WOODWARD

**Product Manual 35041**
**(Revision A, 02/2020)**
**Original Instructions**

# PCM112 Digital Control

Small Engine Powertrain Control Module

**Vehicular Applications**
**Hardware Only**

**Hardware 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:**

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**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 Out-of-date translations are marked with ⚠.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.**



**Manual 35041**

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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 LOTO**

**Ensure that personnel are fully trained on LOTO procedures prior to attempting to replace or service a PCM112 control 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 PCM112.**

**⚠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**

**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.**

# Chapter 1.
# General Information

## Introduction

This manual describes the hardware of Woodward's 112-pin Small Engine Powertrain Control Module (PCM112).

**Application**
The PCM112 control platform fits a variety of applications, including powertrain control and EV supervisory applications. At the heart of the PCM112 control is a powerful 32-bit Freescale MPC5644A microprocessor and an auxiliary 16-bit Freescale MC9S12G microcontroller that both run Woodward's ControlCore operating system. Application programming is accomplished via Woodward's MotoHawk application software tool. MotoHawk is a rapid controls system development tool that allows controls engineers to quickly create controls software directly within Simulink diagrams, which run on any MotoHawk-enabled electronic control modules. Application developers work directly in the Simulink environment and with a one-step build are able to go from an application model to a file that can be programmed directly into Woodward production hardware. MotoHawk provides a high-level programming environment for users who have control systems expertise but don't necessarily have specific embedded programming skills. Once the application program has been generated and loaded into the PCM112 control via the CAN port, the user can view variables and tune the control using an appropriate service interface tool such as Woodward's ToolKit or MotoTune. Connection to other devices, such as a diagnostic tool, is accomplished by means of other CAN ports available on the control. The desired information flow is programmed into the control via MotoTune or ToolKit.

The PCM112 control consists of a single rigid printed circuit board attached to an aluminum housing using thermal adhesive, which is then closed and sealed with an aluminum cover. Connections to the control are made via three automotive-style sealed connectors. The control can be mounted directly to the engine or frame using vibration isolators.

## Control Features

| Woodward P/N | HW Version | Features |
|---|---|---|
| 1751-6685 | 4M DEV | 4M flash, 196k RAM, on-the-fly calibratable |

**Standard Features**

- 2 engine speed inputs: camshaft and crankshaft speed (software configurable for variable reluctance [VR] magnetic pickup sensor or Hall effect proximity sensor inputs)
- 2 frequency inputs
- 23 analog inputs
- 1 emergency stop input
- 5 switch inputs
- 2 HEGO sensor inputs
- 2 LSU sensor inputs (also known as UEGO sensors)
- 2 knock sensor inputs
- 3 transducer power outputs, 2 providing +5 V (100 mA) and 1 providing +5 V (50 mA)
- 8 saturated injector drivers
- 4 ignition coil drivers

**Standard Features (continued)**

- 2 H-bridge driver outputs providing 10 A drive capability and current-sense feedback
- MPRD (Master Power Relay Driver) low-side output
- TACH low-side output
- 15 low-side output drivers
- 3 analog gauge drivers
- 3 CAN communications ports
- 1 RS-485 communication port
- 4-kilobyte serial EEPROM for tunable parameter storage
- Auxiliary micro with 128k of flash, 8k of RAM, 4k of EEPROM

## Environmental Capabilities

The following is a summary list of the environmental limits used for ECM design validation.

| | |
|---|---|
| Operating Voltage | 9–16 V (dc) |
| Minimum Cranking Voltage | 4.5 V |
| Operating Temperature | (–40 to +85) °C (105 °C capable) |
| Storage Temperature | (–40 to +125) °C |
| Mechanical Vibration | 3.53 Grms for 250 hours |
| Mechanical Shock | 50 g, 11 ms, half-sine wave, 4 shocks in each direction (24 total shocks) |
| Ingress Protection | Hot module immersion into cold water |
| EMI/RFI Specification | SAE J1113-41 (Radiated & Conducted Emissions)<br>SAE J1113-13 (ESD)<br>SAE J1113-21 (Radiated RF Immunity)<br>SAE J1113-11 (Transient Testing) |

For more detailed information on the PCM112 environmental validation specifications, please contact Woodward. Sharing of this information requires an NDA (non-disclosure agreement).

**IMPORTANT**

**For new applications, the actual environmental data and OE specifications must be reviewed by Woodward during application development and approved prior to offering warranty coverage for the application.**

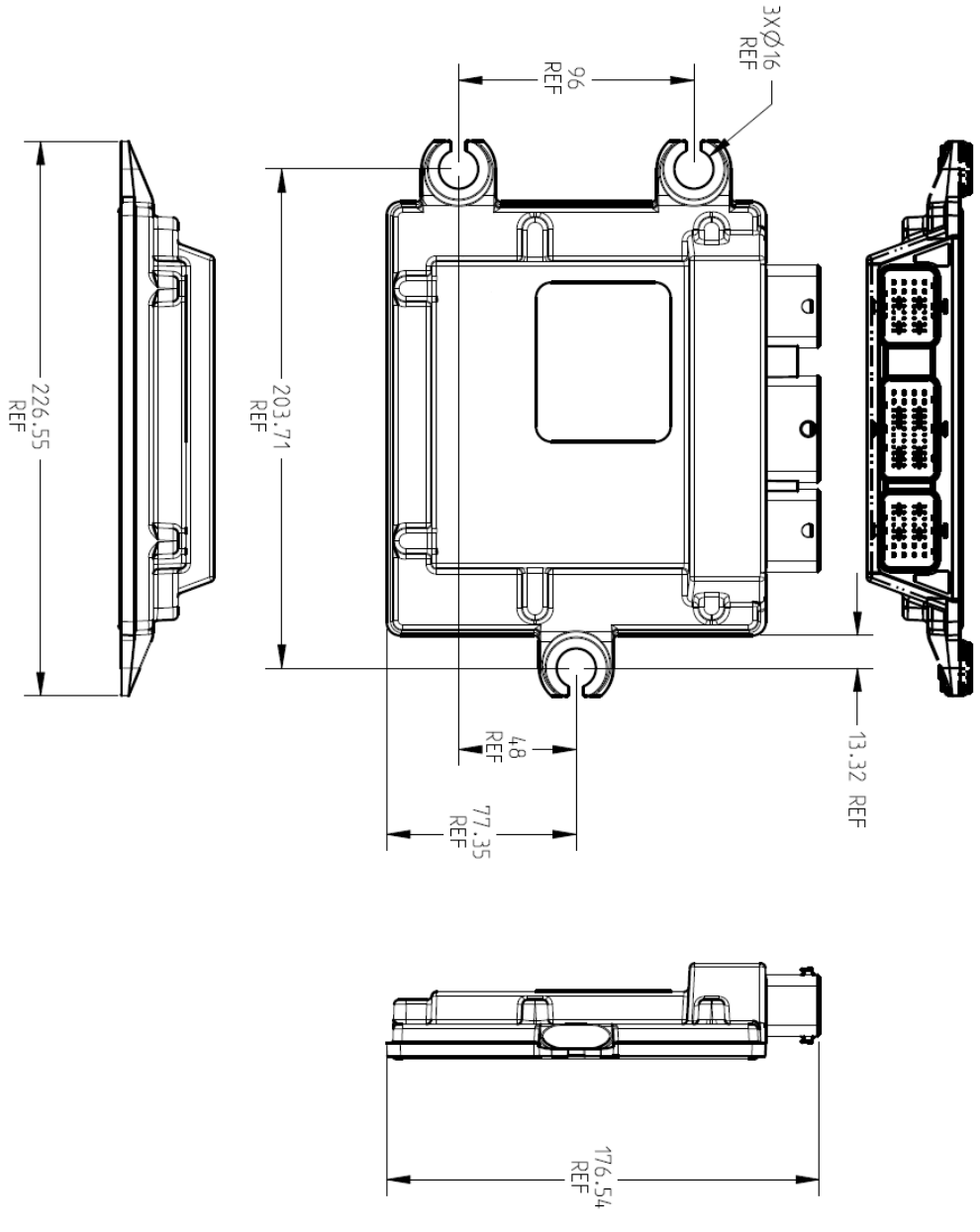


Figure 1-1. PCM112 Control

# Chapter 2
# Installation

## Scope

This chapter contains general installation instructions for the PCM112 control. Power requirements, environmental precautions, and location considerations are included to help you determine the best location for the control. Additional information includes unpacking instructions, electrical connections, and installation checkout procedures.

## Unpacking

Before handling the control, read the Electrostatic Discharge Awareness section (page iv). 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.

## Programming Requirements

PCM112 units are shipped without application software installed. The customer is responsible for programming both microcontrollers with application software. Both micros will power-up in bootstrap mode and will program at 250k baud on CAN1. See the CAN section for details on programming while in bootstrap mode.

## Painting

Painting of the PCM112 is not recommended nor is it required for heat dissipation. If painting must be done, all connectors and labels must be masked prior to painting. The paint must be validated per the following requirements:

- The composition of the paint must be specified to Woodward.
- The specification for thickness of the applied paint must be supplied to Woodward.
- The customer may be asked to participate in vehicle-testing with a thermocouple-instrumented test unit that is painted and installed in the application.

Woodward will work with the customer to determine if paint can be safely applied; however, Woodward reserves the right to deny warranty if the paint is found to be detrimental to the PCM112.

## Welding

Do not conduct any welding on or near the PCM112 control. At a minimum, disconnect wiring to the control if welding near the unit is being conducted.

## Power Requirements

All versions of the PCM112 control require a voltage source of (9 to 16) V (dc) (12 V or 14.5 V) nominal based on system architecture and validation). The power dissipation within the control is typically less than 30W. Standby current draw is 1 mA (nominal).

**IMPORTANT**

**Total power consumption for both the control and the driven loads is dependent on the application. A typical application may require 200W to 300W to drive the loads under all operating conditions. The power source must be sized appropriately for the application.**

**If a battery is used for operating power, an alternator or other battery- charging device is necessary to maintain a stable supply voltage.**

**NOTICE**

**To prevent damage to the control, do not exceed the input voltage range.**

**NOTICE**

**To prevent damage to the control, make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery from the control.**

## Location Considerations

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling.
- Space for servicing and repair.
- Protection from direct exposure to water or to a condensation-prone environment.
- Protection from road debris or material that could impact or deposit on unit and reduce thermal fin cooling.

Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference in excess of levels defined in SAE J1113-13 (ESD), SAE J1113-21 (Radiated RF Immunity), and SAE J1113-11 (EOS Tests).

- The PCM112 may be mounted on-engine, but this is not preferred due to the harsh vibration and thermal environment of an on-engine mount. If the control must be engine-mounted, the location must be approved by Woodward, and the customer may be required to test each application.
- Vibration isolators must be used independent of mounting location. The isolators must be inspected for wear at least once per year. For on-engine mounting, Woodward recommends replacing the vibration isolators once a year or sooner if wear is observed.

Select a location on or near the engine that will provide an operating temperature range in accordance to the Environmental Specifications listed in this manual. Refer to manual 26634, *PCM112 Installation*, for more details on mounting location, orientation, mating connectors, and kitted part numbers.

## Application Approval Process

New applications of the PCM112 module require review and approval by Woodward in order to grant production warranty coverage. This process is either via the Application Management Process (AMP) for Woodward-developed systems or by submittal of I/O usage details and operational and environmental conditions to Woodward via the Account Manager. A Woodward product engineer will review and provide approval or recommendations to gain approval. Early involvement of Woodward will help assure this process goes smoothly.

# Electrical Connections

**WARNING**

**The control will only meet ingress protection specifications with all mating connectors properly installed. In addition, all unused connections in the mating connectors must be plugged to ensure proper sealing of the connectors. Refer to Table 2-1 for the proper connector plug part numbers. Failure to adhere to these guidelines may result in product failure or decreased product life.**

Plant wiring guidelines can be provided by Woodward for each application, and final application wiring must be jointly agreed to with OE and Woodward during the development project. No changes shall occur without approval from Woodward. Figure 2-1 shows the PCM112 connector location and pin orientation. Table 2-1 is the PCM112 control wiring pinout. The highlighted pins use the larger terminals.

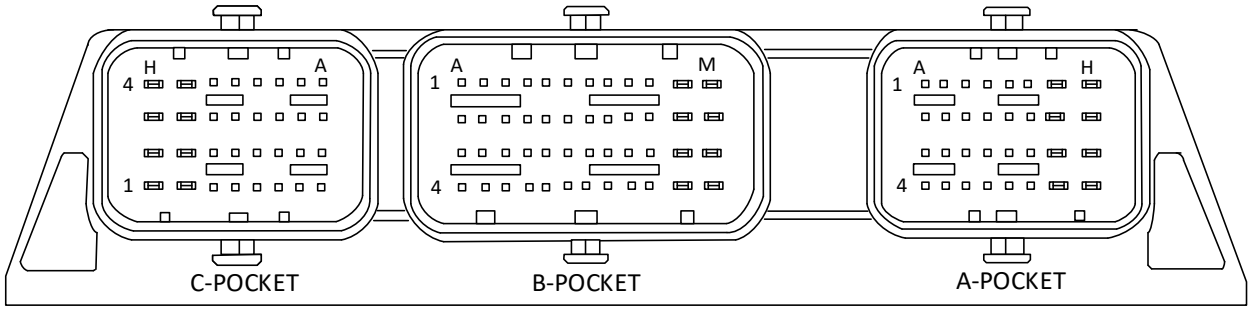


Figure 2-1. Connector Physical Pinout

Table 2-1. PCM112 Control Wiring Pinout

| A | Function | B | Function | C | Function |
|---|---|---|---|---|---|
| A1 | TACH_LINK | A1 | UEGO2_UN | A1 | AN06 |
| A2 | LSO1 | A2 | UEGO2_IP | A2 | SWB1 |
| A3 | LSO9 | A3 | UEGO2_IA | A3 | GAUGE3 |
| A4 | LSO8 | A4 | UEGO2_VM | A4 | BATT |
| B1 | INJ8 | B1 | UEGO1_IP | B1 | AN19 |
| B2 | EK1- | B2 | UEGO1_IA | B2 | AN17 |
| B3 | EK2+ | B3 | UEGO1_VM | B3 | AN03 |
| B4 | LSO3 | B4 | EGO2RTN | B4 | AN02 |
| C1 | INJ7 | C1 | AN13 | C1 | WAKE1 |
| C2 | EK1+ | C2 | AN12 | C2 | WAKE2 |
| C3 | EK2- | C3 | UEGO1_UN | C3 | WAKE3 |
| C4 | CNKVR+ | C4 | EGO1RTN | C4 | AN16 |
| D1 | INJ2 | D1 | AN04 | D1 | GAUGE1 |
| D2 | CNK_OUT | D2 | AN22 | D2 | AN01 |
| D3 | ESTOP | D3 | AN05 | D3 | EGO2+ |
| D4 | CNKVR- | D4 | AN23 | D4 | EGO1+ |
| E1 | INJ5 | E1 | AN21 | E1 | XDRG1 |
| E2 | LSO2 | E2 | AN20 | E2 | XDRG2 |
| E3 | SCL+ | E3 | DGFREQ2 | E3 | XDRG3 |
| E4 | SCL- | E4 | DGFREQ1 | E4 | XDRP3 |
| F1 | INJ4 | F1 | CAN3L | F1 | XDRP1 |
| F2 | INJ6 | F2 | CAN3H | F2 | XDRP2 |
| F3 | INJ1 | F3 | SWG4 | F3 | PWM1 |
| F4 | INJ3 | F4 | SWG3 | F4 | PWM2 |

Table 2-1. PCM112 Control Wiring Pinout (continued)

| A | Function | B | Function | C | Function |
|---|---|---|---|---|---|
| G1 | LSO4 | G1 | CAN1L | G1 | PWRGND1 |
| G2 | LSO6 | G2 | CAN1H | G2 | PWRGND2 |
| G3 | PWRGND3 | G3 | SWG2 | G3 | DRVP1 |
| G4 | LSO5 | G4 | SWG1 | G4 | DRVP2 |
| H1 | SPARKD | H1 | CAN2L | H1 | H1- |
| H2 | SPARKC | H2 | CAN2H | H2 | H1+ |
| H3 | SPARKB | H3 | CASEGND | H3 | H2- |
| H4 | SPARKA | H4 | AN07 | H4 | H2+ |
| | | J1 | AN08 | | |
| | | J2 | AN09 | | |
| | | J3 | CNKDG | | |
| | | J4 | AN10 | | |
| | | K1 | AN11 | | |
| | | K2 | AN15 | | |
| | | K3 | AN14 | | |
| | | K4 | CAMDG | | |
| | | L1 | LSO11 | | |
| | | L2 | AN18 | | |
| | | L3 | GAUGE2 | | |
| | | L4 | LSO7 | | |
| | | M1 | LSO14 | | |
| | | M2 | LSO13 | | |
| | | M3 | LSO12 | | |
| | | M4 | LSO10 | | |

# Wiring Guidelines

**IMPORTANT**

**DO NOT run signal wires next to wires carrying large currents (such as injector outputs, ignition outputs, H-bridge wiring, or power source wiring). See Woodward application note 50532, Interference Control in Electronic Governing Systems, for more information.**

Where shielded cable is used (such as cam or crank speed signals, LSU inputs, or communications signals), cut the cable to the desired length and prepare the cable as instructed below.

Strip outer insulation from BOTH ENDS, exposing the braided or spiral wrapped shield. DO NOT CUT THE SHIELD.

- Using a sharp, pointed tool carefully spread the strands of the shield.
- Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.
- Remove 6 mm (1/4 inch) of insulation from the inner conductors.
- Ground the shield at the source end and cut off the exposed shield at the receiving end.

Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.

- The acceptable wire size range for the small 0.6 mm terminals is (0.35 to 0.75) mm2 with an insulation diameter of (1.25 to 1.9) mm.
- The acceptable wire size range for the large 1.5 mm terminals is (0.5 to 2) mm2 with an insulation diameter of (1.4 to 2.8) mm.

Reference PCM112 installation manual 26634 for proper terminals for chosen wire size.

## Unit Grounding

The PCM112 housing is intended to be mounted through non-conductive vibration isolators with no connection to engine/chassis ground. The CASEGND connector pin is directly connected to the housing, internal to the ECU, bypassing the capacitive path. CASEGND is not normally used. However, if necessary, the CASEGND pin may be grounded to help with EMC issues.

# Chapter 3.
# I/O Description

**IMPORTANT**

**All interface I/O not provided by Woodward must be reviewed by Woodward and approved prior to offering warranty coverage for the application.**

## Power Inputs
## (BATT, PWRGND1, PWRGND2 and PWRGND3)

Power supply output must be low-impedance (for example, directly from a battery). DO NOT power the control from high-voltage sources with resistors and Zener diodes in series with the control power input.

**NOTICE**

**To prevent damage to the control, do not power a low-voltage control from high-voltage sources, do not exceed 24 V on the power inputs for more than 5 minutes, and do not power any control from high-voltage sources with resistors and Zener diodes in series with the power input.**

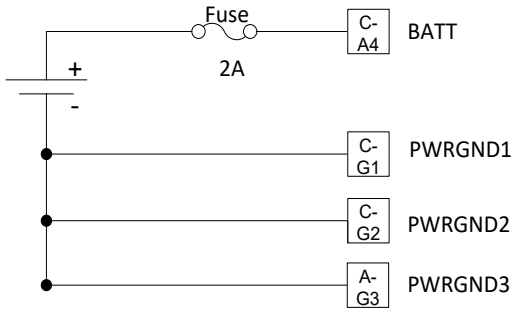


Figure 3-1. Input Power Wiring Diagram

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 BATT input and battery negative (power source common) to PWRGND1, PWRGND2 and PWRGND3 (see Figure 3-1). If the power source is a battery, be sure the system includes an alternator or other battery-charging device.

If the battery is located outside the engine compartment, module grounding to battery shall be via the vehicle chassis. The PCM112 MUST be locally grounded, and the engine must be well grounded to chassis and the chassis well-grounded to battery ground.

The BATT input is protected against damage from a –12 V reverse battery condition for up to 5 minutes.

**NOTICE**

**The PCM112 has loss-of-battery detection capability that should be utilized in the application software to reset the control's adaptive learn mode tunables back to their default values, thus preventing possible engine damage. Refer to the application manual for more information on adaptive learn mode.**

## DRVP1 & DRVP2 Inputs

DRVP1 and DRVP2 provide the primary power for the internal H-bridges and output recirculation diodes. These inputs must not be directly connected to the power source. They must be connected to the power source via the Master Power Relay Driver (see Figure 3-2) to protect the drivers during a reverse-battery condition. The Master Power Relay is energized by the MPRD output, which is under application program control. DRVP voltage monitor is available (see the Analog Inputs section below). Note that the DRVP monitor will typically read 1 V to 2 V when MPRD is off due to internal leakage paths.

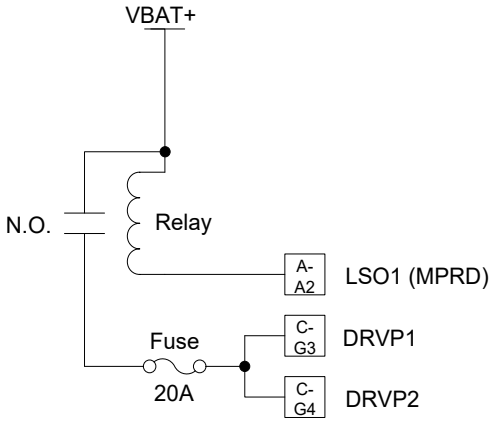


Figure 3-2. Driver Power Wiring Diagram

**NOTICE**

**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.**

## WAKE1 (KEYSW), WAKE 2, WAKE 3

The WAKE1 (KEYSW) discrete input provides a power-on wake-up command signal to the PCM112 control's internal power supply. Once activated, the control's internal power supply will remain active until commanded to shut down by the application program. A normally-open switch is connected between battery positive and the KEYSW input, thus connecting battery voltage to the control when the switch is closed (see Figure 3-3). The VBAT+ supply must be from a fused source. KEYSW voltage monitor is available (see the Analog Inputs section below). WAKE2/3 are additional ECU wake-up pins to allow alternate power-up functions. SW can differentiate between WAKE1/2/3.

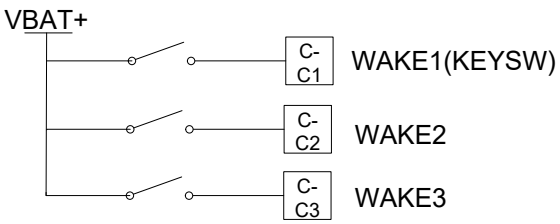


Figure 3-3. Wake1/2/3 Wiring Diagram

**IMPORTANT**

**The control will not power up until the KEYSW input is activated. Once activated, the KEYSW input may be opened, but the control's power supply will remain activated until commanded to shut down by the application program. Typically, the application will monitor the KEYSW input voltage level, and command the control to shut down whenever the KEYSW input voltage drops below a specified minimum level. The application program may include shutdown delays to allow time for tunable settings to be stored in non-volatile memory before shutting down.**

The KEYSW input is protected against damage from a –12 V reverse battery condition for up to 5 minutes

## Internal Temperature Monitor

The PCM112 microcontroller contains an internal temperature monitor that is available to the application. The monitor has an accuracy of ±10 °C. This monitor is a critical parameter for the application thermal study which is a requirement for application approval and warranty coverage.

**IMPORTANT**

**A logged maximum temperature exceeding 135 °C may result in warranty claim denial.**

## MPRD Output

The MPRD (Main Power Relay Driver) Output is used in conjunction with the KEYSW input to control the switching of power to the external loads that are connected to the module. For example, the power to the injectors, ignition coils, wastegate control valve, etc., can be disabled until the relay(s) that are connected to the MPRD output are energized. The power to the injectors should come through a set of normally-open contacts on the relay(s) (see Figure 3-4). It is assumed that the architecture for any system that employs the PCM112 will use the MRPD output to switch power through the master power relay(s). The MPRD output is protected against reverse battery connection by utilizing a blocking diode. The maximum sinking current for the MPRD output is 500mA.

**NOTICE**

**Failure to use the MPR power distribution architecture will leave the output drivers and actuators unprotected from a reverse battery condition and will void the warranty for this failure mode.**

The driver is thermally self-protected and will provide shutdown fault detection. Open-load detection must be based on DRVP diagnostics. The S12 aux core may disable the MPRD, this disable is shared with the encoder disable.

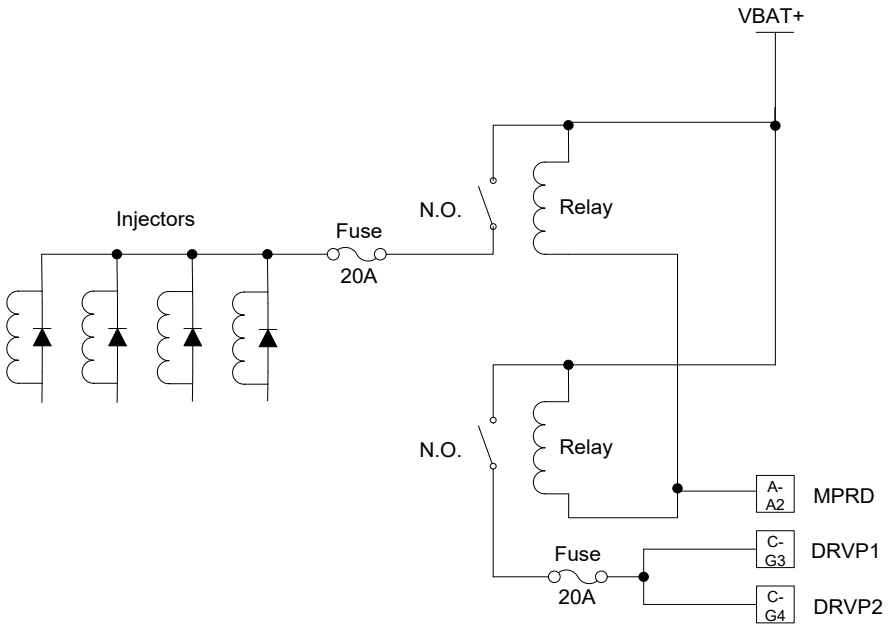


Figure 3-4. MPRD Wiring Diagram

## VR±, & CNKDG (DG1), CAMDG (DG2) Inputs

The Cam and Crank (CNK) inputs are used to detect engine speed and angular position relative to TDC. The CAM and CNK inputs can be connected to either a variable reluctance magnetic pick-up sensor (VR-MPU) as shown in Figure 3-5, or to a Hall-effect proximity switch as shown in Figure 3-6; however, each type of input has dedicated connector pins. Usage of shielded wire for the speed sensor inputs is recommended but not absolutely necessary. Make sure the shield has continuity the entire distance to the speed sensor, and make sure the shield is insulated from all other conducting surfaces. If shielded wire is not used, then twisted wire pairs would be the next best alternative. VR/DG1 or DG2 can be selected as the primary encoder input and this selection is also available to the S12 aux core. The encoder may also be disabled by the S12 core. This disable is shared with the MPRD disable.

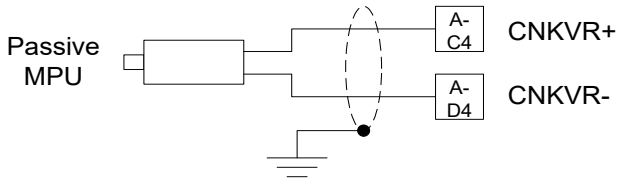


Figure 3-5. MPU Input Wiring Diagram

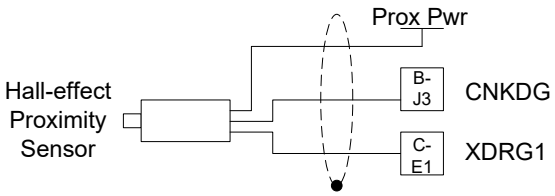


Figure 3-6. Hall-Effect Input Wiring Diagram of CNKDG

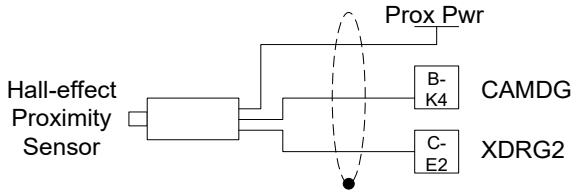


Figure 3-7 Hall-Effect Input Wiring Diagram of CAMKDG

**⚠WARNING**

**The CAM or CNK gear tooth pattern is used by the control to convert pulses from the speed sensing device to engine rpm, and to obtain engine angular position information (TDC and phasing). To prevent possible serious injury from an overspeeding engine or improper cylinder firing, make sure the control is properly programmed with the correct gear pattern. Refer to the software manual for information on gear-tooth pattern selection. Improper pattern selection could cause engine damage.**

The application software allows the programmer to select either VR mode or Hall-effect mode for speed sensing. If VR mode is selected, the PCM112 control utilizes an adaptive variable reluctance sensor amplifier that operates with a positive-going threshold, which is derived by peak-detecting the input signal. If Hall mode is selected, the application software allows the programmer to select to either enable or disable a 3.3 kΩ pull-up resistor which can be used for open collector type sensors. Tables 3-1 and 3-2 list the input circuit specifications.

***IMPORTANT***

**The VR+/– are differential inputs with an offset of 2.5 V. The VR– should not be grounded in the application or via test measurement equipment.**

Table 3-1. VR Input Specifications

| Parameter | Specification |
|---|---|
| VR polarity | VR signal connected to PCM112 shall be configured so that the + and – at PCM112 input results in a waveform with falling edge and fast zero crossing. |
| Amplitude of noise compared to amplitude of pulses at same condition/moment (for pulse frequency > 22 Hz 24 tooth cam > 110 rpm 6 tooth cam > 440 rpm) | Less than 16 % of signal amplitude when pulse amplitude is less than 25 V peak. Fixed voltage threshold not to exceed 4 V peak when amplitude is above 25 V peak. |
| Amplitude of noise compared to amplitude of pulses at same condition (for pulse frequency < 22 Hz 24 tooth cam < 110 rpm 6 tooth cam < 440 rpm) | Must be less than 0.16 V. |
| Tooth center-to-center tolerance | Cam less than ±1 crank angle degree. Crank less than ±0.1 crank angle degree. |
| Tooth-to-tooth pulse peak amplitude variation | Between 0.7 and 1.3 |
| Amplitude maximum (overspeed condition with minimum sensor gap) | 90 V peak (180 V peak-to-peak) |
| Amplitude minimum (slow cranking condition with maximum sensor gap) | 0.2 V peak (0.4 V peak-to-peak) |

Table 3-2. Digital Input Specifications

| Parameter | Specification |
|---|---|
| Input voltage thresholds | Vil(max) = 1.7 V<br>Vih(min) = 3.3 V |
| Hysteresis | VHYST (min) = 0.5 V (dc) |
| Input impedance | CNKDG: 3.3 kΩ ± 5% pull-up to VCC (software controlled)<br>CAMDG: 1 kΩ ± 5% pull-up to VCC (software controlled) |
| Anti-aliasing filter | 1 pole at 4 μs |

## Transducer Power Outputs (XDRP1, XDRP2 & XDRP3)

The PCM112 control provides three independent +5 V (DC) transducer power sources for powering external transducers. The transducer power outputs are protected against over-voltage, over-temperature, short circuits, and reverse power. Figure 3-8 shows a typical connection of the transducer output powering a transducer, with the transducer signal feeding back to an analog input on the PCM112 control.

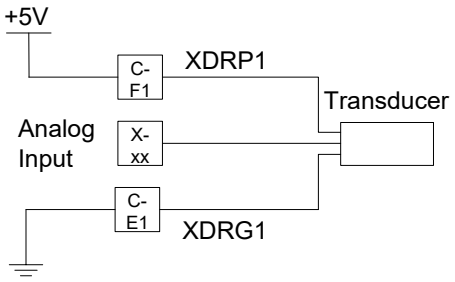


Figure 3-8. Transducer Output Power Wiring Diagram

Table 3-3. Transducer Output Specifications

| Output | Voltage | Current Limit |
|---|---|---|
| XDRP1 | 5 V ± 2 % | 100 mA |
| XDRP2 | 5 V ± 2 % | 50 mA |
| XDRP3 | 5 V ± 2 % | 100 mA |

**NOTICE**

**The ADC reference voltage is VCC. For improved XDRP3-sourced absolute analog input accuracy, it is recommended that the application utilize the precision VCAL 2.5 V reference for compensation.**

# Analog Inputs (AN1—AN23)

There are 23 analog inputs on the PCM112. The analog inputs have either a pull-up resistor as shown in Figure 3-9, or a pull-down resistor as shown in Figure 3-10. Table 3-4 provides the pin-out and configuration information for each of the analog inputs. Analog inputs are protected for shorts up to 14 V. Some analog channels are also available to the S12 aux core, as noted.

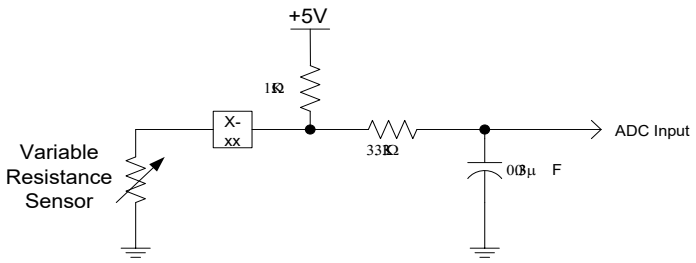


Figure 3-9. Analog Input (with internal pull-up resistor) Wiring Diagram

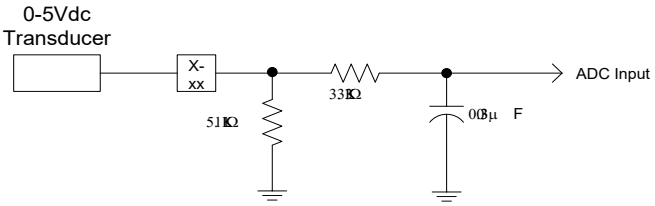


Figure 3-10. Analog Input (with internal pull-down resistor) Wiring Diagram

Table 3-4. Analog Input Configuration

| Channel Number | Connector Pinout | $\tau_{RC}$ (ms) | Configuration | Notes |
|---|---|---|---|---|
| AN1 | C-D2 | 2 | 51.1 kΩ pull-down | |
| AN2 | C-B4 | 20 | 51.1 kΩ pull-down | |
| AN3 | C-B3 | 20 | 51.1 kΩ pull-down | |
| AN4 | B-D1 | 20 | 51.1 kΩ pull-down | |
| AN5 | B-D3 | 20 | 51.1 kΩ pull-down | |
| AN6 | C-A1 | 40 | 51.1 kΩ pull-down | |
| AN7 | B-H4 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN8 | B-J1 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN9 | B-J2 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN10 | B-J4 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN11 | B-K1 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN12 | B-C2 | 2 | 220 kΩ pull-down | |
| AN13 | B-C1 | 2 | 220 kΩ pull-down | |
| AN14 | B-K3 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN15 | B-K2 | 2 | 220 kΩ pull-down | Also available from S12 core |
| AN16 | C-C4 | 20 | 183 Ω pull-up | |
| AN17 | C-B2 | 20 | 183 Ω pull-up | |
| AN18 | B-L2 | 20 | 1 kΩ pull-up | Also available from S12 core |
| AN19 | C-B1 | 20 | 1 kΩ pull-up | |
| AN20 | B-E2 | 20 | 1 kΩ pull-up | |
| AN21 | B-E1 | 20 | 1 kΩ pull-up | |
| AN22 | B-D2 | 20 | 10 kΩ pull-up | |
| AN23 | B-D4 | 20 | 150 kΩ pull-up | |
| SWB1 | C-A2 | 2 | 3 kΩ pull-down | Designed for a switch to VBAT but can be used as a standard analog |
| WAKE1 | C-C1 | 3 | Raw A/D reads 0.181x of pin voltage | |
| WAKE2 | C-C2 | 3 | Raw A/D reads 0.181x of pin voltage | |
| WAKE3 | C-C3 | 3 | Raw A/D reads 0.181x of pin voltage | |
| XDRP1 | internal | – | Raw A/D reads 0.5x of voltage | |
| XDRP2 | internal | – | Raw A/D reads 0.5x of voltage | |
| XDRP3 | internal | – | Raw A/D reads 0.5x of voltage | |
| VCAL | internal | – | – | 2.5 V precision reference; also available from S12 core |
| DRVP | internal | 195 | Raw A/D reads 0.181x of pin voltage | Will read 1–2 V when MPRD is off |

# Switch Inputs (SWG1—SWG4), ESTOP and DGFREQ1/DGFREQ2

The switch inputs on the PCM112 can be used to monitor the state of a ground referenced contact switch. Figure 3-11 shows how the discrete inputs are connected when using a ground-referenced contact switch. The contacts may be either normally open or normally closed. The digital input topology is essentially the same as the analog input topology with a pullup resistor to 5 volts. Unless otherwise specified, digital inputs are monitored by the main micro. Table 3-5 shows the switch input capabilities and characteristics.

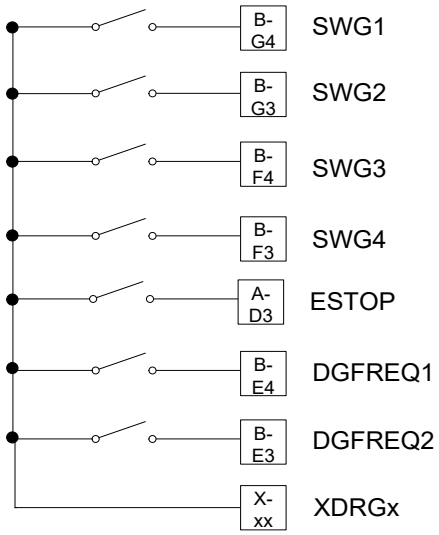


Figure 3-11. Digital Input Wiring Diagram

Table 3-5. Switch Input Characteristics & Capabilities

| Channel Number | Connector Pinout | Type | $\tau_{RC}$ | Thresholds | Configuration | Notes |
|---|---|---|---|---|---|---|
| SWG1 | B-G4 | Boolean | 2 ms | Vil(max) = 1.7 V<br>Vih(min) = 3.3 V<br>Vhyst(min) = 0.5 V | 5 kΩ pull-up to 5 V | |
| SWG2 | B-G3 | Boolean | 2 ms | | 5 kΩ pull-up to 5 V | |
| SWG3 | B-F4 | Boolean | 2 ms | | 5 kΩ pull-up to 5 V | |
| SWG4 | B-F3 | Boolean | 2 ms | | 5 kΩ pull-up to 5 V | |
| ESTOP | A-D3 | Boolean | 20 ms | Vil(max) = 2.0 V<br>Vih(min) = 3.0 V<br>Vhyst(min) = 0.5 V | 1 kΩ pull-up to 5 V | Assertion disables SPARKx & LSO3/4/5/6 |
| DGFREQ1 | B-E4 | Boolean or PWM | 4 µs | Vil(max) = 1.7 V<br>Vih(min) = 3.3 V<br>Vhyst(min) = 0.5 V | None or 1 kΩ pull-up to 5 V | |
| DGFREQ2 | B-E3 | Boolean or PWM | µs | | None or 1 kΩ pull-up to 5 V | |

## HEGO Sensor Inputs

The PCM112 control has two HEGO (Heated Exhaust Gas Oxygen) inputs which are single-ended. EGO1 +/-, EGO2 +/- and LSO13 ~ LSO14 are reserved for HEGO heater control.

**IMPORTANT** **It is highly recommended that the signal wires from the HEGO sensor to the PCM112 control be shielded to reduce the levels of EMI. The heater power wires should also be routed as a twisted pair.**

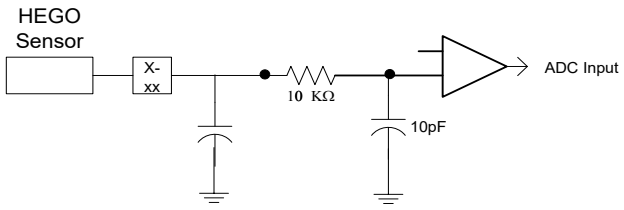


Figure 3-12. HEGO Sensor Wiring Diagram

HEGO Transfer Function:

VADC = 4.56 * VIN

## Lambda Sensor Unit (UEGO) Inputs

The PCM112 control has two LSUs (Lambda Sensor Units), also known as UEGO (Universal Exhaust Gas Oxygen) inputs, which interface with Bosch LSU4.9 wide range λ-sensors (Lambda sensors). The λ-sensor(s) work in conjunction with the on-board Bosch CJ125 ASIC(s) to provide continuous regulation of λ for a sensor in the range of λ = 0.65...∞ (air). The LSU inputs allow the PCM112 to continuously regulate the engine air-to-fuel ratio, thus controlling the percentage of exhaust pollutants during the combustion process. Figure 3-13 shows the wiring diagram for the LSU mating connector to the PCM112 control.

**IMPORTANT** **It is highly recommended that the 4 signal wires from the UEGO sensor(s) to the PCM112 control be shielded to reduce the levels of EMI. The heater power wires should also be routed as a twisted pair.**

The application of the LSU sensor is complex. The sensor installation, heater control, and reading of outputs need to follow Bosch guidelines to ensure accurate A/F ratio reading and protection of the sensor from shortened life. Covering the detail requirements of the application of the LSU sensor is outside the scope of this manual.

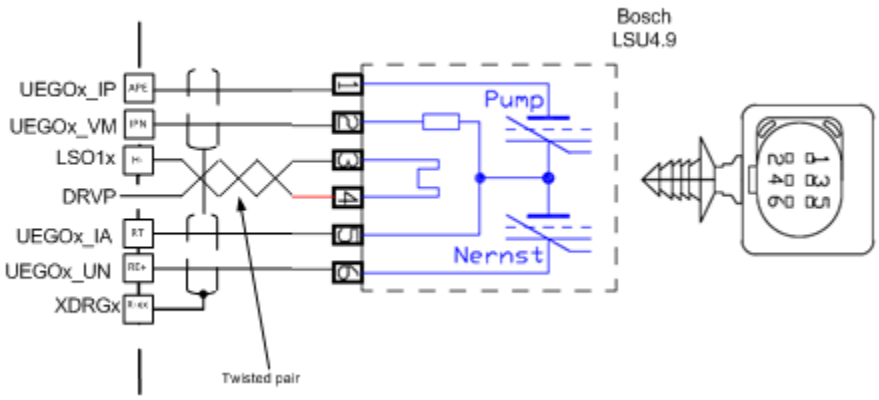


Figure 3-13. Lambda Sensor Unit Wiring Diagram

Table 3-6. UEGO Sensors Pinout

| Sensor | | PCM UEGO1 | | PCM UEGO2 | | Function |
|---|---|---|---|---|---|---|
| PIN | Name | PIN | Name | PIN | Name | |
| 1 | APE | B-B1 | UEGO1_IP | B-A2 | UEGO2_IP | Pumping current |
| 2 | IPN | B-B3 | UEGO1_VM | B-A4 | UEGO2_VM | Virtual Ground |
| 3 | H- | B-L1 | LSO11 | B-M3 | LSO12 | UEGOx Heater Low |
| 4 | H+ | – | – | – | – | UEGOx Heater High (DRVP) |
| 5 | RT | B-B2 | UEGO1_IA | B-A3 | UEGO2_IA | Trim Resistor |
| 6 | RE+ | B-C3 | UEGO1_UN | B-A1 | UEGO2_UN | Nernst Voltage |

## Knock Sensor Inputs

The PCM112 supports two Knock Sensor inputs. These differential inputs are amplified prior to ADC sampling and then processed by the microcontroller's DSP capabilities. Up to an 8th-order IIR filter can be supported using the MPC5644A decimation filter silicon for a minimal CPU bandwidth knock solution. The MPC5644A also supports DSP capability that will allow a software-based solution. This would allow a very feature-rich knock solution to be authored, but at the expense of needing to consume more of the available CPU bandwidth. Figure 3-14 shows the wiring for the knock inputs.

**IMPORTANT** **The knock inputs are differential inputs with an offset of 2.5 V. The inputs should not be grounded in the application or via test measurement equipment.**

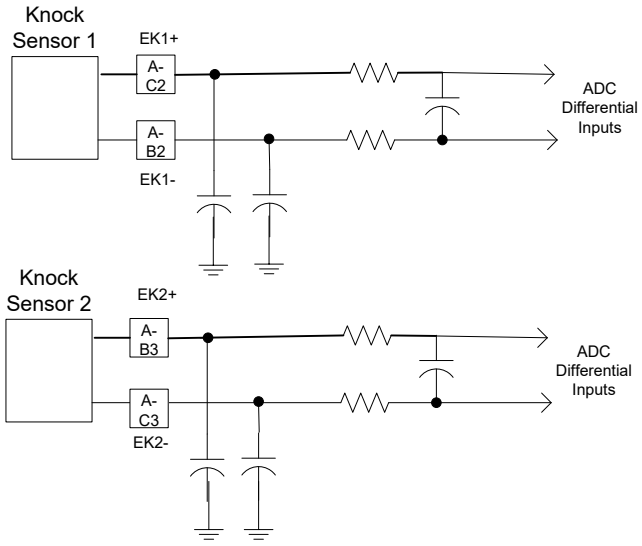


Figure 3-14. Knock Sensor Wiring Diagram

## Low-Side Outputs (LSO)

The PCM112 control has 14 low-side outputs (LSOx, MRPD & START) that can be used as Boolean outputs for driving relays, or some as PWM outputs. LSO1 and LSO2 are also designed to drive the heater coil on a LSU sensor. Some low-side outputs are provided with freewheeling diodes (internal to the PCM112 through DRVP or BATT) to suppress the back EMF caused by inductive loads. The MotoHawk software provides diagnostics for open and short detection of the LSO loads (refer to the SW manual or MotoHawk help files for specifics on the diagnostic capabilities). Figures 3-15 through 3-17 show typical applications of the various outputs to drive a load. Table 3-9 shows the low-side output capabilities, characteristics and diagnostics.

**IMPORTANT**

**LSO1_LSU1H and LSO2_LSU2H should not be operated above 100 Hz when driving the heater coil of a Lambda Sensor Unit (LSU). Exceeding 100 Hz will affect the accuracy of the LSU readings.**

**IMPORTANT**

**LSOs that have a recirculation diode to DRVP must be used with a load powered from DRVP.**

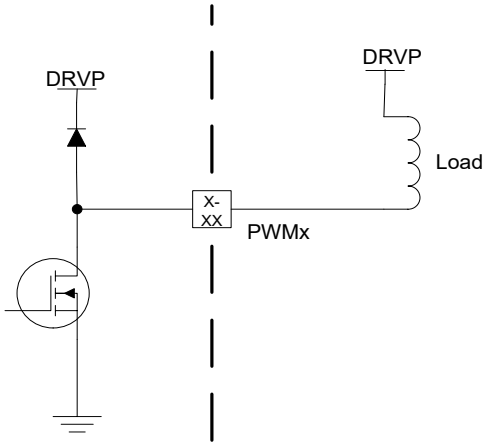


Figure 3-15. PWM1/PWM2 Output Wiring Diagram

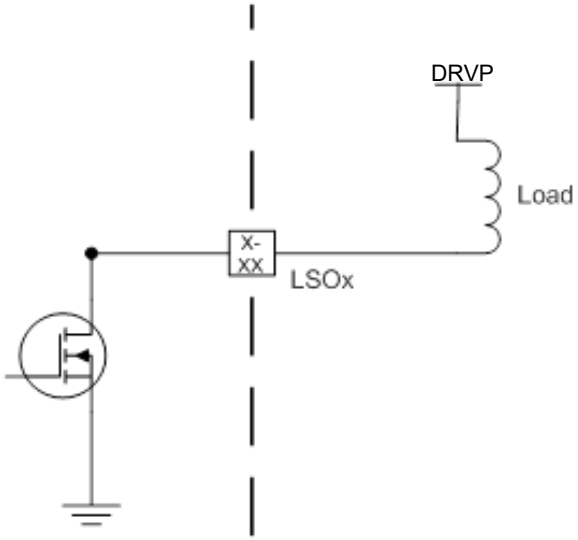


Figure 3-16. LSO2/3/4/5/6/11/12/13/14 Output Wiring Diagram

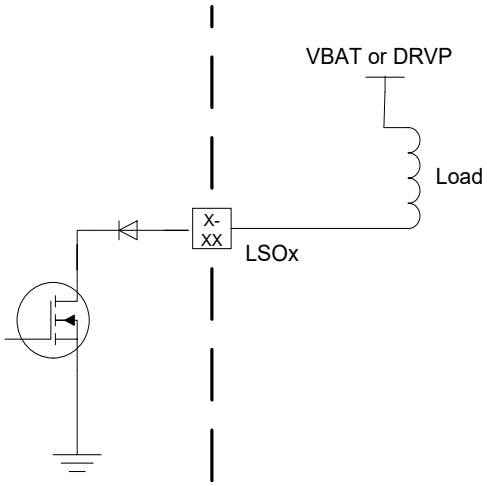


Figure 3-17. LSO1/7/8/9/10 Output Wiring Diagram

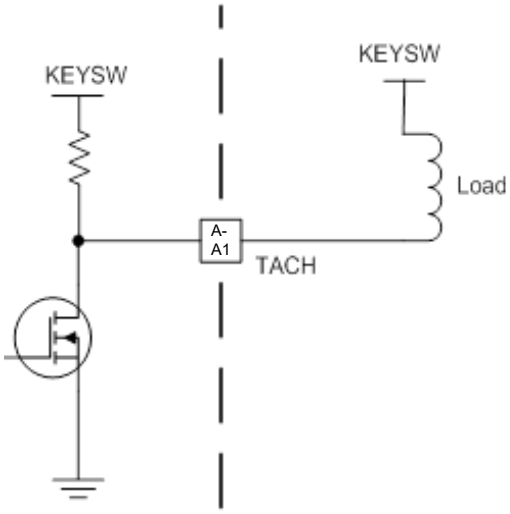


Figure 3-18. TACH Output Wiring Diagram

Table 3-7. LSO Characteristics & Capabilities

| Function | Pin | Drive Capability | Max Current | Diode Type | Open Load Fault Diagnostic (Driver Off) | Open Load Fault Diagnostic (Driver On) | Shorted Load Fault Diagnostic (Driver On) |
|---|---|---|---|---|---|---|---|
| LSO1 (MPRD) | A-A2 | Boolean | 500 mA | Reverse battery diode | $V_{IL}$ (max) = 2.8 V<br>$V_{IH}$ (min) = 5.6 V<br>$V_{HYST}$ = 0.5 V | No detection | 1.7 A to 3.5 A Self-protected MOSFET - pin voltage monitored (calibratable) |
| LSO2 | A-E2 | Boolean | 500 mA | None | >33k (nominal) | No detection | 1.7 A to 3.5 A Self-protected MOSFET – not monitored |
| LSO3 | A-B4 | Boolean or PWM | 500 mA | None | >33k (nominal) | No detection | 3 A to 6 A |
| LSO4 | A-G1 | Boolean or PWM | 500 mA | None | >33k (nominal) | No detection | 3 A to 6 A |
| LSO5 | A-G4 | Boolean or PWM | 500 mA | None | >33k (nominal) | No detection | 3 A to 6 A |
| LSO6 | A-G6 | Boolean or PWM | 500 mA | None | >33k (nominal) | No detection | 3 A to 6 A |
| LSO7 | B-L4 | Boolean | 1 A | Reverse battery diode | >33k (nominal) | No detection | 3 A to 6 A |
| LSO8 | A-A4 | Boolean | 1 A | Reverse battery diode | >33k (nominal) | No detection | 3 A to 6 A |
| LSO9 | A-A3 | Boolean | 1 A | Reverse battery diode | >33k (nominal) | No detection | 3 A to 6 A |
| LSO10 | B-M4 | Boolean | 1 A | Reverse battery diode | >33k (nominal) | No detection | 3 A to 6 A |
| LSO11 | B-L1 | Boolean or PWM | 5 A | None | >166 kΩ (nominal) at 14V | No detection | 16.8 A to 33.6 A |
| LSO12 | B-M3 | Boolean or PWM | 5 A | None | >166 kΩ (nominal) at 14V | No detection | 16.8 A to 33.6 A |
| LSO13 | B-M2 | Boolean or PWM | 5 A | None | >166 kΩ (nominal) at 14V | No detection | 16.8 A to 33.6 A |
| LSO14 | B-M1 | Boolean or PWM | 5 A | None | >166 kΩ (nominal) at 14V | No detection | 16.8 A to 33.6 A |
| PWM1 | C-F3 | Boolean or PWM | 3 A | Recirc to DRVP | >33k (nominal) | No detection | 3 A to 6 A |
| PWM2 | C-F4 | Boolean or PWM | 3 A | Recirc to DRVP | >33k (nominal) | No detection | 3 A to 6 A |
| TACH_ LINK | A-A1 | Boolean or PWM | 250 mA | 1.8k PU to KEYSW | No detection due to PU | No detection | 1.7 A to 3.5 A Self-protected MOSFET – not monitored |
| CNK_OUT | A-D1 | Driven by OS | 50 mA | None | No detection | No detection | 75mA |

# Injector Outputs

The PCM112 control has 8 injector outputs, each capable of driving a single high impedance injector. Each injector output can be used as a Boolean output, a PWM output, or as a synchronous injector pulse.

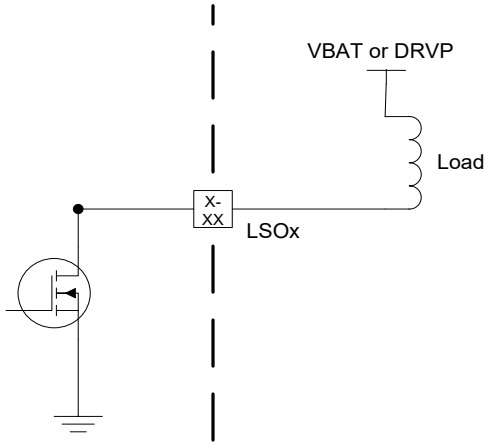


Figure 3-19. Injector Wiring Diagram

Table 3-8. Injector Driver Characteristics & Capabilities

| Function | Pin | Drive Capability | Max Current | Open Load Fault Diagnostic (Driver Off) | Shorted Load Fault Diagnostic (Driver On) |
|---|---|---|---|---|---|
| INJ1 | A-F3 | Boolean or PWM | 3 A peak | >166 kΩ (nominal) at 14V | 1.6 A to 4.1 A Self-protected MOSFET – not monitored |
| INJ2 | A-D1 | | | | |
| INJ3 | A-F4 | | | | |
| INJ4 | A-F1 | | | | |
| INJ5 | A-E1 | | | | |
| INJ6 | A-F2 | | | | |
| INJ7 | A-C1 | | | | |
| INJ8 | A-B1 | | | | |

# Spark Outputs

The PCM112 has IGBT ignition coil drivers which are implemented in hardware via the MC33810 pre-driver IC. Each coil driver is capable of delivering up to 10 A of peak dwell current. Table 3-11 shows the Spark output capabilities, characteristics, and diagnostics. Advanced features of the MC33810 IC such as secondary diagnostics and spark duration feedback are available to the application through the MC33810 block set in MotoHawk. Refer to the MotoHawk help files for specifics on the MC33810 block set.

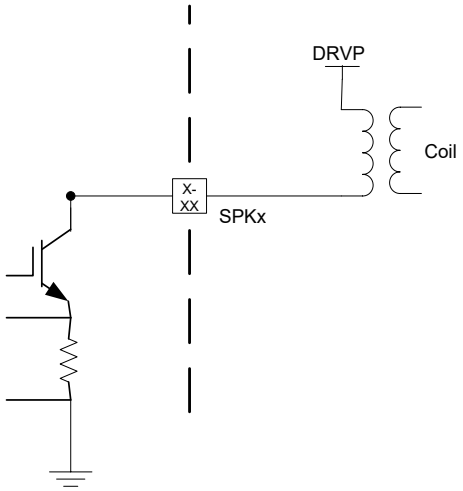


Figure 3-20. Spark Output Wiring Diagram

Table 3-9. Spark Driver Characteristics & Capabilities

| Function | Pin | Drive Capability | Max Current | Open Load Fault Diagnostic (Driver Off) | Shorted Load Fault Diagnostic (Driver On) |
|---|---|---|---|---|---|
| SPKA<br>SPKB<br>SPKC<br>SPKD | A-H4<br>A-H3<br>A-H2<br>A-H1 | Boolean or PWM | 10 A peak dwell | Based on time to nominal current (calibratable time). Open secondary and spark duration feedback available | Based on time to nominal current (calibratable time) |

# H-Bridge Outputs

The PCM112 control has two H-bridge outputs that can be used to drive electric motors such as butterfly throttle valves. The H-Bridge outputs are provided with freewheeling diodes (internal to the PCM112 through DRVP) to suppress the back EMF caused by inductive loads and both H-bridges provide signed load current feedback. Table 3-12 shows the H-bridge output capabilities, characteristics and diagnostics. Each H-bridge can be disabled individually by the S12 core.

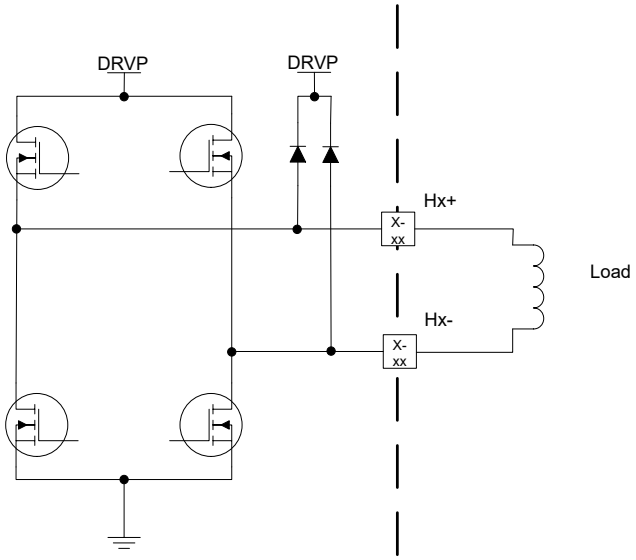


Figure 3-21. H-Bridge Wiring Diagram

Table 3-10. H-Bridge Characteristics & Capabilities

| Function | Pin | Drive C Capability | Max Current | Open Load Fault Diagnostic (Driver On) | Shorted Load Fault Diagnostic (Driver On) |
|---|---|---|---|---|---|
| H1+<br>H1- | C-H2<br>C-H1 | Boolean or PWM | 10 A average w/ load current sense scaled for ±8 A, ±20% accuracy | Based on current sense feedback (calibratable threshold) | 30-70 A (HW protection) App SW must limit current to 10A max |
| H2+<br>H2- | C-H4<br>C-H3 | Boolean or PWM | 10 A average w/ load current sense scaled for ±8 A, ±20% accuracy | Based on current sense feedback (calibratable threshold) | 30-70 A (HW protection) App SW must limit current to 10A max |

# Analog Outputs

The PCM112 control has 3 analog outputs designed to drive gauges with a heavily filtered PWM to minimize ripple. At 50% duty cycle at 2 kHz, the ripple is less than 2mV.

Table 3-11. Gauge Outputs Characteristics & Capabilities

| Function | Pin | Output Voltage Range | Output Current Range | PWM Frequency |
|---|---|---|---|---|
| GAUGE1 | C-D1 | 0 - 15.6V | 0 - 238mA | 2 kHz (min)<br>0 - 100% |
| GAUGE2 | B-L3 | | | |
| GAUGE3 | C-A3 | | | |

Voltage monitor analog feedback reads 0.3197x of output voltage and current monitor analog feedback reads 21x the output sink current in amps.

# CAN Communications Ports

The PCM112 has three CAN ports for distributed I/O, distributed control, and HMI (Human Machine Interface) purposes. Each port operates independently. Communications are controlled via MotoHawk rate groups and are deterministic. Take care in the choice of devices used on each network. HMI devices should generally not be put on distributed control networks with real-time control requirements. The CAN port assignments are provided in the application documentation. The MPC5644A main core supports all three CAN ports and the auxiliary S12G micro only supports the CAN1 port.

The CAN ports on the PCM112 are not isolated from each other or from any of the other circuitry on the PCM112 control, as they share a common ground. As such, neither port should be used for communication off the engine. They are designed for on-engine distributed control. The CAN network must be limited to 30 m or less wiring length between the two devices at the physical ends of the network. This limit is further reduced to 25 m if 1000 kbps baud rate is used.

The PCM112 supports xCP, ISO15765, and SAE J1939 protocols for transmitting data over the CAN lines. The physical wiring of the CAN ports must conform to ISO 11898-2 (see Figure 3-22 for the CANbus topology). Units come from the factory with CAN ports set to 250k baud (bootstrap mode).

Table 3-12. CAN Specifications

| | |
|---|---|
| Transceiver type | CAN 2.0B |
| Internal ECM termination | 121 Ω (CAN3 only) |
| Isolation voltage | None |
| Baud rates supported | 125, 250, 500, and 1000 kbps |
| Protocols supported | xCP, ISO15765, SAE J1939 |

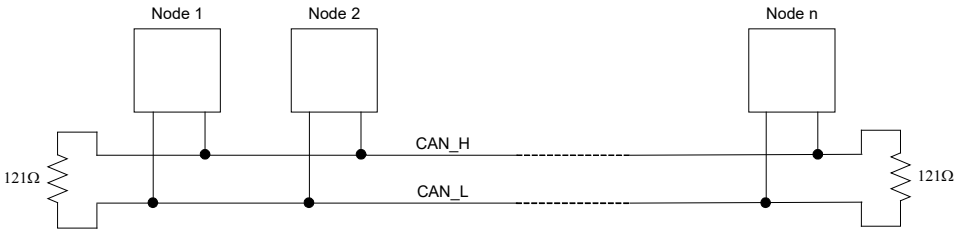


Figure 3-22. CANbus Topology

Per ISO 11898-2 the two-wire CANbus must meet the following criteria:

- A maximum length of 25 m for 1 Mbit/s data rate, 40 m for 250 kbits/s
- A recommended maximum drop line length of 0 m for 1 Mbit/s data rate, 1 m at 250 kbits/s
- Characteristic line impedance of 121 Ω
- Nominal line resistance of 70 mΩ/m
- Nominal specific propagation delay of 5 ns/m

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

### Termination

It is necessary to terminate the network to prevent interference caused by signal reflections. Depending on network length, many CAN networks will not operate without proper termination.

The CAN termination network includes the PCM112 control. An internal 121 Ω CAN termination exists only on CAN3.

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.

Termination is a simple 121 Ω, 0.25 W, 1 % metal film resistor placed between CAN high and CAN low terminals at the two end units, a differential termination. Do not connect the termination resistor to anything besides the CAN high and CAN low wires.

### Shielding

Shielded CAN cable is not required between the PCM112 and any other device(s), but it is highly recommended. 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.

If shielding is used with the PCM112 CAN wiring, the shield should be tied only at the PCM112 control transducer ground pins (XDRG1 on C-E1, or XDRG2 on C-E2). If the shield is grounded at the other end, it should be through a high-frequency AC ground (via a 0.01 µF capacitor to chassis-body ground).

### Bootstrapping

If software becomes corrupted or is resetting, the unit can be re-programmed by bootstrapping the microcontroller. The main micro can be bootstrapped via two different methods: with a boot key or the analog method. The boot key provides a 555 Hz square wave to the ESTOP pin, or an arbitrary waveform generator with a 0–5 V signal can be used. To bootstrap, connect the boot key and initiate programming at 250 kΩ on CAN1 with ID 0xB (PCM-1 on MotoTune) before key-on.

The S12 micro has an analog bootstrap method. Set AN7, AN8, & AN9, AN10, AN11, AN14 and AN15 to 5 V and AN18 to GND. To bootstrap, set the analogs and initiate programming at 250 kΩ on CAN1 with ID 0x81 (SECM-1 on MotoTune) before key-on.

## RS485 Communications Port

The serial communications bus employs an RS485 transceiver to implement a balanced half duplex communications link, through SCL+ and SCL- PINs. The physical layer is similar to that described by the J1708 standard.

# S12 Core Interface

The S12 core can communicate with the main core via CAN1 or via SPI. The S12 also has the ability to force a reset of the main core and read a status pin on the main.

The following are the I/O available on the S12 core:

- **Analog inputs**: AN07-11, AN14-15, AN18, VCAL, WAKE
- **Digital inputs:** TACH (from main core), ESTOP, S12_BOOT (from main)
- **Comms:** CAN1
- **Outputs:** Output Driver Enable (LSO2-14, PWM1/2, SPARKA-D, INJ1-8, TACH), PWRHOLD (keeps ECU power on), main core reset

# Output Driver Enable

The hardware supports a mechanism that will allow software to globally enable/disable many of the ECM's outputs (LSO2-14, PWM1-2, SPARKA-D, INJ1-8, and TACH). The FETs of a disabled output will be off so that current will not flow. Both cores have access to the enable mechanism. The mechanism is connected together by a logic-AND function. Thus the outputs will be enabled only if both cores request it.

This feature is abstracted to MotoHawk by the DRV_ENABLE resource of the Discrete Output block. Each core has an instance of this resource. A core requests the outputs to be enabled by commanding the DRV_ENABLE Discrete Output with logic-1. Logic-0 will disable the outputs. If a DRV_ENABLE instance of the Discrete Output block is not included in the model, then the software will implicitly issue a logic-1 command to DRV_ENABLE during startup to enable the outputs. Note that because the hardware has AND logic, both cores must command their DRV_ENABLE instance with logic-1 before the outputs will be enabled.

# Chapter 4
# 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.*

# Revision History

**Changes in Revision A—**

- Added Lockout/Tagout warning
- Revised Ingress Protection (Chapter 1)
- Revised Figures 3-16, 3-17, and 3-18 (Chapter 3)
- Added Output Driver Enable section (Chapter 3)

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**We appreciate your comments about the content of our publications.**

**Send comments to: icinfo@woodward.com**

**Please reference publication 35041.**

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