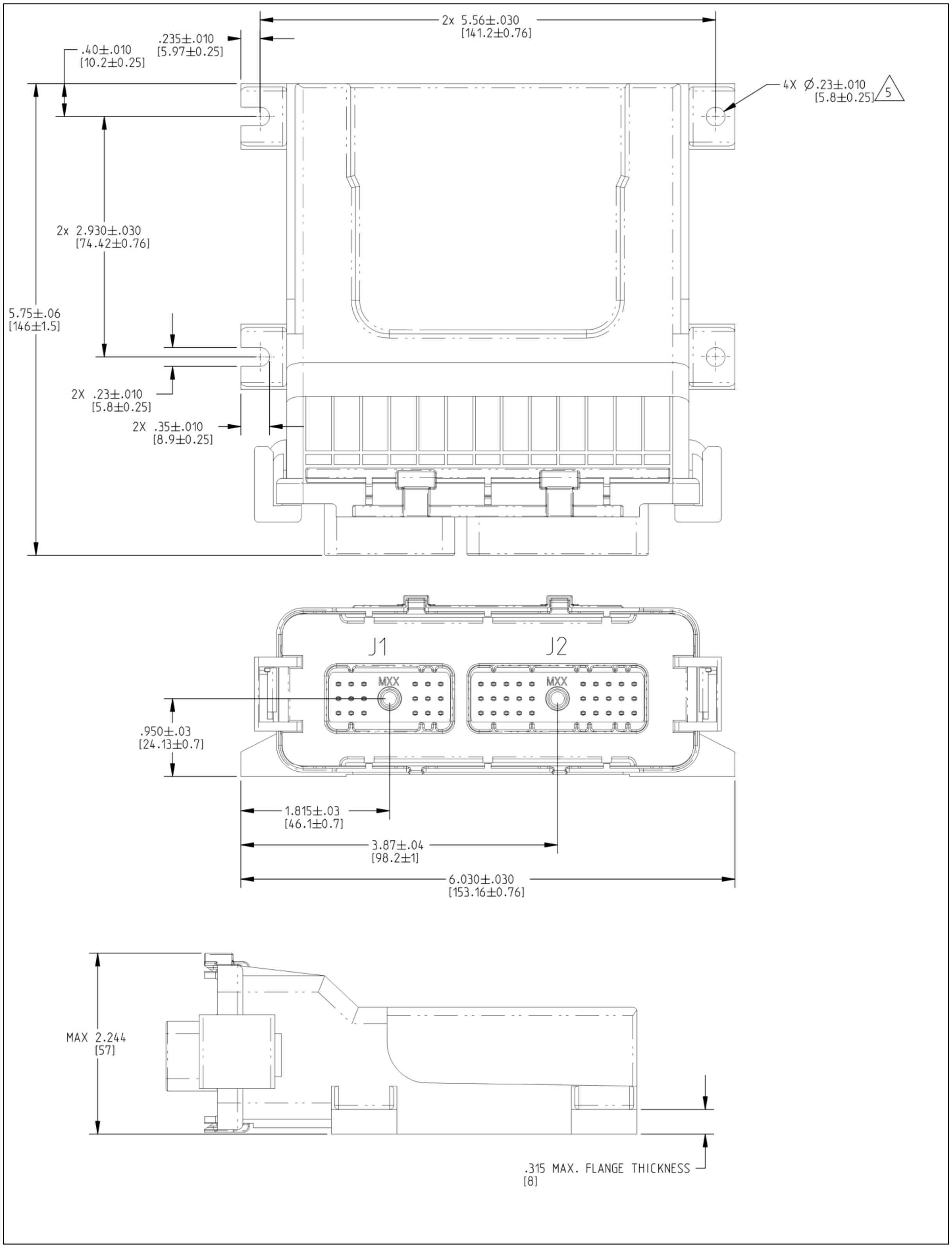


Figure 2-1. APECS 4800 Dimensions

Chapter 3.
Installation & Wiring

This chapter provides general information on selection of a mounting location for the APECS 4800 controller, as well as installation and wiring guidelines.

Unpacking

Before handling the control, refer to the inside front cover and page vii of this manual for Warnings and Cautions, including the Electrostatic Discharge Awareness.

Be careful when unpacking the electronic control. Check the control for signs of damage such as bent panels, scratches, and loose or broken parts. If any damage is found, immediately notify the shipper.

The APECS 4800 is shipped from the factory in an anti-static bag and carton. This bag and carton should always be used for transport of the APECS 4800 before its installation.

Remove all manuals, connectors, mounting screws, and other items before storing the shipping box. The original shipping material or equivalent should be used when sending the unit back for service.

Mounting

Location Considerations

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling and an operating temperature range of –40 to +85 °C (–40 to +185 °F)
- Avoidance of excessive vibration levels, or adequate vibration isolation
- Distance from high-voltage or high-current devices or devices that produce excessive electromagnetic interference
- Protection from direct exposure to water or to a condensation-prone environment
- Space needed for harness wires to be laid without excessive bending
- Protection from direct exposure to exhaust manifolds and pipes
- Space for servicing and repair

Refer to Chapter 2 for detailed information on allowed levels of ambient temperature, vibration, EMI and ingress protection.

The APECS 4800 was designed for off-engine engine bay or skid mount installation. It is suitably protected against water and dust entry, thermal cycles, and exposure to oils, coolant, and fuels. The mating wiring harnesses must be installed to complete the moisture seal.

Figure 3-1 shows the mounting hold pattern and dimensions for use when designing a mounting plate. Mounting fasteners should be torqued to maximum value of 10-12 in-lb (1.13-1.36 Nm). Controller dimensions required for construction of mounting panels are given in Chapter 2.

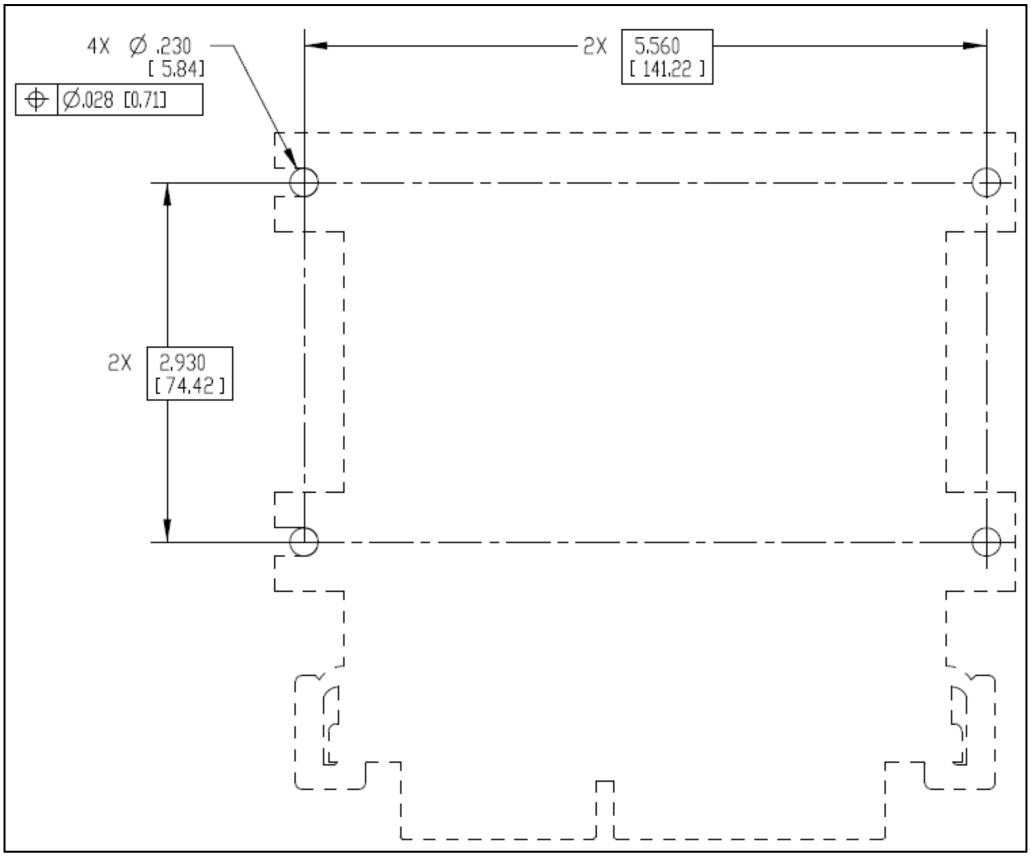


Figure 3-1. Mounting Hole Layout

To ensure proper water ingress protection, the APECS 4800 should be installed with connectors downward.

Figures 3-2 and 3-3 show mounting orientation requirements.

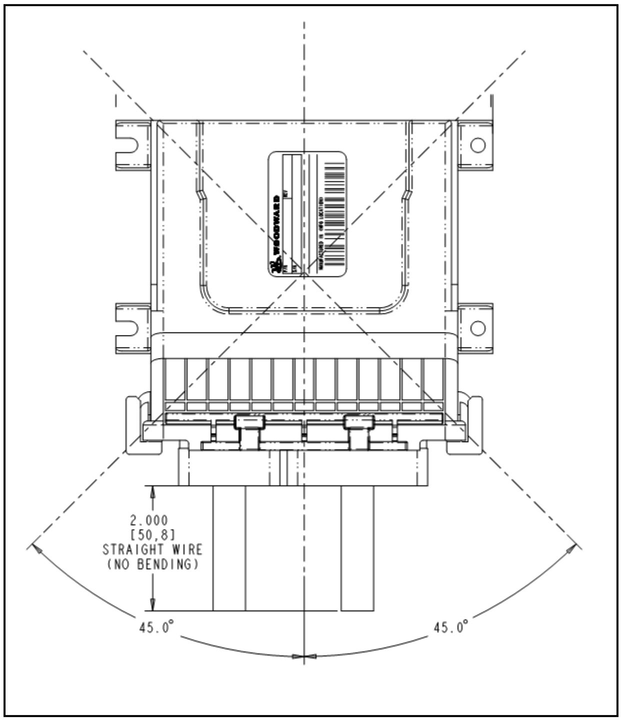


Figure 3-2. Mounting Orientation (Front View)

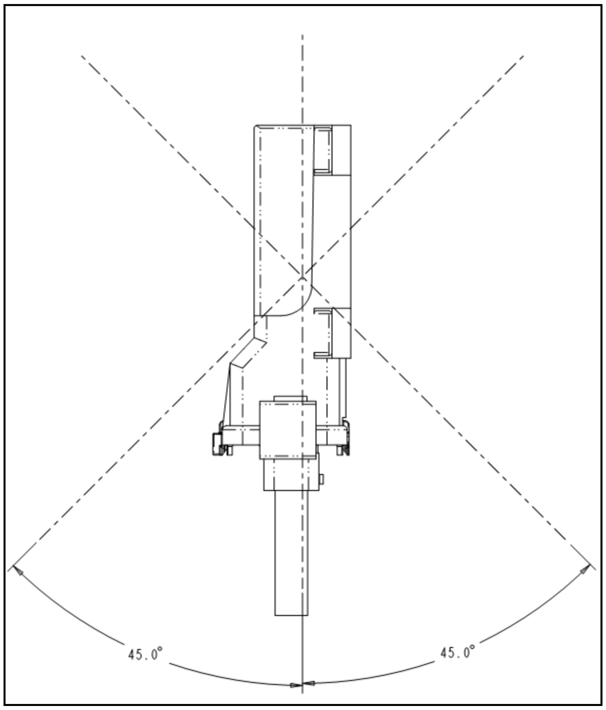


Figure 3-3. Mounting Orientation (Side View)

> **NOTICE** — **To prevent damage to the wiring cables, make sure that the bend radius of the harness has been accurately estimated.**

Wiring

Connectors Description

The APECS 4800 is not shipped with mating connectors since many applications may have a standard wiring harness or it is desirable to have the mating connectors in advance to use when wiring. However, for service and convenience, Woodward also carries APECS 4800 connector kits containing all the mating terminal blocks used on the APECS 4800. See Appendix A for mating connector usage instructions.

The sealed connectors on the APECS 4800 are not designed for removal by hand. After input power is disconnected, the connectors can be removed using a 1/4 inch hex-head driver. When reinstalling the connectors, use 15-20 in-lb (1.69-2.25 Nm) torque for the jackscrew. Using the correct torque is required to avoid damage and provide proper force on the gasket for a moisture seal. Too little force will allow the connector to leak. See Appendix A for instructions.

A hand crimp tool is necessary for use with the hand crimp terminals included in the connector kit. The tool can be purchased from Woodward or directly from Cinch. See Appendix A for part numbers.

Each wire seals individually within the connector body to protect against dust and water intrusion into the connector. In order to make a proper seal, the wire insulation diameter on the 18-pin and 30-pin connectors must be between 0.077 – 0.104 inches (1.96 – 2.64 mm). All unused pins must be sealed with plug. See Appendix A for part number.

Pinout

All connections are located on the front face of the APECS 4800. There are two connectors, J1, and J2. Both connectors must be used because there are required signals on both of them. The connectors are not marked on the enclosure but can be identified by size and position according to **Figure 3-4**. The drawing also identifies the individual connector pins (A1, B1, etc.) which are additionally marked on mating connectors.

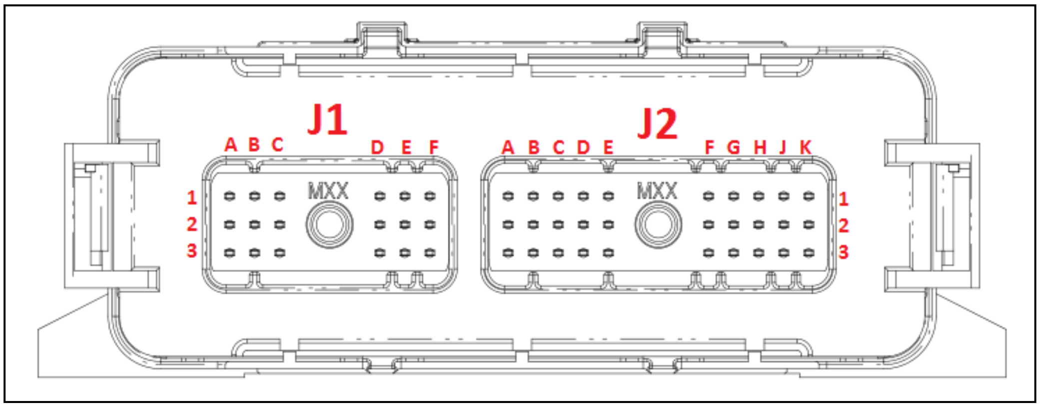


Figure 3-4. Connectors and Pins Identification

Signals are separated logically so that J1 signals are high voltage and J2 signals are low voltage, thus simplifying the harness design and minimizing the risk in case of mis-wiring or wire breaks. The J1 connector pinout is shown in **Figure 3-5** and J2 connector pinout is shown in **Figure 3-6**.

> **IMPORTANT**
>
> **Unused controller pins should be left electrically unconnected. Seal plug should be placed in the corresponding connector sockets to assure ingress protection.**

Power Input

Battery +	J1-A1, B1
Battery -	J1-C1, B2, B3

Actuator Output

Actuator Power Supply	J1-A2
Actuator PWM Output	J1-A3

CAN Communiactions

CAN High	J1-F2
CAN Low	J1-F3

Discrete Outputs

Discrete Output 1 (DO-1)	J1-D3
Discrete Output 2 (DO-2)	J1-E1
Discrete Output 3 (DO-3)	J1-E3
Discrete Output 4 (DO-4)	J1-C3
Discrete Output 5 (DO-5)	J1-D1
Discrete Output 6 (DO-6)	J1-E2
Discrete Output 7 (DO-7)	J1-C2
Discrete Output 8 (DO-8)	J1-D2
Discrete Output 9 (DO-9)	J1-F1

Figure 3-5. J1 (Smaller Connector) Pinout

Speed Input

MPU +	J2-A1
MPU -	J2-A2
Shield (MPU SHLD)	J2-A3

Actuator Position Sensor Input

Position Sensor Power (APS +5V)	J2-B1
Position Sensor Input (APS IN)	J2-B2
Position Sensor Ground (APS -)	J2-B3

Air Pressure Sensor (MAP) Input

MAP Sensor Power (MAP +5V)	J2-H1
MAP Sensor Input (MAP IN)	J2-H2
MAP Sensor Ground (MAP -)	J2-H3

RS-232 Communications

RS-232 Tx (TXD)	J2-C1
RS-232 Rx (RXD)	J2-C2
RS-232 Common (DGND)	J2-C3

Unused Pins

Unused (Do Not Connect)	J2-J1
Unused (Do Not Connect)	J2-J2

Discrete Inputs

Discrete Input 1 (DI-1)	J2-K3
Discrete Input 2 (DI-2)	J2-D1
Discrete Input 3 (DI-3)	J2-D2
Discrete Input 4 (DI-4)	J2-D3
Discrete Input 5 (DI-5)	J2-E3
Discrete Input 6 (DI-6)	J2-E2
Discrete Input 7 (DI-7)	J2-E1

Speed Setpoint Pontentiometer (RSP) Input

Potentiometr +5V (RSP +)	J2-F1
Potentiometr Input (RSP IN)	J2-F2
Potentiometr Ground (RSP -)	J2-F3
Shield (RSP SHLD)	J2-J3

Droop Setpoint Pontentiometer (DSP) Input

Potentiometer +5V (DSP +)	J2-G1
Potentiometer Input (DSP IN)	J2-G2
Potentiometer Ground (DSP -)	J2-G3

Engine Coolant Temperature Sensor (ECT) Input

ECT +	J2-K1
ECT -	J2-K2

Figure 3-6. J2 (Larger Connector) Pinout

Wiring Diagram

The general wiring diagram shown in Figure 3-7 should be used as a guideline for preparing your application’s wiring scheme. Not all presented connections are used for all systems. Detailed information on each electrical connection is given in this chapter’s “Description of Electrical I/O” section.

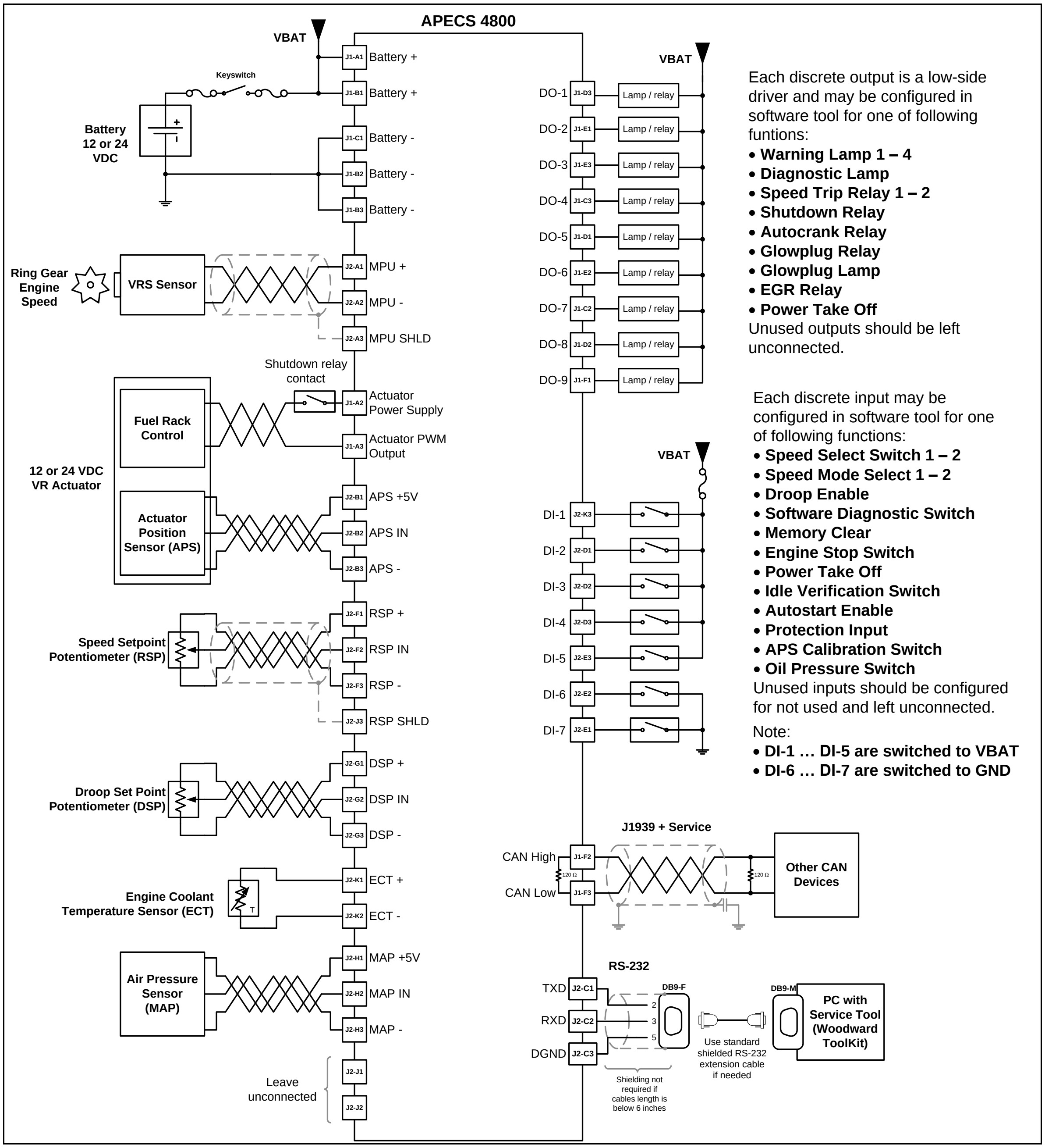


Figure 3-7. General APECS 4800 Wiring Diagram

Wire Type Requirements

The table below shows wiring types for each signal type.

Table 3-1. Wiring for Signal Types

Signal Type	Wiring Type	Gauge	Max Length
Battery Input	May be twisted	18 AWG (1.0 mm²)	22 ft (6.7 m)
		16 AWG (1.5 mm²)	33 ft (10 m)
		14 AWG (2.0 mm²)	66 ft (20 m)
Actuator PWM Output	Twisted pair	18 AWG (1.0 mm²)	22 ft (6.7 m)
		16 AWG (1.5 mm²)	33 ft (10 m)
		14 AWG (2.0 mm²)	66 ft (20 m)
Remote Set Speed Potentiometer Analog Input	Shielded, twisted triple	18 AWG (1.0 mm²) 16 AWG (1.5 mm²)	
Sensor Analog Input	No requirement/ Individual wires	18 AWG (1.0 mm²) 16 AWG (1.5 mm²)	
Position Feedback PWM Input	Twisted triple	18 AWG (1.0 mm²) 16 AWG (1.5 mm²)	
MPU Input	Shielded, twisted pair	18 AWG (1.0 mm²) 16 AWG (1.5 mm²)	10m/33 ft
Discrete Input	No requirement/ Individual wires	18 AWG (1.0 mm²) 16 AWG (1.5 mm²)	Less than 30m/100 ft
Discrete Output	No requirement/ Individual wires	18 AWG (1.0 mm²) 16 AWG (1.5 mm²)	Less than 30m/100 ft
RS-232	Shielded if longer than 6”	Must use serial cable (see Figure 3-15)	Less than 30m/100 ft
CAN	Shielded, twisted pair	Must use CAN cable (see CAN section for details)	Less than 30m/100 ft

Wire Routing

Noise interactions can affect the accuracy of the control. To facilitate noise confinement, it is recommended that:

- All low-current wires should be separated from all high-current wires when routing from the APECS 4800 to the engine components.
- Discrete wiring (such as relay outputs or discrete inputs) may be routed separately or with the analog wiring.

Splicing

Individual returns are not provided for each signal. Some signals share a common return pin. In these cases, harness splicing will be necessary.

Regardless of how the splicing is accomplished, signal routing is still very important. A signal should always be routed together with its return. Signals using twisted pair must have wires in close proximity and separations through the splice should be minimized to the greatest extent possible.

Wiring for discrete signals must be done so that the signal wire and the return are always in the same cable bundle. They should never take different paths between the APECS 4800 and the sensor. This requirement is for signal integrity and EMI/EMC purposes.

Harness splicing should always be done using hot solder-crimp splices. The solder is necessary for good signal conductivity at all frequencies. The crimp is necessary for strength and protection in the on-engine environment. Cold crimp joints alone are not sufficient signal joints and are unreliable in a high vibration environment.

Splicing of shielded, twisted pair wiring is not recommended. These signals should have a single origin and destination. Breaking the signal path or shield is not desirable, as it provides an opportunity for EMI or EMC interference and reduced signal integrity.

Shielded Wiring

The use of cable with individually shielded-twisted pairs is required where indicated by the control wiring diagram (**Figure 3-7**). Discrete outputs, discrete inputs, actuator PWM output, and power supply wiring does not normally require shielding but can be shielded if desired. All shielded cable must be a twisted conductor pair. DO NOT attempt to tin (solder) the braided shield prior to crimping it into the socket or splice. The solder will affect the crimp strength and create vibration susceptibility. DO NOT attempt to directly ground the shield at both ends or an undesired ground loop condition may occur.

Shield terminations are provided through the APECS 4800 connectors for speed input, remote set speed input and RS-232 communication port. CAN communication link does not have separate termination on the connector.

Failure to provide shielding can produce future failure or interference conditions which are difficult to diagnose. Proper shielding at the time of installation is required to assure satisfactory operation of the product.

Description of Electrical I/O

Power Supply Input

Table 3-2. Powerr Supply Input Pins

Pin	Function
J1-A1 and J1-B1	+12/24 Vdc Battery Input
J1-C1, J1-B2 and J1-B3	Ground

The APECS 4800 control will handle a voltage range of 9 to 32 Vdc. Power supply output must be low impedance (for example from large batteries such as used for engine cranking). An alternator or other battery-charging device is necessary to maintain a stable supply voltage.

⚠CAUTION	**To prevent damage to the control, do not power a low-voltage control from high-voltage sources, do not exceed 32 Vdc on the power inputs for more than 60 minutes, and do not power the control from high-voltage sources with resistors and Zener diodes in series with the power input.**

The power supply terminals are reverse polarity protected in case a reverse polarity condition exists. Connecting power supply voltage in reverse will not damage the controller, although it will not operate nor alarm in any way.

The controller provides two terminals for redundant connection of the battery positive. Multiple connections help assure low power supply path resistance.

It also has three terminals for redundant connection of the battery negative. Multiple connections help assure low return path resistance.

Woodward recommends using a 10 A slow-blow fuse on the line feeding power supply input of the APECS 4800 control. Run the power leads directly from the power source to the control. DO NOT power other devices with leads common to the control. Avoid long wire lengths. Connect the battery positive (power source positive) to the BATTERY(+) input and battery negative (power source common) to BATTERY(-). See Figure 3-8 for details.

The input voltage level is monitored for the purpose of application diagnostics and actuator duty cycle compensation.

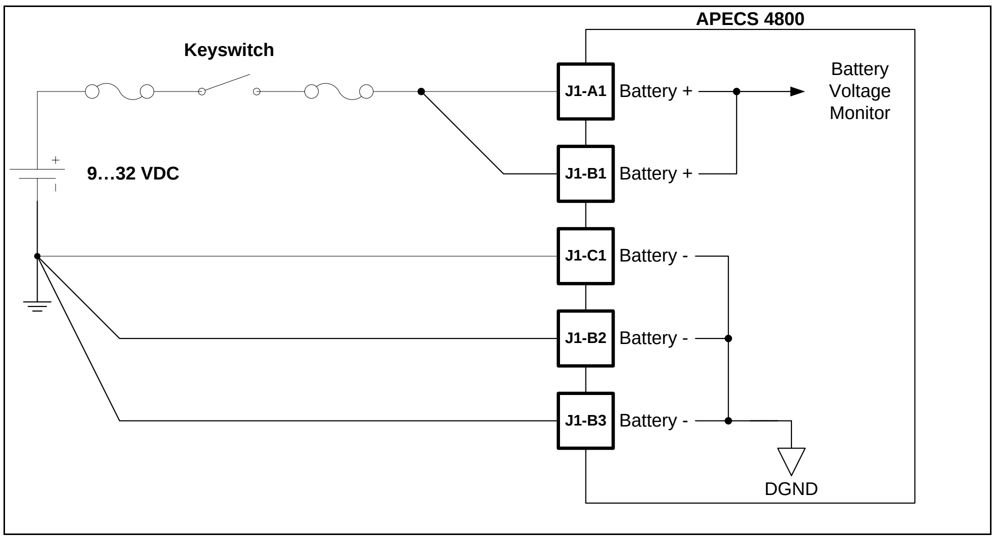


Figure 3-8. Power Supply Wiring

The single wire from the battery to the fuses and key switch should be equivalent gauge or larger gauge than the two wires from the fuse to the control to keep impedance low.

⚠CAUTION **Proper fusing of the control is highly recommended to prevent damage to the control in case of shorts that may occur in the field wiring. Fuses should be wired in series with all the power inputs to the control.**

Actuator Output

Table 3-3. Actuator Output Pins

Pin	Function
J1-A2	Actuator Power Supply
J1-A3	Actuator PWM Output

The controller closes the loop on speed and/or actuator position in order to maintain the speed set point. A PWM drive provides a 5% to 95 % duty cycle at a fixed frequency of 200 Hz. Increasing duty cycle “on-time" causes an increase in actuator current, which causes actuator to move in the increase fuel direction. The controller responds by increasing duty cycle in response to an increasing load or decreasing current to adjust for decreasing load.

The actuator coils are designed for one system voltage and the correct actuator for a nominal system voltage must be used.

IMPORTANT	**It is beyond the scope of this manual to discuss detailed actuator selection and installation procedures for all possible applications. Please contact the factory for specific information concerning your application.**

Woodward recommends using shutdown relay for actuator power supply connection. This relay is opened if engine shutdown is detected reducing risk of actuator staying open in case of Actuator PWM Output is shorted to ground.

The following diagram shows how to connect an actuator to the control.

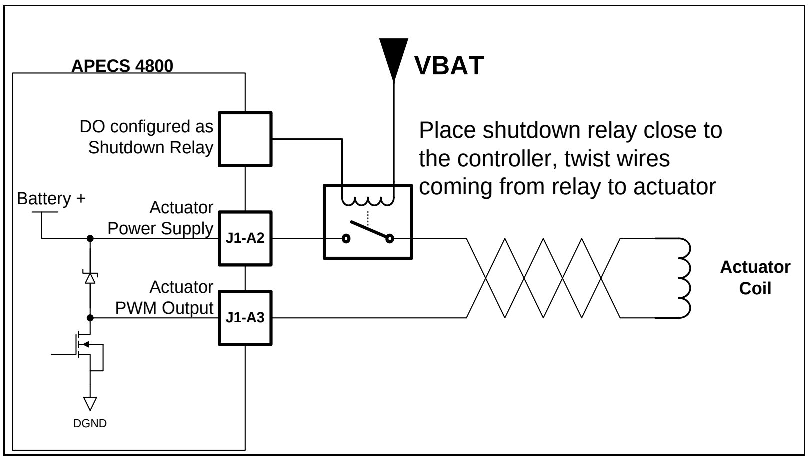


Figure 3-9. Actuator Output With Shutdown Relay Wiring

NOTICE	**Excessive resistance in the wiring will result in insufficient force from the actuator. Such increased resistance can result from too much wire length, inadequate wire gauge, or poor connections.**

CAN Communication

Table 3-4. CAN Communication Pins

Pin	Function
J1-F2	CAN High
J1-F3	CAN Low

There is one CAN port for service purposes. The APECS 4800 supports SAE J1939 protocol.

It is necessary to terminate the network to prevent interference caused by signal reflections. Depending on network length, most CAN networks will not operate without proper termination. One of the two required CAN termination is included inside the APECS 4800 control. As a rule, no matter how many units are on a network, there should never be more than two network terminations installed. Termination resistors must be installed only for the two units that are at the physical ends of the network. Terminating more than two units can overload the network and stop all communications. External termination may be a simple 121 Ω, 1 watt, 1% metal film resistor placed between CAN high and CAN low terminals at the two end units, as a differential termination. Do not connect the termination resistor to anything besides the CAN high and CAN low wires.

IMPORTANT	**SAE J1939 protocol is restricted to 250 kbps and the SAE J1939 standard limits wiring distances to 40 meters, when un-isolated controls are connected on the link.**

Shielded CAN cable is recommended between the APECS 4800 and any other devices. Unshielded or improperly shielded cables are likely to cause communication problems and unreliable control operation. Improper shield termination to ground can also cause communication problems and unreliable control operation. The standard for CAN networks is that each device will have an ac-coupled shield connection (connected through a capacitor – typically 0,01 µF). A single direct network shield ground location should be provided. Typically the direct shield grounding location does not have to be at a unit connector, it can be any convenient place in the system.

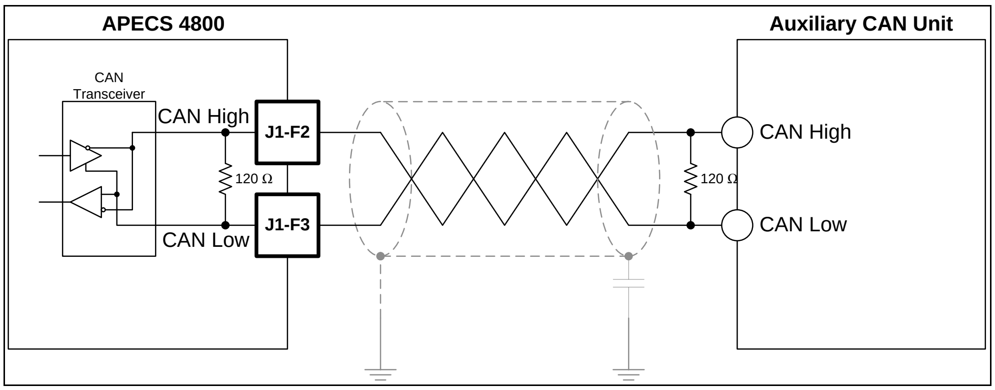


Figure 3-10. CAN Wiring

Discrete Outputs

Table 3-5. Discrete Outputs Pins

Pin	Function
J1-C2, J1-C3, J1-D1, J1-D2, J1-D3, J1-E1, J1-E2, J1-E3, J1-F1	Low Side Discrete Output

There are nine discrete outputs on the APECS 4800. Each of them can be used to control a lamp or relay coil. The function of each output is configured in the software tool and stored in controller settings. If less than nine discrete inputs are needed by an application, remaining outputs should be left unconnected and configured as “not used” in software tool (default value).

Current rating is suitable for direct control of a typical automotive lamp or relays (250 mA max). The electrical circuit is a low-side switch with the return current going to input power minus. The output load must be connected to the discrete output pin and to the Battery (+) of the system. Each output uses a diagnostics that will protect the APECS 4800 if a short circuit is detected (trip current 350 mA max).

Open circuit diagnostics is available allowing to detect unconnected load (e.g. due to wire break). This causes trickle current of 170 µA in 12 V systems and 315 µA in 24 V systems.

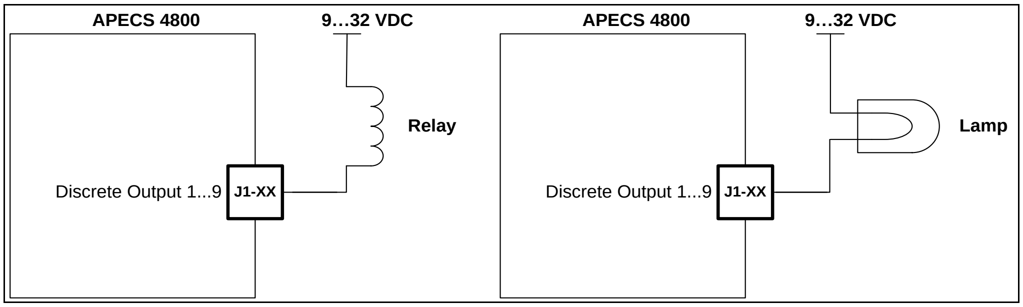


Figure 3-11. Discrete Outputs Wiring

Speed Input

Table 3-6. Speed Input Pins

Pin	Function
J2-A1	MPU +
J2-A2	MPU -
J2-A3	MPU Shield

The APECS 4800 accepts passive magnetic pickup (MPU) sensors. The speed input is used for detecting engine speed.

Wiring for speed sensors must be shielded cable with wire size of 16 or 18 AWG. Smaller wire diameters may not provide a strong crimp at the APECS 4800 connector. Also, smaller wire diameters have been shown to be unreliable in on-engine wiring due to fatigue from vibration. No wire length greater than 10 meters is allowed.

There are multiple techniques in use for shield connections of speed sensors. Each technique has varying results depending on the noise present in the area. The recommended practice is to tie the cable shield to the designated shield pin on the control and leave the opposite end of the shield un-terminated and insulated.

The following diagram shows how to wire a speed sensor.

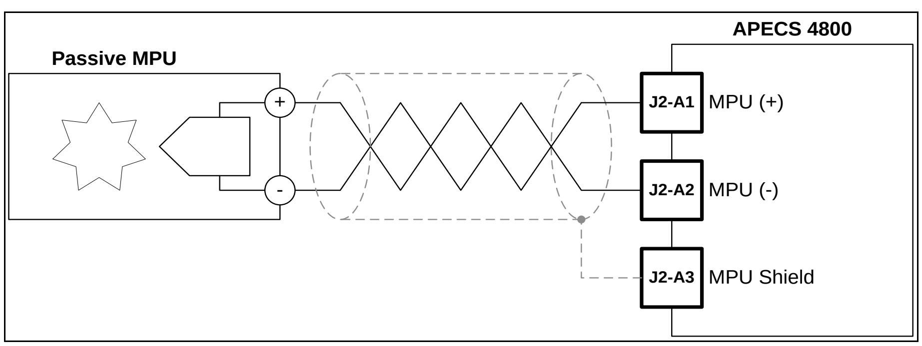


Figure 3-12. Speed Sensor Wiring

Actuator Position Sensor Input

Table 3-7. Actuator Position Sensor Input Pins

Pin	Function
J2-B1	APS +5V
J2-B2	APS IN
J2-B3	APS -

The APECS 4800 has one analog input for actuator feedback signal. 5 Vdc, ground, and a signal input provide for connection of an actuator position feedback sensor.

Analog input signal (J2-B2) originates from a non-contact, Hall Effect position sensor inside the actuator. The sensor is powered from the APECS 4800 controller though pins J2-B1 and J2-B3.

Actuator Position Sensor input wiring should be done with unshielded twisted triple wiring with wire size of 16 or 18 AWG. The following diagram shows how to connect a position sensor with the control. Connections are made to J2.

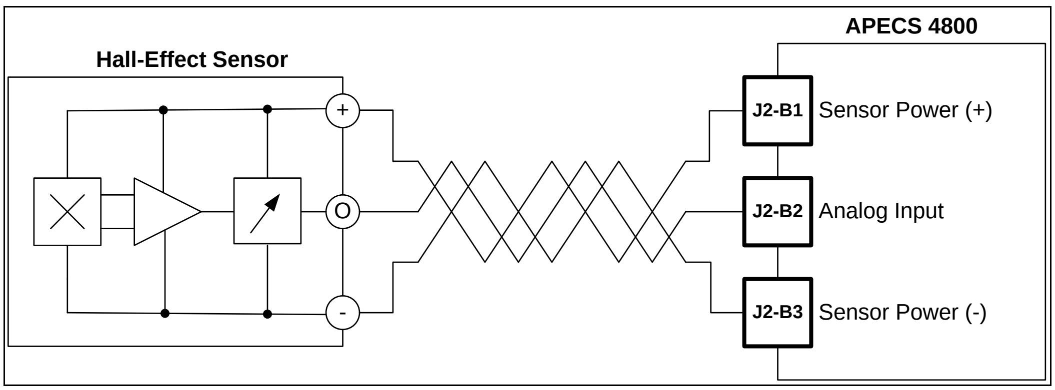


Figure 3-13. Actuator Position Sensor

Air Pressure Sensor Input

Table 3-8. Air Pressure Sensor Input Pins

Pin	Function
J2-H1	MAP +5V
J2-H2	MAP IN
J2-H3	MAP -

The air pressure sensor (or MAP – Manifold Absolute Pressure sensor) is used for the controller's Black Smoke Control feature. 5 Vdc and ground are provided for connection of a three-terminal air pressure sensor. A calibration table is provided in the software tool to characterize the specific voltage vs. air pressure.

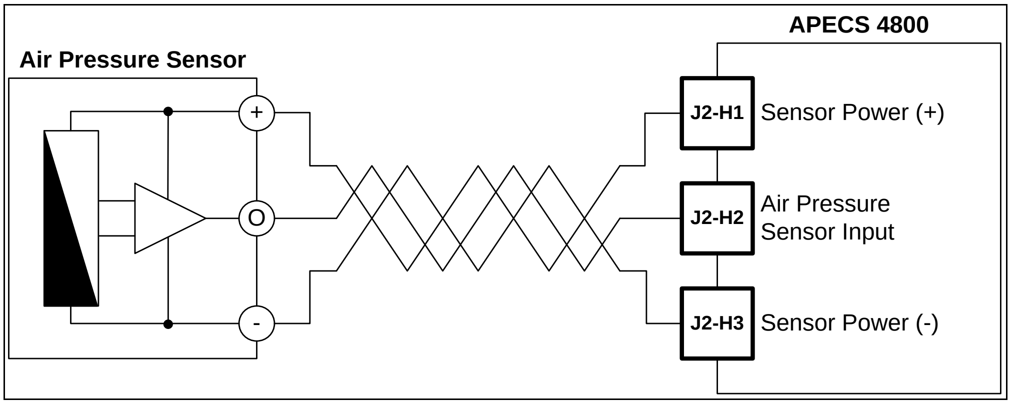


Figure 3-14. Air Pressure Sensor Wiring

RS-232 Communications

Table 3-9. RS-232 Communications Pins

Pin	Function
J2-C1	RS-232 Tx
J2-C2	RS-232 Rx
J2-C3	RS-232 Common

The APECS 4800 has one RS-232 serial port that is used to download new application software or to provide communications between the control and a PC service tool using Woodward's Service Tool software.

CAUTION

There is a potential for serial port damage when communicating with the APECS 4800 control. This is caused by a difference in AC voltage between neutral and earth ground. If the PC RS-232 port ground is referenced to AC neutral, and the APECS 4800 control is referenced to battery ground (AC earth ground), a large amount of current can be experienced. To avoid this situation, we strongly recommend placing an isolation transformer between the AC outlet and the PC.

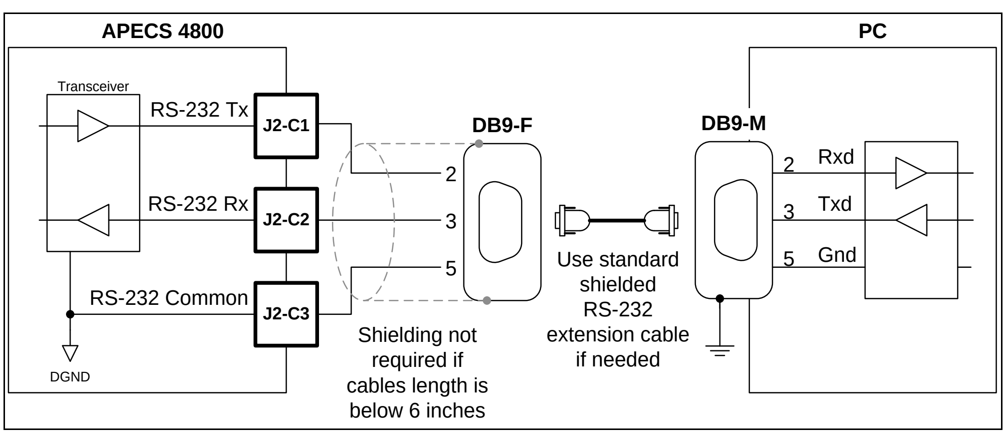


Figure 3-15. RS-232 Interface Wiring

IMPORTANT **Serial communication port is intended as service and monitoring ports; no critical functions should be attributed to them. Data is sent in a free-run mode such that the port is serviced when the microprocessor has extra time.**

Discrete Inputs

Table 3-10. Discrete Inputs Pins

Pin	Function
J2-D1, J2-D2, J2-D3, J2-E3, J2-K3	Discrete Input, switched to VBAT
J2-E1, J2-E2	Discrete Input, switched to ground

There are seven discrete inputs on the APECS 4800. The discrete inputs on the APECS 4800 control can be used to monitor the state of a battery-referenced contact switch. The function of each input is configured in the software tool and stored in controller settings. If less than seven discrete inputs are needed by application, the remaining inputs should be left unconnected.

The electrical connection of each input is fixed. Five inputs are connected in relation to battery voltage and two inputs are to be connected in relation to ground. Each discrete input logic may be configured with software; therefore the contacts may be either normally open or normally closed.

Discrete inputs have identical hardware filtering characteristics. See Appendix A for details.

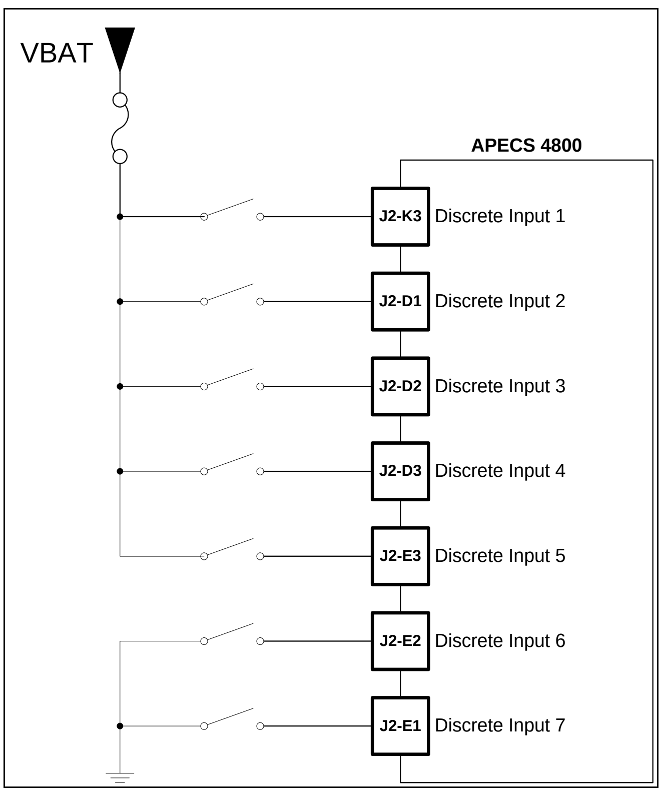


Figure 3-16. Discrete Inputs Wiring

Speed Setpoint Potentiometer (RSP) Analog Input

Table 3-11. Speed Setpoint Potentiometer (RSP) Analog Input Pins

Pin	Function
J2-F1	RSP +
J2-F2	RSP Input
J2-F3	RSP -
J2-J3	RSP Shield

The APECS 4800 provides a dedicated input for an analog signal from the Speed Setpoint Potentiometer (or RSP – Remote Speed Potentiometer). The controller supplies 5 Vdc and ground, and receives a single voltage signal input. The voltage input is ratio-metric to reference (supply) voltage. The potentiometer input accepts a 0-5 Vdc signal from the potentiometer. Potentiometer resistances of 3-5 kΩ are recommended.

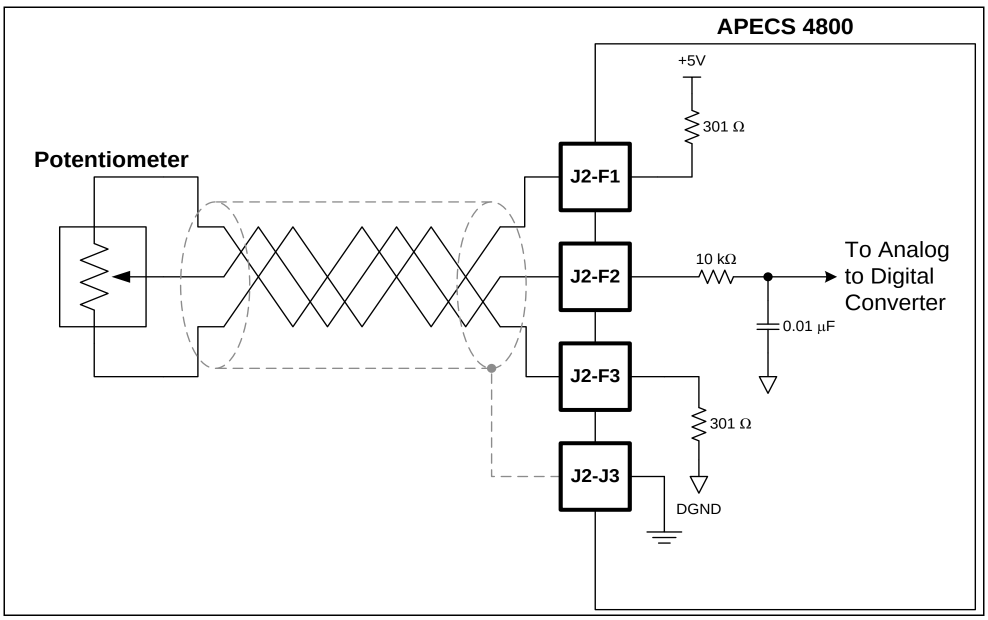


Figure 3-17. Speed Setpoint Potentiometer Wiring

Speed Setpoint Potentiometer input can also be used to connect an external analog speed controller. The controller is expected to provide voltage output in the range of 0-5V. Typically, the voltage range of external controller output is 0.5V-4.5V, which allows for diagnostics of an unconnected sensor by signal out of range detection. Power supply must be provided for sensor externally and may not be drawn from RSP+ pin.

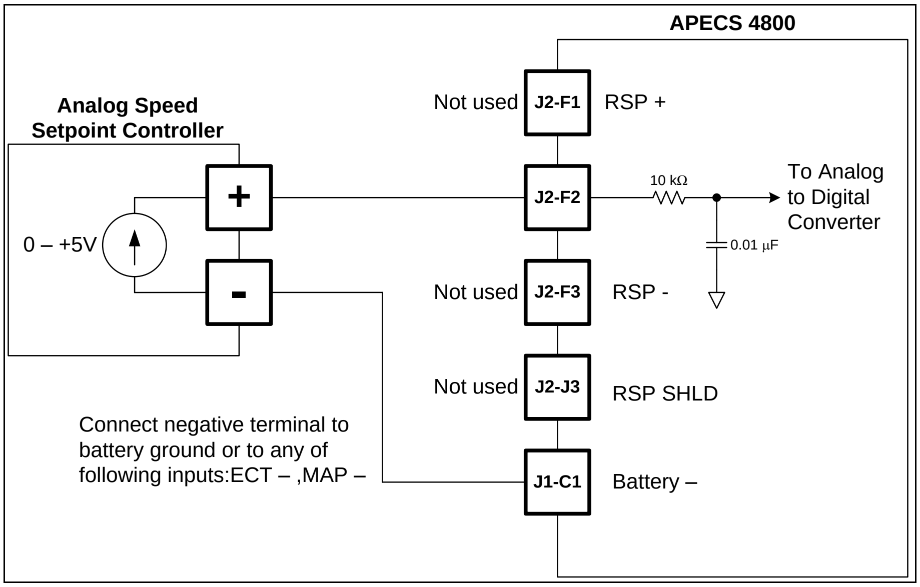


Figure 3-18. Analog Speed Setpoint Controller Wiring

Droop Setpoint Potentiometer (DSP) Analog Input

Table 3-12. Droop Setpoint Potentiometer (DSP) Analog Input Pins

Pin	Function
J2-G1	DSP +
J2-G2	DSP IN
J2-G3	DSP -

The APECS 4800 provides a dedicated input for an analog signal from Droop Setpoint Potentiometer (DSP). The controller supplies 5 Vdc and ground, and receives a single voltage signal input. The voltage input is ratio-metric to reference (supply) voltage. The potentiometer input accepts a 0-5 Vdc signal from potentiometer. Potentiometer resistances of 3-5 kΩ are recommended.

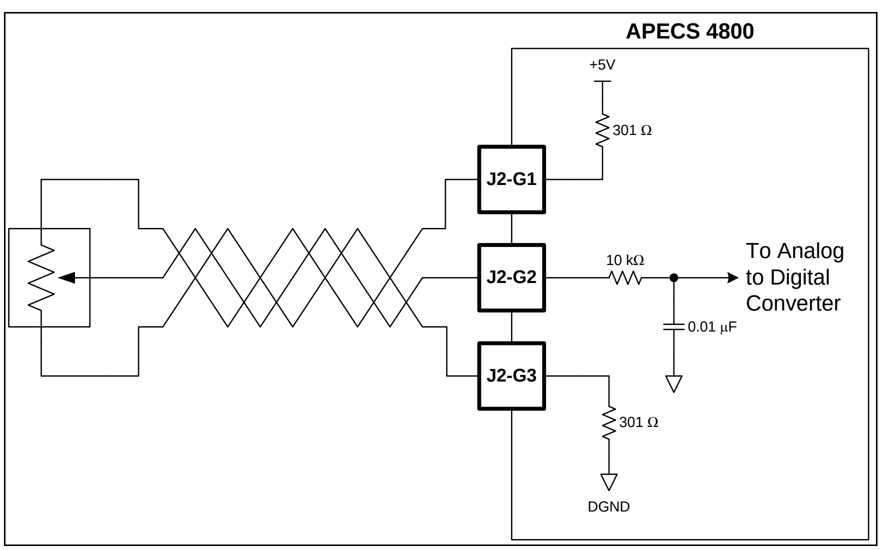


Figure 3-19. Droop Setpoint Potentiometer Wiring

ECT Analog Input

Table 3-13. ECT Analog Input Pins

Pin	Function
J2-K1	ECT +
J2-K2	ECT -

The APECS 4800 provides a dedicated input for analog temperature signal from Engine Coolant Temperature Sensor (ECT). A coolant sensor specific supply and return provide for a two-wire thermistor device used to sense the engine water temperature for purposes of engine startup fuel adjustment and engine diagnostics. The input is single ended with a 2.74 kΩ pull-up resistor to 5 Vdc. The controller provides a two-terminal circuit, which supplies a voltage signal source and ground. A voltage divider is created with the external temperature sensor. The signal voltage is sensed at the supply terminal. The voltage input is ratio metric to reference (supply) voltage.

A calibration of resistance to temperature characteristics is done in the software tool. Users should fill in the 12-point voltage to temperature curve with voltage values calculated for thermistor used. Refer to the "Configuration" section in Chapter 6 for more information.

The analog temperature input should be used with a two-wire ungrounded temperature sensor. It is not acceptable to use an engine block ground for the sensor return.

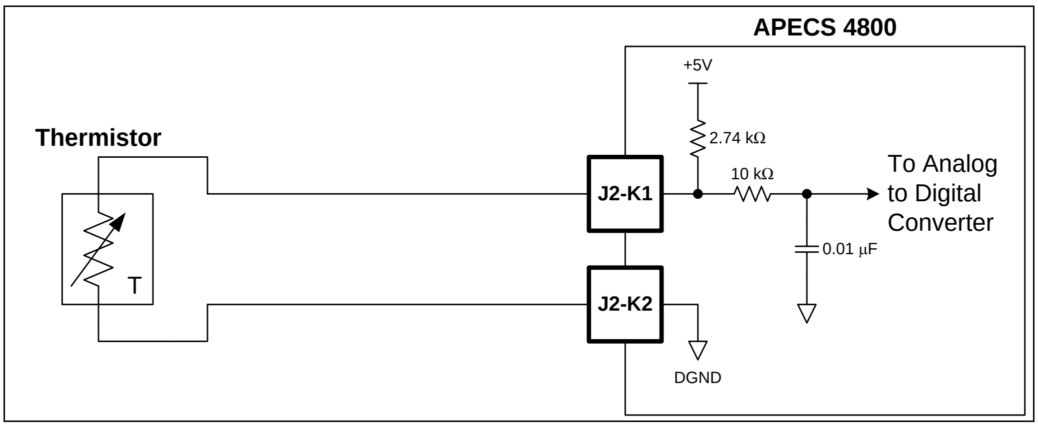


Figure 3-20. Engine Coolant Temperature Sensor Wiring

IMPORTANT **ECT input is not suitable for use with thermocouples and may be used only with thermistors.**

Chapter 4. Description of Operation

Introduction

This chapter describes the basic operation principles of the APECS 4800. Detailed information about configuring the controller for the operations described is provided in Chapter 6.

Engine Speed Control

The APECS 4800 uses two PID control loops in order to achieve precise engine speed governing. The speed control loop accepts an engine speed signal calculated from an MPU (magnetic pickup) frequency input. This signal is compared with the desired speed. The output of the speed control loop is a desired actuator position value that forms an input into a position control loop. The desired actuator position is compared with the actuator position value calculated from the analog position sensor input. The output of the position control loop is the duty cycle of the actuator PWM output.

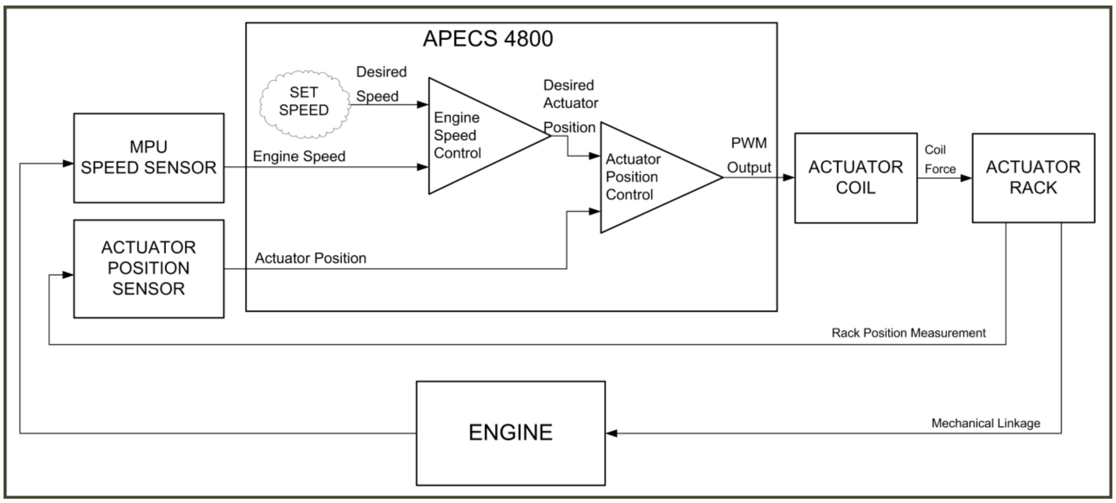


Figure 4-1. APECS 4800 General Control Diagram

Engine Starting

Engine speed input is continuously monitored and the engine is assumed to be in one of the three states:

1. *Stopped:* no speed input signal detected or signal frequency is below 50 rpm.
2. *Cranking*: engine speed is detected but did not pass CRANK_TO_RUN value.
3. *Running:* engine speed passed CRANK_TO_RUN value.

When the engine is stopped, 0% actuator position is commanded. During engine cranking, the 4800 controller opens the actuator to allow enough fueling for engine to start. The actuator position during engine crank is limited in order to reduce over fueling the engine at startup. The actuator position limit can either be fixed or adjusted as a function of the engine coolant temperature. The controller assumes that engine is cranking when speed input signal is being observed. No additional signals to the APECS controller are required.

On some systems there may be a requirement to force crank actuator position without speed being sensed. This may be caused by the speed sensor signal voltage being out of specification at engine cranking speed. Other examples are gensets, which sense engine speed from the generator output. Two configuration options are provided in order to address this situation:

- *Force crank actuator position for defined time after controller powerup*. No additional physical connections are required.
- *Use Autostart Enable discrete input to force crank actuator position.* This requires connection of a discrete input that will be activated together with the starter motor. Normally it is wired to the START position of the keyswitch. Speed sensor failure may be detected if no speed appears after Autostart Enable inputs has been activated. Refer to LOSS_OF_SPEED fault description in "Diagnostics" section of Chapter 4.

In both cases, crank actuator position will be forced on until engine speed exceeding CRANK_TO_RUN values is detected.

Additionally, the controller provides an autocrank procedure for starting the engine remotely by controlling the starter motor relay. This is described in the "Autocrank and Glowplug Control" section.

After engine speed has passed CRANK_TO_RUN value, actuator position is commanded by the PID (Proportional, Integral, Derivative) engine speed governor, based on the desired speed value and the measured engine speed. Engine desired speed is ramped from SET_SPEED_START to the desired speed following RAMP_UP_START_RATE value. After this first ramp is finished, RAMP_UP _RATE and RAMP_DOWN_RATE are used for any speed setpoint changes.

The APECS 4800 has a warm-up speed feature. If used, the first speed commanded after startup will be configurable SET_SPEED_WARMUP. Warm-up time is calculated based on engine coolant temperature from a 3-point curve. After warm-up period has ended, the engine speed will be ramped towards the configured speed setpoint.

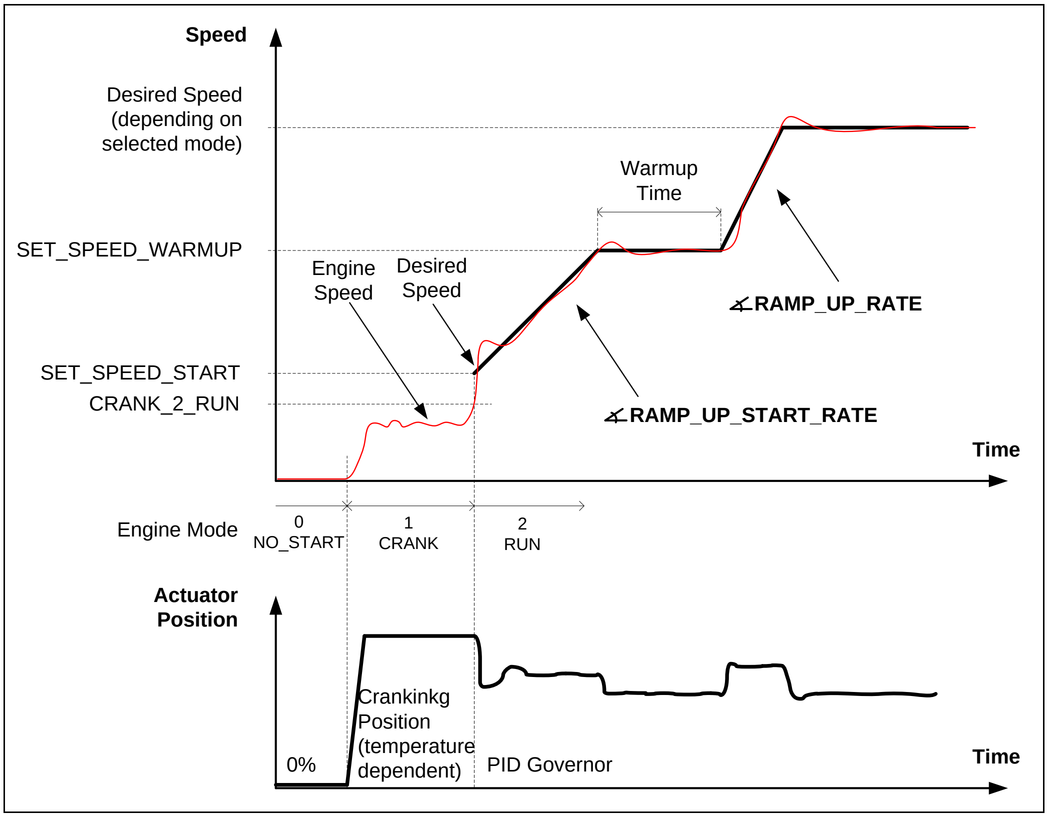


Figure 4-2. Engine Starting Overview

Speed Governor Operation

After the engine is started, the APECS 4800 speed control algorithm will perform the following functions:

- Desired speed is calculated according to currently active speed mode.
- Droop module adjusts the desired speed according to engine load.
- Engine Speed Control PID governor commands the desired actuator position.
- Output of speed governor is limited by a value calculated in the following modules:
  - Torque Limit module
  - Black Smoke Control module
  - Limp Home module in case of oil pressure or over-temperature failures
- Actuator Position Control PID governor commands the output PWM signal to the actuator.

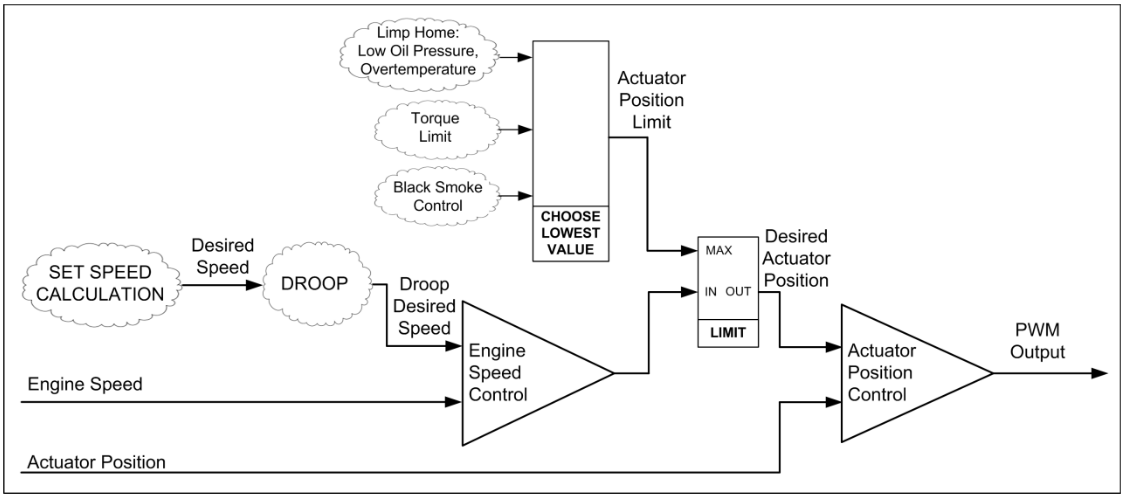


Figure 4-3. Speed Governing Diagram

Speed governor output working range is limited by configurable desired position low and high limits. The default is a full working range (0 – 100%).

If an engine overload situation causes the engine speed to remain below speed setpoint for some period of time, the integral portion of PID output will grow to its maximum allowed value. If increasing actuator position at some point does not affect engine speed, this excessive integral portion will take time to "unwind" before engine speed is properly controlled. This situation is referred to as an "integral windup."

"Integral windup" protection is provided in the controller with SPEED_INTEGRAL_LO_LIMIT and SPEED_INTEGRAL_HI_LIMIT parameters. These values specify desired position where integrator calculation is stopped. The default value for SPEED_INTEGRAL_HI_LIMIT is 95%. It may be decreased in order to reduce overspeed that may occur after prolonged underspeed condition. Similarly, increasing SPEED_INTEGRAL_LO_LIMIT from default value will reduce recovery time after prolonged overspeed condition.

Speed Governor Gains Options

The APECS 4800 provides the following gain configuration options for the speed governor:

- Speed-based scaling for PID gains, with configurable 8-point curve for each gain
- Temperature based scaling for the Master Gain, using a configurable 5-point curve
- Dual Proportional Gain

The Dual Proportional Gain feature modifies the proportional gain depending on the magnitude of the speed error. If the speed error magnitude is less than the DUAL_P_GAIN_WINDOW value, the proportional gain value is not modified. If the speed error value is greater than the DUAL_P_GAIN_WINDOW, the proportional gain is multiplied by the DUAL_P_GAIN_RATIO. If the

DUAL_P_GAIN_RATIO entered is larger than 100%, the result is an increased proportional gain for errors outside the window.

This higher gain produces a faster actuator output response to quickly restore the process setting. The primary gain setting is restored once the control senses a return to steady-state operation (see Figure below). Setting the DUAL_P_GAIN_RATIO to 100% disables this function.

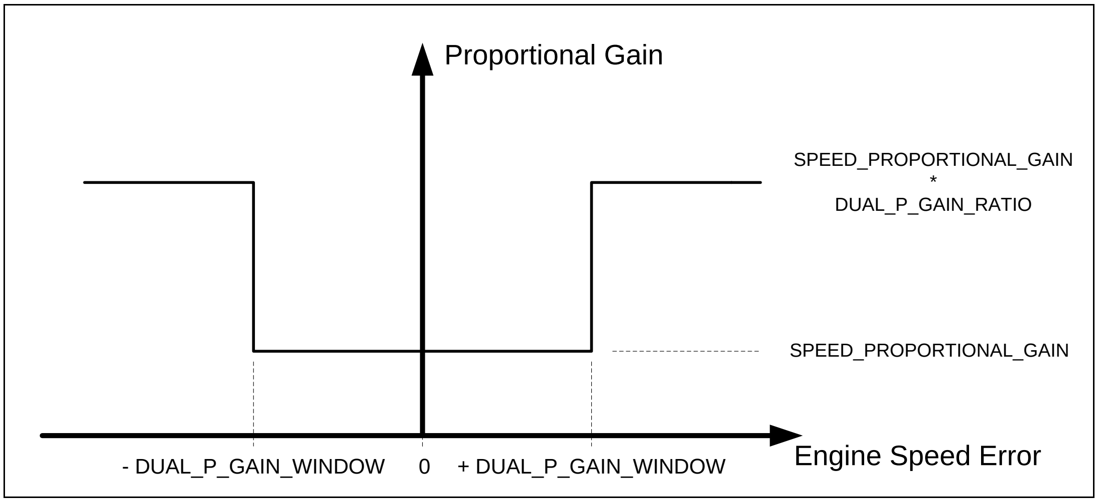


Figure 4-4. Dual Proportional Gain

Speed Setpoint Options

Speed setpoint mode defines the algorithm that is used to calculate the desired engine speed. The APECS 4800 provides the following speed setpoint modes:

- Speed setpoint controlled with switches – either multiple fixed speeds or variable speed with inc/dec switches.
- Speed setpoint controlled with analog input, with the following configuration options:
  - Speed potentiometer input
  - Drive-by-wire pedal
  - Speed trimming input
  - PTO (Power Take Off) discrete input available for drive-by-wire and speed pot modes
  - IVS (Idle Verification Switch) and brake discrete inputs options available for drive-by-wire
- CAN J1939 commanded speed

Additionally, the speed mode can be alternated when the system is running with up to two speed mode discrete inputs. Up to four speed modes may be defined and selected with speed mode switches. Active speed mode is selected using the SS_MODE discrete inputs according to the table below.

The speed mode switch can be used, for example, as a two-position switch that alternates controller between CAN and a fixed speed.

Table 4-1. Speed Mode Switches

SS_MODE1 Switch State	SS_MODE2 Switch State	Selected Speed Mode
0	0	SET_SPEED_MODES[0]
1	0	SET_SPEED_MODES[1]
0	1	SET_SPEED_MODES[2]
1	1	SET_SPEED_MODES[3]

For systems not requiring this function, single speed mode is configured and no discrete inputs for mode selection are used.

The 4800 controller allows defining ramp rates for desired speed that are used in all speed modes when new speed setpoint is selected.

Switched Speed Operation

In this mode, speed setpoint is controlled with discrete inputs. Proper configuration for switches used in the application must be set. Three options are available:

- Fixed Set Speeds with up to two toggle switches or no switches for single speed
- Linear inc/dec discrete inputs for external synchronize.
- Logarithmic inc/dec discrete inputs for momentary switches

Note that APECS 4800 discrete inputs functionality is configured in software but proper electrical connection must be followed. Refer to discrete inputs wiring (**Figure 3-16**) and discrete inputs configuration in **Chapter 6**.

Switched Fixed Speeds

The APECS 4800 allows configuring four fixed speed values. The currently selected speed is controlled with SS_SELECT discrete inputs.

Table 4-2. Switched Fixed Speeds

SS_SELECT1 Switch State	SS_SELECT2 Switch State	Selected Set Speed
0	0	SET_SPEED[0]
1	0	SET_SPEED[1]
0	1	SET_SPEED[2]
1	1	SET_SPEED[3]

Depending on the number of speed settings required by the application, the appropriate number of Set Speed Select discrete inputs should be configured. For single speed applications, no discrete inputs are configured. For two speed mode, a single discrete input is required, normally wired to the toggle switch. For three or four speed applications, two discrete inputs are required, usually wired to a rotary switch.

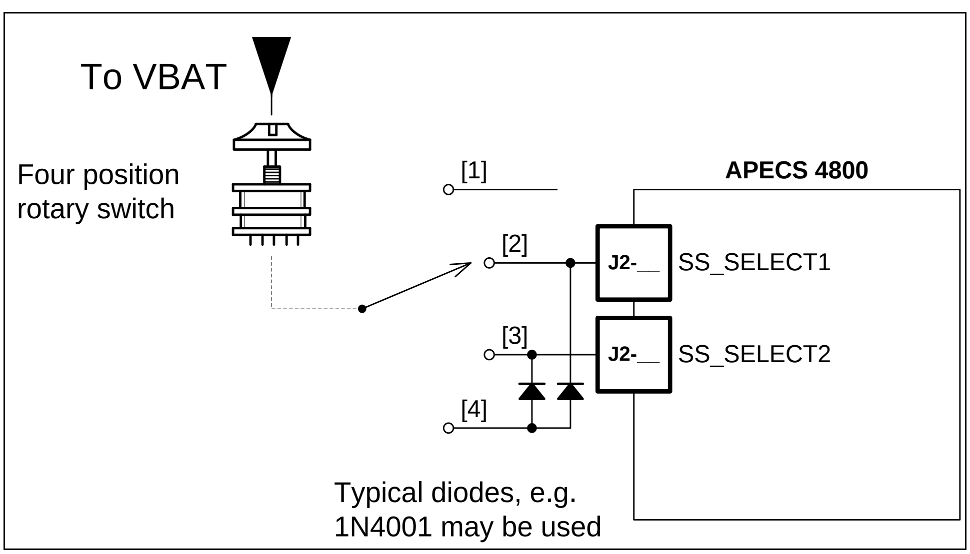


Figure 4-5. Example of Speed Select Switches Wiring for Four Speeds

Speed decrease delay function is available with configurable delay time. If new lower set speed is selected with switches, controller will keep previous value for this time before ramping down. Setting SPEED_DECREASE_DELAY to zero disables this feature.

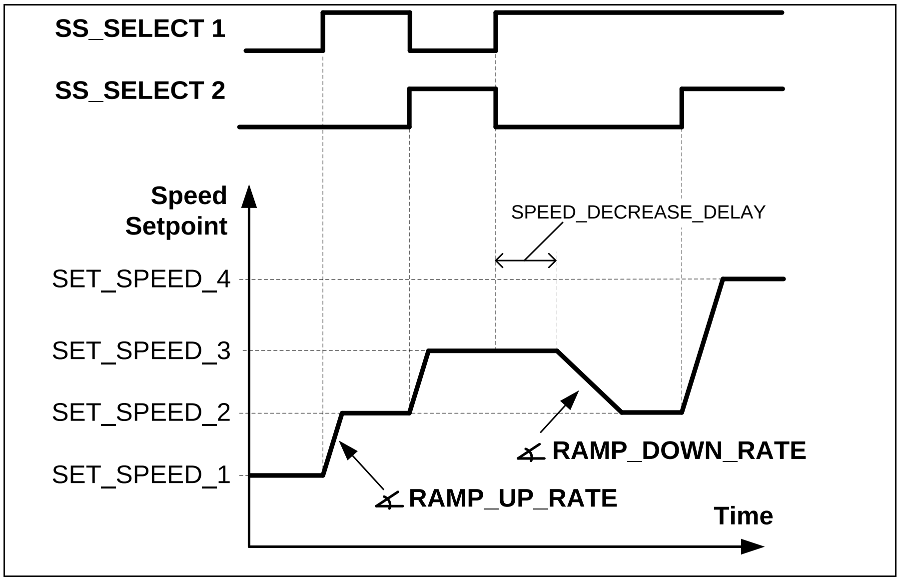


Figure 4-6. Fixed Speeds Operation

Linear inc/dec switches

In this configuration:

- Set Speed Switch 1 (SS_SELECT1) works as DEC (Speed Decrease) input
- Set Speed Switch 2 (SS_SELECT2) works as INC (Speed Increase) input.

When appropriate input is ON, desired speed is ramped up/down with configured ramp rate. Speed values commanded in this mode are limited by SET_SPEED_MAX and SET_SPEED_MIN parameters.

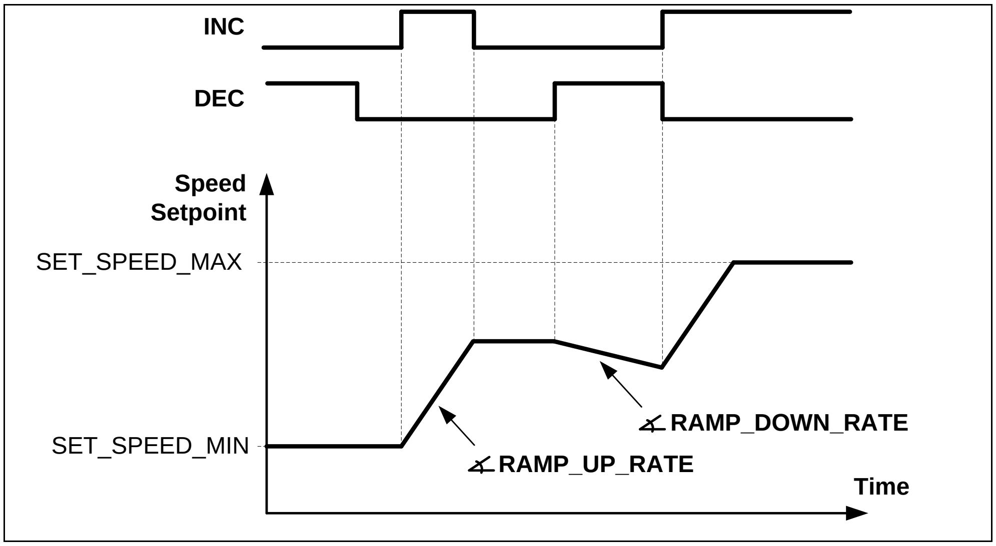


Figure 4-7. Linear Inc/Dec Switches Operation

This switch mode is intended for digital speed synchronizers used in electrical generators connected to main.

Logarithmic Inc/Dec Switches

Logarithmic operation for inc/dec switches adds functionality that facilitates use of inputs like an operator's momentary switches. Operation is modified in the following way:

- If switch is pressed and released instantaneously, speed setpoint is changed by 1 rpm only.
- If switch is kept pressed, speed will start increasing slowly, and then change rate is gradually increased up to defined ramp rate.
- After the switch has been released, the engine change speed command is stopped – speed setpoint will ramp toward present engine speed. This helps enable precise engine speed setting.

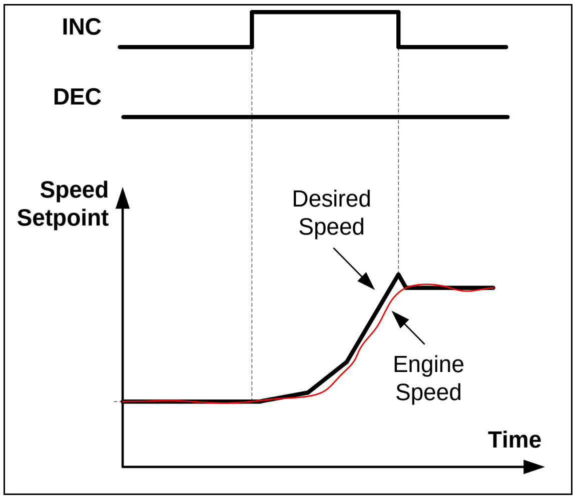


Figure 4-8. Logarithmic Inc/Dec Switches Operation

In this mode, SS_SELECT switches are normally wired to a single, two-position momentary switch.

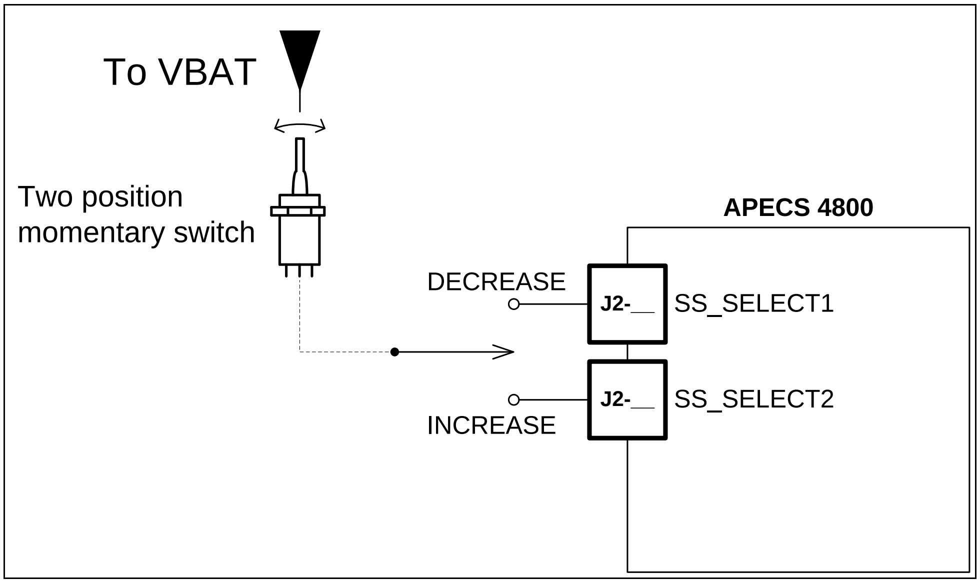


Figure 4-9. Example of Speed Select Switches Wiring for Inc/Dec Switches

Analog Speed Setpoint Operation

Analog speed setpoint modes are generally divided into three groups:

- Speed potentiometer
- Drive-by-wire
- Speed trimming input

In **potentiometer mode**, the speed setpoint is commanded directly by the calculated Speed Setpoint Potentiometer value as a percentage between range SET_SPEED_MIN and SET_SPEED_MAX. Reverse operation is available.

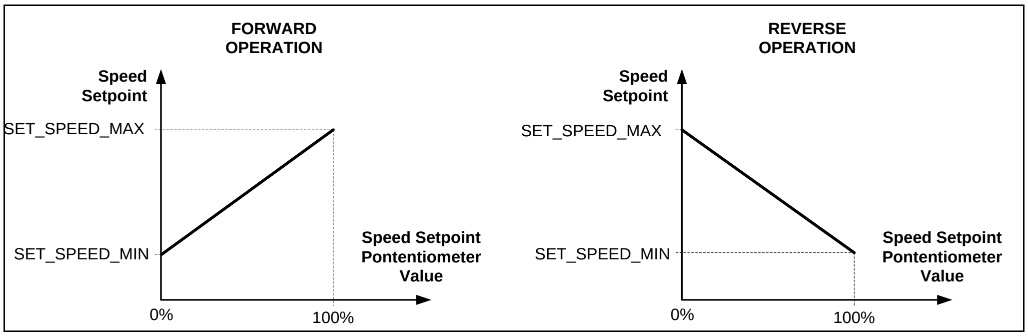


Figure 4-10. Speed Potentiometer Forward and Reverse Operation

If the speed potentiometer with PTO (Power Take Off) mode is selected, the PTO discrete input will change setpoint source to switches on activation. Both fixed speed switches and inc/dec switches configurations may be used in PTO mode. If inc/dec switches are used, controller will go to warmup speed first if PTO input is activated.

Note that maximum rate of speed setpoint change is limited by defined ramp rates. This affects both speed potentiometer and PTO operation, as well as transitioning between them.

Drive-by-wire mode is intended for use with a speed pedal. It is similar to the speed potentiometer mode with following additional features:

- IVS (Idle Verification Switch) input or brake input is available.
- If IVS is not used, minimum Speed Setpoint Potentiometer signal value must be seen after controller power up before any off-idle speed command is accepted.
- If PTO is used, engine is not allowed to start in PTO. After each engine start, operator has to cycle the PTO switch OFF and then back ON to enable PTO operation. This operation may be disabled in configuration.
- Warmup feature is not used.
- PTO speed setpoint operation may be overridden by pedal setpoint if the latter is higher. As a result, PTO speed will be treated as a minimum speed setpoint. See Figure 4-11 for resulting desired speed curve. This operation may be disabled in configuration.

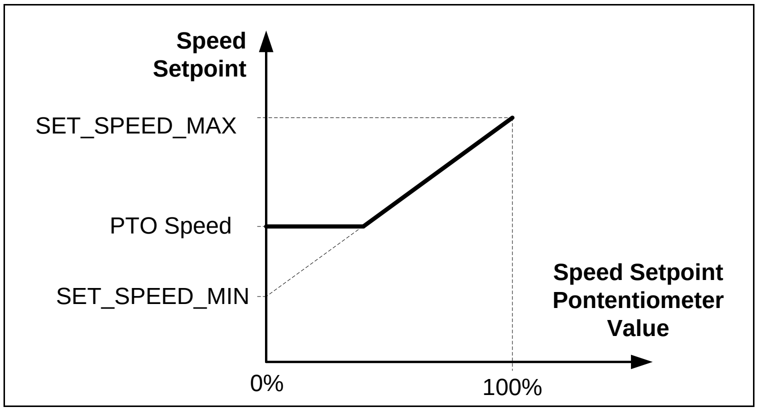


Figure 4-11. PTO Operation In Drive-by-Wire Mode (PTO Input Active)

If IVS input is used, it is expected to be ON when pedal is in idle position. IVS_CONFLICT fault will be enabled in two situations:

- Potentiometer setpoint is above 50% and IVS is ON.
- Potentiometer setpoint is at minimum and IVS is OFF.

As long as IVS input is ON (signaling idle potentiometer) or IVS_CONFLICT fault is active, the potentiometer speed setpoint will be limited to 10%.

If brake functionality is used, it uses IVS input to command immediate return to idle speed. If brake and PTO inputs are both used, brake has the priority.

Speed trimming mode is intended for use with analog speed biasing controller connected to Speed Setpoint Potentiometer. Fixed speed switches are used for a base speed setpoint in this mode (inc/dec switches option is not available). The speed is adjusted with +/- SET_SPEED_TRIM value as presented in Figure 4-12.

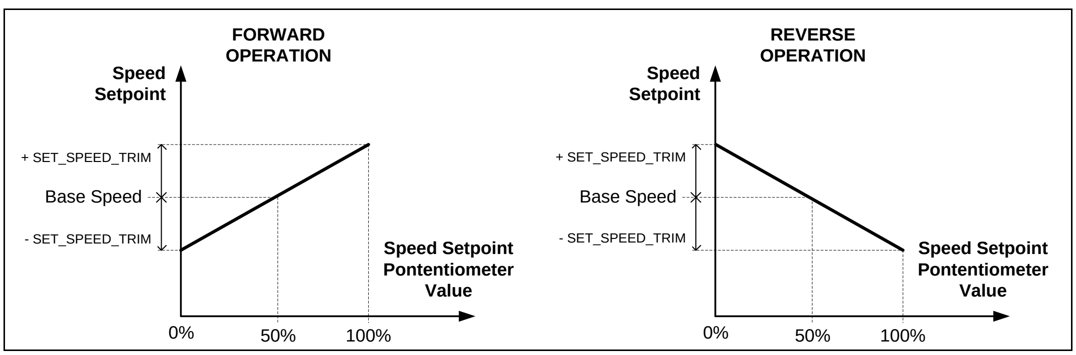


Figure 4-12. Speed Trimming Forward and Reverse Operation

CAN J1939 Speed Setpoint

In CAN J1939 mode, speed is commanded with SPN 898 sent in Torque/Speed Control 1 (TSC1) PGN. CAN module must be enabled. If TSC1 frame is not received within configurable PGN_TSC1_TIMEOUT, configurable CAN_DEFAULT_SPEED will be commanded. Warmup speed feature is not used in CAN speed mode.

Actuator Position Control

Actuator Position Sensing

An analog voltage on the actuator position sensor signal input is converted into a 0 – 100% actuator position calculated value. Two levels of out-of-range diagnostics is performed. The following ranges for position signal are defined:

- *Actuator working range.* Actuator position is linearly calculated, see below in this chapter.
- *0% and 100% passive range.* This is the dead band range for the actuator signal, controlled with the APS_FULL_DEADBAND and APS_IDLE_DEADBAND parameters.
- *POSITION_CAL_HI/LO fault range*. In this region, an indication-only fault is enabled, usually indicating that the actuator has travelled out of mechanical bounds.
- *POSITION_SENSOR_HI/LO fault range*. If a signal in this range is detected, the position sensor is assumed to be damaged or miswired, resulting in an engine shutdown or limp home operation with the position governing loop disabled. Refer to Chapter 4: Limp Home Operation for more information.
-

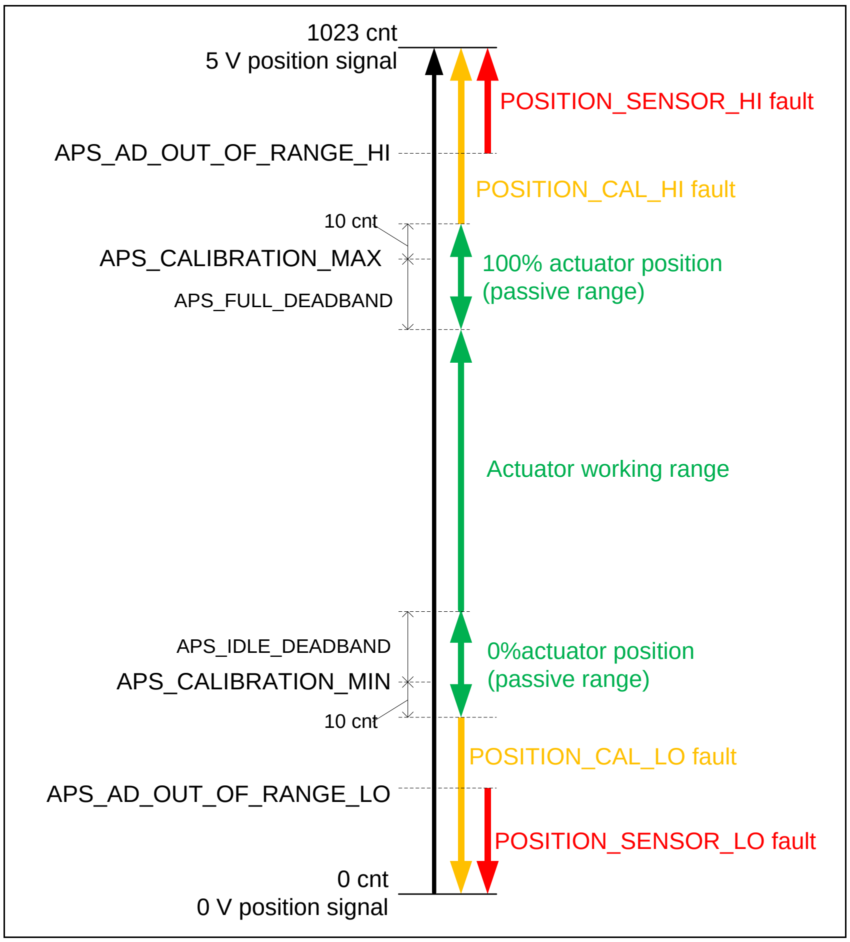


Figure 4-13. Actuator Position Sensor Input Ranges Diagram

The actuator working range is defined by the following parameters: (APS_CALIBRATION_MIN + APS_IDLE_DEADBAND, APS_CALIBRATION_MAX - APS_FULL_DEADBAND). The actuator position is calculated linearly in this region. The input signal is filtered with a lowpass filter.

The configurable offset is added to the calculation result. It may be used to compensate for the mechanical variation of actuator installation (e.g. additional gasket).

Actuator Position Governor Operation

The actuator position commanded by the speed control loop is maintained using a PID (Proportional, Integral, Derivative) control algorithm. Actuator position is adjusted by changing actuator current with PWM (Pulse Width Modulated) output. The user is required to tune PID gain values properly according to the dynamics of the actuator.

The controller provides two gain sets:

- Startup gains – used when engine is cranking.
- Runtime gains – used when engine is running.

Additionally, the controller provides position-based scalers defined in an 8-point curve for each gain. This allows for compensating for spring force variability through rack movement range.

Position governor output working range is limited by values ACT_PWM_DUTY_LO_LIMIT and ACT_PWM_DUTY_HI_LIMIT (both expressed as % duty cycle). Expanding working range is not advised. The default values of 5% and 95% are suitable for most systems.

“Integral windup” protection is provided with POS_INTEGRAL_LO_LIMIT and POS_INTEGRAL_HI_LIMIT parameters. These values specify output PWM duty cycle where integrator calculation is stopped. By default, these values are identical to governor output working range.

In situations where commanded actuator position may not be achieved and actuator settles at higher position (e.g. due to excessive system spring force), integrator will “wind down” fully below value when duty cycle change affects the actuator position. This may result in delayed answer for higher position demand. Increasing the POS_INTEGRAL_LO_LIMIT may help reduce this delay.

Similarly, decreasing POS_INTEGRAL_HI_LIMIT may improve recovery time from position too-low situation if increasing the duty cycle beyond some point does not affect actuator position anymore.

Engine Load Control

The APECS 4800 controller uses the actuator position to calculate engine load. Because the fueling/load relationship varies with engine speed, the controller provides No Load and Full Load operating lines. These lines contain 8-point engine speed vs. actuator position curves. The No Load Actuator Position and Full Load Actuator Position are calculated as a linear interpolation of these lines’ points for current engine speed.

For more configuration versatility, the second curve, called Torque Limit Line, is provided. This line defines a percentage of allowable maximum engine load as a function of engine speed. These lines also have an 8-point engine speed vs. actuator position curve. Calculated Torque Limit of 100% means that the actuator position, up to the value defined in the Full Load Line, is allowed. Calculated Torque Limit of 0% means that the actuator position will be limited to the No Load position.

The Torque Limit Line may be utilized for derating individual engine maximum torque. The Full Load Line remains unchanged and gets adjusted in desired regions. Only values up to 100% are allowed in Torque Limit Lines (allowed torque may only be decreased).

If the actuator position is lower than the No Load Position, engine load is assumed 0%. Engine Load is calculated up to 125% as a proportion of the actuator position between No Load Position and Full Load Position (including Torque Limit). Full Load Actuator Position forms an actuator position limit. If speed governor reaches this position and is not able to maintain the desired speed, TORQUE_LIMIT_ACHIEVED fault will be activated.

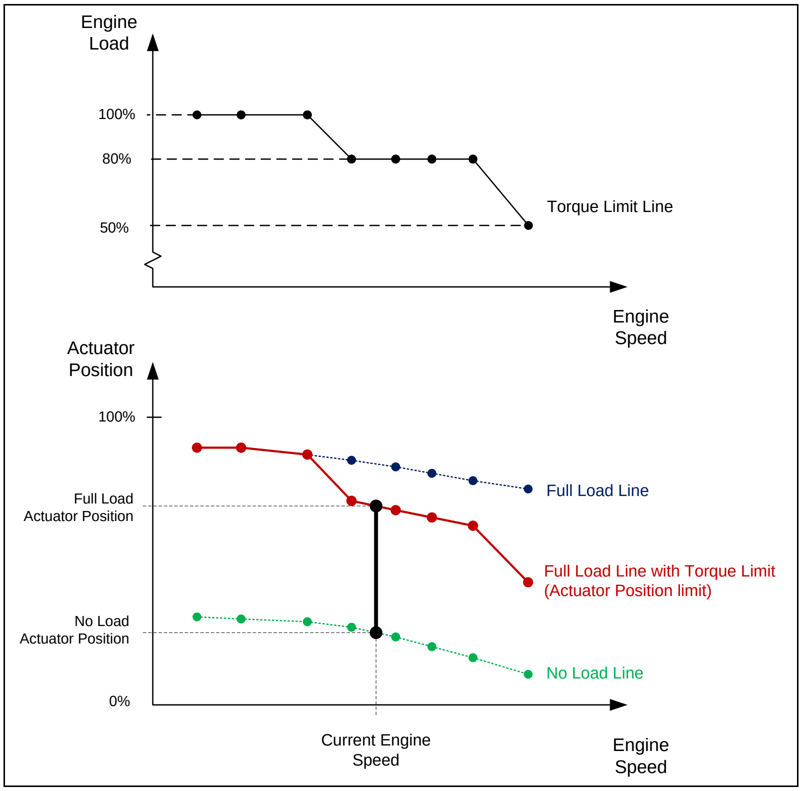


Figure 4-14. Torque Lines Operation Example

Black Smoke Control

Black smoke control is achieved by limiting fuel based on manifold air pressure and the actual engine speed. The position limit is calculated from an 8x8 Fuel Limit Map using engine speed and air pressure values as an input. Therefore, the Fuel Limit Map contains a 64-point surface limiting the actuator position.

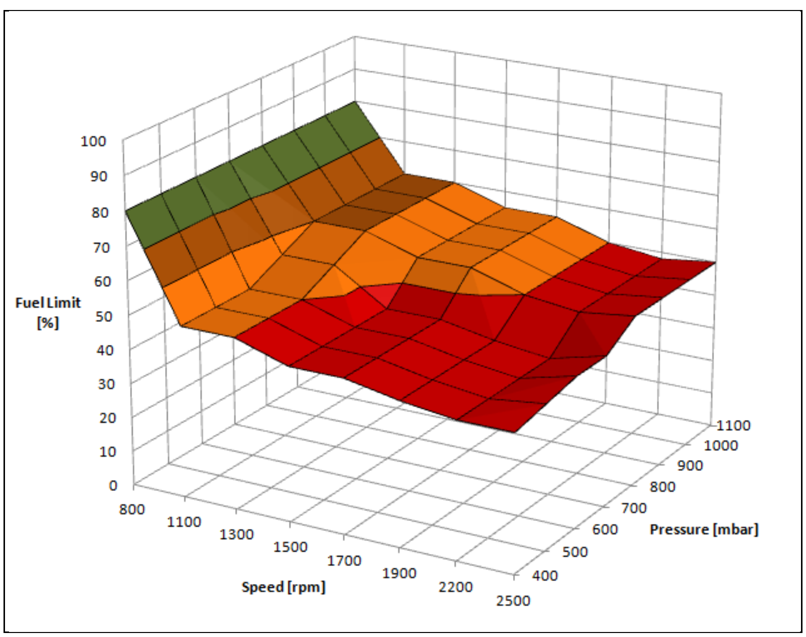


Figure 4-15. Fuel Limit Map Plot Example

A configurable offset is added to the map output. This offset may be utilized to compensate for variability of engine performance.

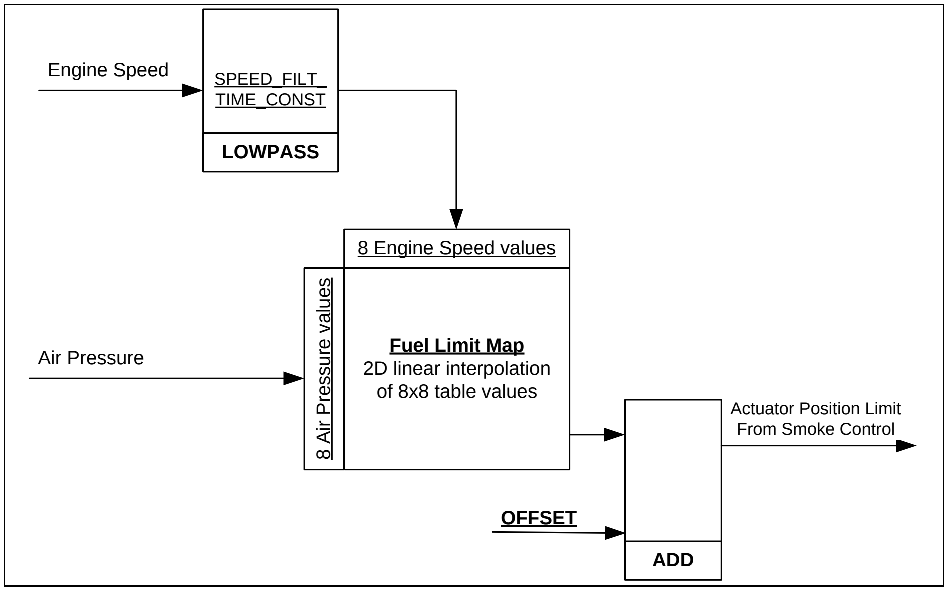


Figure 4-16. Black Smoke Control Functional Diagram

The overall position limit will be applied to the output of the speed control loop. It is only active when engine is running and thus does not affect cranking. Note that the actuator position may be limited due to other factors such as torque limiting and limp home operation. The lowest active limit is always applied.

Droop Operation

The APECS 4800's default operation is isochronous speed governing, in which the governed speed is not affected by engine load. The controller may also be configured for droop operation. With droop, governed speed is modified (normally reduced) with increasing load. Droop operation relies on engine load calculation, which is described above in "Engine Load Control."

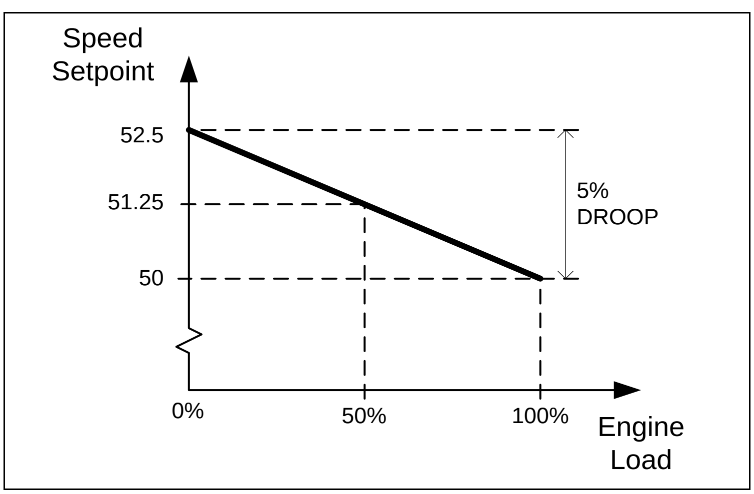


Figure 4-17. Droop Line Example

Droop setpoint (or droop rate) is the amount of speed decrease at 100% engine load. The droop setpoint may be defined in one of two ways:

- *Table*: droop setpoint is calculated from an 8-point engine speed/droop rate curve.
- *Potentiometer*: droop setpoint is adjusted with DSP potentiometer value.

Droop may be operated in two modes: industrial and generator mode. In industrial mode, Droop Desired Speed is equal to Desired Speed at no load. With increasing load, Droop Desired Speed is decreased according to the following formula:

$$Droop\ Desired\ Speed = Desired\ Speed * (1 - Droop\ Rate * Engine\ Load)$$

In generator mode, Droop Desired Speed is equal to Desired Speed at full engine load and is higher than Desired Speed for lower loads, according to the formula:

$$Droop\ Desired\ Speed = Desired\ Speed * (1 + Droop\ Rate * (100\% - Engine\ Load))$$

The APECS 4800 controller also provides a Dual Droop Configuration option with two separate droop rate values being used, depending on engine load range.

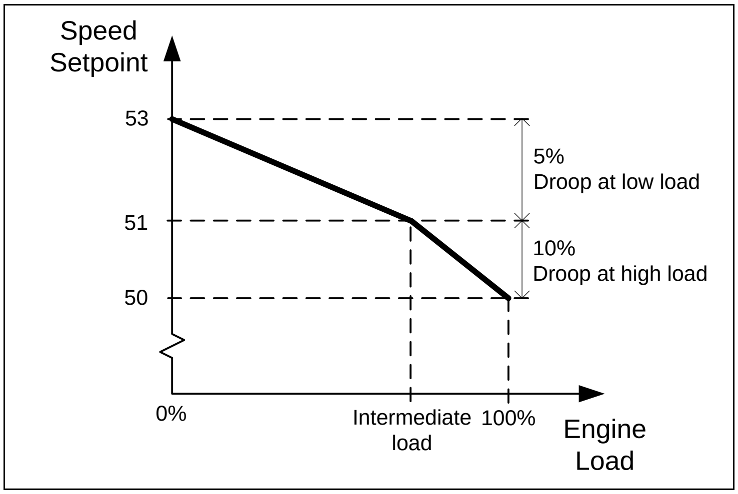


Figure 4-18. Dual Droop Line Example

In dual droop mode, an additional Intermediate Load Line must be defined. For engine load values below the intermediate line, droop is applied the same way as in single droop configuration. For engine load values above intermediate, a separate high load droop rate is applied. High load droop rate is calculated from the 8-point engine speed/droop rate curve.

EGR Relay Control

The APECS 4800 contains logic for the control of an EGR (Exhaust Gas Recirculation) on/off relay. It is controlled with three factors:

- Engine Coolant Temperature – must be higher than defined setpoint before EGR is opened.
- Engine Load – must be below defined setpoint before EGR is opened.
- Engine Speed – must be below defined setpoint before EGR is opened.

The EGR control must be calibrated and qualified to each specific engine for NOx reduction. Contact your local Woodward representative for details on this feature and its limitations.

Autocrank and Glowplug Control

Autocrank Procedure

The APECS 4800 controller provides an autocrank feature for remote starting of the engine. This feature requires the following system components:

- A switch connected to APECS discrete input configured as ASE (Autostart Enable). This switch is used by an operator to initiate engine starting. A toggle switch must be used.
- Autocrank relay controlled with APECS discrete output. This relay enables the engine starter motor.
- (optional) Glowplug relay controlled with APECS discrete output.

When Autostart Enable switch is on, preheat will begin. Preheat Time is calculated based on Engine Coolant Temperature. After preheat, Autocrank Relay becomes active. If engine does not start within the AUTOCRANK_CRANK_TIME, the relay will be disabled and controller will go to rest period for AUTOCRANK_REST_TIME.

During the rest period, the preheat will be repeated. After preheat, the next crank attempt will start. If engine does not start after maximum crank attempts, the AUTOCRANK fault will be activated.

After the engine has started, both autocrank and glowplug relays are disabled. Autostart Enable switch must remain ON throughout the engine operation. After switch is turned off, desired speed setting will be set to zero (this will override configured speed setpoint) in order to stop the engine.

When Autocrank Relay is active, controller will assume speed sensor failure if no speed sensor signal is detected for AUTOCRANK_NO_START_TIME.

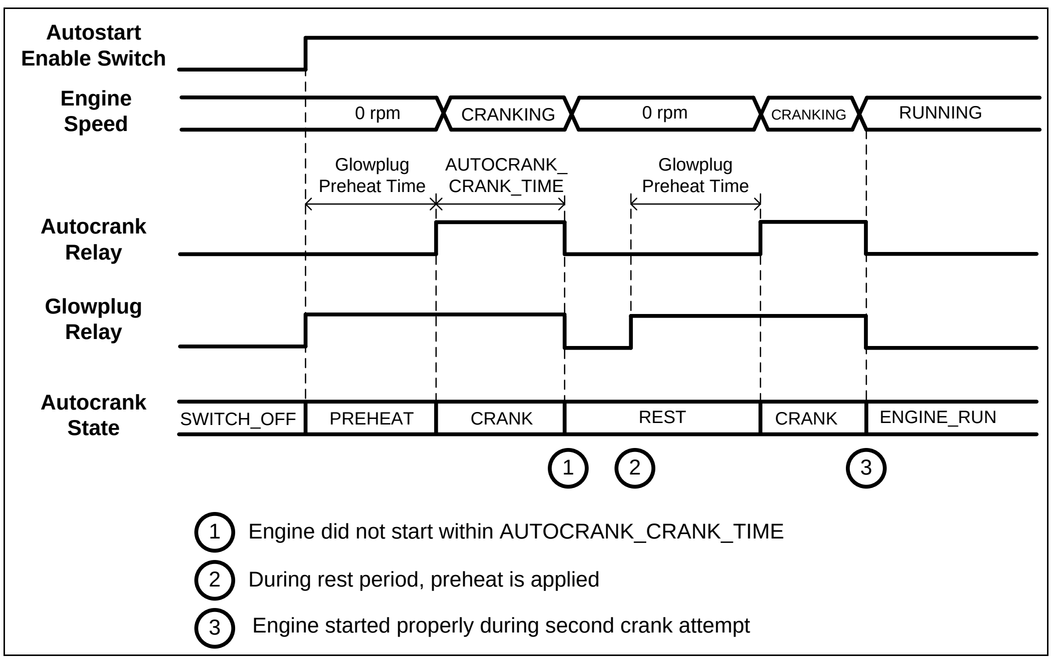


Figure 4-19. Autocrank Timing Example (Two Crank Attempts)

Independent Glowplug Operation

In systems that don't use autocrank (engine is started by an operator), the APECS 4800 controller may be configured to automatically enable the glowplug for preheat. Preheat time can be either fixed or temperature dependent. Lamp output is provided in order to signal the operator that the preheat period has ended and engine can be started.

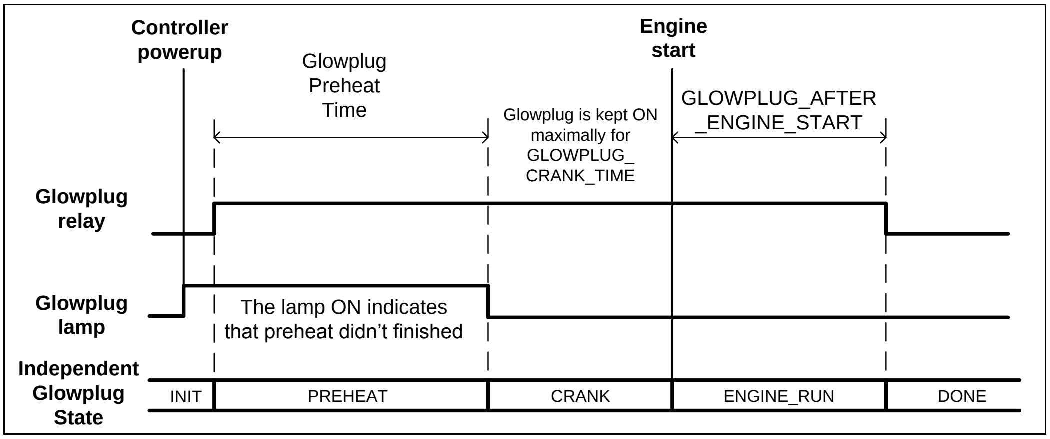


Figure 4-20. Glowplug Control Timing

Glowplug may also be kept on for configurable time after engine start. If preheat time calculated at startup is zero, the glowplug is not enabled at all.

Diagnostics

The APECS controller detects a number of abnormal conditions, called "faults". A fault is considered "active" if the condition defined for this fault is present.

Some faults alter the APECS 4800 controller operation when active, for example, an analog input value being ignored and a default value used instead. An engine shutdown is performed when some faults are activated. Additionally, the limp home mode may be configured instead of a shutdown for selected faults.

Table 4-3 gives a list of detected faults with a brief description. A detailed list of fault actions is given later in this chapter.

Each fault may be configured for latching or non-latching operation. During a non-latching operation, the controller returns to normal operation as soon as the fault condition is removed. During fault latching operation, the controller keeps the fault activated until the controller's power is cycled or all the faults are cleared (see below). Note that some faults don't allow recovery without resetting power to the controller. For those faults, setting latching operation has no effect.

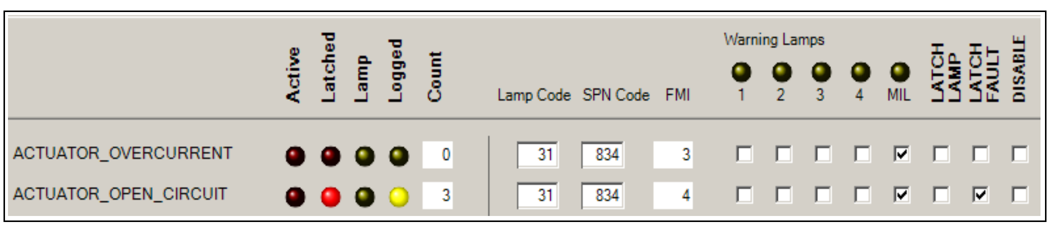


Figure 4-21. Example of Latched Fault Indication in APECS 4800 Service Tool

If a fault is latched, the controller operates the same way as if the fault were active.
Similarly to a latching fault, each fault may be configured to activate a lamp that latches on. When a latching lamp is not used, the controller disables the fault annunciation as soon as fault condition is removed. When a latching lamp is used, the controller keeps the fault annunciation on until the controller's power is cycled or the faults are cleared.

Each time a fault is activated, a logged count for this fault is increased. This allows for troubleshooting intermediate fault conditions that may appear in the system. The logged count value stops at value 126.

Table 4-3. Detected Faults

Fault Name	Short Description	Engine Shutdown	Limp Home Available
ACTUATOR_OCERCURRENT	Actuator output overcurrent	•	
ACTUATOR_OPEN_CIRCUIT	Actuator output unconnected		
APS_FREQ_OUT_OF_RANGE	Actuator Position Sensor wrong frequency		
APS_POWER_SUPPLY	J1-A2 pin short to ground	•	•
AUTOCRANK	Autocrank unable to start engine		
CAN_COMMUNICATION	CAN bus error		
CAN_RECEIVE_TIMEOUT	TSC1 frame receive timeout		
CONFIGURATION	Device configuration corrupted	•	
CPU_FAILURE	Internal hardware failure	•	
CPU_POWER_SUPPLY	Controller internal supply dropout		
DOUT_x_OVERCURRENT	Discrete output overcurrent		
DOUT_x_OPEN_CIRCUIT	Discrete output unconnected		
DROOP_SENSOR_HI/LO	Droop potentiometer input out of range		
ECT_SENSOR_HI/LO	Engine Coolant input out of range		
EEPROM_RW_FAILURE	Internal hardware failure		
HIGH_BATTERY_VOLTAGE	Battery voltage over high threshold		
LOW_BATTERY_VOLTAGE	Battery voltage below low threshold		
IVS_CONFLICT	Idle Verification Switch failure		
LOSS_OF_SPEED	MPU sensor failure	•	•
LOW_OIL_PRESSURE	Engine oil pressure low	•	•
MAP_SENSOR_HI/LO	Air Pressure Sensor out of range		
MAP_POWER_SUPPLY	J1-H1 pin short to ground.		
OPS_WIRE_BREAK	Oil Pressure Switch connection issue	•	•
OVERSPEED	Engine speed limit exceeded	•	
OVER_TEMPERATURE	Engine Coolant Temperature over threshold	•	•
POSITION_GOV	Actuator mechanically stuck	•	
POSITION_CAL_HI/LO	Actuator Position out of working range		
POSITION_SENSOR_HI/LO	Actuator Position Sensor out of range	•	•
PROTECTION_FAULT	External protection device shutdown	•	
SET_SPEED_POT_HI/LO	Speed Setpoint Potentiometer out of range		
TORQUE_LIMIT_ACHIEVED	Engine speed not achieved with max fueling		

Diagnostic Lamps and Switches

The APECS 4800 controller provides the following ways for accessing diagnostic information:

- Diagnostic lamps and switches interface – described further in this section.
- ToolKit interface – fault state may be read by service technicians using APECS 4800 PC Service Tool. See **Error! Reference source not found.Chapter 7** (Troubleshooting). Note that PC nterface is diagnostic only and is not intended for use in normal system operation.
- CAN J1939 interface. This is described in CAN J1939 DM-1 and DM-2 message descriptions.

The APECS 4800 diagnostic lamps and switches may be used to create an operator or service technician diagnostic dashboard panel interface. It consists of the following components:

- MIL (Malfunction Indicator Lamp) output
- Up to four configurable Warning Lamp outputs
- SDS (Software Diagnostic Switch) discrete input
- MCS (Memory Clear Switch) discrete input

Up to four **Warning Lamps** outputs are provided. Each warning lamp activates if the configured fault activates. Any number of faults may be configured to activate a warning lamp. Therefore, for example, a dashboard lamp indicating an actuator wiring issue (open circuit or overcurrent faults) may be created.

MIL (Malfunction Indicator Lamp) can be used to diagnose all present faults by use of a single dashboard lamp. For additional functionality, it can be used together with two optional switches: **SDS (Software Diagnostic Switch)** and **MCS (Memory Clear Switch)**.

If both MCS and SDS are pressed together for one second, the logged faults history will be cleared. As a result all logged faults will be cleared (count will be set to zero). If a given fault source is active (e.g. corresponding analog input is out of range) the logged count will be set to 1. Performing this operation will also clear latched faults.

Each fault may be assigned a configurable flash code of up to three digits long. Each digit of code is flashed separately with alternating pulses length—a short pulse for hundreds and units, a long pulse for tens. If multiple codes are flashed sequentially, they are separated with a longer OFF period.

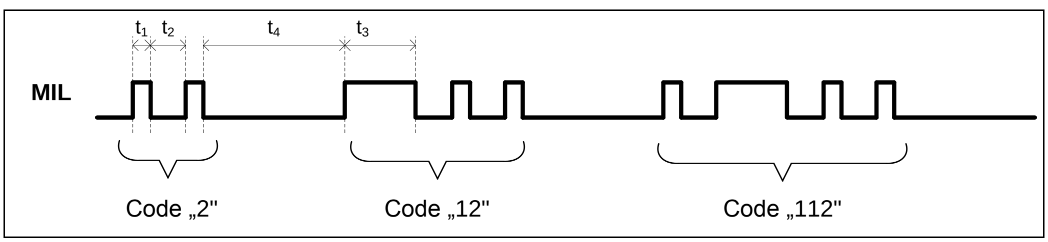


Figure 4-22. One-, Two- and Three-Digit Flash Codes Example

Table 4-4. APECS 4800 Flash Codes Timing

Symbol	Description	Value
t_1	Short blink time (for hundreds and units digit)	300 ms
t_2	OFF time within code	600 ms
t_3	Long blink time (for tens digit)	1200 ms
t_4	OFF time between codes	2400 ms

IMPORTANT **Flash code for each fault is user configurable in the APECS 4800 Service Tool.**

The MIL lamp can be configured to operate in one of two modes:

- Continuous blinking mode
- Momentary switch mode

In the continuous blinking mode, only active faults are flashed. No switch is required, although a two position switch may be used for additional functionality. If the SDS switch is set to ON, the MIL output will flash active faults' codes continuously. When the last code is flashed, it will start over from the first one. If a two-position switch is connected to the SDS input, it may be used to disable fault codes blinking, and the lamp will be lit for fault annunciation instead. After the switch is toggled ON, fault codes will begin blinking.

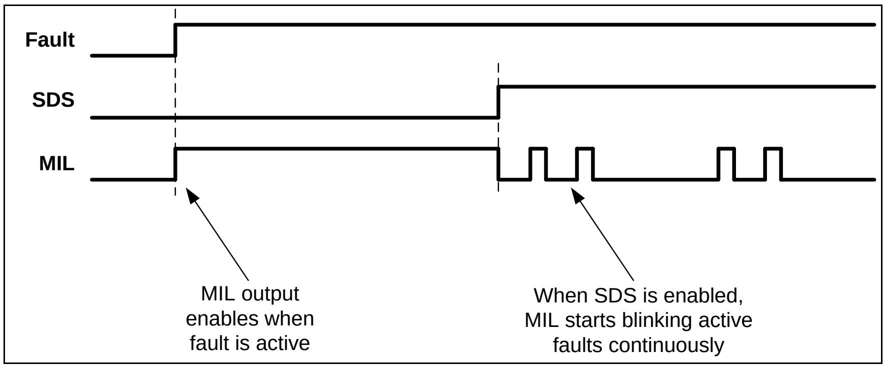


Figure 4-23. Continuous Blinking Mode with Two-Position Switch

Note: If switch is not required, SDS input should be set to ON in software tool (no physical connection to discrete input is required).

The second configuration option for the MIL output is the momentary switch mode, which both present and logged faults can annunciate using MIL output. A momentary switch connected to the SDS input is required. When at least one fault is present, the MIL lamp is enabled. The operator may press and release the SDS switch, which will trigger the flashing of active faults' codes. If the engine is not running, logged faults are also flashed. After the last fault has been flashed, the lamp returns to previous operations, i.e. stays lit as long as there is at least one active fault.

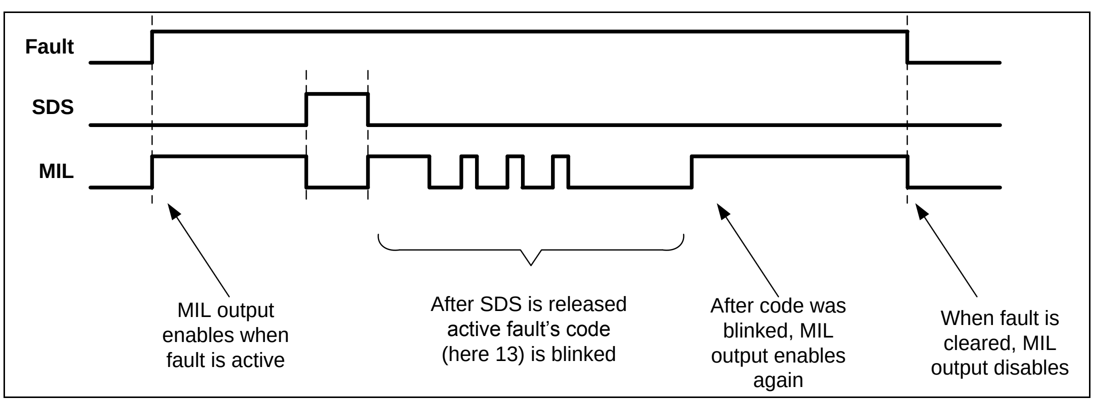


Figure 4-24. Present Fault Annunciation (Momentary Switch Mode)

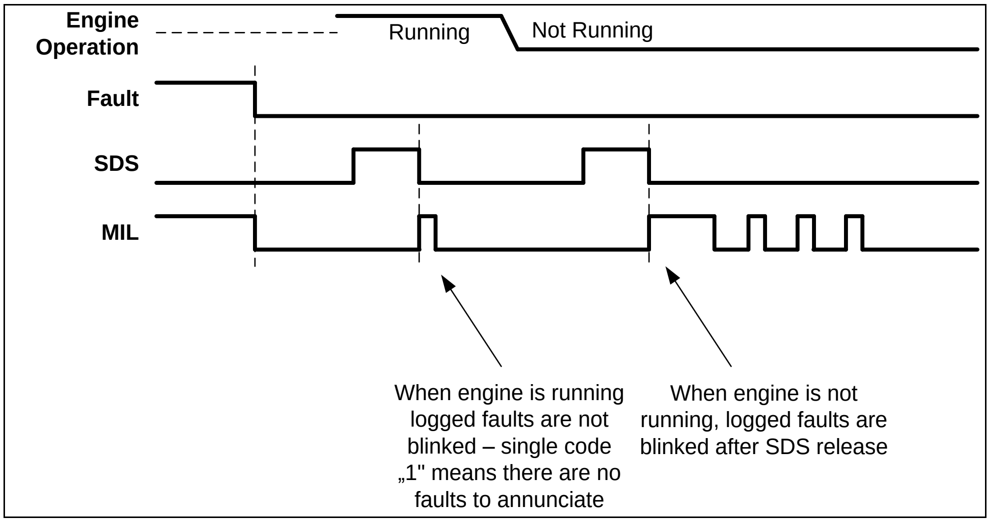


Figure 4-25. Logged Fault Annunciation (Momentary Switch Mode)

Detected Faults Description

The full list of faults detected by APECS controller is given below.

ACTUATOR_OVERCURRENT
Activated when actuator current exceeding threshold is detected.
Fault actions: engine shutdown, controller power cycle required for recovery

ACTUATOR_OPEN_CIRCUIT
Activated when PWM output is enabled and no actuator current is detected.
Fault actions: none (indication only)

APS_FREQ_OUT_OF_RANGE
Activated when incorrect frequency of actuator position sensor PWM input is detected. This fault is not used with analog position feedback actuator.
Fault actions: none (indication only)

APS_POWER_SUPPLY
Activated when Actuator Power Supply output (pin J1-A2) short circuit to ground for at least 100 ms (default value, may be configured) is detected.
Fault actions: engine shutdown, limp home mode available, controller power cycle required for recovery.

AUTOCRANK
Activated when maximum crank attempts number is exceeded during autocrank procedure.
Fault actions: none (indication only)

CAN_COMMUNICATION
Activated when CAN bus off, CAN transmitter/receiver error or CAN synchronization error condition is detected for at least CAN_LOST_DELAY (configurable parameter).
Fault actions: – none (indication only)

CAN_RECEIVE_TIMEOUT
Activated when TSC1 frame with correct SPN898 data is not received within period defined in PGN_TSC1_TIMEOUT. Setting PGN_TSC1_TIMEOUT to zero disables this fault detection.
Fault actions: setpoint in CAN speed mode is switched to CAN_DEFAULT_SPEED

CONFIGURATION
Activated when internal device configuration corruption is detected.
Fault actions: engine shutdown, controller power cycle required for recovery

CPU_FAILURE
Activated when internal device processing unit failure is detected.
Fault actions: engine shutdown, controller power cycle required for recovery

CPU_POWER_SUPPLY
Activated when controller's internal digital circuit power supply dropout is detected.
Fault actions: none (indication only)

DOUT_1_OVERCURRENT … DOUT_9_OVERCURRENT
Activated when corresponding discrete output overcurrent is detected. This is monitored when output is in enabled state.
Fault actions: discrete output is disabled, controller power cycle required for recovery

DOUT_1_OPEN_CIRCUIT … DOUT_9_OPEN_CIRCUIT
Activated when corresponding discrete output open circuit is detected. This condition is monitored when output is in disabled state, only if output is configured for operation
Fault actions: none (indication only)

DROOP_SENSOR_HI, DROOP_SENSOR_LO
Activated when Droop Potentiometer input goes outside the configured range for at least 100 ms (default value, may be configured).
Fault actions: droop input is ignored and last seen droop potentiometer value is used to calculate droop; if device powers up with this failure, DROOP_DEFAULT value is used.

ECT_SENSOR_HI, ECT_SENSOR_LO
Activated when Engine Coolant Temperature input goes outside configured range for at least 100 ms (default value, may be configured). Additionally, ECT_SENSOR_HI fault detection may be disabled until engine has been running for configured time in order to prevent fault detection because of cold NTC thermistor.
Fault actions: ECT_DEFAULT is used as engine coolant temperature value

EEPROM_RW_FAILURE
Activated, when internal device memory hardware failure is detected. This issue will also cause CONFIGURATION fault which results in engine shutdown.
Fault actions: none (indication only).

HIGH_BATTERY_VOLTAGE
Activated when battery voltage exceeding the 135% of nominal voltage is detected for at least 60 seconds (default value, may be changed). Nominal voltage is 14.5 V for 12 volts system or 28.5 V for 24 volts system.
Fault actions: none (indication only)

LOW_BATTERY_VOLTAGE
Activated when battery voltage below 9 V is detected for at least 60 seconds. Both threshold value and delay time default values may be changed.
Fault actions: none (indication only)

IVS_CONFLICT(DBW)
Activated when IVS (Idle Verification Switch) and speed setpoint potentiometer conflict is detected. This may occur in two situations:

- IVS is active and potentiometer setpoint is above 50%
- IVS is inactive and potentiometer setpoint is at minimum position

Fault actions: speed potentiometer setpoint is limited to 10% of configured range.

LOSS_OF_SPEED
Indicates that MPU speed sensor malfunction has been detected. Activated in two situations:

- When sudden drop of engine speed input frequency is detected
- When starter motor is working (autocrank or autostart enable input) for at least AUTOCRANK_NO_START_TIME and speed is not sensed

If the speed signal drops from least 1500 rpm (default value, reconfigurable in parameter FAIL_SPEED_CHANGE) to zero, it is assumed that the speed sensor is malfunctioning. In this situation, calculated speed value is maintained at the last seen value for 100 ms (default value, configurable). If speed input frequency does not re-appear during this time, LOSS_OF_SPEED fault is activated. Refer to **Figure 4-25**.

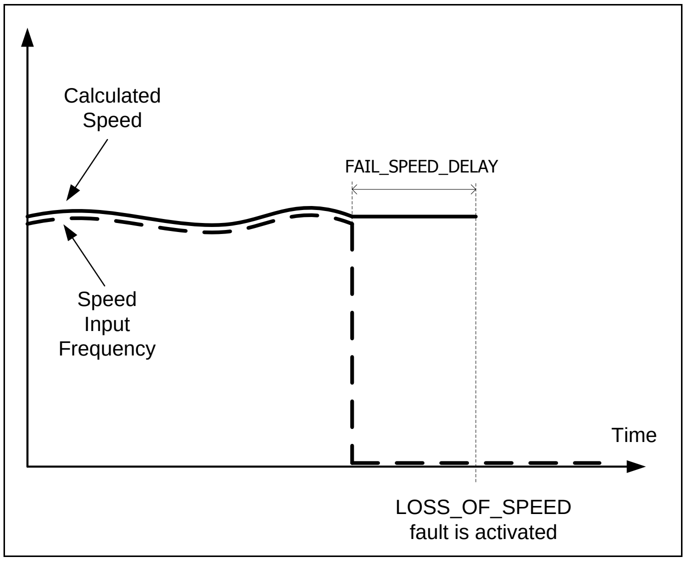


Figure 4-26. LOSS_OF_SPEED Fault Activation Diagram

If not set to latching operation, this fault will be cleared if speed input frequency is observed again. By default, cycling power to the controller will also clear this fault.
Fault actions: engine shutdown, limp home mode available

LOW_OIL_PRESSURE
Activated when OPS (Oil Pressure Switch) input is activated in conditions specified with following parameters:

- LOW_PRESSURE_RUN_TIME – time that the engine must be running before the OPS input is monitored
- LOW_PRESSURE_DELAY – time that OPS input must be constantly enabled before LOW_OIL_PRESSURE fault is activated.
- HIGH_PRESSURE_DELAY – time that OPS_INPUT must in constantly disabled in order to clear existing fault and recover from limp home operation.

Fault actions: engine shutdown, limp home mode available

MAP_SENSOR_HI, MAP_SENSOR_LO
Activated when Air Pressure Sensor input goes outside configured range for at least 100 ms (default value, may be configured).
Fault actions: Air Pressure Sensor input is ignored; air pressure value used for calculations is ramped from last seen value towards AIR_PRESSURE_DEFAULT with MAP_DFFAULT_RAMP_RATE

MAP_POWER_SUPPLY
Activated when Air Pressure Sensor Power Supply output (pin J1-H1) short circuit to ground for at least 100 ms (default value, may be configured) is detected.
Fault actions: air pressure input is ignored; air pressure value is ramped from last seen value towards AIR_PRESSURE_DEFAULT with MAP_DFFAULT_RAMP_RATE

OPS_WIRE_BREAK
Activated when Oil Pressure Switch discrete input is indicating high oil pressure (input not active) when engine is not running.
Fault actions: engine shutdown (not possible to start engine), limp home mode available

OVERSPEED
Activated when configured engine speed limit was reached for at least OVERSPEED_DELAY time. Speed limit is configured in two ways:

- As an absolute speed value configured in SPEED_LIMIT_ABSOLUTE
- As a percentage of maximum currently commanded speed. For fixed speeds this is calculated in relation to speed setpoint value. For variable speeds this is calculated in relation to SET_SPEED_MAX.

At any moment, the lower of these two limits is used.
Fault actions: engine shutdown

OVER_TEMPERATURE
Activated when Engine Coolant Temperature is higher than configurable OVERTEMP_THRESHOLD longer than configurable OVERTEMP_DELAY.
Fault actions: engine shutdown, limp home mode available

POSITION_GOV
Activated when controller is unable to reach desired actuator position with maximum duty cycle output for 2 seconds (default value, configurable). This situation usually means that the actuator is mechanically stuck or is unable to reach desired position due to spring/coil force balance. To address the situation where force balance does not allow the actuator to reach maximum or minimum position, two additional parameters are provided allowing it to disable POSITION_GOV fault detection in certain conditions.
By default, POSITION_GOV fault is ignored if the actuator position is below 50% and the return spring force balance results in an actuator setting at position higher than desired. The minimum position for detection may be adjusted depending on force balance in order to achieve the most accurate actuator stuck detection.

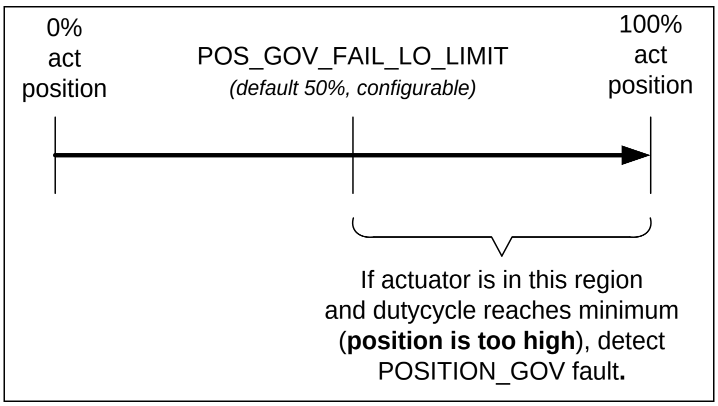


Figure 4-27. Position Too High Detection Range

By default, the POSITION_GOV fault is always detected if the coil force is too low for the actuator to reach the desired position, resulting in an actuator position that is too low. The maximum detection position can be decreased in order to allow situations where the coil force is insufficient to overcome the spring force at high actuator positions.

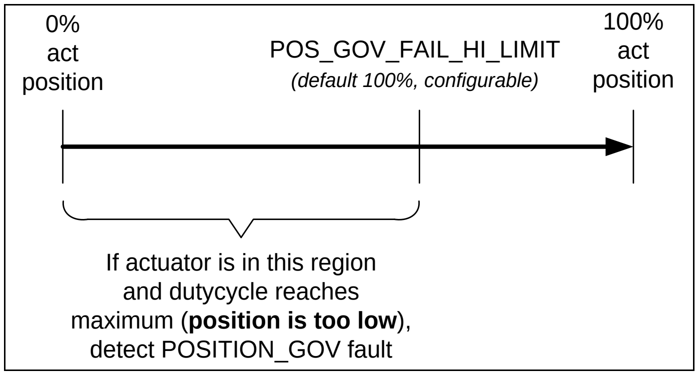


Figure 4-28. Position Too Low Detection Range

This fault clears automatically when the engine is stopped and the actuator is in position below 50% (this value is configurable using POS_GOV_FAIL_LO_LIMIT parameter).
Fault actions: engine shutdown

POSITION_CAL_HI, POSITION_CAL_LO
Activated when the Actuator Position signal exceeds the calibrated range is detected for at least 100 ms (default value, configurable). Refer to **Chapter 4**: Actuator Position Control for a description of the actuator position input working ranges.
Fault actions: none (indication only)

POSITION_SENSOR_HI, POSITION_SENSOR_LO
Activated, when the Actuator Position Sensor input goes outside a configured range for at least 100 ms (default value, may be configured). Refer to **Chapter 4**: Actuator Position Control for a description of the actuator position input working ranges.
Fault actions: engine shutdown, limp home mode available, controller power cycle required for recovery

PROTECTION_FAULT
Activated when Protection discrete input is activated in conditions specified with two parameters:

- ENGINE_PROTECTION_INPUT_RUN_TIME – time that the engine must be running before the engine protection input is monitored
- ENGINE_PROTECTION_INPUT_DELAY – time that protection input must be constantly enabled before PROTECTION_FAULT is activated (and engine shut down)

Fault actions: engine shutdown

SET_SPEED_POT_HI, SET_SPEED_POT_LO
Activated when Speed Setpoint Potentiometer input goes outside the configured range for at least 100 ms (default value, may be configured).
Fault actions: the Speed Setpoint Potentiometer input is ignored; speed setpoint value is set to 0% for all speed modes except trim mode, and 50% for trim mode. Refer to **Chapter 4**: Speed Setpoint Options for description of speed setpoint modes.

TORQUE_LIMIT_ACHIEVED
Activated when controller is unable to reach desired engine speed with maximum actuator position for 5 seconds.
Fault actions: none (indication only)

Limp Home Operation

Limp home is an emergency operation after critical fault detection. The following faults may be configured to either shut the engine down immediately or force limp home operation if detected:

- Speed sensor failure – enabled with LOSS_OF_SPEED fault
- Position sensor failure – enabled with APS_POWER_SUPPLY, POSITION_SENSOR_LO and POSITION_SENSOR_HI fault.
- Low oil pressure – enabled with LOW_OIL_PRESSURE and OPS_WIRE_BREAK fault.
- Overtemperature – enabled with OVERTEMPERATURE fault.

If **Speed Sensor Failure Limp Home** is enabled, the controller will continue operation in case of LOSS_OF_SPEED fault occurrence. Due to lack of engine speed feedback, speed governing is inoperable.

If speed pedal is present in the system, it may be used to command the actuator position directly in limp home mode. After entering limp home mode, operator is first required to set speed pedal into minimum position. Then, actuator position will be commanded within configured limits by speed pedal position.

Additionally, if oil pressure switch is used, it may be used as feedback of the engine state. With low oil pressure engine is assumed not running, therefore crank actuator position is commanded in order to allow engine starting in limp home mode. Speed potentiometer will be commanding position after high oil pressure was present for configured time. This operation may be disabled in software.

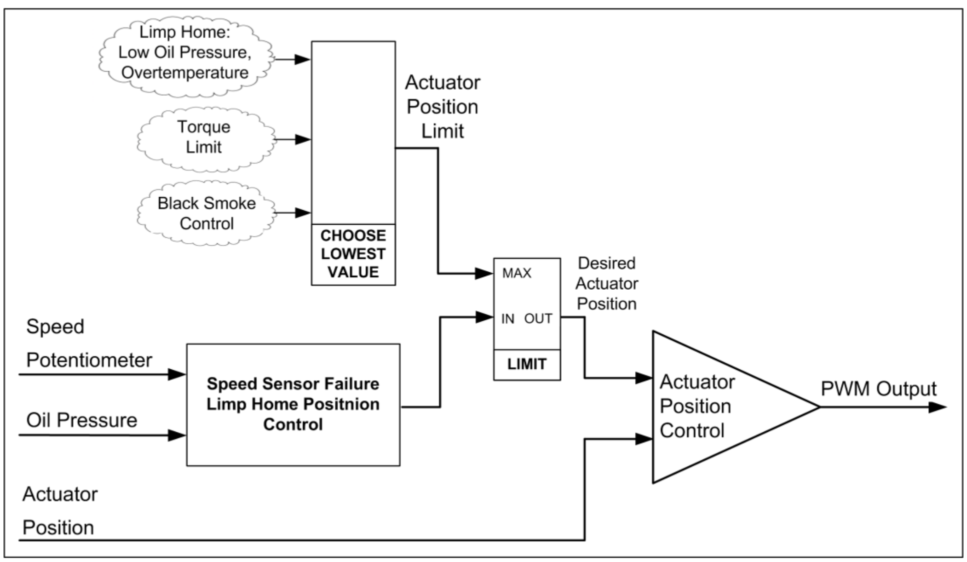


Figure 4-29. Speed Sensor Failure Limp Home Operation Diagram

⚠CAUTION **In Speed Sensor Failure Limp Home mode operation, the APECS controller's overspeed protection is not functional. External speed limiting device must be provided in order to operate the device in this mode.**

If **Position Sensor Failure Limp Home** is enabled, the controller will continue operation in case of actuator position sensor malfunction occurrence. Due to lack of position feedback, position governing becomes inactive. Therefore desired position is translated into PWM output using configurable 10-point lookup table. Droop becomes inactive in this mode. Maximum speed may be additionally decreased in this mode. After entering limp home operation, controller will gradually decrease maximum allowed duty cycle down to defined maximum value.

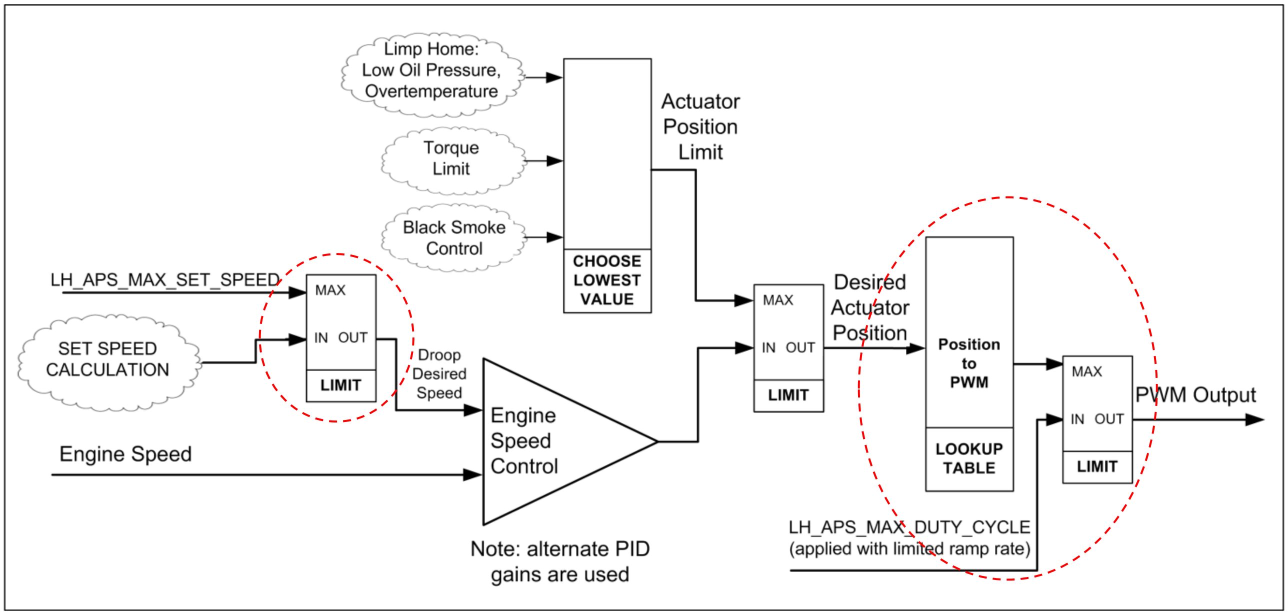


Figure 4-30. Position Sensor Failure Limp Home Operation Diagram

Note that although Torque Limiting and Black Smoke Control remain functional in this mode, without position feedback its accuracy is significantly decreased. This is caused by the variability of actuator's current to position relationship.

If **Low Oil Pressure Limp Home** mode is enabled, the controller will continue operation for configured maximum time after low oil pressure has been detected. After this time, the engine will be shut down. During limp home operation engine torque may be limited be applying fixed actuator position limit.

If **Overtemperature Limp Home** mode is enabled, the controller will continue operation for configured maximum time after low overtemperature has been detected. After this time, the engine will be shut down. During limp home operation engine torque may be limited by applying fixed actuator position limit. Additionally, controller may force idle speed operation during overtemperature limp home by applying additional speed setpoint limit.

Engine Monitoring Functions

Engine Coolant Temperature Monitoring, Fan Control

The APECS 4800 uses analog input for Engine Coolant Temperature monitoring. See **Chapter 3** for wiring information and **Chapter 6** for calibration details on the temperature sensor. Calculated coolant temperature is used for the following functions:

- Speed Control Master Gain scaler – see Speed Governor Gains Options for description
- Crank Actuator Position and Warmup Time calculation – see Engine Starting for description
- EGR (Exhaust Gas Recirculation) relay control
- Overtemperature diagnostics - see Diagnostics for description of OVERTEMPERATURE fault
- Fan Control discrete output – the output provides configurable ON temperature above which it will be enabled. The output is disabled if temperature goes below ON threshold with a configurable hysteresis.

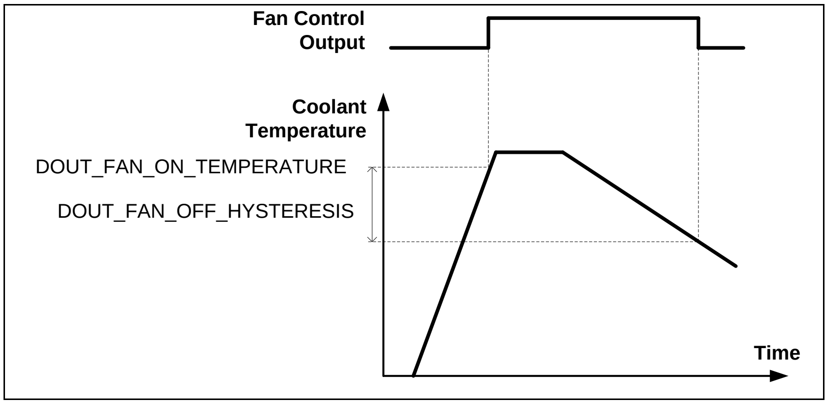


Figure 4-31. Fan Control Output Operation

Speed Trip Outputs

Two discrete Speed Trip Outputs may be configured. Each of them has a configurable speed threshold. If engine speed goes above the speed threshold, the appropriate output is activated.

Battery Voltage Monitoring

The APECS 4800 controller measures battery voltage and uses that information for:

- Battery voltage low/high diagnostics- see Diagnostics for description of faults: CPU_POWER_SUPPLY, LOW_BATTERY_VOLTAGE, HIGH_BATTERY_VOLTAGE
- Battery voltage compensation for actuator PWM generation – if enabled, at every moment PWM output values is multiplied by a battery voltage dependent factor. This reduces actuator position fluctuations during battery voltage transients.

External Shutdown Devices

The APECS 4800 controller provides following discrete input options for external engine shutdown command:

- Oil Pressure Switch input – shutdown input providing additional diagnostics of miswired switch. See Diagnostics for description of faults: LOW_OIL_PRESSURE and OPS_WIRE_BREAK.
- Protection Input – a general purpose external shutdown device input. Delay from engine start to start of monitoring this input can be configured. See Diagnostics for description of PROTECTION fault generated by this input.
- Engine Stop Switch – emergency shutdown input. If activated, will result in immediate engine shutdown regardless of engine state.

CAN J1939

General CAN Information

The APECS 4800 controller supports CAN communications in the SAE J1939 Higher Layer Protocol format. Further detailed information regarding the J1939 Standards Collection can be purchased at www.sae.org. Information about CAN may be found in ISO 11898. A subset of the SAE J1939 standard messages defined in J1939-21, J1939-71, J1939-73, and J1939- 81 is supported with further details indicated here.

All APECS 4800 J1939 messages use the CAN 2.0B 29-bit Extended Data Frame Format. Little-Endian format is used when handling multiple-byte parameters (i.e., a position demand of 50% is $FF0F, not $0FFF). All parameters shall use this format unless otherwise specified.

The APECS 4800 bit timing is limited to provide a data rate of 250 kbps only.

The available J1939 frames (PGN – Parameter Group Number) are listed further in this chapter. For each PGN only selected data fields (SPN – Suspect Parameter Number) are used.

Broadcasted Messages

APECS 4800 broadcasts the J1939 messages listed below. Only SPNs mentioned in the tables signals are used, remaining bytes are filled with 0xFF. If SPN value is not available due to active fault, error indicator (0xFE for byte values, 0xFEFF for word values) is sent.

Transmission repetition rate is configurable for all broadcasted messages.

Electronic Engine Controller 1 (EEC1)

Table 4-5. Electronic Engine Controller 1 (EEC1) Message

Description	Value	
Transmission Repetition Rate	Configurable PGN_EEC1_DELAY – default 10ms	
Transmitter	APECS 4800	
Data Length	8	
Data Page	0	
PDU[1] Format	240	
PDU Specific	4	
Default Priority	3	
Parameter Group Number	61444 (0xF004)	
Byte	3	SPN 513 - Actual Engine - Percent Torque
	4-5	SPN 190 - Engine Speed

SPN 513 Actual Engine - Percent Torque
The calculated engine load. Error indicator sent if POSITION_SENSOR_HI or POSITION_SENSOR_LO fault active.
Data Length: 1 byte
Resolution: 1 %/bit, -125 % offset
Data Range: -125 to 125 % Operational Range: 0 to 125%
Type: Measured

SPN 190 Engine Speed
Actual engine speed. Error indicator sent if LOSS_OF_SPEED fault active.
Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Measured

[1] PDU –Data

Electronic Engine Controller 2 (EEC2)

Table 4-6. Electronic Engine Controller 2 (EEC2) Message

Description	Value	
Transmission Repetition Rate	Configurable PGN_EEC2_DELAY – default 50 ms	
Transmitter	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	240	
PDU Specific	3	
Default Priority	3	
Parameter Group Number	61443 (0xF003)	
Byte	4	SPN 974 - Remote Accelerator Pedal Position

SPN 974 Remote Accelerator Pedal Position
Speed Setpoint Potentiometer value. Error indicator sent if SET_SPEED_POT_HI or SET_SPEED_POT_LO fault active.
Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 % Operational Range: same as data range
Type: Measured

Electronic Engine Controller 3 (EEC3)

Table 4-7. Electronic Engine Controller 3 (EEC3) Message

Description	Value	
Transmission Repetition Rate	Configurable PGN_EEC3_DELAY – default 250 ms	
Transmitter	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	254	
PDU Specific	223	
Default Priority	6	
Parameter Group Number	65247 (0xFEDF)	
Byte	2-3	SPN 515 - Engine's Desired Operating Speed

SPN 515 Engine's Desired Operating Speed
Current Desired Speed used by speed governor.
Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm
Operational Range: (upper byte resolution = 32 rpm/bit)
Type: Status

Engine Temperature 1 (ET1)

Table 4-8. Engine Temperature 1 (ET1) Message

Description	Value	
Transmission Repetition Rate	Configurable PGN_EEC3_DELAY – default 1 s	
Transmitter	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	254	
PDU Specific	238	
Default Priority	6	
Parameter Group Number	65262 (0xFEEE)	
Byte	1	SPN 110 - Engine Coolant Temperature

SPN 110 Engine Coolant Temperature
Actual value of Engine Coolant Temperature. Error indicator sent if ECT_SENSOR_HI or ECT_SENSOR_LO fault active.
Data Length: 1 byte
Resolution: 1 deg C/bit, -40 deg C offset
Data Range: -40 to 210 ° C
Operational Range: same as data range
Type: Measured

Vehicle Electrical Power 1 (VEP1)

Table 4-9. Vehicle Electrical Power 1 (VEP1) Message

Description	Value	
Transmission Repetition Rate	Configurable PGN_PVEP_DELAY – default 1 s	
Transmitter	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	254	
PDU Specific	247	
Default Priority	6	
Parameter Group Number	65271 (0xFEF7)	
Byte	7-8	SPN 158 - Keyswitch Battery Potential

SPN 158 Keyswitch Battery Potential
Actual Battery Voltage value.
Data Length: 2 bytes
Resolution: 0.05 V/bit, 0 offset
Data Range: 0 to 3212.75 V Operational Range: same as data range
Type: Measured

Requested Messages

Requested messages are sent by the controller when corresponding request PGN frame is received.

Address Claimed

Table 4-10. Address Claimed Message

Description	Value	
Transmission Repetition Rate	After power-up, on demand	
Transmitter	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	238	
PDU Specific	255 (global address)	
Default Priority	6	
Parameter Group Number	60928 (0x00EE00)	
Source Address	0 to 253	
Byte	1..8	NAME of Controller Application

NAME of Controller Application

Contains the configurable fields which values are in parameters given in brackets. The default value for Manufacturer Code is set to 153 (Woodward identifier). All the others values are set by default to 0.

Byte: 1 Bits 8-1 Least significant byte of Identity Number (PGN_NAME_ID)
Byte: 2 Bits 8-1 Second byte of Identity Number (PGN_NAME_ID)
Byte: 3 Bits 8-6 Least significant 3 bits of Manufacturer Code (PGN_NAME_MANUF)
Bits 5-1 Not used (ignore value)
Byte: 4 Bits 8-6 Not used (ignore value)
Bits 5-1 Most significant 5 bits of Manufacturer Code (PGN_NAME_MANUF)
Byte: 5 Bits 8-4 Function Instance (PGN_NAME_FUN_INST)
Bits 3-1 ECU Instance (PGN_NAME_ECU_INST)
Byte: 6 Bits 8-1 Function (PGN_NAME_FUNCTION)
Byte: 7 Bits 8-2 Vehicle System (PGN_NAME_SYSTEM)
Bit 1 Reserved (ignore value)
Byte: 8 Bit 8 Arbitrary Address Capable (always zero because dynamic addressing is not supported)
Bits 7-5 Industry Group (PGN_NAME_INDUSTRY)
Bits 4-1 Vehicle System Instance (PGN_NAME_SYS_INST)

CAN Source Address cannot be changed by Address Claim Procedure. The default value is set to 0x00. If it is required (another device uses the same source address) APECS 4800 CAN Source Address parameter can be modified by Service Tool.

Component Identification

Table 4-11. Component Identification Message

Description	Value	
Transmission Repetition Rate	On demand	
Transmitter	APECS 4800	
Data Length	Variable	
Data Page	0	
PDU Format	254	
PDU Specific	235	
Default Priority	6	
Parameter Group Number	65259 (0x00FEFB)	
Source Address	0 to 253	
Byte	1..a	Make – SPN 586
	(a+1)..b	Model – SPN 587
	(b+1)..c	Serial Number – SPN 588
	(c+1)..d	Unit Number – SPN 233

<u>SPN 586 Make</u>
Make of the component corresponding to the codes defined in the American Trucking Association Vehicle Maintenance Reporting Standard (ATA/VMRS). Isn't defined in application. Only delimiter is inserted.
Data Length: 1 character (an "*" delimiter)
Resolution: ASCII

<u>SPN 587 Model</u>
Model of the component. Engine Type, user defined, up to 13 characters long.
Data Length: Variable – 1 to 14 characters ("*" delimited)
Resolution: ASCII

<u>SPN 588 Serial Number</u>
Serial number of the component. Engine Serial Number, user defined, up to 12 characters long.
Data Length: Variable – 1 to 13 characters ("*" delimited)
Resolution: ASCII

<u>SPN 233 Unit Number</u>
Owner assigned unit number for the power unit of the vehicle. Controller Settings Version, user defined, up to 10 characters long.
Data Length: Variable – 1 to 11 characters ("*" delimited)
Resolution: ASCII

Commanded Messages

The APECS 4800 controller receives and interprets the messages described below.

Torque/Speed Control 1 (TSC1)

Table 4-12. Torque/Speed Control 1 (TSC1) Message

Description	Value	
Transmission Repetition Rate	To engine: Control Purpose dependent or 10 ms	
Receiver	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	0	
PDU Specific	APECS Source Address	
Default Priority	3	
Parameter Group Number	0 (0x0000)	
Byte.bit	2-3	SPN 898 - Engine Requested Speed/Speed Limit

SPN 898 Engine Requested Speed/Speed Limit
Desired engine speed that will be used in CAN_J1939 speed mode.
Data Length: 2 bytes
Resolution: 0.125 rpm/bit, 0 offset
Data Range: 0 to 8,031.875 rpm Operational Range: same as data range
Type: Status

Shutdown (SHUTDN)

Table 4-13. Shutdown (SHUTDN) Message

Description	Value	
Transmission Repetition Rate	1s	
Receiver	APECS 4800	
Data Length	8	
Data Page	0	
PDU Format	254	
PDU Specific	228	
Default Priority	6	
Parameter Group Number	65252 (0xFEE4)	
Byte.bit	5.1-5.2	SPN 1110 - Engine Protection System has Shutdown Engine

SPN 1110 Engine Protection System has Shutdown Engine
This SPN may be used to force immediate shutdown of the engine.
00 - No
01 - Yes (force shutdown)
10 – Ignored
11 - Ignored
Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3 Operational Range: same as data range
Type: Status

Diagnostic Messages

The APECS 4800 controller supports the following diagnostic messages per SAE J1939-73 (Sept2006) Diagnostics document. For each defined fault in the APECS 4800 controller, SPN can be assigned in the software tool. Default values are set in accordance to the SAE guidelines.

Active Diagnostic Trouble Codes (DM1)

The information communicated is limited to the currently active diagnostic trouble codes (DTCs). The active diagnostic codes are preceded by the diagnostic lamp status. Together they convey the diagnostic condition of the transmitting electronic component to other components on the network. Occurrence counts for currently active diagnostic trouble codes are also provided. DM1 contains all active codes.

Note that this parameter group will be sent using the “multipacket transport” parameter group as specified in SAE J1939-21 when applicable.

Table 4-14. Active Diagnostic Trouble Codes (DM1) Message

Description	Value	
Transmission Repetition Rate	When DTC becomes an active fault and once per second thereafter.	
Transmitter	APECS 4800	
Data Length	Variable	
Data Page	0	
PDU Format	254	
PDU Specific	202	
Default Priority	6	
Parameter Group Number	65226 (0x00FECA)	
Byte	1..2	Lamps Status
	3..6	First DTC
	7..10	Second DTC (if present)
	n..n+3	Next DTC if present. Up to 127 bytes.

Byte: 1 Lamps Status – for APECS 4800 fixed to 0x00
Byte: 2 Flash Lamps – for APECS 4800 fixed to 0xFF

<u>first DTC</u>

Byte:	3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte:	4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte:	5	bits 8-6	SPN, 3 most significant bits of SPN (most significant at bit 8)
		bits 5-1	FMI (most significant at bit 5)
Byte:	6	bit 8	SPN Conversion Method
		bits 7-1	Occurrence Count

<u>n-th DTCs (if present)</u>

Byte:	n	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte:	n+1	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte:	n+2	bits 8-6	SPN, 3 most significant bits of SPN (most significant at bit 8)
		bits 5-1	FMI (most significant at bit 5)
Byte:	n+3	bit 8	SPN Conversion Method
		bits 7-1	Occurrence Count

Previously Active Diagnostic Trouble Codes (DM2)

The information communicated is limited to the previously active trouble codes. It is used to notify other components on the network of the diagnostic condition of the transmitting electronic component. The data contains a list of diagnostic codes and occurrence counts for previously active trouble codes. Whenever this message is sent, it contains all previously active trouble codes with an occurrence count not equal to zero.

Note that this parameter group will be sent using the "multipacket transport" parameter group as specified in SAE J1939-21 when applicable.

Table 4-15. Previously Active Diagnostic Trouble Codes (DM2) Message

Description	Value	
Transmission Repetition Rate	On request using PGN 59904	
Transmitter	APECS 4800	
Data Length	Variable	
Data Page	0	
PDU Format	254	
PDU Specific	203	
Default Priority	6	
Parameter Group Number	65227 (0x00FECB)	
Byte	1..2	Lamps Status
	3..6	First DTC
	7..10	Second DTC (if present)
	n..n+4	Next DTC if present. Up to 127 bytes.

Byte: 1 Lamps Status – for APECS 4800 fixed to 0x00
Byte: 2 Flash Lamps – for APECS 4800 fixed to 0xFF

<u>first DTC</u>

Byte:	3	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte:	4	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte:	5	bits 8-6	SPN, 3 most significant bits of SPN (most significant at bit 8)
		bits 5-1	FMI (most significant at bit 5)
Byte:	6	bit 8	SPN Conversion Method
		bits 7-1	Occurrence Count

<u>n-th DTCs (if present)</u>

Byte:	n	bits 8-1	SPN, 8 least significant bits of SPN (most significant at bit 8)
Byte:	n+1	bits 8-1	SPN, second byte of SPN (most significant at bit 8)
Byte:	n+2	bits 8-6	SPN, 3 most significant bits of SPN (most significant at bit 8)
		bits 5-1	FMI (most significant at bit 5)
Byte:	n+3	bit 8	SPN Conversion Method
		bits 7-1	Occurrence Count

Chapter 5.
Service Tool

Introduction

The APECS 4800 Service Tool software is used to configure, monitor and troubleshoot an APECS 4800 controller. It supports the following controller part numbers: 8800-4801 rev A (firmware 5418-3440 rev A).

This chapter describes the installation and general usage of the Service Tool. Detailed instructions for configuring, calibrating and troubleshooting the APECS 4800 controller for customer-specific applications are provided in Chapters 6 and 7.

The Service Tool software resides on a PC (Personal Computer) and communicates with the APECS 4800 through a serial interface. Refer to Chapter 3 for wiring instructions. For newer computers without serial ports, a USB-to-serial converter is required, (Woodward P/N 8928-1151).

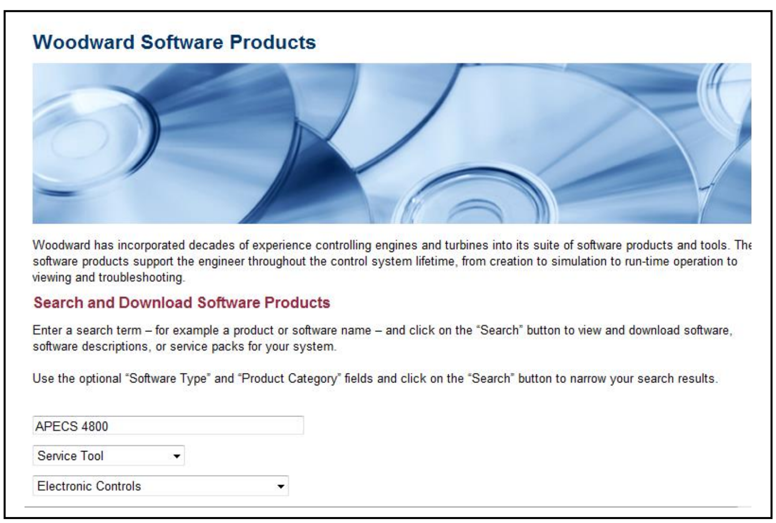
System Requirements:

- Microsoft Windows® 7, Vista, XP (32- & 64-bit)
- Microsoft .NET Framework ver. 3.5
- 600 MHz Pentium® CPU
- 512 MB of RAM
- Minimum 800 by 600 pixel screen with 256 colors
- Recommended screen resolution 1024 x 768 or higher
- 9 pin-D serial port (RS232)
- 9 pin-D straight through serial cable (not a null modem cable)

WARNING	**An unsafe condition could occur with improper use of these software tools. Only trained personnel should have access to these tools.**

Obtaining the PC Software Tool

The 4800 Service Tool can be obtained from Woodward's software products web page. Click on the link or type www.woodward.com/software into your Internet browser.

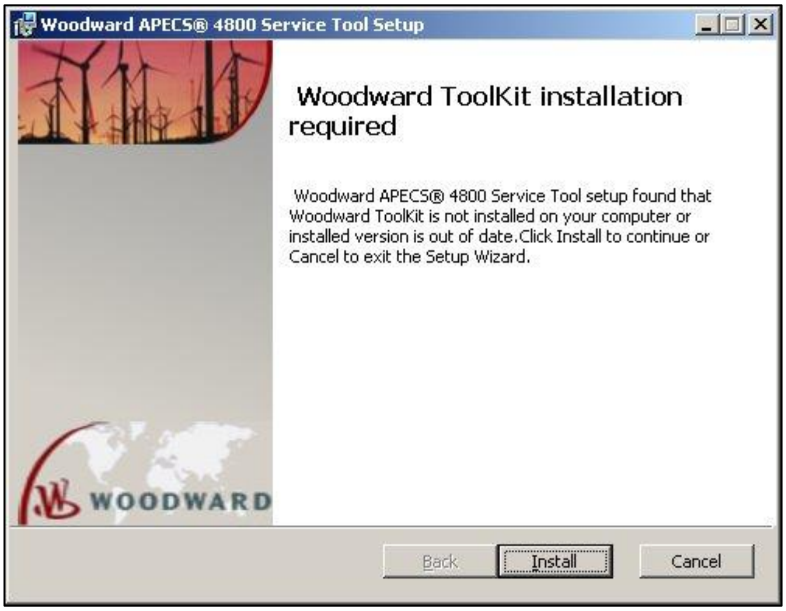


Type "APECS 4800" into the search field. Select Download on the next screen. New users are required to register with an active email address.

Download the software and install it on your PC. Follow the instructions in the installation wizard to load all appropriate application components.

Installation

The APECS 4800 Service Tool was developed to work in conjunction with Woodward ToolKit. Therefore, the first step in the installation process verifies that ToolKit is already installed. If not (or if the installed version of ToolKit is out-of-date), the user will be notified that ToolKit installation is required (as shown below). Click 'Install' to initiate ToolKit installation.



The user should be aware that ToolKit requires Microsoft .NET Framework 4.0. The ToolKit installer will attempt to install the .NET Framework automatically from the Internet. If this is not possible (e.g. due to lack of Internet connection), user can also obtain the .NET Framework 4.0 Redistributable package from Microsoft's website.
Once loaded, the ToolKit will be accessible via the Start menu (All Programs, Woodward/ToolKit folder).

If the current version of ToolKit is already installed, the installation wizard will proceed directly to installation of the APECS 4800 Service Tool (as shown below).

During installation, the wizard will not require a user-specified directory in which to save the installation files. Instead, ToolKit is installed to the following default location: C:\Program Files\Woodward\ToolKit

Similarly, the APECS 4800 Service Tool is installed to the default location: C:\Program Files\Woodward\APECS 4800 Service Tool.

In order to run the APECS 4800 Service Tool, from the Start Menu, select All Programs → Woodward → APECS 4800 Service Tool → APECS 4800 Service Tool or double-click the shortcut that is automatically created on the Desktop during installation of the APECS 4800 Service Tool.

Connecting to the APECS 4800 Controller

Connection of a generic PC to the APECS 4800 is required in order to load application software and view/tune within that software application. The wiring of APECS 4800 to a PC serial port is described in Chapter 2.

At power-up, the APECS 4800 runs through its boot-up routine and performs a set of initial diagnostics to verify CPU and memory health. When boot-up is complete, the application program will initialize, the control's outputs will be enabled, and system control will begin.

Make sure that all other programs or devices that may access your computer's communication port are closed or disconnected. Select Connect from the Communication menu in ToolKit. The user must select the COM port to which the controller is connected. Baud Rate parameter should be set to AutoDetection.

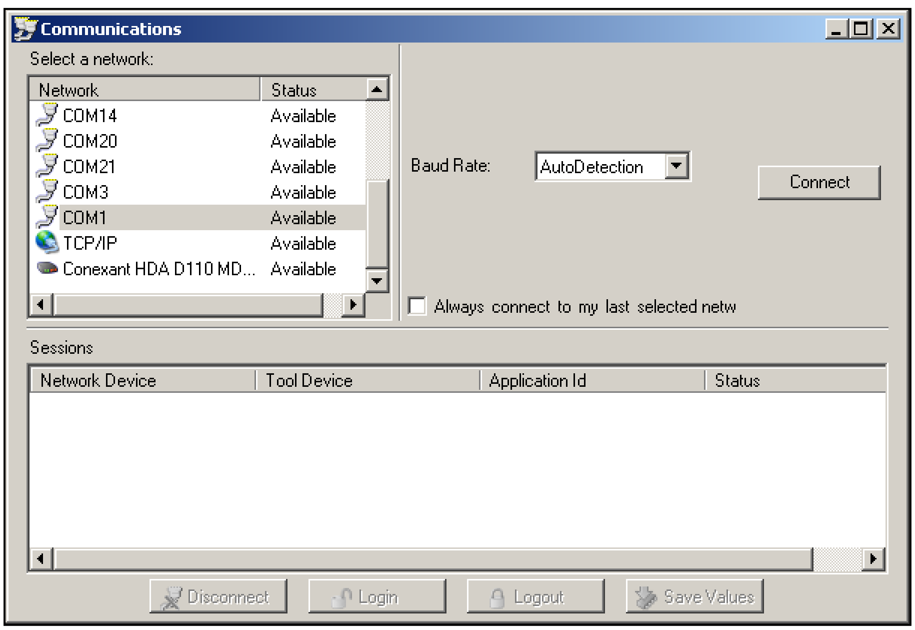


Figure 5-1. ToolKit Connecting Dialog

If ToolKit successfully connects to the controller, it will display the "Connected on COMx" information in the status bar on the bottom of ToolKit window. Software tool will prompt for password, which is described in the following chapter.

If the connection cannot be established, refer to Chapter 7 (Troubleshooting).

Security Levels and Passwords

The APECS 4800 controller provides configurable password security with three access levels. It allows an OEM (Original Equipment Manufacturer) to provide partial access to the device or to certain individuals, such as engine resellers. Passwords are not assigned by Woodward. If access to the controller is required, the system OEM should be contacted.

Three access levels are provided:

- Level 3 – Full Access – provides access to all parameters in software tool.
- Level 2 – Partial Write – provides access to all read only controls used to monitor or troubleshoot system performance (as described in **Chapter 7Error! Reference source not found.**) and to elected configuration parameters that are utilized during system servicing (as described in **Chapter 6** "Detailed Configuration Instructions" section). Basic system functions cannot be altered using this access level.
- Level 1 – Read Only – provides access to only to read only controls used to monitor or troubleshoot system performance, with addition of access to clearing faults history.

After connecting to the controller user is presented a "Security Login" dialog.

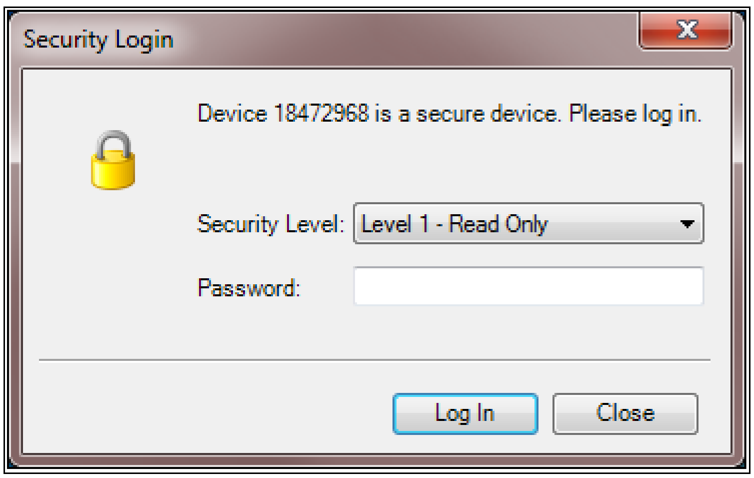


Figure 5-2. Security Login Dialog

User login requires selection of the correct security level with the appropriate password. For brand new units, the password is blank (empty). The passwords for each access level can be updated individually, using the procedure described in Chapter 6: Configuration.

Working with ToolKit Screens

Below are brief instructions for using the ToolKit to view and tune the variables for your APECS 4800. These instructions are meant to be introductory. Full on-line help is available in ToolKit.

The two basic types of control parameters within ToolKit are:

- Non-adjustable parameters
- Adjustable parameters

Non-adjustable parameters
A non-adjustable parameter is shown in a white, frameless box or in a graphic format. See below for an example of non-adjustable parameters.

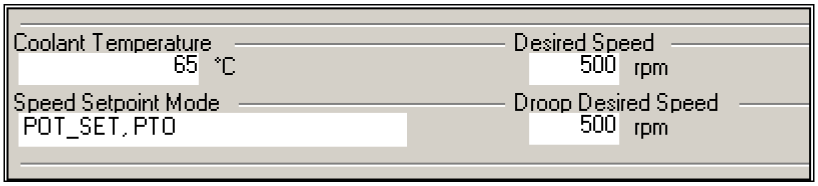


Figure 5-3. Non-Adjustable Parameters Example

Adjustable Parameters
Adjustable control parameters are displayed in a sunken box, as shown below, or sometimes as a check box or enumerated list in a drop down.

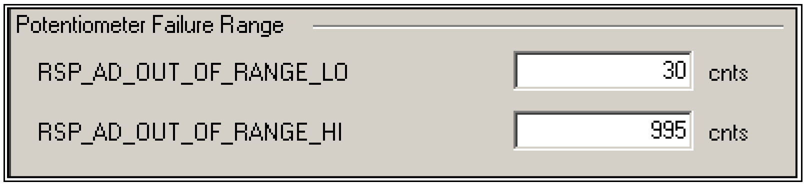


Figure 5-4. Adjustable Parameters Example

To change an adjustable parameter, either click the box for a Boolean, select from a drop down list, or click within the cell for an analog or integer. Every adjustable parameter has limits associated with it. The limit can be found when the cursor is within an adjustable parameter box by looking at the bottom of the screen as shown below.

Figure 5-5. Sample Parameter: Minimum Limit of 0 and Maximum Limit of 1023

Also if the user types a value outside the range allowed, the error prompt will be displayed.

When a value is modified the change immediately takes effect in the control, but is not automatically stored in nonvolatile memory. To save the changes permanently, select 'Save Values' from the 'Device' menu.

IMPORTANT	**After turning the power off, values of unsaved parameters will return to the previous state.**

Monitoring Parameter's Trends
Some of the APECS 4800 Service Tool pages contain trend charts. Additionally, each parameter in the software tool may be added to a temporary trend. This is done by right-clicking the parameter and selecting "Add to trend" option.

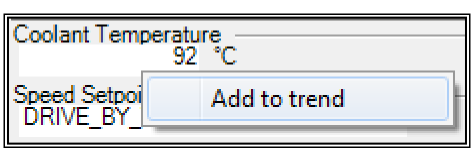


Figure 5-6. Adding the Parameter to a Temporary Trend

A new window with a trend chart will appear. Up to 16 additional parameters may be added to the same chart in this way.

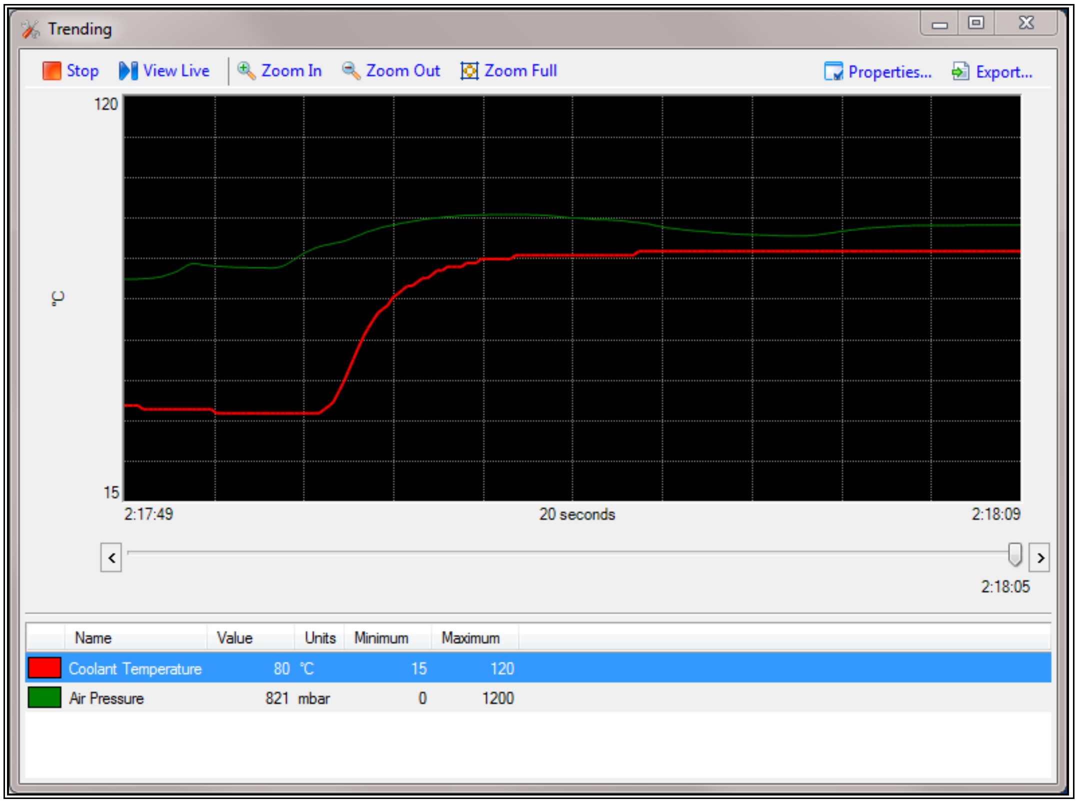


Figure 5-7. Temporary Trend Chart Example

The minimum and maximum values need updating for most parameters added to the trend. These values are configured in the dialog box that is opened by clicking the "Properties…" above the chart. Trending properties allow changing of several other features, including individual trend colors and time span.

Lookup Tables

A number of characteristics in the APECS controller are defined as lookup tables (LUT). The lookup table defines the curve for calculation some output value from another value. The example is calculation of the crank actuator position from the engine coolant temperature value.

One or two rows of each lookup table are always highlighted, representing the present value of the input parameter.

Crank Actuator Position Calculation

Engine Coolant Temperature (°C)	Crank Actuator Position (%)
-20	100
20	95
40	90
60	80
80	60
100	50

Figure 5-8. Lookup Table Example

The input value vs. output value curve is created by linear interpolation of the table points. If the input value is smaller than the first input point or larger than the last input point, table values are not extrapolated.

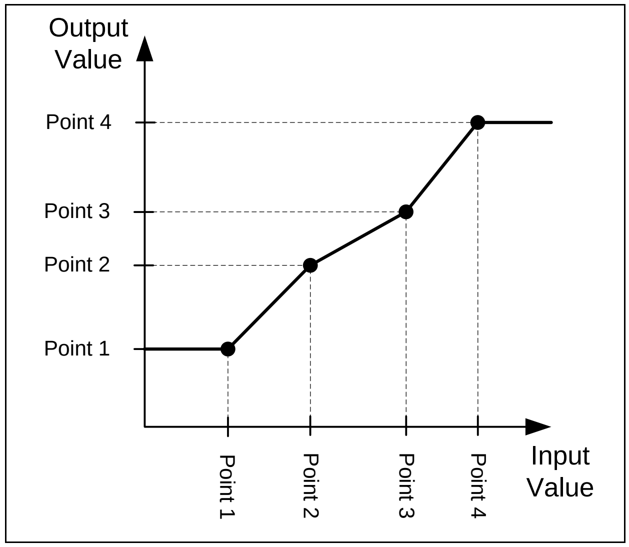


Figure 5-9. Curve Defined by 4-Point Lookup Table Example

The size of lookup tables is fixed. If not all points are needed, the required number of points should be filled from the start of lookup table. The remaining points should be set to the same output value as the last used point.

Crank Actuator Position Calculation

Engine Coolant Temperature (°C)	Crank Actuator Position (%)
-20	100
20	60
95	50
96	50
97	50
98	50

Figure 5-10. Configuration of 6-Point Lookup Table Using Only 3 Points

Working with Settings Files

All settings from the controller connected to the Service Tool can be stored in settings file using “Save from Device to File…” option from menu “Settings”.

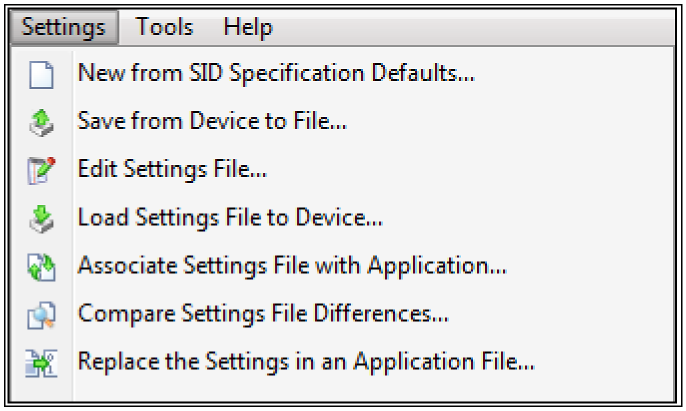


Figure 5-11. Settings Menu Items

This initiates a Save Setting Wizard that saves the APECS configuration to a settings file. You will be prompted for a File name. The ToolKit settings files have the “.wset” extension.

The settings file may be uploaded to controller by using “Load Settings File to Device…” option. This will replace all the settings in the connected controller with the settings from the settings file. User must have write access to the parameter in order to modify it when uploading settings file. Therefore uploading the settings file when logged on security level 1 will have no effect and when logged on security level 2 will only update parameters that are accessible on this level.

If the settings file has been created for the different controller firmware version, it can be converted to the current version using “Associate Settings File with Application…” option. When using this option user will be presented with a list of incompatibilities between the parameters’ lists in setting file and in current firmware version. Parameters that are not present in settings file will be set to its default values. Contact your local Woodward representative regarding the reasons for firmware change before migrating the settings to an updated controller.

Two settings files saved on disk can be compared using the “Compare Settings File Differences…” option. This can be used for example to compare the controller configuration to the existing settings file. Controller configuration must be saved to temporary settings file using “Save from Device to File…” option. This temporary settings file may be then compared to the existing file.

Remaining ToolKit features in “Settings” menu (i.e. “New from Sid Specification Defaults…”, “Edit Settings File…”, “Replace the Settings in an Application File…”) are not supported by the APECS 4800 controller and should not be used.

Chapter 6.
Configuration

Introduction

This chapter describes the steps required to configure an APECS 4800 for operation in a customer's system.

It is assumed that all mechanical and electrical connections are created per the "Installation" section of Chapter 3. Familiarity with the APECS 4800 operating principles outlined in Chapter 4 is also required.

Configuration and Calibration Overview

The typical steps for configuring an APECS 4800 system are:

1. Configuring the off-engine settings of the APECS 4800 controller in accordance with the list of electrical connections to APECS controller.
2. Installing APECS on target system.
3. Calibrating the APECS 4800 on-engine settings.
4. Testing and troubleshooting the system if necessary.
5. Saving controller settings to a file that will be used to program units during the production process.
6. Adjusting the production offsets for each unit individually (as required).

Controller configuration and calibration is performed using the APECS 4800 Service Tool. Details on installation and use of this service tool are provided in **Chapter 5**. All changes to the unit settings are done on-line (i.e., with Service Tool connected to the controller).

IMPORTANT	**Controllers are shipped with the default configuration, which is not suitable for operations without adjustments. Even for simple applications, a range of basic adjustments are required.**

Default parameters can be used on certain APECS 4800 parameters if there are no specific application requirements. For example if the system is not using Droop functionality, the droop related parameters should be left unchanged from defaults. This is discussed in detail further in this chapter.

The table below lists the parameters that are required for adjustment before the controller is operated. Default values for those parameters are, in general, not intended for use in target application. By adjusting these parameters properly, the APECS controller is prepared to operate in a basic single speed engine governing system with only LAPS (Linear Actuator with Position Sensor) actuator and engine speed sensor connected to the APECS controller.

Table 6-1. APECS 4800 Parameters Requiring Adjustment Prior to Operation

Parameter	Description	Notes
PULSES_PER_REV	Number of speed sensor flywheel teeth	
PULSES_PER_UPDATE	Period of engine speed updates	
VBAT_NOMINAL	Nominal battery voltage	By default is set to 12 volt system
APS_AD_OUT_OF_RANGE_LO APS_AD_OUT_OF_RANGE_HI	Out of range values for actuator position sensor	Needs adjustment in order to allow sensor fault detection
APS_CALIBRATION_MIN APS_CALIBRATION_MAX	Working ranges for actuator	
SET_SPEED_1	Speed setpoint in single speed application	
SPEED_PROPORTIONAL_GAIN SPEED_INTERGRAL_GAIN SPEED_DERIVATIVE_GAIN	Speed governor PID gains	Needs calibration to match engine characteristics
POS_PROPORTIONAL_GAIN POS_INTEGRAL_GAIN POS_DERIVATIVE_GAIN POS_P_GAIN_STARTUP POS_I_GAIN_STARTUP POS_D_GAIN_STARTUP	Position governor startup and runtime PID gains	Needs calibration to match actuator characteristics

Adjusting the Production Offsets

Depending on system requirements, there may be a need to adjust some values individually for each unit during the production process. For example: adjustment to the fuel limits map used for Black Smoke Control after measuring engine emissions performance.

Some of the APECS parameters are specially intended for per unit calibration during the production process. These parameters are normally left on default values during the configuration and calibration steps. The default value (usually zero) is stored in a settings file that is uploaded to the controller at the beginning of the production process of each unit. Later in the process, engine performance is measured and adjustments are made to the offset parameters if necessary. The adjusted parameters' values should be stored together with produced unit specifications either as a separate settings file or a simple list of adjusted parameters and their values.

Below is the list of APECS 4800 offset parameters.

Table 6-2. APECS 4800 Offset Parameters

Offset Parameter	Function
Full Load Line OFFSET	Shifts the full load line to compensate the engine torque variability.
Black Smoke Control OFFSET	Shifts the fuel limits values to compensate the engine emission variability.
APS_OFFSET	Added to the calculated actuator position e.g., to compensate for actuator mounting mechanical variation

Disabling the Speed Governing (Fuel Limiter Operation)

The APECS 4800 controller may be used as a fuel limiter on mechanically governed engines. Speed governing loop is not used in this configuration and actuator position (and resulting fuel limit) is controlled by the APECS fuel limiting features:

- Black smoke control
- Engine torque limiting
- Limp home operation

In order to configure the APECS 4800 controller for limiter operation, it is enough to configure fixed speed mode (the default setting), and set the speed setpoint to a value higher than maximum mechanical governor speed. Speed governor gains configuration should be omitted; derivative gain for speed governor should be set to zero. Remaining features should be configured normally.

Detailed Configuration Instructions

The recommended configuration procedure for the APECS 4800 controller is shown in Figure 6-1.

Changing the value of most of the listed parameters require user to be logged into security level 3 (Full Access).

If user is logged into access level 2 (Partial Write), reconfiguration of the following features is allowed:

- Speed control gains
- Position control gains
- System identification (engine type, engine serial number, controller settings version)
- Speed and droop potentiometer calibration

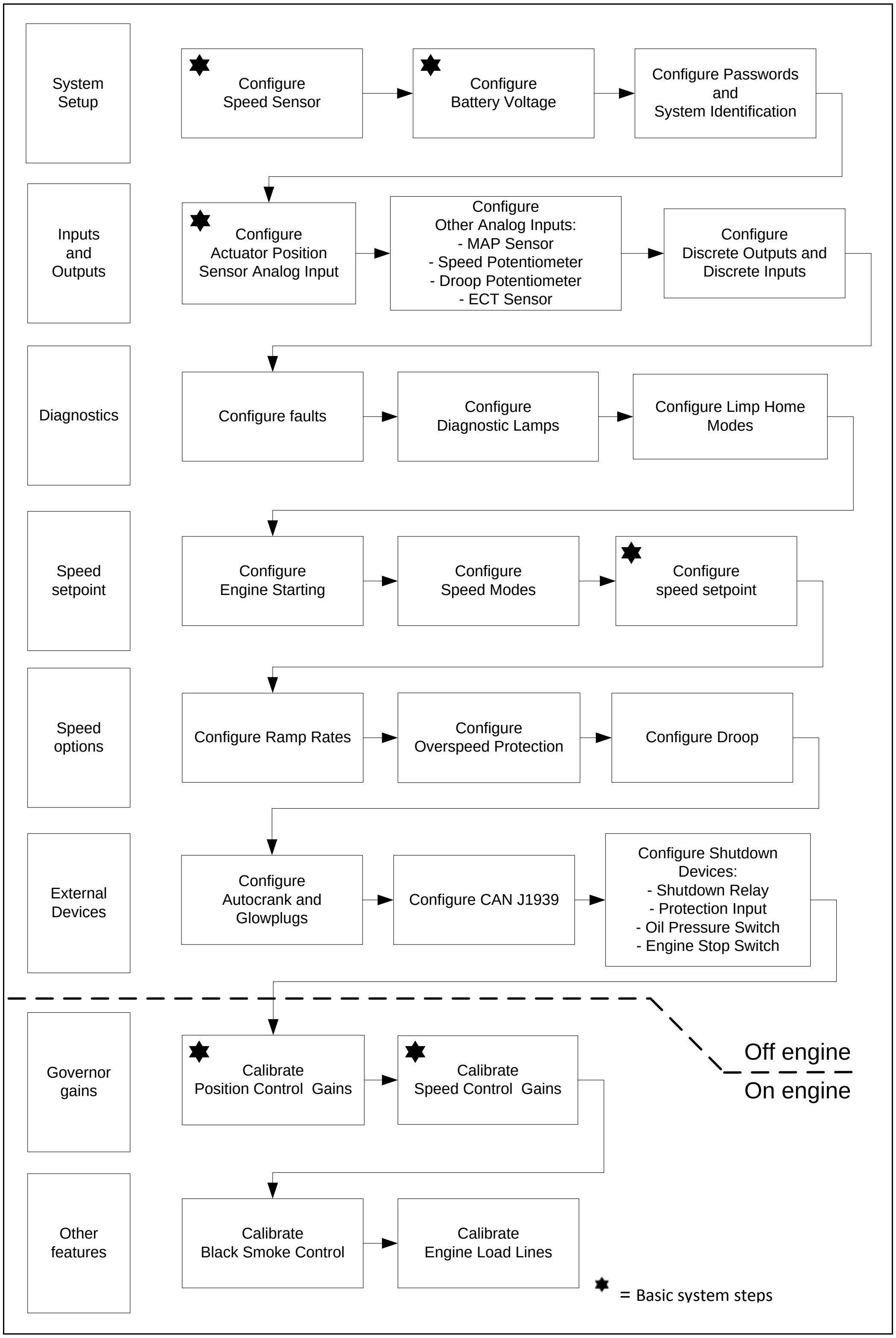


Figure 6-1. APECS 4800 Configuration Procedure

Configure Speed Sensor Input

For proper detection of engine speed, speed sensor parameters must be configured. This step is required for all systems before running the engine.

Speed sensor failure detection is also configured on the page shown below.

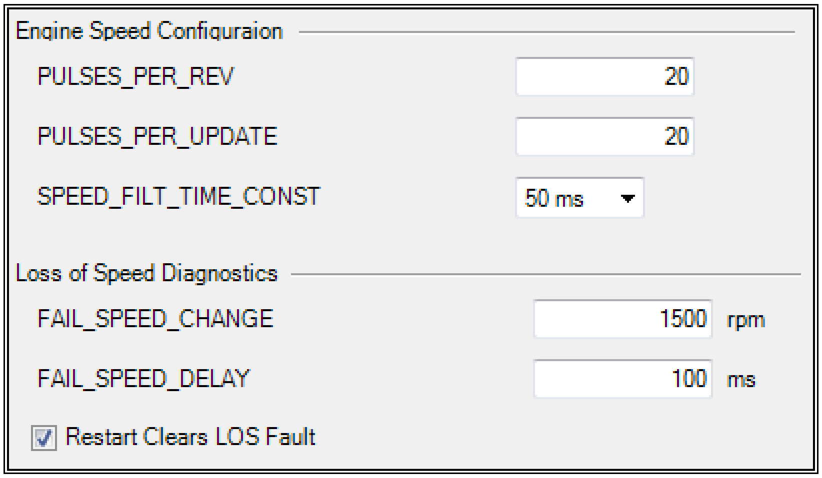


Figure 6-2. Speed Sensor Configuration
on Battery Voltage, Speed Sensor, Shutdown Devices Page

PULSES_PER_REV – number of speed sensor input pulses per engine revolution. The number of teeth on the engine speed pickup wheel should be entered here.

PULSES_PER_UPDATE – number of pulses received by the controller between engine speed calculation updates. Proper value for this parameter reduces the number of sensed engine speed fluctuations resulting from engine combustions events. The optimal value should be calculated from PULSES_PER_REV, number of engine cylinders and engine type (two stroke of four stroke) according to the following calculation:

$$PULSES\_PER\_UPDATE = \frac{no\_of\_strokes * PULSES\_PER\_REV}{2 * no\_of\_cylinders}$$

SPEED_FILT_TIME_CONST – lowpass filtering time constant. The higher this value, the more filtering is applied. The filtered value is used for:

- engine load calculation
- black smoke control
- speed trip outputs
- EGR relay control

Note: this setting does not affect speed governing. The only engine speed filtering applied for speed governing is controlled by PULSES_PER_UPDATE parameter.

FAIL_SPEED_CHANGE – maximum allowed speed drop without speed sensor fault description. See LOSS_OF_SPEED fault description in Chapter 4 for details.

FAIL_SPEED_DELAY – the amount of time to keep last seen speed after drop before speed sensor fault is launched. See LOSS_OF_SPEED fault description in Chapter 4 for details.

Restart Clears LOS Fault – if checked (default setting), cycling power to the controller will clear LOSS_OF_SPEED fault. Default setting may be changed for systems that require the possibility of restarting engine with speed sensor nonfunctional after failure.

Configure Battery Voltage

Proper system voltage must be selected before operating the controller in order to get proper overvoltage fault detection.

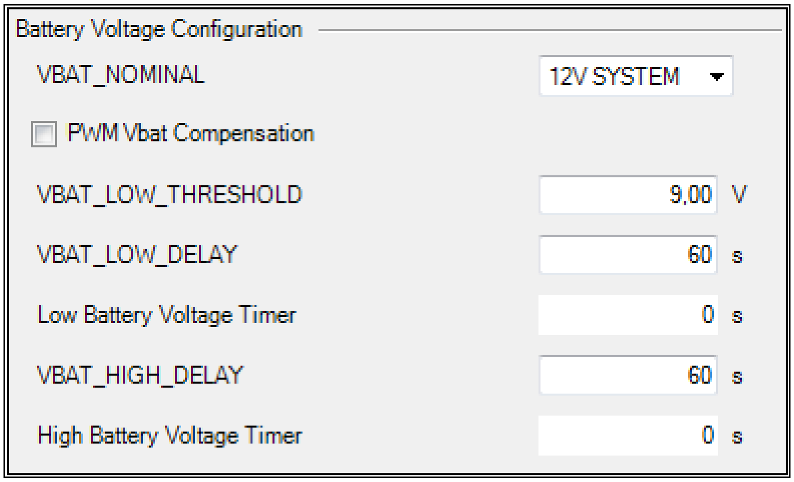


Figure 6-3. Battery Voltage Configuration
on Battery Voltage, Speed Sensor, Shutdown Devices Page

VBAT_NOMINAL – Select either 12V or 24V system. This setting is used for battery voltage compensation adjustment. Nominal battery voltage is 14.4 V for 12V system and 28.8 V for 24V system. The default value is 12V system, therefore this parameter must be updated for 24V systems.

Note – powering a controller configured for a 12V system (default value) from a 24V power supply is allowed in order to change the VBAT_NOMINAL setting (there is no need to use separate power supply for configuration).

PWM Vbat Compensation – if enabled, generated PWM is multiplied by compensation factor calculated as a proportion of measured battery voltage to nominal battery voltage. This functionality is disabled by default.

VBAT_LOW_THRESHOLD – battery voltage below which LOW_BATTERY_VOLTAGE fault is detected. Default value of 9 volts is the minimum supply voltage required by controller and is recommended for most systems.

VBAT_LOW_DELAY – amount of time the device must be detecting voltage below threshold before LOW_BATTERY_VOLTAGE fault is activated. Low Battery Voltage timer is provided on this page that will count up to VBAT_LOW_DELAY when low voltage is detected.

VBAT_HIGH_DELAY – amount of time the device must be detecting voltage above 135% of nominal before HIGH_BATTERY_VOLTAGE fault is activated. High Battery Voltage timer is provided on this page that will count up to VBAT_LOW_DELAY when low voltage is detected.

Configure Passwords

After the device is connected, passwords for each security level can be changed on the page "Statistics and Password Control." Changing a password is only allowed at access level 3.

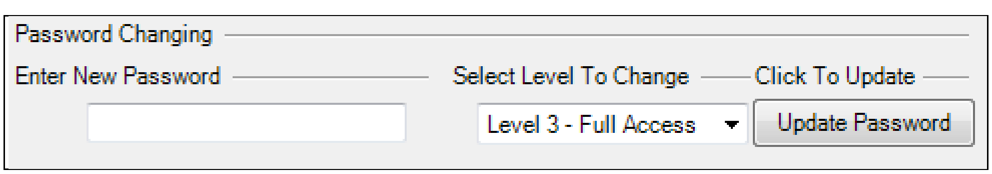


Figure 6-4. Password Updating Interface

To change the password:

1. New password must be entered into “Enter New Password” box.
2. Access level that will use this password should be selected.
3. After clicking “Update Password” button, password for the selected level will be updated.

This should be repeated for each access level.

The new password applies to the connected controller. If the device settings file is created, passwords will be stored in this setting file. If settings are then uploaded to new controller, the same password will be required to log into the controller.

IMPORTANT	**Retain password to Level 3 in a secure, readily accessible place. If the Level 3 password is forgotten, it will be impossible to change the basic controller functionalities and passwords.**

Configure System Identification

The first page of the APECS 4800 service tool contains the system identification controls. These parameters can be entered as short text information indicating the engine type, engine serial number and controller settings version. These values have no effect on controller operation but can be used for future reference. These values are stored in settings files the same way as other parameters and can also be accessed through CAN message “Component Identification.”

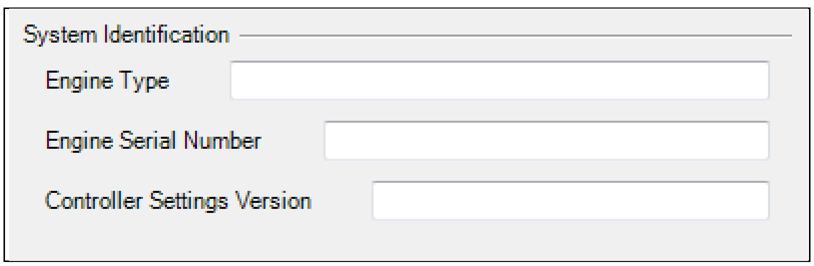


Figure 6-5. System Identification Controls

Configure Actuator Position Sensor

Actuator Position Sensor input must be configured in order to allow proper position control. The settings on this page should be configured according to the specifications of the position sensor in the actuator that is being used. Detailed information on algorithm for position sensor input is provided in **Chapter 4**. Actuator position sensor value is displayed in ADC counts (abbreviated as *cnts*). 0 counts represent 0V signal and 1023 counts represent 5V signal. In general, input in counts can be calculated as:

$$Signal\ [counts] = \frac{Signal\ [V]}{5\ [V]} * 1023\ [counts]$$

All the parameters on this page that define the actuator working range are represented in ADC counts.

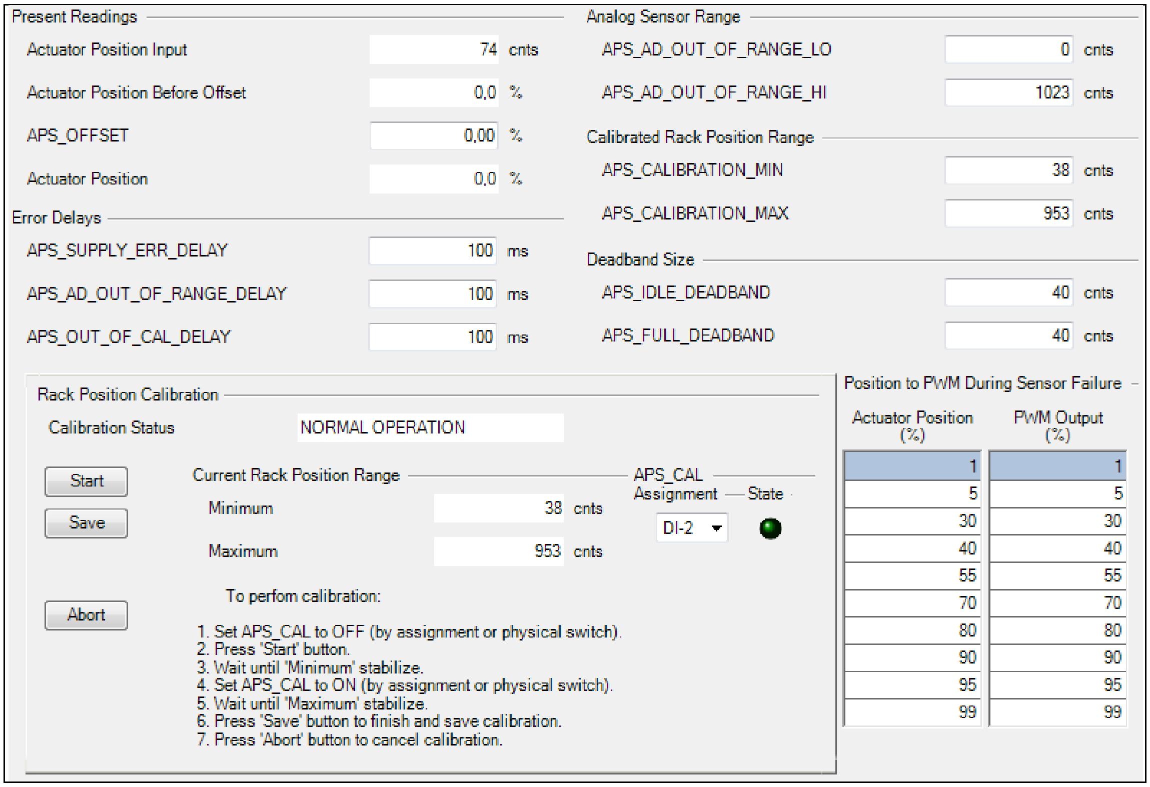


Figure 6-6. Actuator Position Sensor Configuration Page

APS_AD_OUT_OF_RANGE_LO, APS_AD_OUT_OF_RANGE_HI – out of range values outside which the POSITION_SENSOR faults are activated. These values should be set to voltages outside the operating range of position sensor. This allows for miswired or unconnected sensor detection. These values should not be left at default value.

APS_CALIBRATION_MIN, APS_CALIBRATION_MAX – base working ranges for actuator. These values should be set to sensor voltage levels at minimum and maximum actuator position.

APS_IDLE_DEADBAND, APS_FULL_DEADBAND – deadbands within the actuator working range. Normally only the small deadband is applied to get stable signal at 0% and 100% position. Otherwise, the actuator working range will be decreased by the deadband. No fault is activated within deadband regions but actuator position is treated as 0% (idle deadband) or 100% (full deadband) throughout this range.

APS_SUPPLY_ERR_DELAY – delay time after which APS_POWER_SUPPLY error is activated in case of short circuit. Normally it can be left at default value.

APS_AD_OUT_OF_RANGE_DELAY – delay time after which POSITION_SENSOR errors are activated in case of signal going out of range. Normally it can be left at default value.

APS_OUT_OF_CAL_DELAY – delay time after which POSITION_CAL errors are activated in case of signal going out of range. Normally it can be left at default value.

APS_OFFSET – offset for calculated actuator position. It is added to final calculated Actuator Position. This parameter is normally left at default value of zero during configuration. It is intended to compensate for part-to part variability of actuator placement. This parameter may be set to both positive and negative value. Actuator Position value is used as feedback for position governor, therefore increasing this value (with positive offset) will effectively reduce fuelling.

Position to PWM During Sensor Failure – this lookup table defines desired actuator position to PWM duty cycle relation. It is used only in Actuator Position Sensor failure limp home operation. If the limp home operation is not desired (engine is shut down in case of position sensor failure), this parameter is not used; therefore it does not need configuration. For proper limp home operation, this lookup table should be configured to match the position to duty cycle relationship for actuator that is used in the system. This will allow for the most precise limp home operation.

IMPORTANT	**PWM duty cycle to position relationship in the actuator is strongly dependent on temperature. Therefore the calculation used in Actuator Position Sensor failure limp home should be treated as a rough estimation.**

Rack Position Calibration – this section allows for quick calibration of actuator position sensor. It uses APS_CAL discrete input that will force actuator going to 100% position during the calibration. This procedure will automatically assign the minimum observed actuator position to APS_CALIBRATION_MIN and the maximum observed actuator position to APS_CALIBRATION_MAX. This is useful for quick calibration of actuator position sensor.

IMPORTANT	**For production configuration of actuator position sensor ranges, actuator specification and specifics of fuel pump and mechanical linkage should be taken into account. The calibration procedure may not always be desired.**

Configure Speed Setpoint Potentiometer

If speed setpoint potentiometer is used in the system, working ranges for potentiometer need to be defined. The configurable parameters available for calibration are explained in **Figure 6-8**. Normally, automatic potentiometer calibration is used, so there is no need for manual configuration.

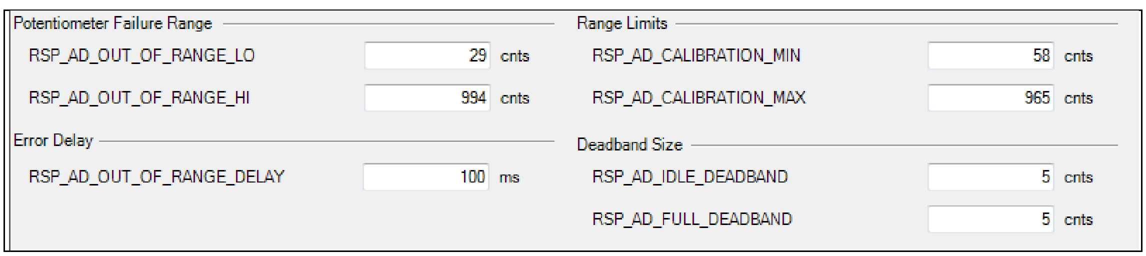


Figure 6-7. Speed Setpoint Potentiometer Configuration Page

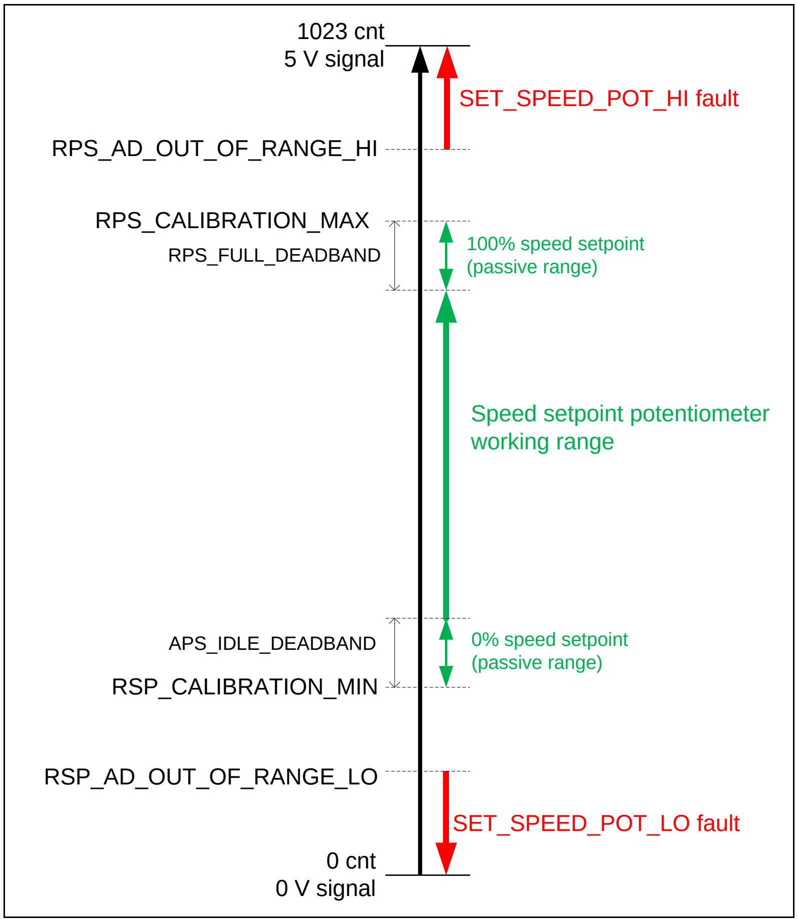


Figure 6-8.Speed Potentiometer Working Ranges

Potentiometer Calibration procedure is also available. During calibration, user is required to simply move the potentiometer between minimum and maximum position. The potentiometer signal is recorded and automatically put into RS_AD_CALIBRATION_MIN and RS_AD_CALIBRATION_MAX. Also RSP_AD_OUT_OF_RANGE_LO and RSP_AD_OUT_OF_RANGE_HI parameters are updated.

NOTE: Potentiometer Calibration is allowed on both Level 3 and Level 2 security access.

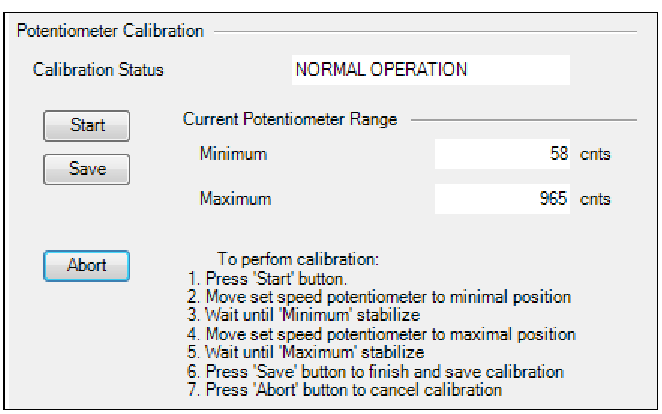


Figure 6-9. Potentiometer Calibration Procedure Interface

Configure Droop Potentiometer

Droop Potentiometer configuration procedure is the same as for the Speed Setpoint Potentiometer. All the configurable parameters have the same function (parameter name starts with DP_ instead of RSP).

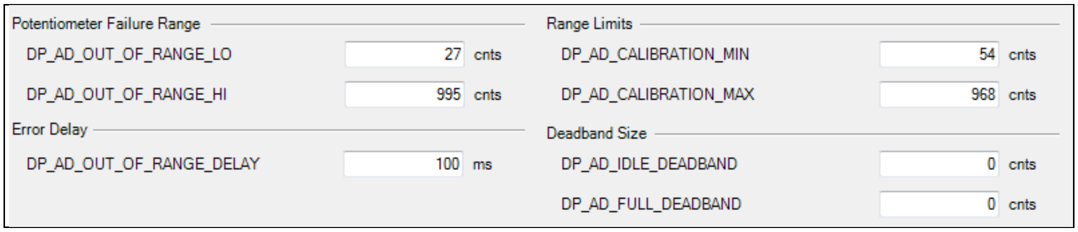


Figure 6-10. Droop Potentiomter Calibration Parameters

Droop Potentiometer Calibration procedure is done in the same way as speed setpoint potentiometer calibration.

Configure Air Pressure Sensor

If Air Pressure Sensor (or MAP – Manifold Air Pressure sensor) is used, proper configuration of sensor characteristics is required.

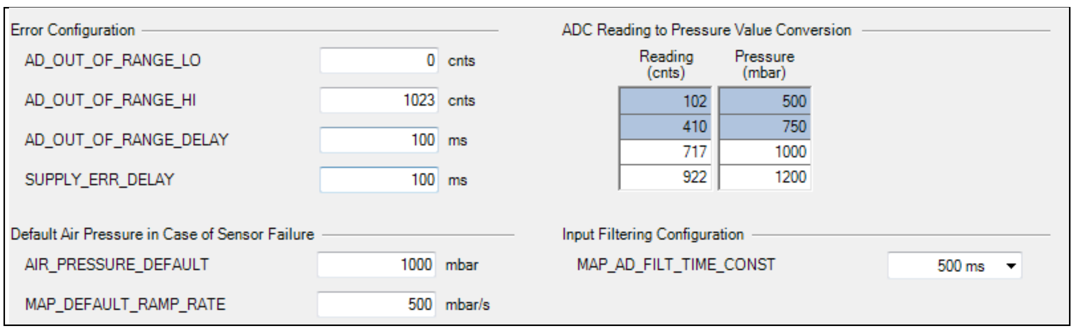


Figure 6-11. Air Pressure Sensor Configuration

ADC Reading to Pressure Value Conversion – defines the input voltage to air pressure calculation. This lookup table should be filled out according to pressure sensor characteristics. To calculate the signal in counts:

$$Signal\ [cnts] = \frac{Signal\ [V]}{5\ [V]} * 1023\ [cnts]$$

MAP_AD_OUT_OF_RANGE_LO, MAP_AD_OUT_OF_RANGE_HI – out of range values for MAP input, outside which MAP_SENSOR_LO or MAP_SENSOR_HI fault will be activated. If MAP input is used this value should be changed from default to allow unconnected sensor detection.

MAP_AD_OUT_OF_RANGE_DELAY – the delay time for activation of MAP_SENSOR faults. Normally may be left at default value.

MAP_SUPPLY_ERROR_DELAY - the delay time for activation of MAP_POWER_SUPPLY fault. Normally may be left at default value.

AIR_PRESSURE_DEFAULT – if MAP_SENSOR fault is detected, MAP input signal is ignored. In the moment of failure detection, the calculated air pressure will start ramping towards the default value. Then, this default will be used for black smoke control calculations. This value should be selected according to the desired black smoke control operation in case of sensor failure.

MAP_DEFAULT_RAMP_RATE – defines the speed at which the air pressure will be changed after sensor fault.

MAP_AD_FILTER_TIME_CONST – defines the amount of lowpass filtering applied to the MAP input. The longer this time, the slower the controller response for air pressure changes will be. Normally, the default value of 500 ms can be used.

Configure Engine Coolant Temperature Sensor

If engine coolant temperature sensor is used, proper configuration of sensor characteristics is required.

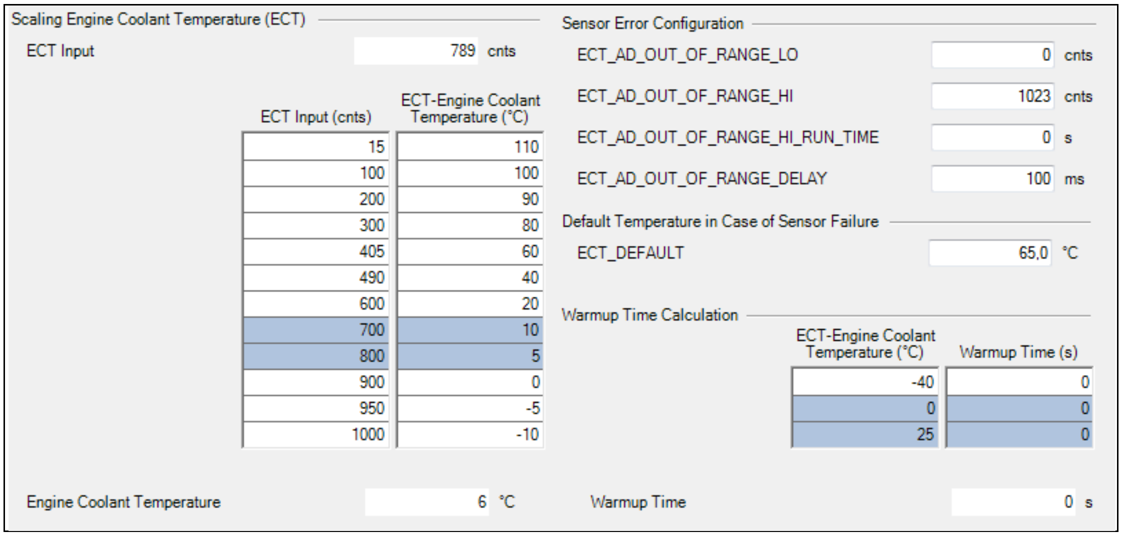


Figure 6-12. ECT Input Configuration
on Engine Coolant Temperature Sensor Page

Scaling Engine Coolant Temperature (ECT) – Normally a thermistor is used for ECT (Engine Coolant Temperature) sensing. Therefore, the sensor's resistance to voltage characteristics must be defined. This is achieved by populating the analog voltage to ECT lookup table. Analog voltage in converter counts on the ECT input can be calculated from sensor resistance using the following formula:

$$ECT\ [counts] = \frac{R}{R + 2.74k\Omega} * 1023$$

ECT_AD_OUT_OF_RANGE_LO, ECT_AD_OUT_OF_RANGE_HI – out of range values for ECT input, outside which ECT_SENSOR_LO or ECT_SENSOR_HI fault will be activated. If ECT input is used this value should be changed from default to allow disconnected sensor detection.

ECT_AD_OUT_OF_RANGE_HI_RUN_TIME – if this parameter is set to nonzero value, ECT_AD_OUT_OF_RANGE_HI fault will be ignored until engine has been running for specified time. This may be used if the ECT sensor resistance may be out of defined specification (too high) in cold condition.

ECT_AD_OUT_OF_RANGE_DELAY – the delay time for activation of ECT_SENSOR faults. Normally may be left at default value.

ECT_DEFAULT – if ECT_SENSOR fault is detected, ECT input signal is ignored. This default temperature value will be used for all ECT based calculations.

Warmup Time Calculation – this LUT is discussed with Engine Starting Configuration.

Apart from sensor input configuration, the engine coolant temperature monitoring functions are also configured on this page.

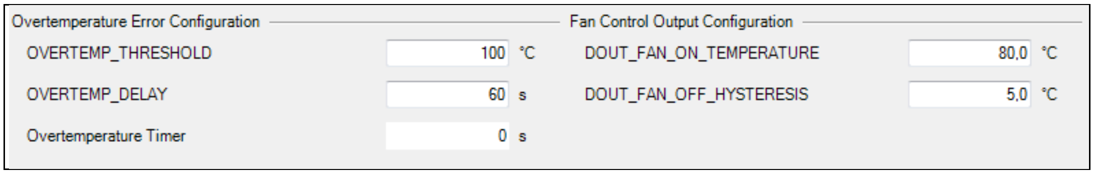


Figure 6-13. ECT Monitoring Configuration on Engine Coolant Temperature Sensor Page

OVERTEMP_THRESHOLD – defines the maximum ECT value above which OVER_TEMPERATURE failure will be activated.

OVERTEMP_DELAY – time the ECT must be constantly above threshold before failure is activated. Overtemperature Timer indicator will show the time of operation in temperature exceeding threshold.

DOUT_FAN_ON_TEMPERATURE – the temperature above which fan control output will be enabled.

DOUT_FAN_OFF_HYSTERESIS – the amount of hysteresis when disabling the fan control discrete output. The exact fan off temperature is DOUT_FAN_ON_TEMPERATURE – DOUT_FAN_OFF_HYSTERESIS.

Configure Discrete Inputs

APECS 4800 controller offers seven discrete inputs configurable for a range of different functions. By default, discrete inputs are configured as unused and have no effect on controller operation. Basic speed governing system does not require using any discrete input.

The following discrete inputs functions are available:

- SS_SELECT1, SS_SELECT2 – Speed switches used to control the speed setpoint
- DEN – Droop enable switch used to switch between droop and isochronous governing
- SDS – Software diagnostic switch used to control the MIL diagnostic lamp
- MCS – Memory clear switch used to clear logged faults
- ESS – Engine stop switch, an emergency shutdown input
- PTO – Power Take Off input used to select between analog and switched speed setpoint
- IVS – Idle Verification Switch used to diagnose the speed pedal in drive by wire speed mode
- SS_MODE1, SS_MODE2 – Speed mode switches used to change the speed setpoint source
- ASE – Autostart enable used in autocrank procedure or to facilitate engine starting
- PROT – protection input – a general purpose shutdown device input
- APS_CAL – Position sensor calibration input
- OPS – Oil pressure switch – shutdown input dedicated for engine oil pressure monitoring
- TEST – special input used to test the discrete outputs operation

A detailed description of discrete inputs is given together with the description of the corresponding functional block in Chapter 4 (Description of Operation) and Chapter 6 (Configuration). Note that there are more logical discrete input functions than available physical inputs; therefore not all functions may be utilized in the single system.

Figure 6-14. Discrete Inputs Allocation Configuration

Input Switches Allocation controls the functionality of each physical input. Logical functions (e.g., Speed Switch 1) can be either assigned to a physical input (e.g., Discrete Input 1) or set in software to OFF or ON. If the functionality connected with the logical function is not used (e.g., single speed application not using speed switches), it is normally assigned to OFF, which is the default value. For some functions, user may want to assign the physical switch to ON in software.

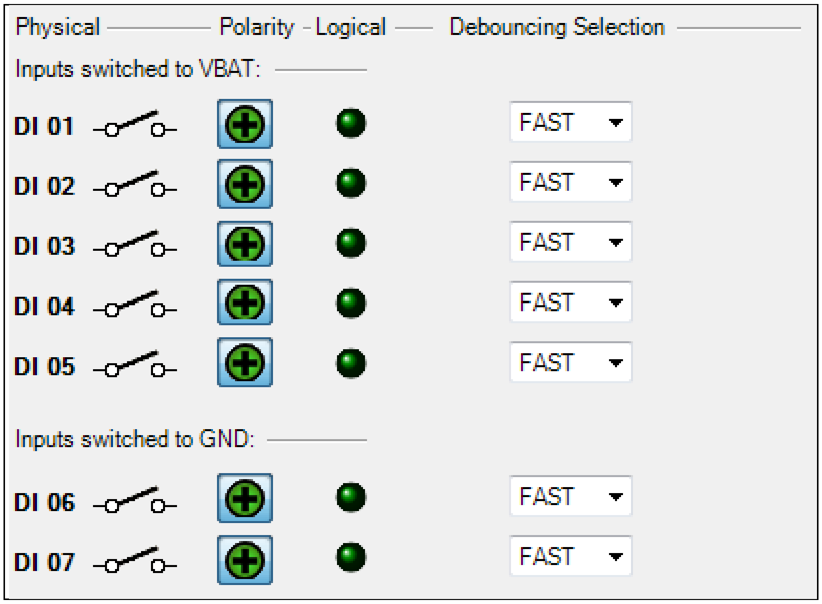


Figure 6-15. Discrete Inputs - Debouncing And Polarity Configuration

Each discrete input has a fixed physical connection. Discrete inputs 1 to 5 are switched in relation to battery voltage; discrete inputs 6 and 7 are switched in relation to ground. This is discussed in Chapter 3. Logical **polarity** is configurable for each input individually. Positive polarity (marked with "+" symbol in the software tool), means that input is considered ON (or active) when switch is closed (either to VBAT or to GND, depending on wiring). Negative polarity (marked with "-") means that input is considered active when the switch is open. The exact function of switch being ON or OFF depends on the input functional allocation. Polarity for each input should be configured according to application needs.

Debouncing Selection for each input can be set to either fast or slow. The debouncing time defines the amount of lowpass filtering that prevents the input from changing state due to electromagnetic interference or voltage spikes that may occur in the system.

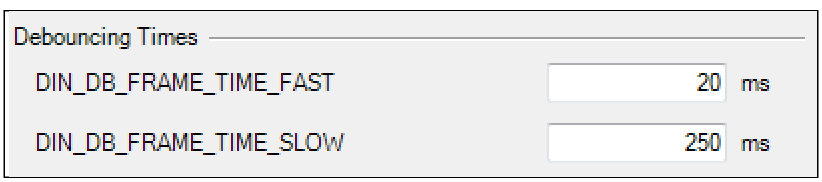


Figure 6-16. Discrete Inputs - Debounce Times Configuration

The exact slow and fast debouncing times can be changed in the software tool. Normally, it is advised to leave the default values.

Configure Discrete Outputs

There are nine electrically identical discrete outputs on the APECS 4800 controller. The function of discrete outputs is configured in software. By default, discrete outputs are configured as unused and will not have any function. Basic speed governing system does not require using of any discrete output.

Each physical discrete output can be assigned to one logical output functionality. If less than nine discrete outputs are used in the system, unused outputs should be assigned to NOT_USED option (default value). The description of each logical output functionality can be found in Chapter 4.

Available discrete outputs functions are:

- DIAGNOSTIC_LAMP – Malfunction Indication Lamp used to indicate faults by blinking codes
- WARNING_LAMP_1 … WARNING_LAMP_4 – warning lamps indicating faults occurrence
- SPEED_TRIP_RELAY_1, SPEED_TRIP_RELAY_2 – speed trip outputs (for relay or lamp) enabled when configured speed threshold is reached
- SHUTDOWN_RELAY – relay disabling current to the actuator if shutdown condition occurs
- AUTOCRANK_RELAY – relay enabling the starter motor in autocrank procedure
- GLOWPLUG_RELAY_DEP – output controlling glowplug used in autocrank procedure
- GLOWPLUG_RELAY_IND – output controlling independent glowplug (for systems not using autocrank)
- GLOWPLUG_LAMP – lamp used together with independent glowplug control
- POWER_TAKE_OFF – output for lamp that is activated when PTO (Power Take Off) mode is active
- TEST – diagnostic function described later in this section
- FAN_CONTROL – output enabled when Engine Coolant Temperature reaches the configured level

A detailed description of discrete outputs and corresponding functional block is provided in block in Chapter 4 (Description of Operation) and Chapter 6 (Configuration). Note that there are more logical discrete output functions than available physical outputs; therefore not all functions may be utilized in the single system.

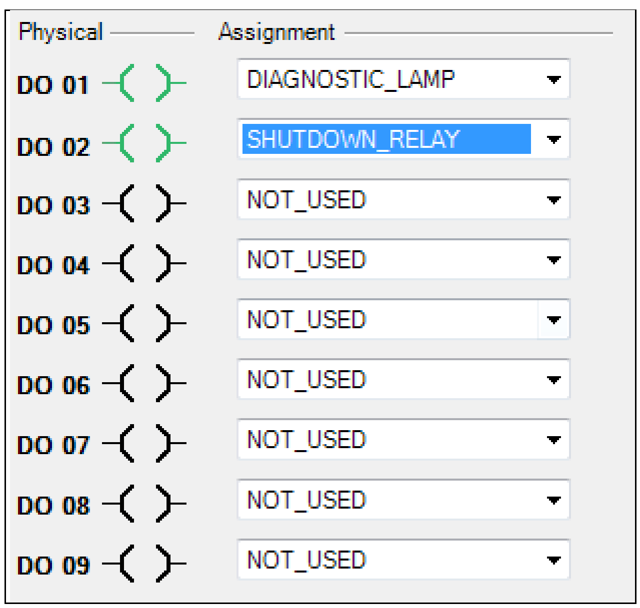


Figure 6-17. Discrete Outputs Configuration

To facilitate discrete outputs configuration and debugging, TEST output functionality is provided. All outputs assigned to TEST will behave depending on DOUT_TEST_MODE setting:

- TEST_MODE_OFF – disables test outputs
- TEST_MODE_ON – enables test outputs
- TEST_MODE_TOGGLE – test outputs are toggled each 0.5s
- TEST_MODE_SWITCH – test outputs will follow the state of the discrete input configured as TEST

TEST output functionality may be used to detect wiring issues or easily check the lamp and relays functionality.

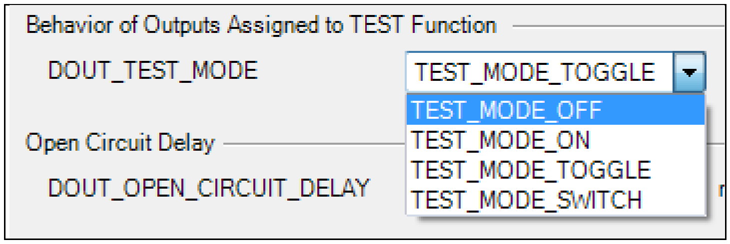


Figure 6-18. Test Output Mode Options

DOUT_SPEED_THRESHOLD_1 – defines the engine speed above which SPEED_TRIP_RELAY_1 output is enabled.

DOUT_SPEED_THRESHOLD_2 – defines the engine speed above which SPEED_TRIP_RELAY_2 output is enabled.

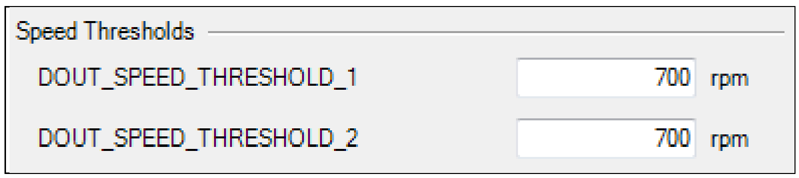


Figure 6-19.Speed Thresholds for Speed Trip Outputs Configuration

Configure Faults

Faults are configured on four pages: Diagnostics 1 – Diagnostics 4.

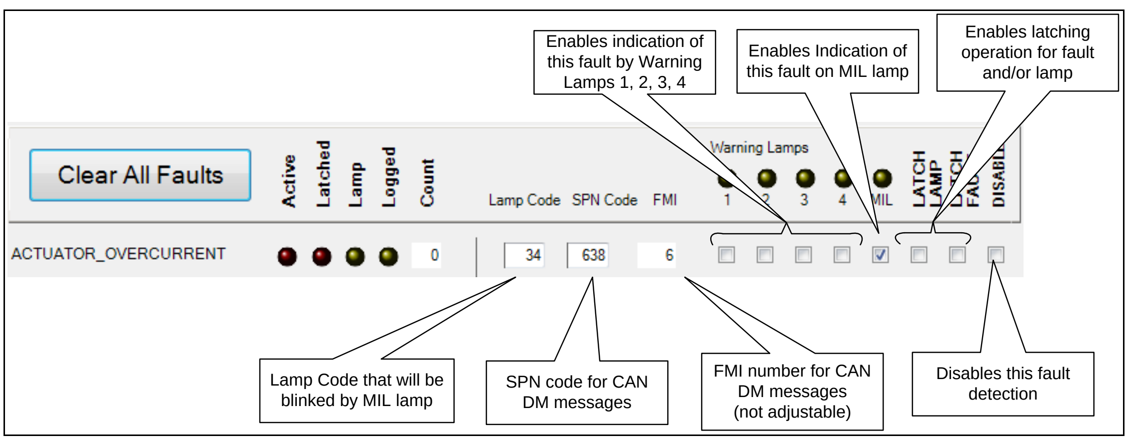


Figure 6-20. Fault Configuration Options

Warning Lamps 1 - 4 – if needed, configure which dashboard warning lamp will indicate this fault occurrence.

MIL – configure whether MIL lamp should indicate this faults occurrence. By default this is active for all faults because the MIL lamp is intended as a single point indication of all faults in the system.

LATCH FAULT– defines whether the fault operation will persist if fault is cleared. The default is OFF for all faults.

LATCH LAMP – defines whether the lamp indication for this fault will persist when the fault is cleared. The default is OFF for all faults.

Lamp Code – code for MIL lamp indication. Should be set to one-, two- or three-digit number. Value “1” should not be used because the controller uses a single short pulse to indicate that there are not active faults. Setting zero will disable MIL lamp indication for this fault. Multiple faults may be assigned the same lamp code.

SPN code – code used in CAN J1939 diagnostic messages to indicate this fault occurrence. The default values are selected according to J1939 Application Layer. The codes may be modified if this is required.

Configure Diagnostic Lamps

Warning Lamps (if used) require no further configuration after proper discrete outputs have been assigned and faults to be indicated have been selected.

MIL lamp allows selection of algorithm for faults indication.

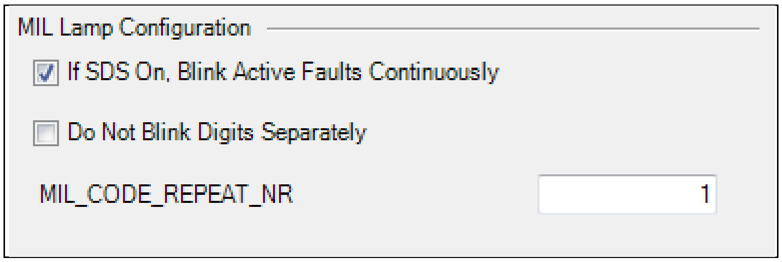


Figure 6-21. MIL Lamp Configuration ("Diagnostics 1")

If SDS On, Blink Active Faults Continuously – selects between momentary switch mode (unchecked) and toggle switch mode (checked). A detailed description of these options is given in the Diagnostics section of **Chapter 4**. Usually, the following configuration options are recommended, depending on whether physical diagnostic switch is used:

- MIL blink active or logged faults (depending on engine state) after diagnostic switch is pressed – uncheck this box, assign SDS discrete input to physical input to which switch is connected.
- MIL blinks active faults only, no diagnostic switches used – check this box, assign SDS discrete input to ON.

Do Not Blink Digits Separately – controls the way individual fault is being blinked. The default value is unchecked which gives the algorithm as described in **Chapter 4** (each digit blinked separately). Otherwise (if the parameter is checked), the fault code X is simply blinked by X short pulses. If this option is used, smaller values (usually a number between 1 and 20) should be assigned as Lamp Codes in order to avoid overly long codes duration.

Lamp Codes. **MIL_CODE_REPEAT_NR** – controls the repeat number for each fault blinking. The default value is 1, meaning that each fault will be blinked only once.

Configure Limp Home

Limp Home is the emergency controller operation mode that is entered after the critical fault is detected. This allows the engine to continue operation with limited performance or functionality instead of immediate shutdown. Limp home modes are defined for specific faults and the exact operation in limp home varies depending on which fault has caused it.

If a given limp home mode is not used in the system (i.e. engine should be shut down if corresponding fault is detected), the appropriate Limp Home Enable checkbox should be left unchecked. The remaining parameters can also be left at default values.

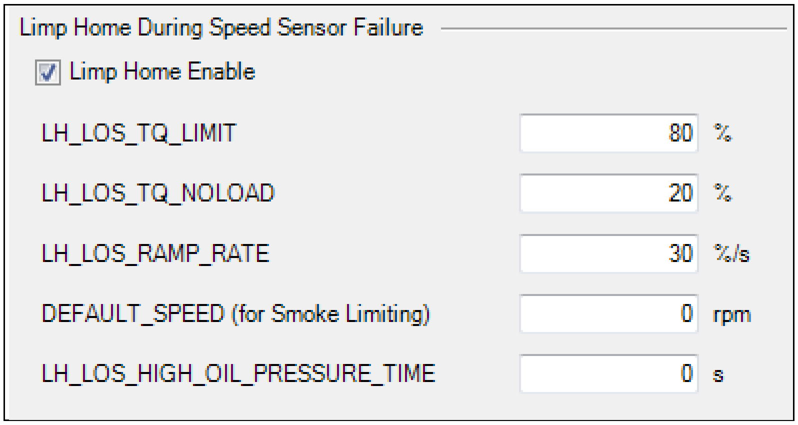


Figure 6-22. Speed Sensor Failure Limp Home Configuration

Limp Home Enable (Limp Home During Speed Sensor Failure) – if checked, the controller will not shut the engine down in case of LOSS_OF_SPEED fault detection, but will enter limp home mode defined for this fault. If not checked (default), limp home is disabled for this faults and remaining parameters in this block are ignored.

LH_LOS_TQ_LIMIT – maximum actuator position that can be commanded by speed potentiometer during limp home operation. If speed potentiometer is not used in the application, this is ignored.

LS_LOS_TQ_NOLOAD – minimum actuator position that will be commanded when speed potentiometer is fully released. If speed potentiometer is not used in the application this parameter defines the constant actuator position that will be commanded in limp home mode.

LH_LOS_RAMP_RATE – maximum change rate for actuator position when entering or working in the limp home mode.

DEFAULT_SPEED – this speed value will be used as an input to Black Smoke Control fuel map when controller is operating in limp home mode. If Black Smoke Control is not used, this is ignored.

LH_LOS_HIGH_OIL_PRESSURE_TIME – If this parameter is configured to a nonzero value, the controller will command crank actuator position when limp home is active as long as oil pressure switch signals low oil pressure. Once high pressure is signaled, crank actuator position will be maintained for the time defined in this parameter.

If Oil Pressure Switch is not used in the application, this value should be set to zero (default).

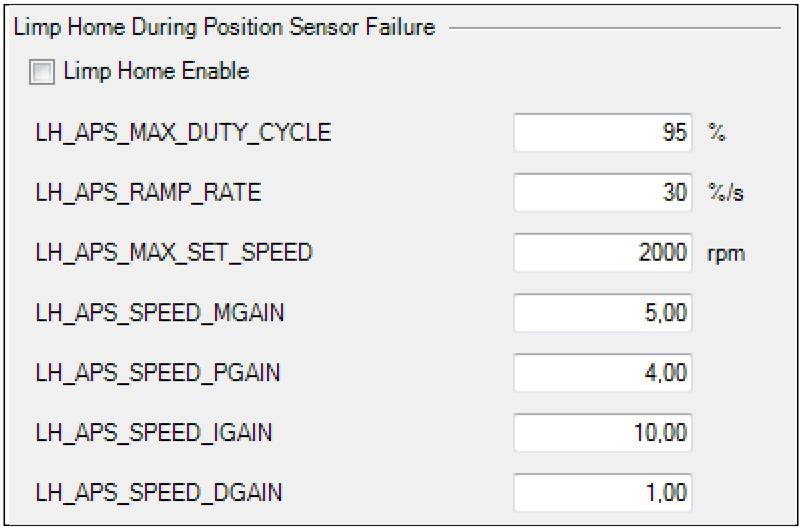


Figure 6-23. Position Sensor Failure Limp Home Configuration

Limp Home Enable (Limp Home During Position Sensor Failure) – if checked, the controller will not shut down the engine in case of APS_POWER_SUPPLY or POSITION_SENSOR faults detection, but will enter limp home mode defined for these faults. If not checked (default), limp home is disabled for those faults and remaining parameters in this block are ignored.

LH_APS_MAX_DUTY_CYCLE – the maximum allowed duty cycle in limp home operation.

LH_APS_RAMP_RATE – the rate at which the duty cycle limit will be applied when entering the limp home mode.

LH_APS_MAX_SET_SPEED – the desired speed limit that will be applied in limp home operation.

LH_APS_SPEED_MGAIN – the master gain for speed governor that will be used during the limp home operation instead of SPEED_MASTER_GAIN. This gain is subject to the same temperature-dependent scaler as normal gain.

LH_APS_SPEED_PGAIN – the proportional gain for speed governor that will be used during the limp home operation instead of SPEED_PROPORTIONAL_GAIN. This gain is subject to the same desired speed dependent scaler as normal gain.

LH_APS_SPEED_IGAIN – the integral gain for speed governor that will be used during the limp home operation instead of SPEED_INTEGRAL_GAIN. This gain is subject to the same desired speed dependent scaler as normal gain.

LH_APS_SPEED_DGAIN – the derivative gain for speed governor that will be used during the limp home operation instead of SPEED_DERIVATIVE_GAIN. This gain is subject to the same desired speed dependent scaler as normal gain.

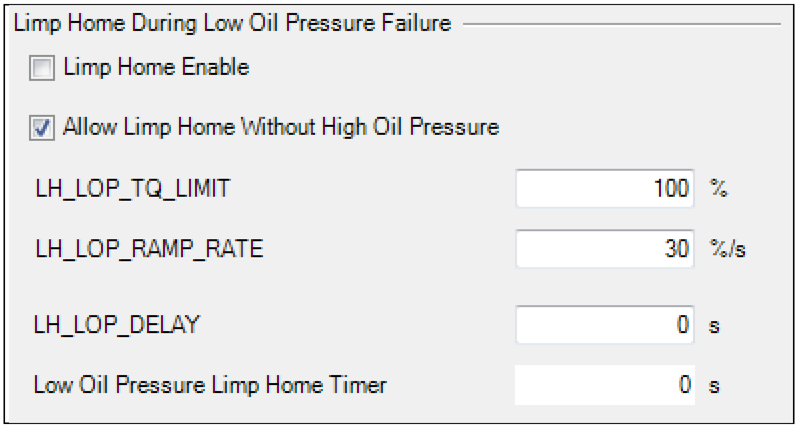


Figure 6-24. Low Oil Pressure Limp Home Configuration

Limp Home Enable (Limp Home During Low Oil Pressure Failure) – if checked, the controller will not shut the engine down in case of LOW_OIL_PRESSURE or OPS_WIRE_BREAK faults detection, but will enter limp home mode defined for these faults. If not checked (default), limp home is disabled for those faults and remaining parameters in this block are ignored.

Allow Limp Home Without High Oil Pressure – if this checkbox is checked, the engine is allowed to start in low oil pressure limp home. This is the default configuration. If unchecked, the limp home is only allowed if engine has been running and high oil pressure was observed by controller but has been lost.

LH_LOP_TQ_LIMIT – actuator position limit applied when controller is working in low oil pressure limp home.

LH_LOP_RAMP_RATE – the rate at which the actuator position limit will be applied when entering the limp home mode.

LH_LOP_DELAY – the maximum allowed time for engine running operation in low oil pressure. The controller will shut the engine down afterwards.

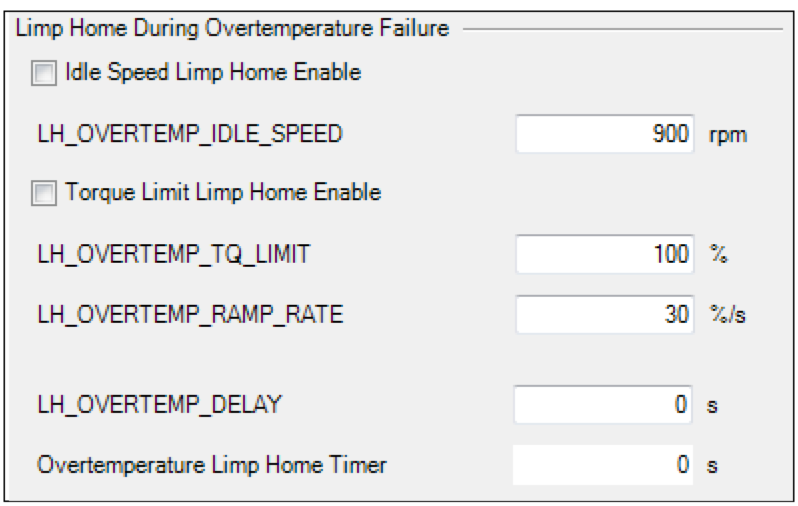


Figure 6-25. Overtemperature Limp Home Configuration

Idle Speed Limp Home Enable (Limp Home During Overtemperature Failure)
– if checked, the controller will not shut down the engine in case of OVERTEMPERATURE fault detection, but will continue operation with maximum speed limit. If not checked (default), speed limp home is disabled.

Torque Limit Limp Home Enable (Limp Home During Overtemperature Failure) – if checked, the controller will not shut down the engine in case of OVERTEMPERATURE fault detection, but will continue operation with actuator position limit applied. If not checked (default), speed limp home is disabled.

Both idle speed and torque limit operation can be used together for overtemperature limp home. If neither of those options is enabled, the engine will be shut down in case of overtemperature.

LH_OVERTEMP_IDLE_SPEED – the limit for desired speed that will be applied during overtemperature limp home operation if Idle Speed Limp Home is enabled.

LH_OVERTEMP_TQ_LIMIT – the limit for actuator position that will be applied during overtemperature limp home operation if Torque Limit Limp Home is enabled.

LH_ OVERTEMP _RAMP_RATE – the rate at which the actuator position limit will be applied when entering the limp home mode.

LH_ OVERTEMP _DELAY – the maximum allowed time for engine running in overtemperature. The controller will shut down the engine afterwards.

Configure Engine Starting

Engine starting control the speed governor behavior before set speed governing begins.

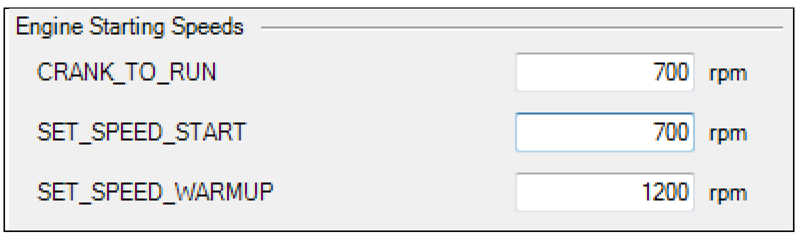


Figure 6-26. Engine Starting Speeds Configuration

CRANK_TO_RUN – the speed above which engine is assumed running. Should be set above the engine's cranking speed.

SET_SPEED_START – the initial speed commanded immediately after engine has started. Speed ramping begins from this value immediately. Normally, this parameter is set to the same value as CRANK_TO_RUN.

SET_SPEED_WARMUP – engine speed to be commanded during warmup period. If warmup time is calculated as zero, this parameter is ignored.

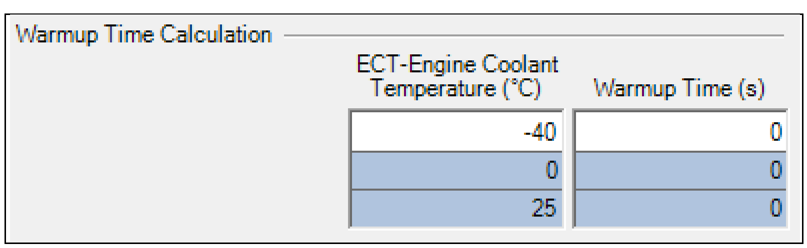


Figure 6-27. Warmup Time Configuration
on Engine Coolant Temperature Sensor Page

Warmup Time Calculation – the 3-point lookup table defines temperature to warmup time relationship. By default, all time values are set to zero, meaning that warmup feature is not used. If needed, appropriate non-zero time values should be entered into the table.

Additional configuration is required for systems that does not generate valid speed signal during cranking (see Engine Starting description in **Chapter 4**). One of two options is available:

- Commanding crank actuator position for configured time after power up
- Commanding crank actuator position with Autostart Enable discrete input

If **Autostart Enable** (ASE) discrete input is used, only configuration needed is assigning proper physical input to ASE. When this input is active, crank actuator position will be commanded (unless engine running speed is detected). This functionality may not be used together with autocrank feature. Autocrank relay and dependent glowplug relay must not be used in the system (must not be assigned to any discrete output).

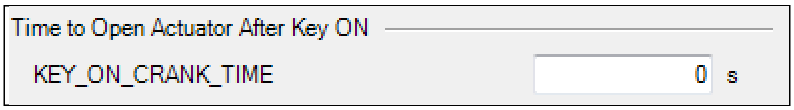


Figure 6-28. Timed Cranking Configuration

KEY_ON_CRANK_TIME – the time that actuator should be driven at crank position following the controller power up (unless engine running speed is detected). The default value is zero which disables this operation.

⚠CAUTION

If KEY_ON_CRANK_TIME functionality is set to non-zero value, actuator will be driven to crank position even if no engine speed signal is present. This may lead to overspeed situation if MPU sensor is broken.

Configure Speed Modes

Speed mode defines the speed setpoint source. The speed mode may be either fixed during configuration or selected with discrete inputs from up to four configured modes. The exact operation of each available speed mode is discussed in **Chapter 4**. By default, the device is configured for “switches” speed mode which is suitable also for fixed speed applications. For systems using another speed mode or multiple speed modes, the configuration as explained in this section should be done.

For fixed speed mode, both SS_MODE1 and SS_MODE2 discrete inputs must be assigned to OFF. Only one speed mode selection parameter, **SET_SPEED_MODES[0],** is shown in the service tool. Proper speed mode should be configured in this parameter.

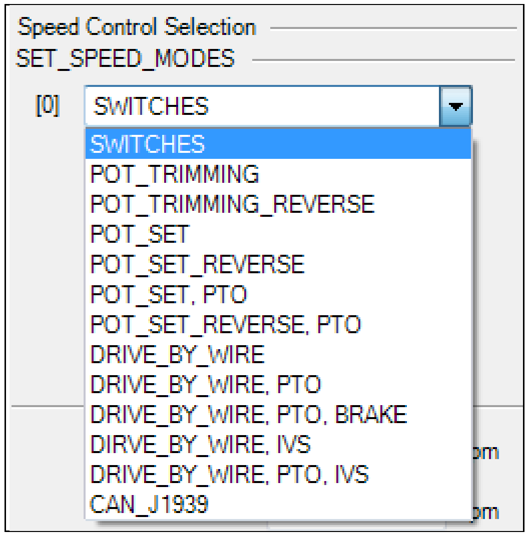


Figure 6-29. Speed Mode Selection

Available speed mode options are:

- **SWITCHES** – speed controlled with discrete inputs (either switched fixed speeds or inc/dec switches), also used for single speed applications
- **POT_TRIMMING, POT_TRIMMING_REVERSE** – speed trimming mode
- **POT_SET** – speed potentiometer mode
- **POT_SET_REVERSE** – speed potentiometer mode with potentiometer operating in reverse
- **POT_SET, PTO; POT_SET_REVERSE, PTO** – speed potentiometer modes using the PTO input
- **DRIVE_BY_WIRE** – drive by wire mode
- **DRIVE_BY_WIRE, PTO** – drive by wire mode using the PTO input
- **DRIVE_BY_WIRE, PTO, BRAKE** – drive by wire mode using both PTO and brake input
- **DRIVE_BY_WIRE, IVS** – drive by wire mode using the IVS input
- **DRIVE_BY_WIRE, PTO, IVS** – drive by wire mode using both PTO and IVS input
- **CAN_J1939** – CAN speed setpoint

If at least one of SS_MODE1 and SS_MODE2 discrete input is assigned to physical input, multiple **SET_SPEED_MODES** selection is available.

For two speed modes, SS_MODE1 switch should be used. Switch will select between SET_SPEED_MODES[0] and SET_SPEED_MODES[1]. Currently active Speed Setpoint Mode is always displayed in service tool on page Set Speed Configuration.

In the configuration example shown in **Figure 6-30**, a two-position switch connected to SS_MODE1 discrete input will select between speed potentiometer and CAN speed setpoint.

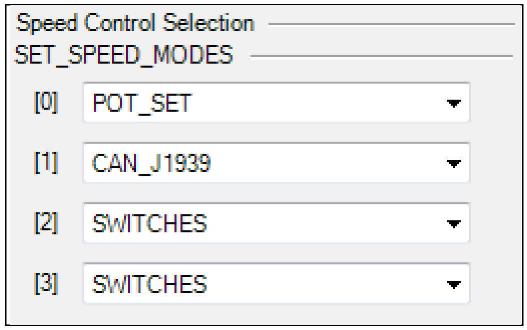


Figure 6-30. Two Speed Modes Configuration

If three or four speed modes are needed, both SS_MODE switches must be used. In the configuration example shown in **Figure 6-31**, SS_MODE2 switch will select between CAN and potentiometer trimming speed setpoint. SS_MODE1 switch will select the potentiometer operation (forward or reverse) in trimming mode. If CAN mode is selected, SS_MODE1 will be ignored.

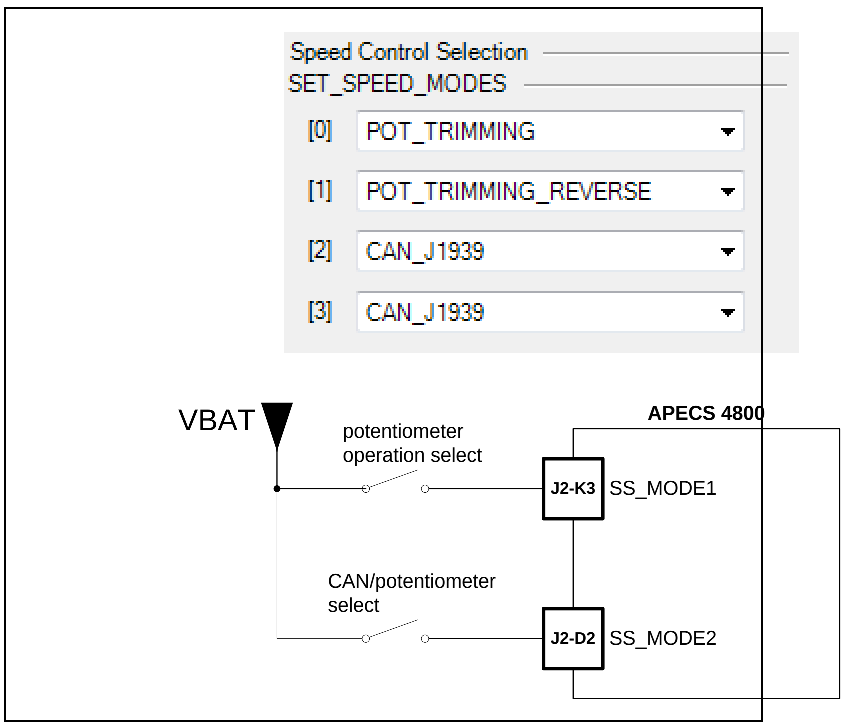


Figure 6-31. Three Speed Modes Configuration with Switches Wiring Example

Configure Speed Setpoint

The APECS 4800 default configuration is fixed speed 1500 rpm application. Speed setpoint may be changed by entering desired speed value to SET_SPEED_1 parameter.

For applications using another speed mode, remaining speed setpoint related parameters should be configured.

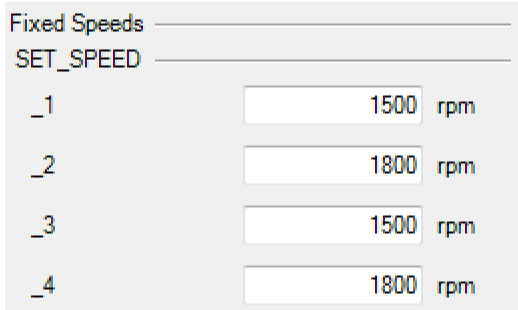


Figure 6-32. Fixed Speeds Configuration

SET_SPEED_1 … SET_SPEED_4 – define the fixed speeds that are used in SWITCHES and POT_TRIMMING speed modes. If any of these modes is used, the appropriate speed values must be configured.

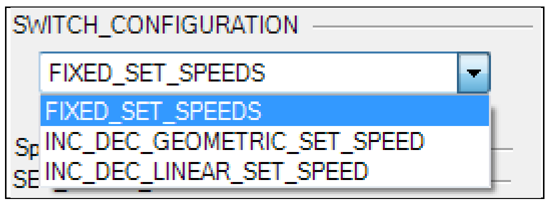


Figure 6-33. Switch Configuration

SWITCH_CONFIGURATION – defines the SS_SELECT1 and SS_SELECT2 discrete inputs behavior in SWITCHES speed mode.

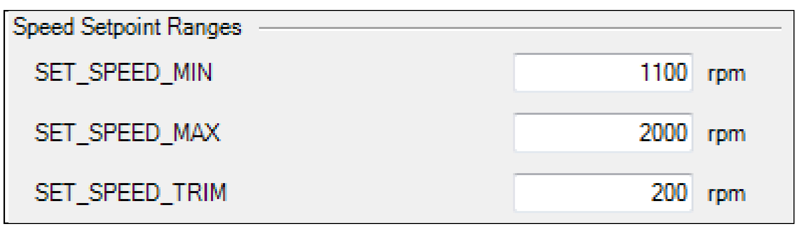


Figure 6-34. Speed Setpoint Ranges Configuration

SET_SPEED_MIN – low speed range used in following speed modes: SWITCHES (only inc/dec switch configuration), POT_SET, DRIVE_BY_WIRE.

SET_SPEED_MAX – high speed range used in following speed modes: SWITCHES (only inc/dec switch configuration), POT_SET, DRIVE_BY_WIRE.

SET_SPEED_TRIM – the maximum speed change in POT_TRIMMING modes.

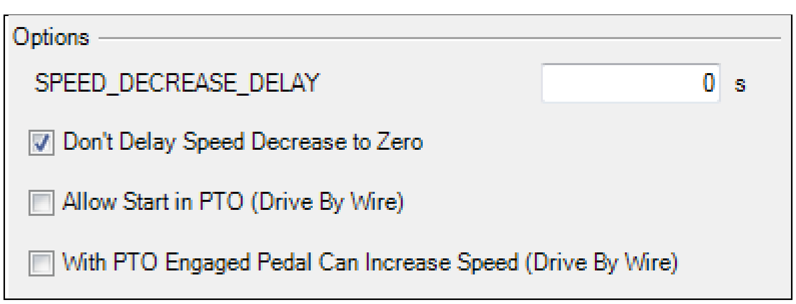


Figure 6-35. Speed Setpoint Additional Options

SPEED_DECREASE_DELAY – the delay before lower speed is commanded in SWITCHES (only fixed speed switches configuration). Normally, this parameter is set to zero (meaning no delay).

Don't Delay Speed Decrease to Zero – if checked, the speed decrease delay operation will not affect shutting down the engine (decreasing the speed to zero). This is used only if nonzero value is entered into SPEED_DECREASE_DELAY parameter.

Allow Start in PTO – only used in drive by wire speed modes with PTO input. If checked, the engine will go directly to the PTO mode if engine is started with PTO input active. Otherwise, operator has to cycle the PTO switch OFF and then back ON to enable PTO operation. The default is unchecked.

With PTO Engaged Pedal Can Increase Speed – only used in drive-by-wire speed modes with PTO input. If checked, the PTO speed will be overridden by the potentiometer speed setpoint if the latter is higher.

Configure Speed Ramp Rates

By default all ramp rates are set to 1000 rpm/s, this value may need changing for some applications.

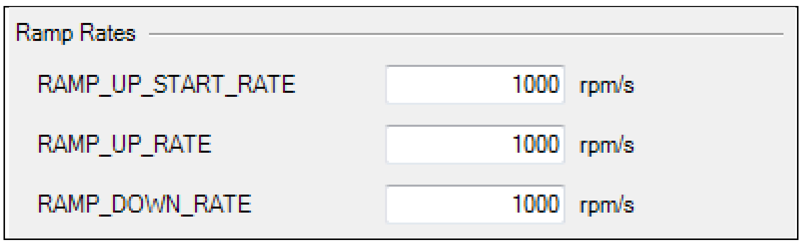


Figure 6-36. Speed Ramp Rates Configuration
on Set Speed Configuration Page

RAMP_UP_START_RATE – the ramp rate that is used immediately after engine start until the first desired speed is reached.

RAMP_UP_RATE – the ramp rate that limits accelerating speed when engine is running.

RAMP_DOWN_RATE – the ramp rate that limits decelerating speed when engine is running.

Configure Overspeed Protection

Overspeed limit is calculated in relation to currently selected desired speed. Therefore the default configuration may be suitable for many systems. By default, overspeed threshold is set to 125% of selected speed with an absolute limit of 3000 rpm.

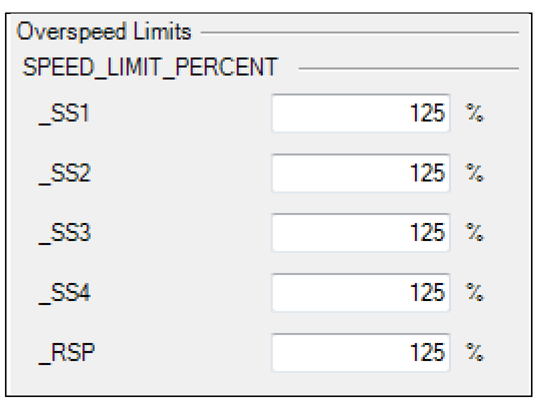


Figure 6-37. Overspeed Limits Configuration
on Set Speed Configuration Page

SPEED_LIMIT_PERCENT_SS1 … SPEED_LIMIT_PERCENT_SS4 – relative overspeed limits used when corresponding fixed speed is selected. These parameters are used only if the following speed modes are used: SWITCHES, POT_TRIMMING, POT_SET with PTO, DRIVE_BY_WIRE with PTO.

In SWITCHES and PTO speed mode, overspeed threshold is calculated as a product of the selected speed setpoint and the relative limit.

In POT_TRIMMING speed mode, overspeed threshold is calculated as:

SPEED_LIMIT_PERCENT_SSn * (SET_SPEED_n + SET_SPEED_TRIM)

SPEED_LIMIT_PERCENT_RSP – relative overspeed limit used when speed potentiometer is commanding the speed (in POT_SET and DRIVE_BY_WIRE modes). Overspeed threshold is calculated as a product of SPEED_LIMIT_PERCENT_RSP and SET_SPEED_MAX.

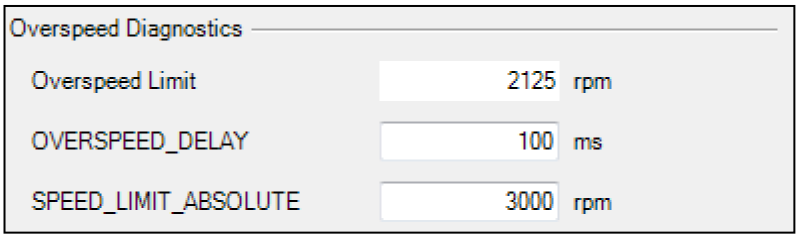


Figure 6-38. Overspeed Fault Detection Configuration

Overspeed Limit – this read only control displays the currently calculated overspeed limit.

OVERSPEED_DELAY – defines the amount of time the engine speed must be constantly above the overspeed threshold before OVERSPEED fault is activated.

SPEED_LIMIT_ABSOLUTE – defines the maximum allowed overspeed limit. It will be applied if the speed limit calculated using the SPEED_LIMIT_PERCENT_x parameters is lower than SPEED_LIMIT_ABSOLUTE.

Configure Droop

By default, the controller is configured for isochronous operation (droop disabled). For applications using droop, configuration of droop parameters is required.

NOTE: Configuration of Engine Load Control feature is also required when using droop.

The Droop Mode page contains the read only monitoring values that may be used during the tuning of the droop parameters.

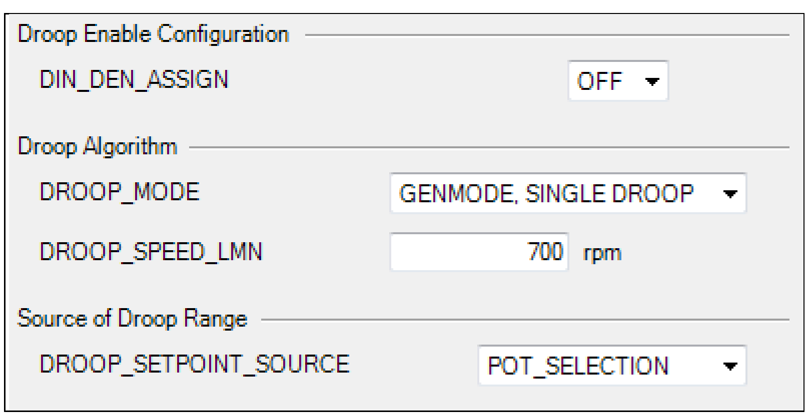


Figure 6-39. General Droop Configuration

DI_DEN_ASSIGN – assignment of Droop Enable switch. This control is also available on Discrete Inputs Configuration page. If droop is used without external Droop Enable switch, this control should be set to

ON. Setting to OFF permanently disables droop. If Droop Enable switch is used in the application, this parameter should be assigned to a proper discrete input.

DROOP_MODE – two droop options are controlled by this setting:

- GENMODE/INDMODE – generator mode (desired speed unchanged at full load, increased at lower load) or industrial mode (desired speed unchanged at no load, decreased at higher loads)
- SINGLE / DUAL droop – for single droop, the droop rate is constant for the whole load range, for dual droop, the droop rate for load above intermediate load line may be set independently.

DROOP_SPEED_LMN – defines the minimum speed setpoint for droop. Droop algorithm will not adjust the speed below this point.

DROOP_SETPOINT_SOURCE – defines how the droop rate is decided. Two options are available:

- TABLE_SELECTION – droop rate is calculated from 8-point curve, depending on desired engine speed.
- POT_SELECTION – droop rate

If no droop rate variability is needed, this parameter should be set to TABLE_SELECTION, and all droop rate values in Droop From No Load Line Calculation should be populated with the desired droop rate value.

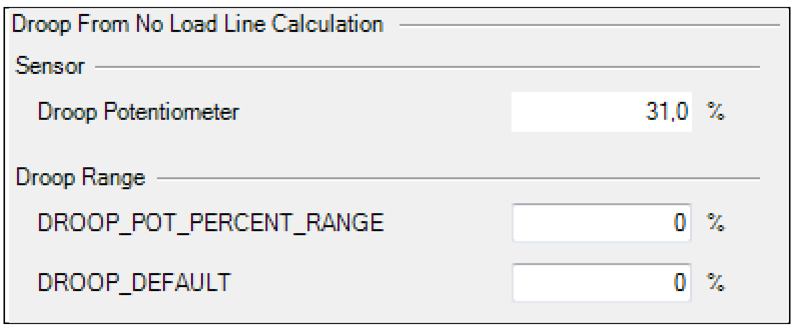


Figure 6-40. Droop Potentiometer Setpoint Configuration

Droop Potentiometer – this read only control shows the current value of Droop Potentiometer signal. **DROOP_POT_PERCENT_RANGE** – the droop rate applied when droop potentiometer is in 100% position. Droop rate is calculated as a product of the Droop Potentiometer value and DROOP_PERCENT_RANGE. Used only if DROOP_SETPOINT_SOURCE is set to TABLE_SELECTION (otherwise, this parameter is not displayed in the software tool).

DROOP_DEFAULT – the droop rate used in case the device powers up with Droop Potentiometer fault. If the fault occurs during the operation, droop rate locks in last proper value signaled by the potentiometer. Used only if DROOP_SETPOINT_SOURCE is set to TABLE_SELECTION (otherwise, this parameter is not displayed in software tool).

Droop From No Load Line Calculation

Desired Speed (rpm)	Droop Rate (%)
700	0,0
1100	0,0
1450	0,0
1500	0,0
1550	0,0
1750	0,0
1800	0,0
1850	0,0

Figure 6-41. Droop Table Setpoint Configuration

Droop From No Load Line Calculation – defines the desired speed to droop rate relationship. Used only if DROOP_SETPOINT_SOURCE is set to TABLE_SELECTION (otherwise, this parameter is not displayed in the software tool). In the single droop mode, this parameter defines the droop rate for the whole engine load range.

Intermediate Load Line

Desired Speed (rpm)	Intermediate Load (%)
700	80,0
1100	80,0
1450	80,0
1500	80,0
1550	80,0
1750	80,0
1800	80,0
1850	80,0

Droop From Intermediate Load Line Calculation

Desired Speed (rpm)	Droop Rate (%)
700	0,0
1100	0,0
1450	0,0
1500	0,0
1550	0,0
1750	0,0
1800	0,0
1850	0,0

Present Reading

Droop Rate 0,0 %

Figure 6-42. Intermediate Droop Configuration (Used in Dual Droop Mode)

Intermediate Load Line – defines the engine speed to intermediate load curve. The intermediate load is used in dual droop algorithm only.

Droop From Intermediate Load Line Calculation – defines the relationship of the desired speed to droop rate that is used in dual droop operation when engine load is above the intermediate load.

Configure Autocrank and Glowplugs

The APECS 4800 controller provides the capability to automatically enable the starter motor and/or glowplug in a predefined sequence.

The autocrank functionality is enabled by configuring the autocrank relay to a discrete output. This output should be connected to a relay that enables the started motor. Together with the autocrank relay, the dependent glowplug relay may be used in order to perform engine preheat before starting.

Alternatively, the controller may be configured to only perform preheat automatically after power up and inform an operator that engine may be started. The independent glowplug relay and glowplug lamp outputs are used in this configuration.

If autocrank relay of glowplug relay is used in the system, configuration of timing for these outputs is required. Refer to the description provided in Chapter 4 before configuring these features.

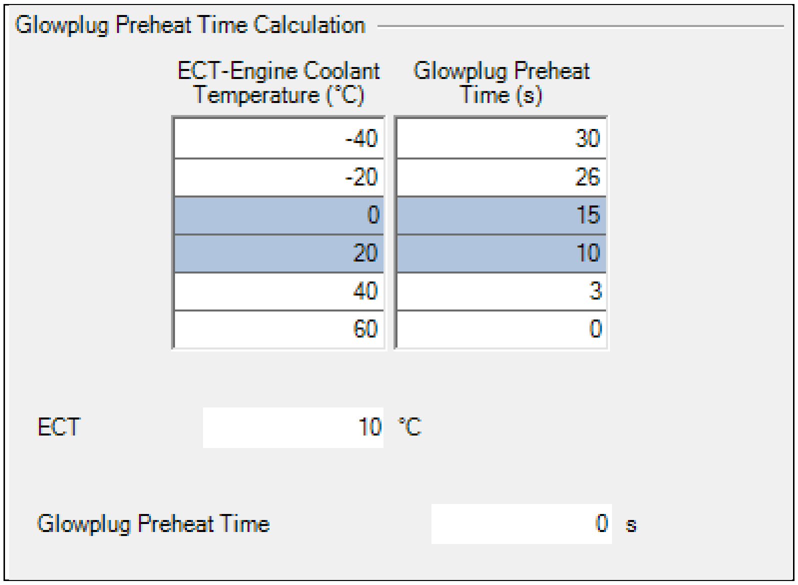


Figure 6-43. Glowplug Preheat Time Configuration

Glowplug Preheat Time Calculation – defines the ECT (Engine Coolant Temperature) to glowplug preheat time. The calculated time is used for both independent and dependent (synchronized with autocrank) glowplug. If fixed preheat time is required, all output entries in this table should be set to the same time value.

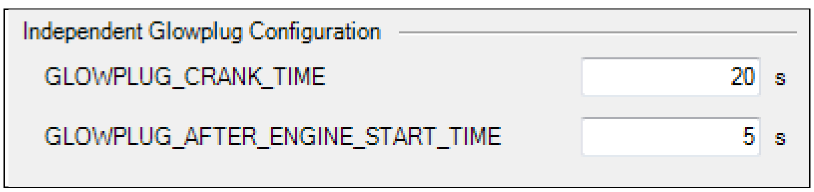


Figure 6-44. Independent Glowplug Configuration

GLOWPLUG_CRANK_TIME – the maximum amount of time independent glowplug will be kept on. During this time an operator is expected to start the engine. If this time passes and the engine is not started, independent glowplug is disabled until next controller power cycle.

GLOWPLUG_AFTER_ENGINE_START_TIME – the amount of time the independent glowplug will be kept on after engine has been started.

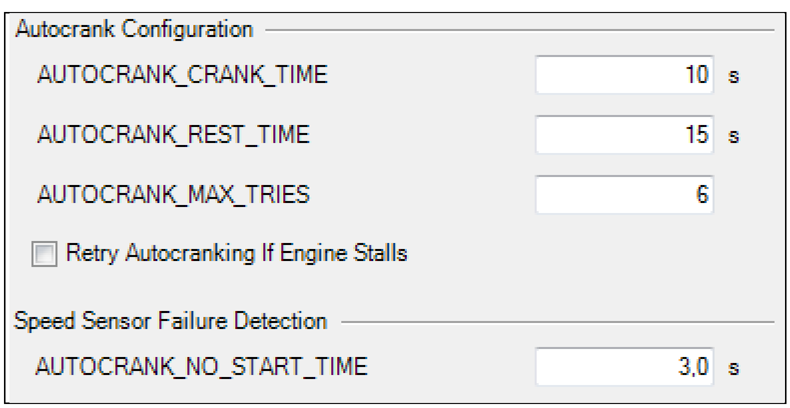


Figure 6-45. Autocrank Configuration

AUTOCRANK_CRANK_TIME – the maximum time the autocrank relay will be kept on while engine is cranking. If the time passes, crank attempt is assumed failed and controller either goes into rest phase before next attempt or aborts the autocrank if no more crank attempts are allowed.

AUTOCRANK_REST_TIME – the amount of pause after failed crank attempt. This time should be enough for the starter motor to cool.

AUTOCRANK_MAX_TRIES – maximum number of crank attempts allowed. If the number of attempts fail, AUCTORANK fault is activated.

Retry Autocranking If Engine Stalls – if this option is enabled, the controller will automatically retry autocrank if engine has stopped. The rest period will precede the first crank attempt. By default, this option is disabled and operator is required to turn the Autostart Enable switch off and then back on to restart the engine.

AUTOCRANK_NO_START_TIME – defines the maximum time the controller will keep the crank relay enabled if cranking engine speed is not sensed. If the time is exceed (no speed sensed), the speed sensor fault is detected.

Configure CAN J1939

Before using CAN communication it has to be enabled in the software by using the **Enable Can Module** option. The changed option takes effect after first controller power cycle.

The content of the **NAME Fields** sent in Address Claimed message can be configured. By default, only the Manufacturer Code is configured to 153 (Woodward), remaining fields are set to zero.

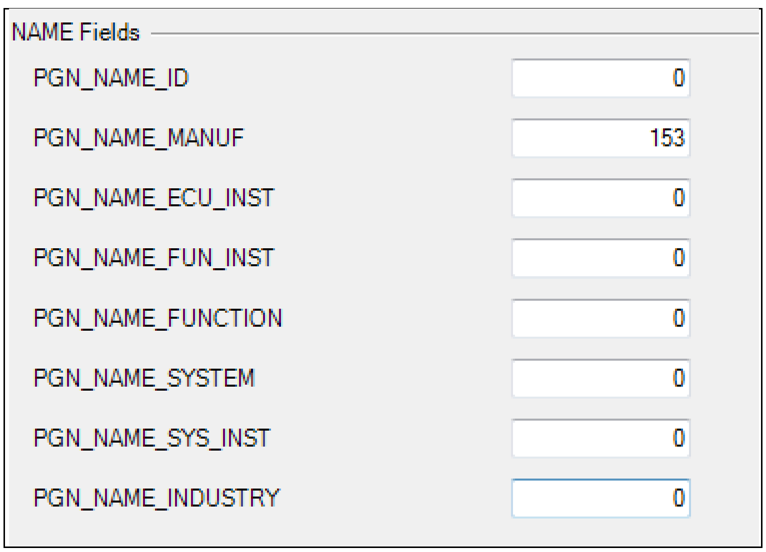


Figure 6-46. NAME Field Content Configuration

CAN_SOURCE_ADDRESS – CAN Source Address is configurable. The APECS 4800 controller does not support J1939 dynamic addressing. Individual CAN address must be assigned to each unit on the bus that does not support dynamic addressing.

Address Claim Status gives information if address claiming was successful.

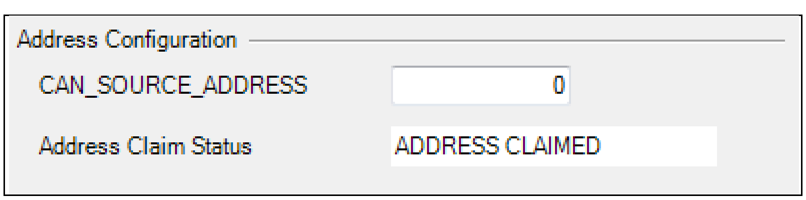


Figure 6-47. CAN Source Address Configuration

Transmitting period for each **broadcasted PGNs** and timeout for **received PGN'S** can be configured on this page.

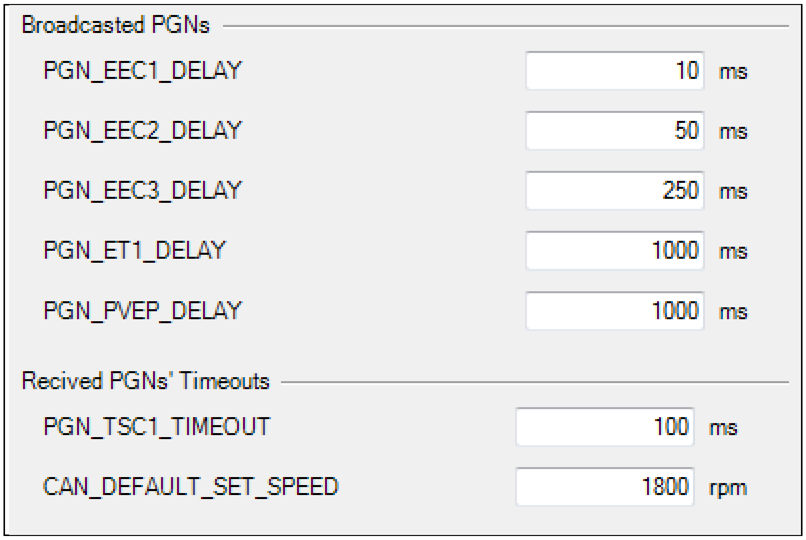


Figure 6-48. PGNs Periods Configuration

PGN_EEC1_DELAY, PGN_EEC2_DELAY, PGN_EEC3_DELAY, PGN_ET1_DELAY, PGN_PVEP_DELAY define the broadcasting period for related PGNs. These parameters can normally be left at default values unless there are specific application requirements.

PGN_TSC1_TIMEOUT – defines the timeout for TSC1 message when using CAN commanded speed. If the TSC1 message is not received within this time, CAN_RECEIVE_TIMEOUT fault will be activated. This parameter should be sent to the value higher than the period of TSC1 message sent by CAN controller commanding speed to APECS .

CAN_DEFAULT_SET_SPEED – this parameter should be set to the speed the APECS should start commanding in CAN mode in case of CAN_RECEIVE_TIMEOUT fault. Can be set to zero or safe speed used in emergency situation.

Configure Shutdown Devices

If Oil Pressure Switch or Protection Input is used in the application, apart from allocating the proper discrete input, the corresponding parameters should be configured. If Engine Stop Switch is used, only the discrete input assignment is required.

Shutdown Relay is recommended for all systems. This relay should be placed in the actuator wiring according to the description in the Chapter 3, section "Actuator Output". Except for discrete output allocation, no further configuration is required.

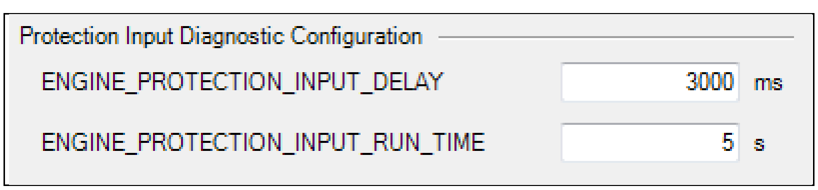


Figure 6-49. Protection Input Configuration

ENGINE_PROTECTION_INPUT_DELAY – the amount of time the Protection Input must be continuously active before engine is shut down.

ENGINE_PROTECTION_INPUT_RUN_TIME – the time that the engine must be running before controller begins to monitor the Protection Input.

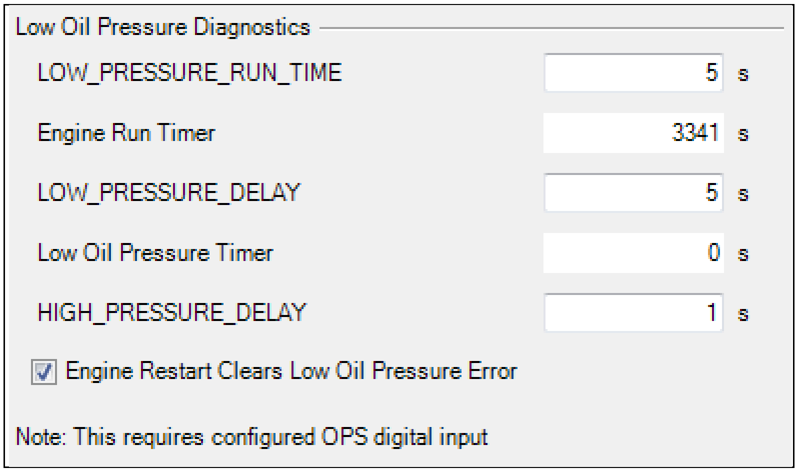


Figure 6-50. Oil Pressure Switch Configuration

LOW_PRESSURE_RUN_TIME – the amount of time the engine must be running before the controller starts to monitor the Oil Pressure Switch input.

Engine Run Timer – this read only control shows the current engine running time.

LOW_PRESSURE_DELAY – the amount of time the low oil pressure input must be active before the low oil pressure fault is detected.

Low Oil Pressure Timer – this read-only control shows the time that engine has been working with Oil Pressure Switch active.

HIGH_PRESSURE_DELAY – if during the low oil pressure limp home operation, Oil Pressure Switch deactivates for this time, fault will be cleared and device will return to normal operation.

Engine Restart Clears Low Oil Pressure Error – if this option is active, cycling the power to the controller will clear the low oil pressure failure. This is the default operation. If disabled, the failure will persist after controller restart, and if engine is started, it will work in low oil pressure limp home mode.

Calibrate Position Control Gains

Actuator position control PID gains calibration is required to obtain fast and stable actuator response. The main factors that affect the actuator response are:

- Type of actuator used
- Force balance within fuel pump

Therefore, the calibration should be done with the actuator installed on the engine.

Runtime and startup gains can be tuned on the “Actuator Position Control” page. This page provides the trend display showing the desired and actual actuator position together with current engine mode (0 – stopped, 1 – cranking, 2 – running). The same PID gains parameters, together with additional position control parameters are available on the “Actuator Position Control Gains Settings” page. Changing the value of startup and runtime gains is available on security access levels 2 and 3.

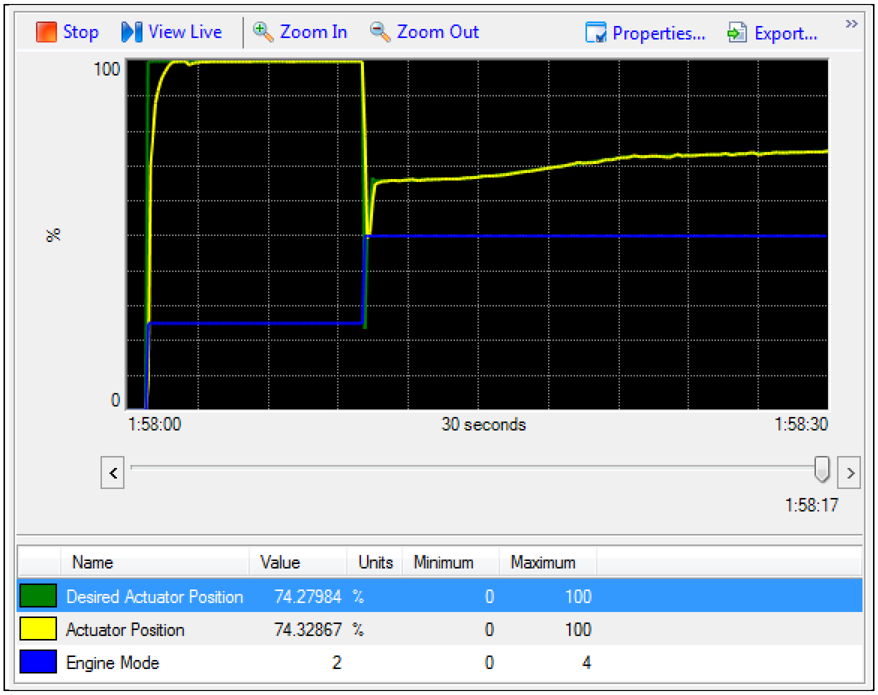


Figure 6-51. Actuator Position Control Chart

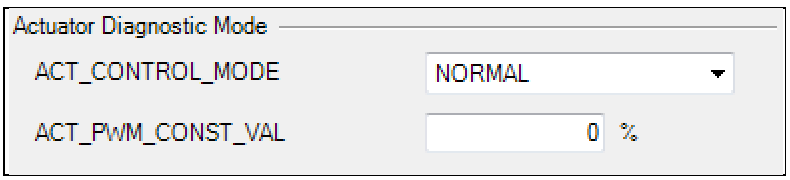


Figure 6-52 Diagnostic Actuator Modes Configuration

ACT_CONTROL_MODE – actuator position control logic may be set to the diagnostic mode using this drop down list parameter. Available options are:

- NORMAL – actuator position is controlled to meet the speed control output demand
- CONSTANT_PWM – position control is disabled and fixed duty cycle value is being maintained on actuator output. The duty cycle value is controlled by ACT_PWM_CONST_VAL parameter.
- RAMPING_PWM – position control is disabled and duty cycle value on actuator output is ramped in configured actuator output working constraints (by default 5% to 95%).
- RSP_CTRL_PWM – position control is disabled and duty cycle value on actuator output is controlled by speed potentiometer input.
- RSP_CTRL_RACK_POS – desired actuator position is set by speed potentiometer value.

This parameter may be used to test the actuator operation. The “RSP_CTRL_RACK_POS” may be used to test the actuator position control governor gains operation. A simple potentiometer may be used temporarily to assist during the position control gains calibration. See the “Wiring” section in Chapter 3. for information on connecting the Speed Setpoint Potentiometer.

⚠CAUTION	**ACT_CONTROL_MODE options other than “NORMAL” are intended only for testing and calibration. In these modes, the APECS 4800 has no control over the engine speed.** **The value of ACT_CONTROL_MODE parameter is stored in the controller’s nonvolatile memory and in settings files; therefore, care should be taken to ensure that production settings have this parameter set to “NORMAL” value.**

ACT_PWM_CONST_VAL – this is the PWM duty cycle value commanded in CONSTANT_PWM diagnostic actuator control mode. This parameter is ignored in all other actuator mode, including normal operation.

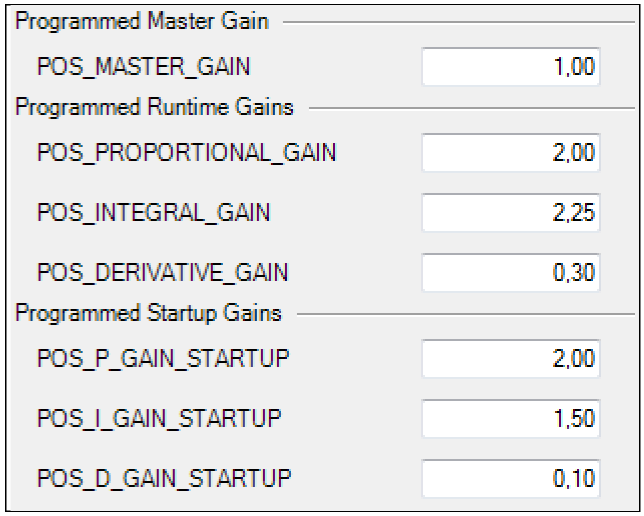


Figure 6-53. Runtime and Startup Gains Configuration

POS_MASTER_GAIN – Master Gain operates as a multiplier to all three position control PID gains. It is used to increase or decrease the combined integral, derivative and proportional response with a single parameter.

POS_PROPORTIONAL_GAIN – position control proportional gain used when engine is running. Proportional control is required to achieve stability and fast response time. As a general rule, maximum amount of proportional gain should be used while still maintaining stability.

POS_INTEGRAL_GAIN – position control integral gain used when engine is running. Integral gain is required to remove steady state actuator position error. As a general rule, maximum amount of integral gain should be used while still maintaining stability.

POS_DERIVATIVE_GAIN – position control derivative gain used when engine is running. May be increased in order to improve stability.

POS_P_GAIN_STARTUP, POS_I_GAIN_STARTUP, POS_D_GAIN_STARTUP – position control startup gains. These values are used during engine cranking. This allows for decreasing the actuator gains during startup in order to prevent actuator fluctuations during cranking which may occur due to power supply fluctuations. If this is not required, startup gains should be set to the same value as runtime gains.

PID Gains Scalers Calculation

Actuator position (%)	Master Gain Scaler (/)	Proportional Gain Scaler (-)	Integral Gain Scaler (/)	Derivative Gain Scaler (-)
5	1,00	1,00	1,00	1,00
30	1,00	1,00	1,00	1,00
40	1,00	1,00	1,00	1,00
55	1,00	1,00	1,00	1,00
70	1,00	1,00	1,00	1,00
80	1,00	1,00	1,00	1,00
90	1,00	1,00	1,00	1,00
95	1,00	1,00	1,00	1,00

Figure 6-54. Position Control Gains Scalers Configuration

PID Gains Scalers Calculation – defines the scalers for Master, Proportional, Integral and Derivative gains in relation to actuator position. This may be used to compensate for actuator dynamics varying with actuator position.

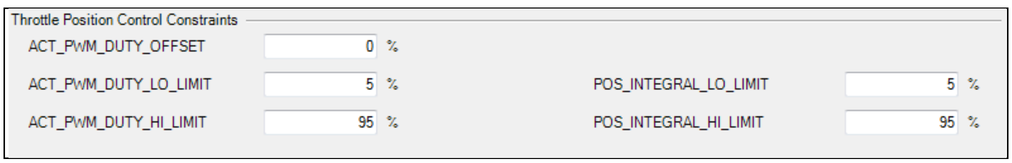


Figure 6-55. Actuator Output Working Constraints Configuration

ACT_PWM_DUTY_OFFSET – the constant offset added to the output of position controller. This parameter is normally left at its default value.

ACT_PWM_DUTY_LO_LIMIT – the minimum output duty cycle value to be used by position controller. The default value is 5% and is recommended for most systems. This parameter should not be decreased from default value. In some cases it may be increased in order to narrow down the duty cycle working range.

ACT_PWM_DUTY_HI_LIMIT – the maximum output duty cycle value to be used by position controller. The default value is 95% and is recommended for most systems.

POS_INTEGRAL_LO_LIMIT – the low limit for position governor integrator operation. If output duty cycle is below this value, integral operation is halted. For most systems, this parameter should be set to the same value as ACT_PWM_DUTY_LO_LIMIT.

POS_INTEGRAL_HI_LIMIT – the high limit for position governor integrator operation. If output duty cycle is above this value, integral operation is halted. For most systems, this parameter should be set to the same value as ACT_PWM_DUTY_HI_LIMIT.

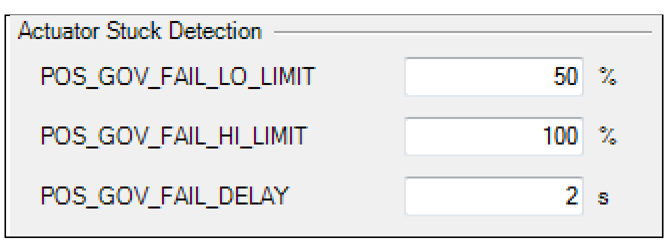


Figure 6-56. POSITION_GOV Fault Detection Configuration
on Actuator Position Control Page

POS_GOV_FAIL_LO_LIMIT – the lowest position above which actuator position too high is active. The detailed description is given in the description of POSITION_GOV fault in the “Diagnostics” section of Chapter 4. This parameter may be left at default value for most systems.

POS_GOV_FAIL_HI_LIMIT – the highest position below which actuator position too low fault is detected. The detailed description is given in the description of POSITION_GOV fault in the “Diagnostics” section of Chapter 4. This parameter may be left at a default value for most systems.

POS_GOV_FAIL_DELAY – the time after which POSITION_GOV fault is enabled if fault condition occurs. The default value is suitable for most systems.

Calibrate Speed Control Gains

Speed governor gains calibration is required for all systems in order to obtain fast and precise engine speed control. Basic PID gains can be configured on “Speed Control” page. This page also contains trend chart displaying desired and actual engine speed as well as current engine mode (0 – stopped, 1 – cranking, 2 – running). Access to the speed control gains is allowed on security levels 2 and 3.

Additional speed governor parameters are available on “Speed Control Gains Settings” page.

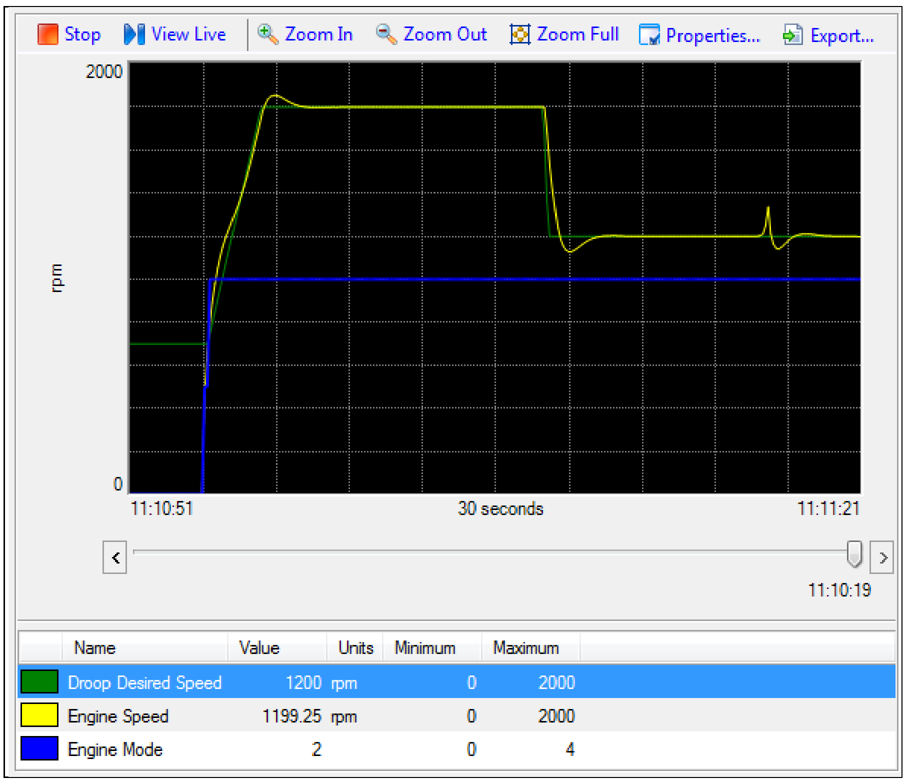


Figure 6-57. Engine Speed Chart

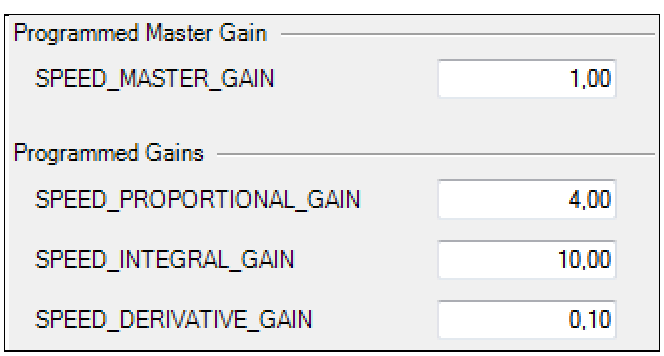


Figure 6-58. Speed Control PID Gains Configuration

SPEED_MASTER_GAIN – Master Gain operates as a multiplier to all three speed control PID gains. It is used to increase or decrease the combined integral, derivative and proportional response with a single parameter.

SPEED_PROPORTIONAL_GAIN – speed control proportional gain. Proportional control is required to achieve stability and fast response time. As a general rule, maximum amount of proportional gain should be used while still maintaining stability.

SPEED_INTEGRAL_GAIN – speed control integral gain. Integral gain is required to remove steady state engine speed error. As a general rule, maximum amount of proportional gain should be used while still maintaining stability.

SPEE_DERIVATIVE_GAIN – speed control derivative gain. Derivative gain is used to improve stability. Increase derivative gain until response has a slight overshoot on load transients.

PID Gain Scalers Calculation

Desired Speed (rpm)	Proportional Gain Scaler (/)	Integral Gain Scaler (/)	Derivative Gain Scaler (/)
700	1,00	1,00	1,00
1100	1,00	1,00	1,00
1450	1,00	1,00	1,00
1500	1,00	1,00	1,00
1550	1,00	1,00	1,00
1750	1,00	1,00	1,00
1800	1,00	1,00	1,00
1850	1,00	1,00	1,00

Figure 6-59. Speed Based PID Gains Scalers Configuration

PID Gain Scalers Calculation – defines the scalers for Proportional, Integral and Derivative gains in relation to desired engine speed.

Master Gain Scaler Calculation

ECT (°C)	Master Gain Scaler (/)
-10	1,00
0	1,00
10	1,00
40	1,00
80	1,00

Figure 6-60. ECT Based Master Gain Scaler Configuration

Master Gain Scaler Calculation – defines the scaler for Master Gain in relation to Engine Coolant Temperature (ECT).

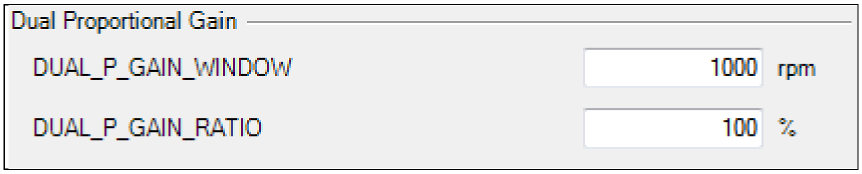


Figure 6-61. Dual Proportional Gain Configuration

DUAL_P_GAIN_WINDOW – speed error window width. As long as speed error is lower than this value, proportional gain is not unmodified by DUAL_P_GAIN_RATIO. This parameter should be set to a value high enough to make sure that speed error does not exceed the window width in steady state.

DUAL_P_GAIN_RATIO – multiplier applied to Proportional Gain when speed error is higher than DUAL_P_GAIN_WINDOW. Normally, this parameter is set to a value slightly above 100% in order in improve the load transient response. Setting this parameter to 100% effectively disables the dual proportional gain feature.

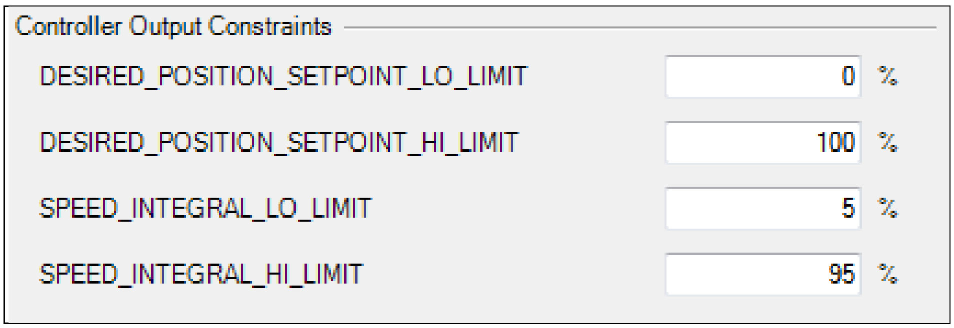


Figure 6-62. Speed Controller Output Constraints Configuration

DESIRED_POSITION_SETPOINT_LO_LIMIT – the minimum desired actuator position that can be commanded by speed governor. For most systems, full actuator position working range is desired and this parameter should be set to 0% (default value).

DESIRED_POSITION_SETPOINT_HI_LIMIT – the maximum desired actuator position that can be commanded by speed governor. For most systems, full actuator position working range is desired and this parameter should be set to 100% (default value).

SPEED_INTEGRAL_LO_LIMIT – the low limit for position governor integrator operation. If output duty cycle is below this value, integral operation is halted. For most systems, this parameter can be left at a default value of 5%.

SPEED_INTEGRAL_HI_LIMIT – the high limit for position governor integrator operation. If output duty cycle is above this value, integral operation is halted. For most systems, this parameter can be left at a default value of 95%.

Calibrate Black Smoke Control

If Black Smoke Control is used in the system, the fuel limit map should be properly tuned according to the measured emission record.

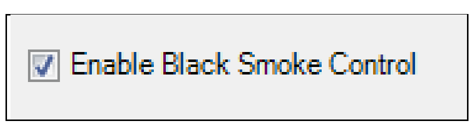
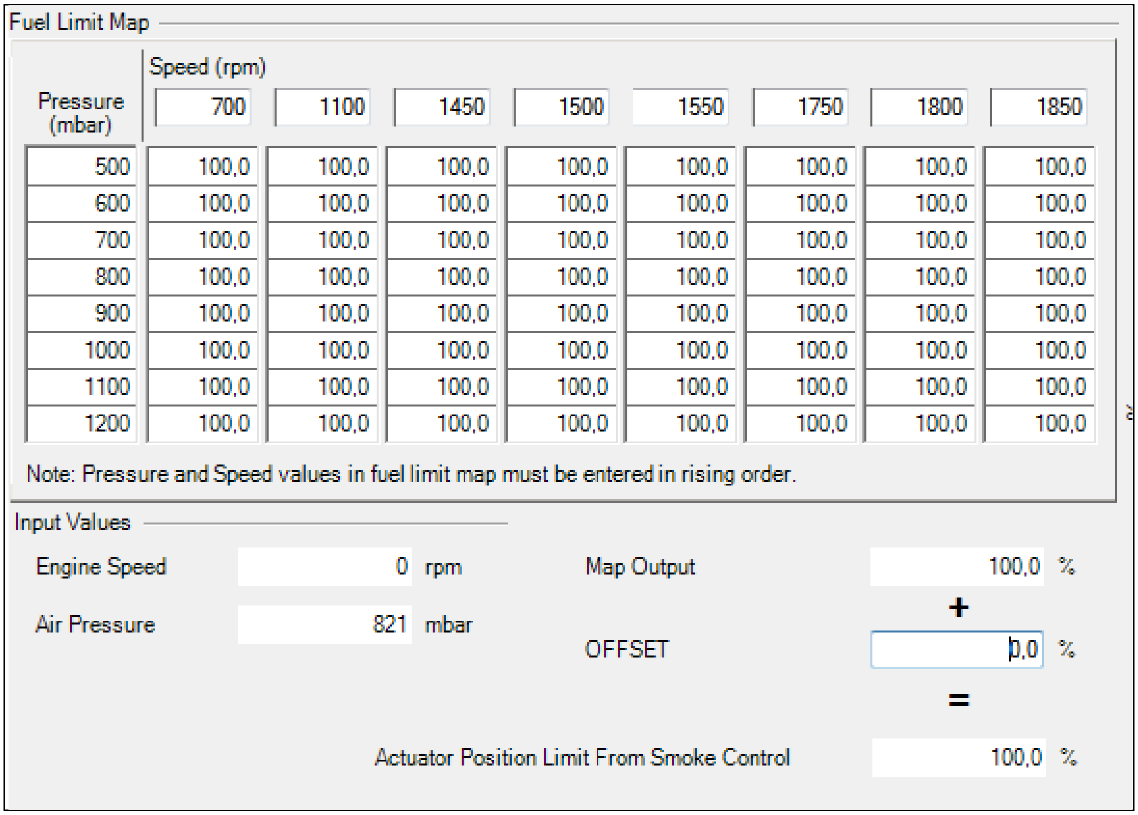


Figure 6-63. Enabling Black Smoke Control

Enable Black Smoke Control – if this parameter is unchecked, this feature is disabled and Fuel Limit Map has no effect.



Pressure (mbar) \ Speed (rpm)	700	1100	1450	1500	1550	1750	1800	1850
500	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
600	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
700	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
800	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
900	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1100	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1200	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Figure 6-64. Fuel Limits Map Configuration

Fuel Limit Map – the 2-D table used to calculate fuel limit as a function of engine speed and air pressure. Calibration should begin with setting proper values to the Speed and Pressure axes according to the application's specifications (engine speed range and air pressure sensor range). Then, desired fuel limiting values should be calibrated.

OFFSET – single value added to the result of fuel limit calculation. Normally it is set to 0% during calibration and used for individual unit performance tuning. This is explained in "Adjusting Production Offsets" section earlier in this chapter.

Calibrate Engine Load Control

Engine Load Control calibration is required in the following situations:

- Systems applying the torque limit
- Systems using droop operation

By default, No Load Line is set to all 0% values and Full Load Line is set to all 100% values. As a result, calculated Engine Load is equal to the Actuator Position Value. By calibrating the load lines according to the engine performance, engine load is properly scaled and the engine speed to fuelling at given load relationship is taken into account.

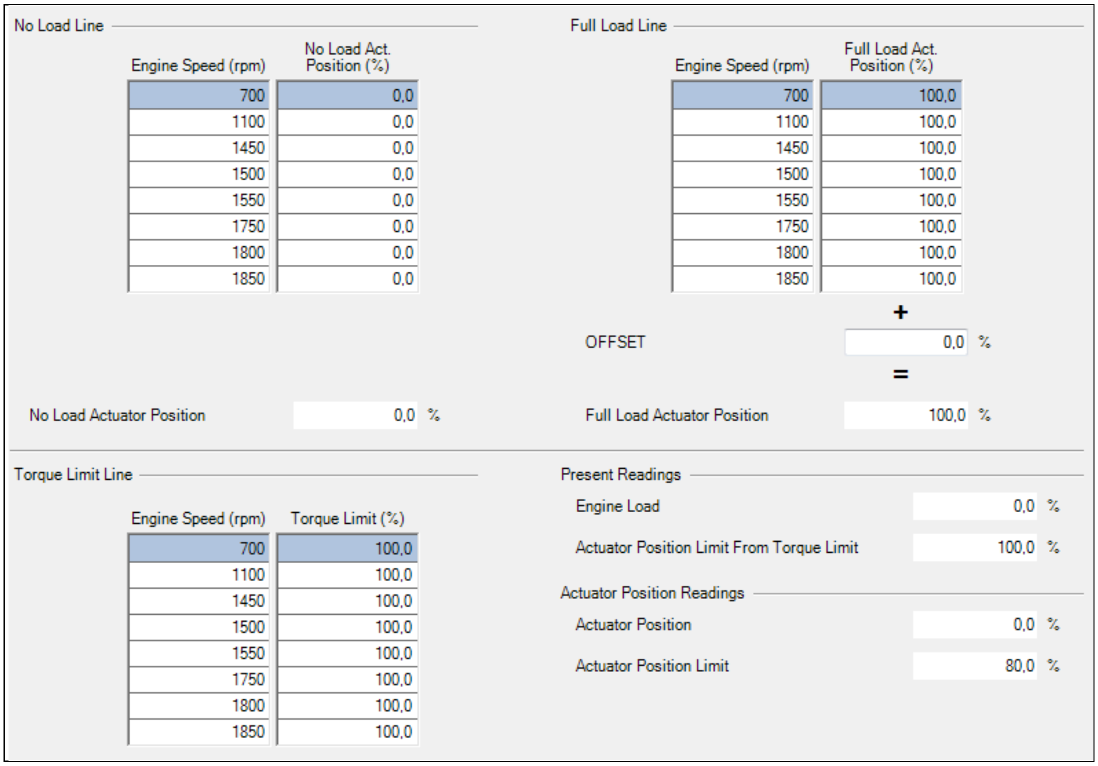


Figure 6-65. Engine Load and Torque Limit Lines Configuration

No Load Line – 8-point curve defining the No Load Actuator Position in relation to Engine Speed. This line defines the actuator position values where calculated engine load is equal to 0%.

Full Load Line – 8-point curve defining the Full Load Actuator Position in relation to Engine Speed. Full Load Actuator Position defines the point at given speed where calculated engine load equals 100%. This value also forms an actuator position limit – speed governor will not command positions higher than this value.

OFFSET – single value added to the result of Full Load Actuator Position calculation.

Torque Limit Line – 8-point curve defining the maximum allowed load in relation to Engine Speed. The actuator position limit value is calculated as:

$$Torque\ Limit\ \ * (Full\ Load\ Act.\ Pos. - No\ Load\ Act.\ Pos.) + No\ Load\ Act.\ Pos.$$

If this value is set to 100%, no change is applied and actuator position is limited to the Full Load Position. This parameter is accessible at security level 2 (partial write access).

Chapter 7
Troubleshooting

This chapter presents the application failures typically experienced in the field or during device configuration with possible causes, and suggested solutions.

Because the exact failure experienced in the field is generally the product of the mechanical/electrical failure combined with the configuration file resident in the control, it is left as the OEM's responsibility to create a more detailed troubleshooting chart for the end user. Ideally, that end-user troubleshooting chart would contain information about mechanical, electrical, engine, and load failures in addition to the possible governor failures. Properly configured APECS 4800 diagnostic functionality facilitates investigation of end-user's system issues.

The troubleshooting scenarios listed below assume that the end user has a digital multi-meter for testing voltages and checking continuity. It is also assumed that the application has been engineered and tested thoroughly.

Troubleshoot Diagnostic Fault Flags

Diagnostic faults should be checked first in case of system malfunction. The APECS 4800 controller provides the following ways for accessing diagnostic information:

- APECS 4800 PC Service Tool
- MIL lamp and/or warning lamps if used in the system
- CAN J1939 interface. This is described in CAN J1939 DM-1 and DM-2 messages description.

Fault states in the Service Tool are displayed on Diagnostics 1 – Diagnostics 4 pages. Buttons for clearing faults history are also available on those pages. These buttons' operation is identical to using MCS+SDS physical switches (see the Diagnostics description in Chapter 4). Both viewing and clearing the faults is possible on all security levels, including Read Only level. This allows service personnel to troubleshoot the system issues.

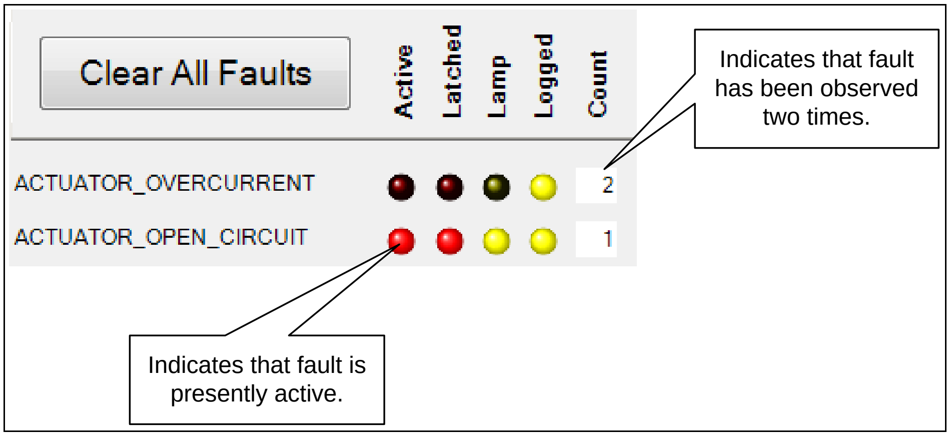


Figure 7-1. Meaning of Fault Indicators

Both active and logged faults may provide information regarding the system malfunction cause. For example, a damaged connector may lead to the situation where analog input connection is lost momentarily due to vibration but restored later. This may result in sensor out of range fault being logged (but inactive) at the time of diagnosis.

A detailed description of each fault's meaning is given in the "Diagnostics" section of Chapter 4. If the fault source is not clear, consult the table below for possible solutions.

Table 7-1 Fault Codes

Fault	Possible Cause	Suggested Actions
ACTUATOR_OVERCURRENT	Wire short circuit	Check for Actuator Power Supply line short to ground.
	Short circuit inside the actuator	Power the controller off and replace the actuator.
ACTUATOR_OPEN_CIRCUIT	Shutdown relay	If a shutdown relay is used in the system, check that: - the discrete output is properly configured - relay coil is properly wired
	Wire unconnected	Check actuator and shutdown relay contact wiring.
APS_FREQ_OUT_OF_RANGE	Improper firmware version	Contact Woodward (see Service Options).
APS_POWER_SUPPLY	Wire short to ground	Check the APS +5V (J2-B1) wiring.
AUTOCRANK	Unable to start the engine	Check engine fuel reserve. Verify that crank actuator position allows enough fuel for engine to start.
CAN_COMMUNICATION	CAN wiring issue	Check CAN wiring
CAN_RECEIVE_TIMEOUT	CAN controller issue	Verify that CAN controller is transmitting the TSC1 frames within required period.
CONFIGURATION	Obsolete configuration in memory	If the controller firmware has been updated, upload the configuration in order to update the configuration memory.
	Controller defective	Return the controller to Woodward (see Service Options chapter).
CPU_FAILURE	Controller defective	Return the controller to Woodward (see Service Options chapter).
CPU_POWER_SUPPLY	Excessive battery voltage drop	Verify that power supply voltage does not fall below specification.
DOUT_x_OVERCURRENT	Lamp/relay wiring short to battery voltage	Check the wiring of the device connected to the discrete output.
	Lamp/relay current draw excessive	Check that the current drawn for discrete output does not exceed 250 mA. Note that current draw may vary with temperature.
DOUT_x_OPEN_CIRCUIT	Lamp/relay wiring open circuit	Check the wiring of the device connected to the discrete output.
	Discrete output misconfiguration	Verify that proper discrete output is configured. Unconnected outputs must be configured to NOT_USED).
DROOP_SENSOR_HI/LO	Wiring issue	Check the DSP analog input wiring.
	Droop potentiometer defective	Check/replace the droop potentiometer
ECT_SENSOR_HI/LO	Wiring issue	Check the ECT analog input wiring.
	Temperature sensor defective	Check/replace the coolant temperature sensor.
EEPROM_RW_FAILURE	Controller defective	Return the controller to Woodward (see Service Options).
HIGH_BATTERY_VOLTAGE	Configuration	If the system is 24 volts, verify that controller battery voltage is properly configured.
	Wiring issue	Verify the voltage at controller supply pins.

Table 7-1 Fault Codes (cont'd.)

LOW_BATTERY_VOLTAGE	Battery discharged	Verify the battery voltage, replace or charge the battery.
	Battery wiring issue	Check the power supply wiring for defects. Verify that wiring is of sufficient thickness and length.
IVS_CONFLICT	Speed pedal malfunction	Verify the speed pedal and IVS operation.
	IVS input wiring	Check the wiring of the IVS discrete input.
LOSS_OF_SPEED	MPU wiring issue	Check/replace MPU wire.
	MPU damaged	Check/replace MPU sensor.
	Autocrank issue – controller unable to enable starter motor	Check the autocrank relay wiring. Check/replace the starter motor.
	Autostart Enable Switch issue	Verify that engine speed is sensed when ASE input is active.
LOW_OIL_PRESSURE	Engine oil pressure low, oil pressure sensor damaged	Check the engine oil reserve. Check engine oil pressure sensor.
	OPS input wiring	Check the wiring of the oil pressure switch.
MAP_SENSOR_HI/LO	Wiring issue	Check the analog input wiring.
	MAP sensor defective	Check/replace the MAP sensor.
MAP_POWER_SUPPLY	Wire short to ground	Check the MAP +5V (J2-H1) wiring.
	MAP sensor current draw excessive	Verify that MAP sensor supply current does not exceed 15 mA.
OPS_WIRE_BREAK	Oil pressure switch misconfiguration	Verify that OPS discrete input has a properly configured polarity (input should be active when pressure is low).
	Oil pressure switch wiring issue	Check the OPS discrete input wiring.
	Oil pressure switch defective	Verify that oil pressure switch is properly indicating low oil pressure.
OVERSPEED	Actuator not capable of closing the fuel throttle	Check the force needed to close the fuel against the actuator force.
	Speed control gains not calibrated properly	Calibrate (increase) gains for better handling of load rejection.
	Overspeed value set too low	Check the overspeed configuration.
OVER_TEMPERATURE	Engine coolant temperature exceeded	Verify the engine coolant temperature.
	Temperature sensor defective	Verify the temperature sensor signal against measured engine coolant temperature.
POSITION_GOV	Excessive actuator friction or actuator blocked	Verify that actuator movement is not hampered mechanically.
	Actuator PWM output short to ground	Check the actuator PWM output wire. If this pin is short to ground, actuator will open fully until the shutdown relay opens.
	Actuator voltage too low	Measure the voltage at actuator Power Supply pin. Verify that actuator wiring is of sufficient thickness and length. Verify that battery voltage does not drop excessively.

Table 7-1 Fault Codes (cont'd.)

POSITION_GOV (cont'd.)	Coil force not enough to obtain position (fault occurs in high actuator position)	Check actuator force balance. Verify that actuator PWM is not limited excessively by ACT_PWM_DUTY_HI_LIMIT parameter. If needed, update the value of POS_GOV_FAIL_HI_LIMIT parameter.
	Return spring force not enough to obtain position (fault occurs in minimum actuator position)	Check actuator force balance. If needed, update the value of POS_GOV_FAIL_LO_LIMIT parameter.
POSITION_CAL_HI/LO	Actuator travelled out of mechanical bounds	If actuator travel should be limited mechanically, check the actuator mounting.
	Actuator position sensor calibration improper	Recalibrate the actuator position sensor working range.
POSITION_SENSOR_HI/LO	Wiring issue	Check the APS analog input wiring.
	Position sensor defective	Measure the position signal against the actuator position. Replace the actuator if needed.
PROTECTION_FAULT	The device connected to the protection input shuts the engine	Check the device that triggers the protection input.
	Wiring issue	Check the protection discrete input wiring.
SET_SPEED_POT_HI/LO	Wiring issue	Check the RSP analog input wiring.
	Speed setpoint potentiometer defective	Check/replace the speed setpoint potentiometer.
TORQUE_LIMIT_ACHIEVED	Actuator unable to control fuel throttle	Check the actuator mounting.
	Maximum allowed fueling achieved	Maximum allowed fuel calculated from Full Load line and Torque Limit line has been achieved. If this situation is allowed in the system this fault should be treated as information only.

General System Troubleshooting Guide

The table below describes issues that may be encountered in the system but are not diagnosed with fault flags.

Table 7-2. General Troubleshooting Guide

Issue	Possible Cause	Suggested Actions
Service Tool not communicating – establishing connection on Com x' status indicated	Power not applied to the controller	Check controller's power supply.
	Wiring fault	Check the wiring of power supply and RS232.
	Incorrect cable used	Check that the interconnect cable is selected in accordance to wiring diagram (straight-through).
	The wrong communications port has been selected	Verify the port setting.
Service Tool not communicating – displays message "Unable to locate the correct SID file for device application…"	Improper tool version is being used	Obtain the newest version of APECS 4800 Service Tool from Woodward website. If the problem persists, contact Woodward for support.
Engine speed not sensed properly	MPU sensor or wiring issue	Check MPU wiring; check or replace the sensor.
	MPU voltage too low	Verify that MPU voltage is within spec. The voltage is lowest at low speed.
Desired speed always zero, engine shuts down after cranking	Autocrank configuration	If autocrank relay or dependent glowplug is configured, ASE switch must be active to allow engine starting.
Engine unstable	Improperly tuned speed or position PID gains	Recalibrate the position control and then the speed control.
	Intermittent or incorrect speed signal	Check/replace the speed signal wiring and the MPU sensor.

Chapter 8
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email (**EngineHelpDesk@Woodward.com**) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Flat Rate Repair: Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in “like-new” condition. This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:
- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:
- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE	**To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.**

Replacement Parts

When ordering replacement parts for controls, include the following information:
- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

Product Training is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at **www.woodward.com/directory**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (124) 4399500
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name

Site Location

Phone Number

Fax Number

Prime Mover Information

Manufacturer

Engine Model Number

Number of Cylinders

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.)

Power Output Rating

Application (power generation, marine, etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter

Control Description or Governor Type

Serial Number

Symptoms

Description

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix A. Acronyms/Abbreviations

Table A-1. Acronyms/Abbreviations

APECS®	Advanced Proportional Engine Control System
APS	Actuator Position Sensor
ASE	Auto Start Enable
CAN	Controller Area Network
DSP	Droop Set-point Potentiometer
DVM	Digital Volt-Meter
ECT	Engine Coolant Temperature
EEPROM	Electrically-Erasable Programmable Read-Only Memory
EGR	Exhaust Gas Recirculation
EMC	Electro-Magnetic Compatibility
ESS	Engine Stop Switch
FMI	Failure Mode Indication
GPL	Glow Plug Status Lamp
GPR	Glow Plug Relay
I/O	Inputs / Outputs
IVS	Idle Verification Switch
J1939	Vehicle CAN bus standard used for communication and diagnostics
LOL	Low Oil Pressure Indicator Lamp
LUT	Lookup Table
MAP	Manifold Air Pressure
MCS	Memory Clear Switch
MIL	Malfunction Indicator Lamp
MPU	Magnetic Pick Up
OEM	Original Equipment Manufacturer
OPS	Oil Pressure Sensor
OSL	Over Speed Indicator Lamp
OTL	Over Temperature Indicator Lamp
PGN	Parameter Group Number
PSD	Power Shutdown
PTO	Power Take-Off
PWM	Pulse-Width Modulated
RS-232	PC serial communications standard
RSP	Remote Speed Potentiometer
SAE	Society of Automotive Engineers
SDS	Software Diagnostic Switch
SPN	Suspect Parameter Number
VRS	Variable Resistance Sensor

Appendix B. Connector Information

The APECS 4800 is not shipped with mating connectors because many applications may use a standard wiring harness or because the mating connectors are needed in advance for wiring harness wiring. For service and convenience, Woodward has an APECS 4800 connector kit that contains all the mating terminal blocks used on the 4800 controller.

A single kit provides all the necessary parts for the APECS 4800. The kit part number is 8923-1633. Contents of the kit include:

- J1 mating connector
- J2 mating connector
- 48 hand crimp sockets for 14 – 20 AWG wire
- 35 seal plugs

Those who wish to create standard harnesses may want to purchase the connectors only and get the socket terminals on reels for automated assembly. In support of this need, the manufacturer part numbers are provided below for the parts that are available from Cinch.

Table B-1. Harness Assembly and Application Tooling

Component	Cinch Part Number	Notes
J1 mating connector	581-01-18-023	18-position sealed connector, black
	581-01-18-024	18-position sealed connector, natural
J2 mating connector	581-01-30-029	30-position sealed connector, black
	581-01-30-027	30-position sealed connector, gray
	581-01-30-030	30-position sealed connector, natural
Terminal	425-00-00-872	20 AWG TXL – 18 AWG TXL
Terminal	425-00-00-873	18 AWG GXL - 16 AWG GXL (product not rated for 14 AWG amperage, however can be used for voltage drop only)
Seal plug	581-00-00-011	For maintaining proper seal
Hand crimping tool	599-11-11-615	For terminals # 425-00-00-872
Hand crimping tool	599-11-11-616	For terminals # 425-00-00-873
Tweezer tool	599-11-11-628	For removing the secondary lock
Terminal removal tool	581-01-18-920	For removing all types of terminals

The sealed connectors on the APECS 4800 are not designed for removal by hand. After input power is disconnected, the connectors can be removed using a 1/4 inch head driver. When reinstalling the connectors, use 15-20 lb-in (1.69-2.25 N-m) torque for the jackscrew. Using the correct torque is required to avoid damage and provide proper force on the gasket for a moisture seal.

These connectors use a “push-to-seat” design. To use the connectors, it is first necessary to strip the wire, crimp on a terminal, and then push the wire into the connector body from the back to seat it into the connector locking mechanism. Care must be taken to align the terminal correctly with the connector when pushing it into the connector body. If it must be removed, a special tool is necessary to avoid damage to the wire, terminal, and connector.

A crimp tool is necessary for proper field crimping of the mating terminals. Hand crimping tools are available from Woodward; see Table A-1 for selecting proper crimping tool.

If a wire must be removed from the connector, removal tools are necessary to avoid damage to the connector. Individual wires can be removed using extraction tools. Removing the terminal from the sealed connector is a two-step process: (1) removing the secondary lock, and (2) removing the terminal itself. Specific Cinch tools are required for both operations. Tools work for both the 18- and 30-position harness connector. Woodward provides terminal removal tools; see Table A-1 for selecting proper tool.

IMPORTANT	**Using the wrong removal tool will very likely result in damage to the internal connector retaining clip.**

Revision History

Changes in Revision B—
Updated Regulatory Compliance section with RoHS information

Changes in Revision A—
- Added EU Declaration of Conformity

Declarations

EU DECLARATION OF CONFORMITY

EU DoC No.:	DOCFORM
Manufacturer's Name:	WOODWARD POLAND SP. Z O.O.
Manufacturer's Contact Address:	Skarbowa 32 32-005 Niepolomice, Poland
Model Name(s)/Number(s):	APECS 4800 Controller, P/N 8800-4801
The object of the declaration described above is in conformity with the following relevant Union harmonization legislation:	Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC)
Applicable Standards:	EN 61000-6-2:2005 - Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments EN 61000-6-4:2007/A1:2011 - Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

This declaration of conformity is issued under the sole responsibility of the manufacturer
We, the undersigned, hereby declare that the equipment specified above conforms to the above Directive(s).

MANUFACTURER

Signature

Dominik Kania
Full Name

Managing Director
Position

Woodward Poland Sp. z o.o., Niepolomice, POLAND
Place

18.05.2016.
Date

Doc.: 5-09-1183 Rev26

00379-04-EU-02-01

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 36750.

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