CONTROL TECHNOLOGIES FOR THE WORLD'S BEST ENGINES

CONTROL SOLUTIONS FOR SMALL ENGINES

Always Innovating for a Better Future

WOODWARD

ENGINE SOLUTIONS FOR SMALL- TO MEDIUM-SIZED ENGINES

SOLUTION BENEFITS

- **Better Engine Responsiveness and Performance**
  (Through Tighter Speed Control)
- **Lower Emissions**
  (Through Improved Air/Fuel Ratio Control)
- **Better System Operation**
  (Through Fully Integrated Functionality and Proven Reliability)

ALWAYS INNOVATING FOR A BETTER FUTURE

Every day, we commit our resources, knowledge, and skills to help you tackle any challenge presented – from addressing efficiency initiatives, to innovating new control solutions for your future engine systems, to providing critical insight into your customers' environments. We take pride in knowing that you count on us for our technical knowledge, problem-solving capabilities, and collaborative nature. But most importantly, we value the confidence you place in us by selecting Woodward to play an essential role in your success.

INTEGRATED SYSTEMS AND COMPONENTS

Woodward offers completely integrated control systems as well as individual control component technologies that integrate easily with other controls to provide total engine equipment control that meets user requirements for efficiency, emissions, performance, and reliability. Our control technologies have been proven in a wide range of mobile and stationary engine equipment, including natural gas buses and trucks, construction and agricultural equipment, material handling, electric power generation, pumping, and welding applications.

Woodward's engine control system solutions for spark-ignited engine applications include:

- OH (On-Highway) systems solutions for buses and trucks
- MI (Mobile Industrial) systems for forklifts, man lifts, aircraft tugs, small cranes, and excavators
- SSIG (Stationary Small Industrial Gas) systems for stationary applications like generator sets, pumps, welders, and air compressors

Woodward's component solutions designed for various diesel and spark-ignited engines include:

- APECS controllers and actuators
- L-Series governors, actuators, and integrated throttle bodies (ITBs)
- F-Series actuators and ITBs

OH-SERIES
CONTROL SYSTEMS

PROVEN ELECTRONIC CONTROL SYSTEMS FOR NATURAL GAS AND PROPANE-FUELED, MEDIUM- OR HEAVY-DUTY VEHICLES

Woodward's OH-Series engine control systems provide clean-burning engines, strong performance and outstanding fuel economy, essential to OEMs worldwide for both new vehicles and repowering existing ones. Whether you're running CNG (compressed natural gas), LNG (liquefied natural gas) or LPG (liquid petroleum gas) in your vehicle, Woodward has a control solution for you.

OH-SERIES CONTROL SYSTEMS

Operating under an OH system, an engine can meet any targeted emissions level from Euro 2 to Euro 6 (or equivalent) while maintaining diesel-like drivability and excellent fuel economy along with the reliability vehicle operators demand.

Woodward has extensive experience and knowledge in designing complete system solutions for any application. And, our global network of local Woodward engineering centers provides superior engineering and product support.

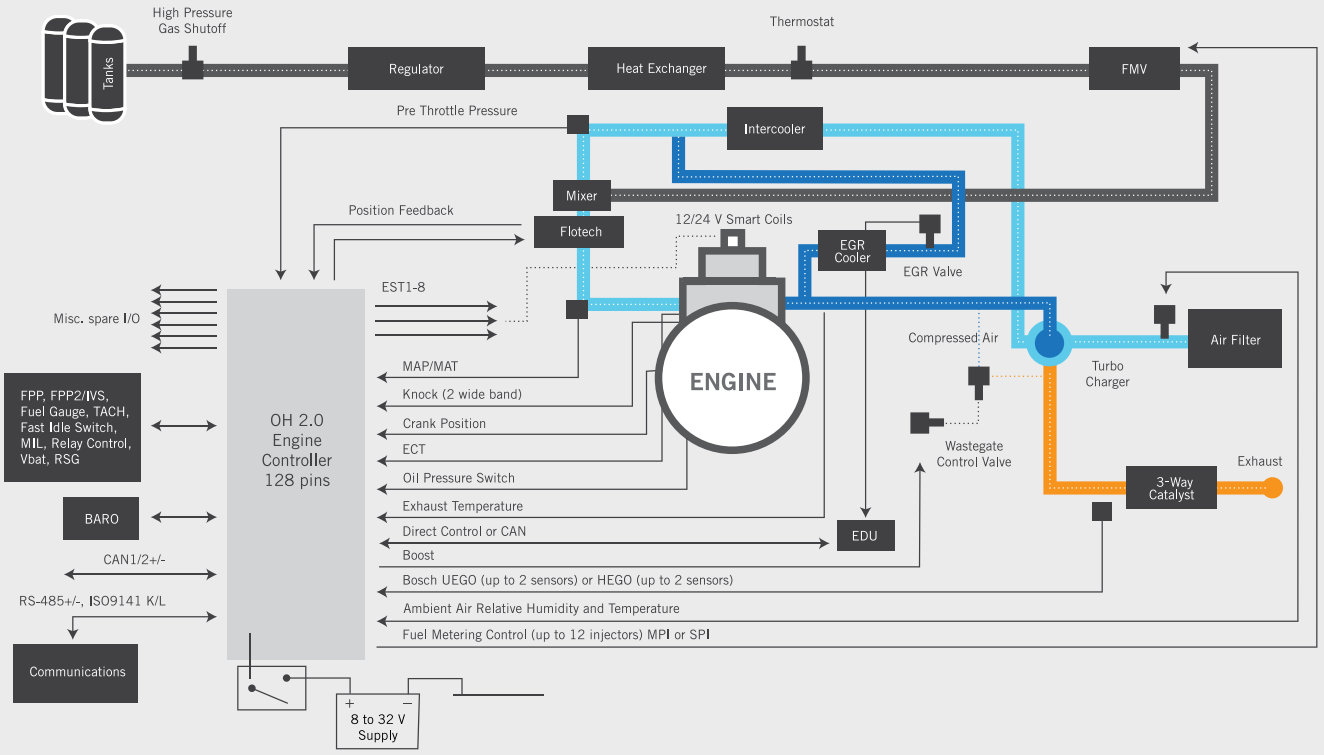
Our integrated system of electronic controls, sensors, valves, and actuators work together to precisely control air flow, fuel flow, exhaust flow, and the combustion processes of the engine.

FEATURES INCLUDE:

- Single-point injection fuel metering valves or multipoint injection capabilities
- Lean burn or stoichiometric combustion strategy
- Misfire and knock detection
- System designed to meet Euro 6 and US 2010 emission standards
- Compatible with CNG
- Customizable for the application with a variety of different sized components that make up the system

INTEGRATED SYSTEM APPROACH

This diagram shows the system approach using Woodward components. This control system is for a natural gas powered bus, but can be scaled to meet the system requirements for any small- to medium-sized engine application.



SSIG AND MI SERIES
CONTROL SYSTEMS

INTEGRATED ENGINE MANAGEMENT SYSTEMS TO REDUCE EMISSIONS IN PROPANE AND CNG ENGINES

Woodward's Stationary Small Industrial Gas (SSIG) and Mobile Industrial (MI) system architectures are similar to On-Highway (OH) systems, but are intended for slightly different market applications requirements. Although these systems are focused on small applications, they are designed with the same attention to detail as the On-Highway systems.

SSIG CONTROL SYSTEMS

Woodward's SSIG (Stationary Small Industrial Gas) control system controls engines in generator sets, irrigation and oil well pumps, and other stationary industrial equipment. It controls spark-ignited engines fueled by LPG (vapor or liquid), natural gas or gasoline. The SSIG system is suitable for engines ranging in size from 1 L to 22 L (18 kW to < 1 mW). The closed-loop control system helps OEMs and packagers comply with New Source Performance Standards (NSPS) implemented by the Environmental Protection Agency (EPA). These standards became effective in 2008 for stationary spark-ignited engines. SSIG also helps meet requirements of the National Emission Standard for Hazardous Air Pollutants (NESHAP). SSIG provides accurate and reliable performance control over the useful life of the engine in the extreme operating environments typical of heavy-duty, stationary industrial applications.

The SSIG system commands full authority over spark, fuel, and air. This integrated approach permits precise steady-state speed governing for generator frequency control and air/fuel ratio control for low fuel consumption and emissions at best torque. Continual updates to adaptive parameters allow for fast response to rapid changes in load.

MI CONTROL SYSTEMS

Woodward's MI (Mobile Industrial) control system is an advanced engine management system for propane and CNG engines in forklifts and other mobile industrial vehicles. The MI is emissions certified on eight engines to the 2007 standards for Large Spark Ignited (LSI) engines as established by the California Air Resources Board (CARB) and the US Environmental Protection Agency (EPA). The emissions results are demonstrated to meet the 2010 emissions standards that are proposed by CARB.

The MI system provides closed-loop control of stoichiometric air-fuel ratio for accurate application with three-way catalysts. Full authority control of an electronic throttle provides a range of options for speed governing. With these capabilities, and the control of ignition timing and dwell, the MI offers a system with 5000-hour or 5-year emissions compliance. The components and ECU are designed for on-engine and under-hood mounting. The system offers capability for both single and dual fuel on engines with up to eight cylinders.

COMPONENTS FOR BOTH SSIG AND MI SYSTEMS INCLUDE:

- Electronic control module
- Electric fuel lock off solenoid valve
- Fuel pressure regulator
- Fuel trim valves
- Fixed venturi mixer assembly or air valve mixer
- Electronic throttle assembly
- Oxygen sensors
- Integrated temperature and manifold pressure sensor
- Smart ignition coils

APECS™ SERIES
GOVERNING SYSTEMS

DIESEL EMISSIONS CONTROL, CAN COMMUNICATIONS, AND ENGINE PROTECTION ARE ALL POSSIBLE WITH THE APECS FAMILY OF ELECTRONIC CONTROLLERS.

Woodward's Advanced Proportional Engine Control Systems (APECS™) provides isochronous or multi-speed engine governing through a wide speed range. The complete system consists of a powerful microprocessor-based controller driving a precision proportional actuator. The actuator is connected to the engine's throttle or fuel pump speed lever to precisely control engine speed for off-road light utility vehicles or construction equipment, stationary and mobile generator sets, construction machinery, and farm vehicles.

> **APECS™ 0175**
Linear Actuator

APECS™ CONTROLLERS

The APECS controllers combine a digital electronic controller with a rotary or linear actuator to provide speed control of engines under 75 hp (56 kW). The controller provides accurate, reliable, and durable control over the service life of the engine in extreme operating environments.

These digital controllers provide isochronous speed control, with the ability to be influenced by other engine or operational parameters to trim the engine's speed. Some models offer actuator position control, torque limiting, droop, glow plug control, CAN J1939-based communications, and additional engine management and protection functions to optimize engine operating efficiency.

APECS controllers are readily configured using the APECS software calibration tool, helping to prevent field tampering of control settings, and all include diagnostics to make setup and troubleshooting easier. A worldwide network of sales and support make answering your operational questions easier and more convenient.

APECS 500 SPEED CONTROL

This single speed controller is designed to meet the needs of the small genset market where simplicity, ease of operation, and low cost are key features.

APECS 4500 CONTROLLER

The APECS 4500 controller is integrated into commercial and construction vehicles, and industrial engine systems and compressors by original equipment manufacturers.

APECS 4800 CONTROLLER

The 4800 provides NOx control through EGR and particulate control with smoke limiting technology using actuator position feedback control.

APECS™ ACTUATORS

Woodward's APECS linear and rotary actuators provide proportional fuel control for construction, industrial, and agricultural equipment, forming the foundation of full electronic governing systems. These actuators are suitable for speed governing on generator sets, forklifts, pump sets, wood chippers, pleasure boats, and many types of off-road vehicles.

The actuators are easily mounted near the fuel system and direct-connected to the fuel control rod or lever. In most installations, the normal rotary-to-rotary connection is eliminated, resulting in a more trouble-free and accurate control system.

Whatever your force, travel, terminal connection, or mounting requirements, you'll find a Woodward actuator to meet your needs. Or, we can custom design one for your exact specifications.

APECS GBA ROTARY ACTUATOR

Roughly the diameter of a golf ball, the GBA is suitable for power generation (stationary and mobile gensets) and industrial equipment applications.

APECS 0175 LINEAR ACTUATOR

1.75" spring-return actuator, available with position sensing feedback, provides proportional fuel control for construction, industrial, and agricultural equipment.

APECS 0154 LINEAR ACTUATOR

Purpose built to be an integral part of PF fuel pumps. The actuator is also available with position sensing feedback for the control.

L- AND F-SERIES
INTEGRATED SYSTEMS

> **L-SERIES**
Integrated Throttle Body

L-SERIES

The L-Series family of products provides a low-cost, precise, and reliable solution for a multitude of control functions. The L-Series is a rugged, engine-mounted, microprocessor-based controller with integrated actuator in one small package. Most applications use the L-series as part of an Integrated Throttle Body (ITB) which comes in five sizes from 25 to 50 mm, but it also comes with a straight output shaft that can be attached to a linkage or directly to a throttle plate. It has 0.34 N-m (0.25 lb-ft) of output torque with internal position feedback for fast, accurate control in small- to medium-sized engine applications.

The L-Series is adaptable for specific engine applications and parameters through standard software programs that are easily configured. It can be used as a speed control (governor), a positioner (actuator) that receives a position command signal from another controller, or as a process controller, the same as a governor, to maintain control of a specific parameter like oxygen level in engine exhaust. The speed controller version is also used with an integrated throttle body and fuel mixer assembly called an LC-50, again available in five different throat sizes.

L-SERIES

Integrated Throttle Body
and Actuator

F-SERIES

The F-Series is the big brother to the L-Series with the same advantages and attributes as the L-Series, including rugged, engine-mounted construction. It has 1.4 N-m (1.0 lb-ft) of output torque with internal position feedback for fast, accurate control in medium-sized engine applications in industrial and off-highway service and receives a position command from another controller.

Position control application examples can include fuel rack positioning, throttle valve positioning, wastegate valve positioning, as well as other engine position control functions. The F-Series ITB is designed to throttle air or air/fuel mixtures for gaseous engines. It is designed for the direct replacement of traditional throttle valves, and requires no linkage between valve and actuator. The ITB contains a return spring to fully comply with US DOT 571.124 specifications. The five offered sizes range from 33 mm to 75 mm, providing a size that can meet most applications. The F-Series ITB is also available in a high-temperature version.

F-SERIES

Integrated Throttle Body
and Actuator

HIGH-PERFORMANCE CONTROL ELECTRONICS

> **2000 SERIES**
Dual Coil Solenoid

SOLENOIDS

From operating engine run/stop levers, throttles, chokes, valves, and clutches to protecting expensive diesel engines from overspeed, low lube pressure, and high temperature, you can rely on Woodward solenoids to meet the ever-changing technical demands of modern industry.

Woodward's extensive line of solenoid protection products features either external or internal electronics. Coil Commanders™ and pull coil timer modules (PCTMs) are externally attached to the solenoid to prevent overheating of the pull coil. ICE (Integrated Coil Electronics) and AICE (Advanced ICE) solenoids have built-in electronics that prevent overheating of the pull coil.

Dual-coil solenoids are constructed of two wound coils. The pull coil operates at high currents in order to provide maximum pull or push force. The hold coil retains the plunger in place after it has completed its stroke. After energizing, the pull coil must be turned off as soon as possible to prevent burnout. The protection modules energize the solenoid pull coil for approximately one second.

FEATURES

- Dual-coil design for higher pull force in a smaller package than similar size single-coil solenoid
- Customer-specified option to switch from high-current "pull" operation to low-current "hold" operation with internal mechanical switch or external electronic switch
- Hold coil provides continuous duty operation
- Hard chrome-plated plunger and brass liner for smooth, reliable, wear-resistant operation, tested in one million cycles
- Corrosion-resistant plated steel housing and mounting base/flange
- Choice of flange, threaded, or base mountings
- Electrical connections available with choice of screw or spade terminals, or wire/connectors
- Two boot types available: bellows boot is tapered to eliminate expansion in tight spots; constant-volume boot has no breather hole and so provides contaminant protection of the plunger and bore

2000 SERIES

Models 2001, 2001ES , 2003, and 2003ES Pull force range: 21–29 lbs (93–129 N) Hold force range: 41–51 lbs (182–227 N)

COIL COMMANDERS™

Coil Commanders time out a solenoid's high amperage pull coil within approximately 1.5 seconds. The in-line cylindrical tube design comes in 5-, 6-, and 7-wire SSR configurations.

GLOBAL SUPPORT

Woodward knows that its customers need to locate in growth areas, so we are right there with them – designing, manufacturing, and servicing our products. Careful consideration of environmental and cultural differences is the key to establishing Woodward as a concerned global citizen.

Our internal teams are comprised of employees from many locations as well – encouraging fresh ideas, offering a variety of views on how to meet new challenges, and providing our employees the opportunity to make a worldwide impact. Woodward's plants, offices, and service centers span the globe:

North and Central America, South America, Europe, Middle East and Africa, Russia, China, India, ASEAN and Oceania.

Our global presence allows us to respond quickly to the needs of our customers. Customers and the industry at large recognize our people as a competitive advantage through their diverse representation of the global community. Additionally, as a company and as employees, we respond to the needs of our local communities by donating our time, talent, and money.

Technical and other after-sales support services for your Woodward on-engine control products.

Woodward's global network of independent Business Partners and our engine manufacturer and engine packager customers provide an extensive range of technical and other after-sales support services for your Woodward on-engine control products.

WOODWARD, INC.

Americas I Asia I Europe I Middle East
For location information, visit us at:
www.woodward.com/locations

DISTRIBUTORS & SERVICE

TURNER ENGINE CONTROL SOLUTIONS

Stoke-on-Trent, United Kingdom	info.uk@turner-ecs.com
Hoofddorp, The Netherlands	info.nl@turner-ecs.com
Langen, Germany	info.de@turner-ecs.com
Desio, Italy	info.it@turner-mcs.com
Middle East (KSA, Qatar, UAE)	info.me@turner-ecs.com

www.woodward.com

51475

WOODWARD