Released

Product Manual 26348
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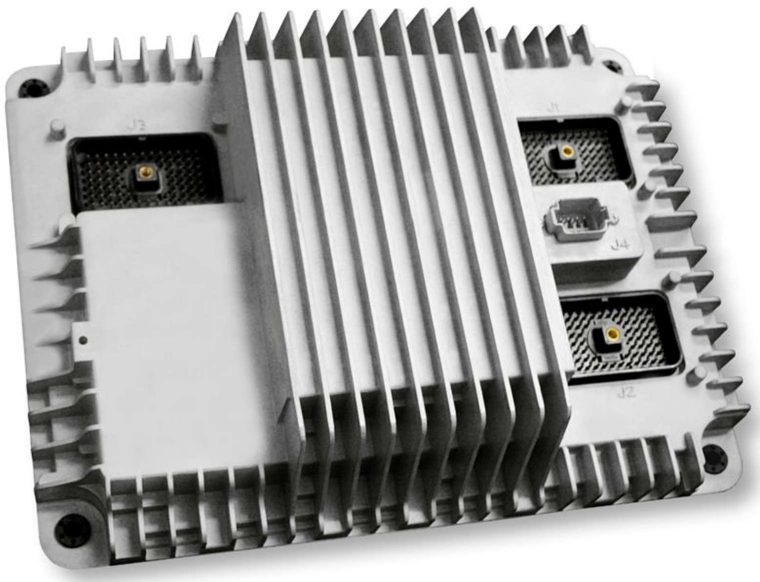
Original Instructions



ECM3
Electronic Fuel Injection Control

Installation and Operation Manual

Released

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:** **http://www.woodward.com** **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 Out-of-date translations are marked with ⚠.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.

Contents

Illustrations and Tables

Warnings and Notices

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 **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.**

WARNING **IOLOCK**	**IOLOCK: driving I/O into a known state condition. When a control fails to have all the conditions for normal operation, watchdog logic drives it into an IOLOCK condition where all output circuits and signals will default to their de-energized state as described below. The system MUST be applied such that IOLOCK and power OFF states will result in a SAFE condition of the controlled device.** • **Microprocessor failures will send the module into an IOLOCK state.** • **Discrete outputs / relay drivers will be non-active and de-energized.** • **Analog and actuator outputs will be non-active and de-energized with zero voltage or zero current.** **The IOLOCK state is asserted under various conditions, including:** • **Watchdog detected failures** • **PowerUp and PowerDown conditions** • **System reset and hardware/software initialization** • **PC tool initiated** **NOTE—Additional watchdog details and any exceptions to these failure states are specified in the related section of the product manual.**

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. Touch your finger to a grounded surface to discharge any potential before touching the control or installing cabling connectors. Alternatively, ESD mitigation may be used as well: ESD smocks, ankle or wrist straps and discharging to a reference grounds surface like chassis or earth are examples of ESD mitigation.
   - ESD build up can be substantial in some environments: the unit has been designed for immunity deemed to be satisfactory for most environments. ESD levels are extremely variable and, in some situations, may exceed the level of robustness designed into the control. Follow all ESD precautions when handling the unit.
     - I/O pins within connectors have had ESD testing to a significant level of immunity to ESD, however do not touch these pins if it can be avoided.
       - Discharge yourself after picking up the cable harness before installing it as a precaution.
     - The unit is capable of not being damaged or improper operation when installed to a level of ESD immunity for most installation as described in the specifications. Mitigation is needed beyond these specifications.

Regulatory Compliance

European Compliance for CE Marking
These listings are limited only to those units bearing the CE Marking.

EMC Directive: 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)

North American Compliance
These listings are limited only to those units bearing the CSA agency identification.

CSA: CSA Certified for Class I, Division 2, Groups A, B, C & D, T4 with application-defined temperature limits. For use in Canada and the United States.
Certificate 1801919 (LR 79726)

Marine Compliance

Lloyds Register of Shipping: Lloyd's Register of Shipping: LR Type Approval Test Specification No. 1, 2002 for Environmental Categories ENV1, ENV2, ENV3, and ENV4

Det Norske Veritas: Standard for Certification No. 2.4, 2006: Temperature Class B, Humidity Class B, Vibration Class B, EMC Class A, and Enclosure Class B.

Nippon Kaiji Kyokai: Rules Ch. 1, Part 7, of Guidance for the approval and type approval of materials and equipment for marine use and relevant Society's Rules.

General Compliance:
This product is certified as a component for use in other equipment. The final combination is subject to acceptance by CSA International or local inspection.

The ECM3 is suitable for use in Class I, Division 2, Groups A, B, C, D per CSA for Canada and US or non-hazardous locations only.

Wiring must be in accordance with North American Class I, Division 2 wiring methods as applicable, and in accordance with the authority having jurisdiction.

Field wiring must be suitable for at least 105 °C. Grounding is required to the input PE terminal.

Product listings are limited only to those units bearing the CSA or CE logos.

The 8-pin power connector should be used with a PVC boot (Deutsch part number DT8S-BT) when exposed to direct sunlight.

⚠WARNING	EXPLOSION HAZARD—Do not remove covers or connect/disconnect electrical connectors unless power has been switched off or the area is known to be non-hazardous. Substitution of components may impair suitability for Class I, Division 2. Do not use any test points on the power supply or control boards unless the work area these will be used in is known to be a non-hazardous location.

⚠AVERTISSEMENT	RISQUE D'EXPLOSION—Ne pas enlever les couvercles, ni raccorder / débrancher les prises électriques, sans vous en assurez auparavant que le système a bien été mis hors tension; ou que vous vous situez bien dans une zone non explosive. Le remplacement de composants peut rendre ce matériel inacceptable pour des applications de Classe I, Division 2. Ne pas utiliser aucun points-test de l'alimentation ou des cartes de controle à moins que l'atmosphere soit non dangereuse.

⚠WARNING	HIGH VOLTAGE—Before doing any maintenance, always disconnect power and any hazardous voltages that may be connected and follow all appropriate lockout/lockdown procedures.

⚠WARNING	ELECTRIC SHOCK—To reduce the risk of electric shock, Protective Earth (PE) must be connected to the termination point on the top of the unit next to the label with the ⏚ symbol. The conductor providing the connection must have a properly sized ring lug and wire gauge larger than or equal to 4 mm² (12 AWG). The ring lug should be placed between the nut and star washer. The calibration and checkout procedure should only be performed by authorized personnel. To be authorized personnel, personnel must be knowledgeable of the risks posed by live electrical equipment.

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

Chapter 1.
General Information

Introduction

⚠WARNING **A gas engine should be equipped with equipment to detect and protect against engine detonation (knocking) to prevent damage to the prime mover with possible personal injury, loss of life, or property damage.**

This manual describes the installation procedures for the Woodward ECM3 Electronic Fuel Injection Control. The ECM3 provides control of electronic fuel injection systems for gas, diesel, and dual fuel reciprocating engines.

The ECM3 (depending on GAP program) can perform a number of functions in addition to fuel injection, but its primary purpose is fuel injection.

Via the use of expanded I/O on the CAN networks, many additional engine monitoring and protection functions can be provided. Multiple ECM3 units can be used, networked via CAN, for engines with more than 24 injection outputs to control.

The ECM3 is designed to be installed directly on the engine. On engine mounting minimizes wiring cost by minimizing wiring length and the number of junctions.

Input/Output Arrangement

Table 1-1 shows standard I/O (input/output) for the ECM3 control.

Table 1-1. Input/Output Arrangement

Type of Input	Quantity	Options/Details
DC Power Input		
Low Voltage DC Input	1	18–32 Vdc, protected from reverse polarity
Analog Inputs		
Function Configurable Inputs	3	Current (4–20 mA) or Voltage (0–5 Vdc)
Sensor Inputs	13	51.1 kΩ Pull Down resistor
Thermistor Inputs	12	1 kΩ Pull Up resistor
MPU / Proximity Speed Sensor	2	10–10000 Hz (general purpose use) 10–6000 Hz (when used as fuel injection “speed” input)
Proximity Speed Sensor	1	5–2000 Hz (when used as fuel injection “TDC” or “Phase” input)
Fuel Injection Outputs		
EFI outputs	24	Up to 11 A pull-in current
Discrete Inputs		
Configurable Switch or PWM Inputs	2	Differential input
Switch or Contact Inputs	14	Switch to return pins to activate
Key Switch Input	1	Switch to B+ to enable operation

Table 1-1. Input/Output Arrangement (cont'd.)

Type of Input	Quantity	Options/Details
Discrete Outputs		
Configurable Relay Driver or PWM Outputs	2	Low side drivers, 3 A
Configurable Relay Driver or PWM Outputs	2	Low side drivers, 500 mA
Relay Driver Outputs	8	Low side drivers, 500 mA
Communication Ports		
Serial Ports	2	(1)—RS-232, (1)—RS-485
CAN Ports	3	(1)—Isolated, (2)—On-Engine use

Control Specifications

The ECM3 I/O accuracies and environmental specifications are listed inside the back cover of this installation manual.

Control CPU

The ECM3 control uses a GAP programmable processing core that provides all the necessary functions in a single CPU. The below listed specifications give some insight to the processor capability relative to other Woodward controls.

Table 1-2. ECM3 Processor Capabilities

Processor Type	Motorola MPC565
Clock Frequency	56 MHz
Math Support	Floating point CPU
Real Time Clock	Built into CPU
RTC Accuracy	1 Minute / month
Flash Memory	1 Mbyte
RAM	512 Kbytes
EEPROM	32 Kbytes

The Real Time Clock (RTC) is a part of the CPU. It is not a software clock, but it does not have battery backup. The RTC clock will function as long as power is applied to the ECM3 power input.

A temperature monitor is also provided inside the control housing on the circuit board. It provides the internal control temperature to the application with 2 °C accuracy. The GAP application engineer is encouraged to use this temperature to warn operators of conditions above the control rating. Such conditions can occur when long injection durations are used for extended periods of time, ambient temperature is higher than normal, and/or injection currents are higher than normal due to mechanical reasons in the injector. A temperature limit of 100 °C or lower should be used as the warning temperature.

Applications and Functions

The ECM3 control is a microprocessor-based, electronic fuel injection control. It is designed for use with the following fuel systems: Gas Admission Valve, Electronic Unit Injector (EUI), Electronic Unit Pump (EUP), and Common Rail (CR).

The primary purpose of the ECM3 is to control the timing and duration of up to 24 fuel injection devices on a "group 3" reciprocating engine. Group 3 engines include all reciprocating gas and diesel engines producing more than 500 kW per engine but less than 100 kW per cylinder. Typical engine speeds are greater than 1200 rpm. The speed and angular position of the engine are determined using Magnetic

Pickup (MPU) sensors or active Proximity sensors located on the crankshaft flywheel and/or camshaft gear wheel.

Using the Controller Area Network (CAN) communication ports, it is possible to increase functionality by measuring additional sensors and controlling additional actuators, valves, ignition equipment, and system components. Using the CAN communication links to expand functionality and control creates a networked engine with less wiring, thereby increasing reliability.

The ECM3 uses a patented automatic calibration procedure for all fuel injectors that it controls. The automatic calibration procedure runs continuously while the control is operational to compensate for electrical resistance changes over temperature and valve movement differences caused by pressure and wear out effects. This feature eliminates the need for detailed injector configuration that would require using manufacturer proprietary information about the injector electrical and mechanical characteristics. It also ensures repeatable performance throughout the life of the injectors.

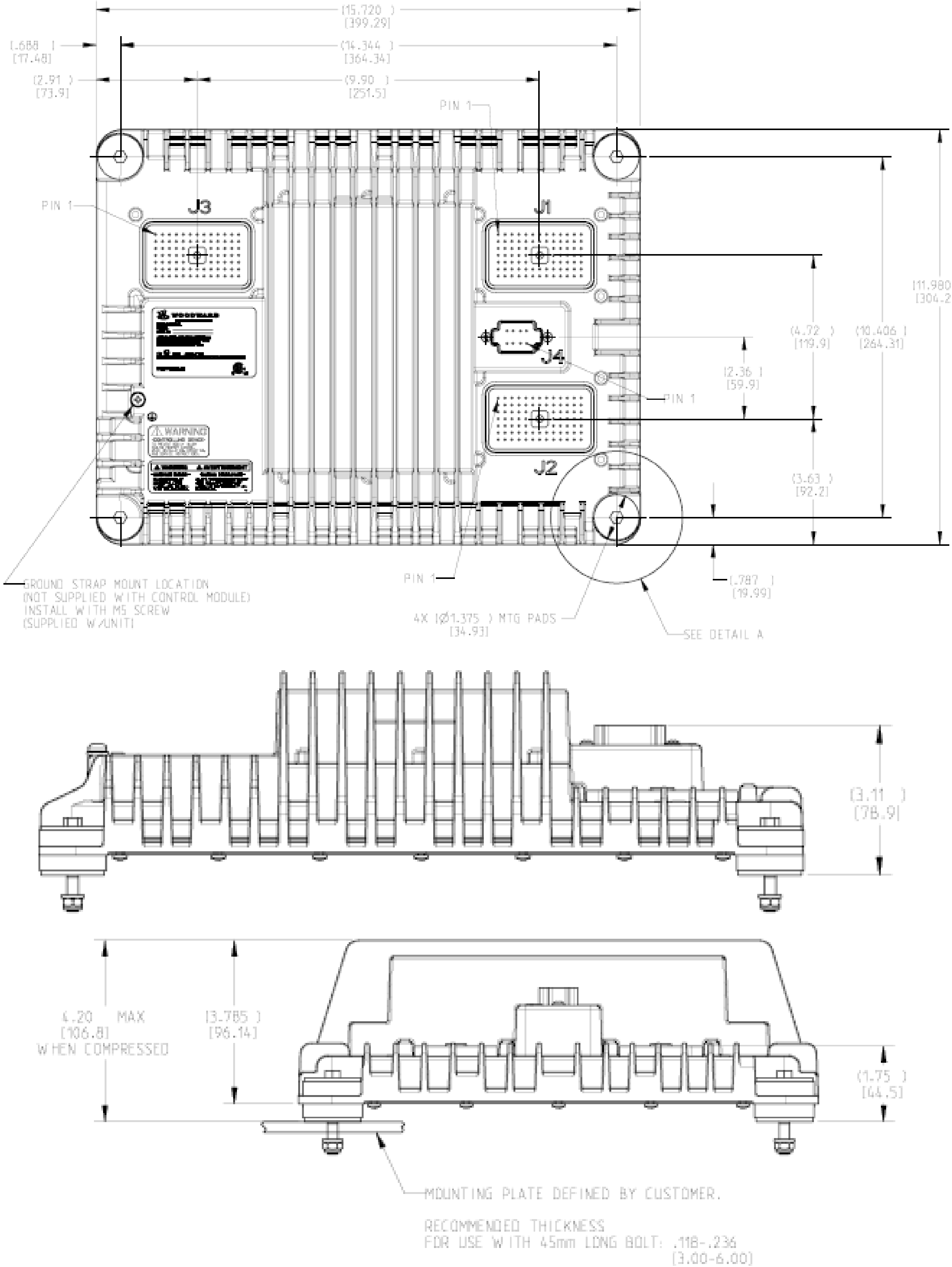


Figure 1-1. ECM3 Outline Drawing
(Dimensions are shown in inches)

Chapter 2.
Installation

Introduction

This chapter provides the general information for selecting a mounting location, installation, and wiring of the ECM3 control. Information, on hardware dimensions for mounting, electrical ratings, and application requirements, is given in this section.

Unpacking the Shipping Carton

Before unpacking the control, refer to the inside front cover and pages 4 through 6 of this manual for WARNINGS and CAUTIONS, including the Electrostatic Discharge Awareness procedures, before handling the ECM3 Control.

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

The ECM3 was shipped from the factory in an anti-static, foam-lined, carton. This carton should always be used for transport of the ECM3 when it is not installed.

Check for and remove all manuals, connectors, mounting screws, and other items before discarding (storing) the shipping box.

General Installation Notes and Warnings

⚠WARNING	**Due to typical noise levels in engine environments, hearing protection should be worn when working on or around the ECM3.**

⚠WARNING	**The surface of this product can become hot enough or cold enough to be a hazard. Use protective gear for product handling in these circumstances. Temperature ratings are included in the specification section of this manual.**

⚠WARNING	**External fire protection is not provided in the scope of this product. It is the responsibility of the user to satisfy any applicable requirements for their system.**

⚠WARNING	**Due to the hazardous location listings associated with this product, proper wire type and wiring practices are critical to operation.**

When selecting a location for mounting the ECM3 control, consider the following:

- Protect the unit from direct exposure to exhaust manifolds. Mount low on the engine.
- The operating range of the ECM3 control is –40 to +85 °C or less depending on injector current output.
- Do not install near high-voltage or high-current devices.
- Allow adequate space around the unit for servicing.

- Ground the chassis for proper safety and EMI shielding.
- When installing on the engine, provide vibration isolation.
- Mount the unit to a solid metal mounting plate grounded to the engine structure so the rear facing side does not have access.

The ECM3 is an integrated control package. All control hardware is contained in one compact enclosure. All field wiring connects to the ECM3 through sealed connectors located on the top face of the control. Installation placement of the ECM3 must allow sufficient room for wiring access and harness strain relief.

The ECM3 weighs approximately 5.8 kg (12.8 lb).

On-Engine Mounting

Vibration isolators should be used when mounting the ECM3. For example, when mounting to a plate directly on a side or end of the engine, the vibration isolators are used between the ECM3 and the mounting plate.

To install the ECM3 using the vibration isolators, first install the isolators onto the ECM3. Then install the ECM3 with isolators onto the mounting plate. Attach a ground strap as described in the GROUNDING sections following.

Vibration isolator components include:

- (12) M6 snubbing washers
- (4) M6 locking nuts
- (4) sleeves
- (4) M6 x 45 mm bolts
- (4) isolation mount pairs

When installing the vibration isolators, use 8.5 N·m (75 lb-in) torque to install the nut onto the bolt.

Vibration isolators should be inspected at 3 years after installation. If any visual damage, drying (cracking), or wear is observed, replace with a new kit of 4 isolators. If new isolators are not needed, recheck every year thereafter.

The ECM3 should be mounted vertically with the connectors facing away from the engine to prevent moisture entry. Horizontal orientations are not recommended due to internal heat flow that causes temperature increases within the control and to avoid water puddles on the connectors.

A minimum clearance of 15 cm (6 inches) in all directions except to the mounting plate should be left free around the control to allow a free airflow and heat dissipation.

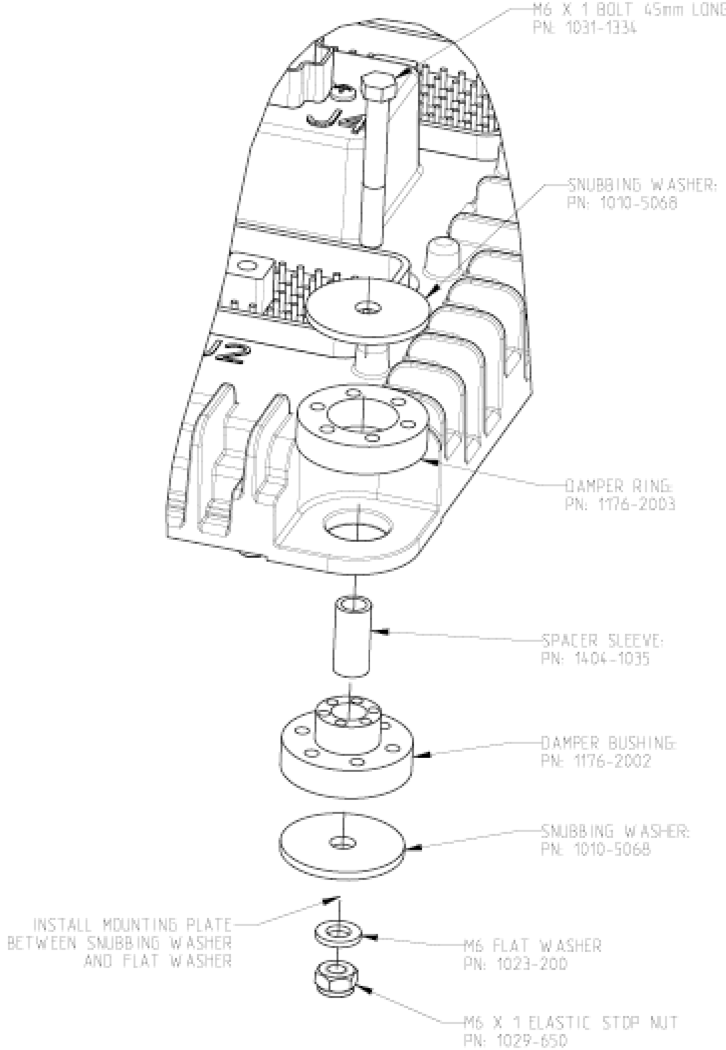


Figure 2-1. Vibration Isolator Installation

Wiring harnesses should have strain relief no further than 30 cm (12 inches) from the control. The ECM3 must be located so that no wire or cable (except those noted later) in the ECM3 harness exceeds 10 meters in total length.

The ECM3 is shipped from Woodward with a clear chromate finish to protect it from corrosion. Further painting of the control is anticipated. If the control is to be painted (such as during engine painting), take care to minimize paint thickness and to mask all labels so they are readable after painting. Thick layers of paint will inhibit the thermal transfer and can cause overheating of the control.

NOTICE	**To prevent damage to the ECM3, do not use any electrostatic painting process.**

The ECM3 was designed for on-engine 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. Pressure washing of the engine will not harm the ECM3 but take care to avoid long-term exposure to high pressure water at the connector interface.

Figure 1-1 shows a physical outline drawing with dimensions of the ECM3 for reference during the construction of mounting panels, etc. The enclosure size is 305 mm high x 400 mm wide x 96 mm deep (12 inches H x 15.7 inches W x inches 3.8 D).

Figure 2-2 below shows the mounting hold pattern and dimensions for use when designing a mounting plate.

Temperature Specifications

The temperature rating of the ECM3 is generally listed as –40 to +85 °C. However, the actual temperature rating depends on many factors which influence the amount of heat dissipated inside the enclosure. These factors include engine rpm (injection frequency), injection duration, use of pre or post injection, the number of injection outputs used, and the level of current used for each injection event.

Consider the below cases to determine the proper ambient temperature application for the ECM3. If your application does not fit one of the cases below, contact Woodward for assistance.

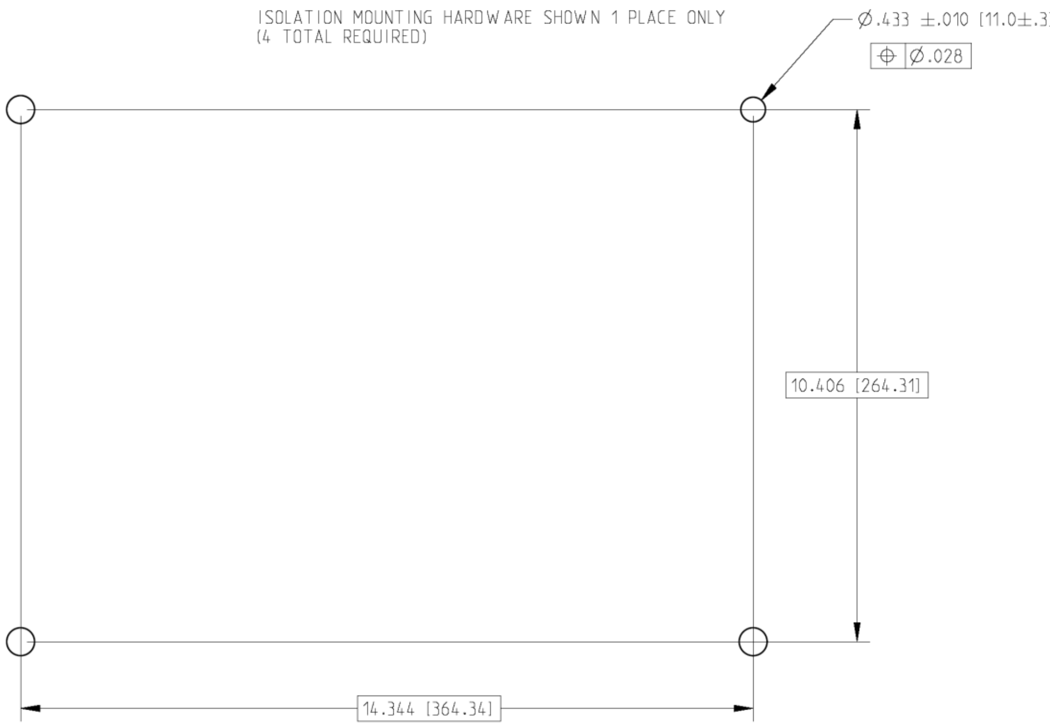


Figure 2-2. Mounting Hole Layout

Case 1—Rated for use in ambient temperatures up to 85 °C

A 12-cylinder engine using 24 injection outputs where pairs are operated simultaneously but no pre or post injection is used. The engine is a 4-cycle diesel with rated speed of 1800 rpm and maximum injection duration of 50° crank angle at rated speed. The injectors use a pull-in current of 11 A and hold-in current of 4 A with CPD achieved in 1.2 ms.

Case 2—Rated for use in ambient temperatures up to 85 °C

A 12-cylinder engine using 12 injection outputs and up to one pre-injection event. The engine is a 4-cycle diesel with rated speed of 1800 rpm and maximum injection duration of 50° crank angle at rated speed plus another 10 degrees for the optional pre-injection event. The injectors use a pull-in current of 11 A and hold-in current of 4 A with CPD achieved in 1.2 ms.

Electrical Connections

The ECM3 is not shipped with mating connectors because 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 ECM3 connector kits containing all the mating terminal blocks used on the ECM3. See Appendix A for mating connector usage instructions.

The sealed connectors on the ECM3 are not designed for removal by hand. After input power is disconnected, the connectors can be removed using a 4 mm Allen head driver. Individual wires can be removed using an extraction tool (included in connector kit). See Appendix A for instructions. When replacing the connectors, use 6.0 ±0.1 N·m of force on the jackscrew. Too little force will allow the connector to leak, and too much force may damage the connector.

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

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 ECM3 to the engine components.
- Injector cables should be routed away from all other types of cables.
- Communications, analog, and speed signals should be routed separately from the injector wiring.
- Discrete wiring (such as relay outputs or Boolean inputs) may be routed separately or with the analog wiring.

Table 2-1 shows the wiring types for each signal type.

Table 2-1. Wiring Types

Signal Type	Wiring Type	Comment
Differential Analog Input	Shielded, twisted pair	Use 1.0 mm^2 (18 AWG) or 1.5 mm^2 (16 AWG)
Sensor Analog Input	No requirement	Use 1.0 mm^2 (18 AWG) or 1.5 mm^2 (16 AWG)
PWM Input	Shielded, twisted pair	Use 1.0 mm^2 (18 AWG) or 1.5 mm^2 (16 AWG)
PWM Output	Twisted pair	Use 1.0 mm^2 (18 AWG) or 1.5 mm^2 (16 AWG)
Discrete Input	No requirement	Use appropriate return pin – **do NOT return to B-**
Discrete Output	No requirement	Use appropriate return pin – **do NOT return to B-**
MPU or Proximity Input	Shielded, twisted pair	Use 1.0 mm^2 (18 AWG) or 1.5 mm^2 (16 AWG)
Injector Output	Shielded, twisted pair	Use 1.0 mm^2 (18 AWG) or 1.5 mm^2 (16 AWG)
RS-232 or RS-485	Shielded, twisted pair	Must use serial cable
CAN	Shielded, twisted pair	Must use CAN cable (See CAN section for details)
Battery Input	Twisted pairs	Use 2.0 mm^2 (14 AWG)

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 ECM3 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.

Grounding for Protection against Electrical Shock

Protective Earth (PE) must be connected to the termination point on the side of the unit next to the label with the symbol to reduce the risk of electric shock. The conductor providing the connection must have a properly sized ring lug and wire larger than or equal to 4 mm^2 (12 AWG). It is acceptable to use the EMI ground strap for this purpose. See Grounding for Protection Against Electrical Noise following this paragraph for details.

Recommended Grounding Practices

Providing a proper ground for the ECM3 is important. Improper connection of the ECM3 chassis to the ground plane may affect accuracy of I/O and immunity to noise. Differences in potential between the chassis and the ground reference result in an equalizing current flow. The current flow produces unacceptably high common mode noise voltages.

Common mode voltages may result in improper readings for analog and speed inputs or even damage to the ECM3 in extreme cases. To minimize this problem, it is necessary to provide a low resistance (impedance) path between ground and the chassis of the ECM3. Typically a single ground point is designated for the engine and all related equipment.

Grounding for Protection against Electrical Noise

A proper ground strap must be connected to the chassis termination point to provide a low impedance path for EMI. The strap providing the connection must have a properly sized ring lug and be constructed of ½ inch wide, flat, hollow braid no more than 12 inches long or any strap that is equivalent at DC-to-RF frequencies. (Example braid: International Wire, Continental Cordage Corp. P/N 233/2, Woodward P/N 2008-957) This strap may be used in place of the PE grounding conductor if desired. In such cases, this strap becomes both the EMI ground strap AND the protective earth connection.

Shields and Grounding

Signals that require shielding include speed inputs, some analog inputs, PWM inputs, communications links, and injector wiring. Relay outputs, contact inputs, high current PWM outputs, 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.

Shield terminations are provided through the ECM3 connectors for each of the signals requiring shielding.

⚠WARNING	**It is important that only the shield pin designated for a specific type of signal be used. Do not substitute shield pin connections between different groups. Not all shields are connected the same way within the ECM3 control.**

Signal lines are shielded to prevent picking up stray signals from adjacent equipment. Injector wiring is shielded to suppress emissions that can affect other wiring and equipment. Wire exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches). In most cases, one end of the shields must be left open and insulated from any other conductor. Typically, the shield at the end opposite of the control is un-terminated, but not always. The sections of this manual describing wiring for each I/O point will indicate the best shielding methods for the given signal type.

The ECM3 is designed for shield termination to only the designated shield connections on the ECM3. If intervening terminal blocks are used in routing a signal, the shield should be continued through the terminal block without a local ground connection.

If a shield grounding point is desired at the terminal block, it should be ac coupled to earth via a capacitor. A 1000 pF capacitor, rated at ≥500 V, is usually sufficient, however cables >30 m should use a capacitor rated at ≥1500 V. The intent of ac coupling is to provide a low impedance path to earth for the shield at frequencies of 150 kHz and up. Multiple, direct or capacitive, connections of a shield to earth increases the risk of high levels of current to flow within the shield below 150 kHz so take care in choosing ground schemes.

It may be beneficial for all additional shield terminations, except at the ECM3, to be ac coupled to earth through a capacitor or not connect to earth at all.

Where shielded cable and shield termination is required, cut the cable to the desired length and prepare the cable as instructed below.

1. Strip outer insulation, exposing the braided or spiral wrapped shield. Do not cut the shield or nick the wire inside the shield.
2. Using a sharply pointed tool carefully spread the strands of the braided shield.
3. Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.
4. Remove 6 mm (1/4 inch) of insulation from the inner conductors.
5. Connect wiring and shield as shown in plant wiring diagram.
6. If a shield connection is not required or desired, fold back and secure or remove the excess shield as needed.

For noise suppression reasons, it is recommended that:

- All low-current wires should be separated from all high-current wires.
- The input power ground terminal should also be wired to earth ground at a single point near the power source.

Installations with severe electromagnetic interference (EMI) may require additional shielding precautions, such as wire run in conduit or double shielding. See the Harsh EMC Environmental Guidance section for more information.

Shields, with the exception of injector cable shields, can be directly grounded at both ends (ECM3 and load) if the cable length is sufficiently short to prevent ground loop current in the shield. Cables remaining within the same cabinet as the control is an example of this.

Shields, with the exception of injector cable shields, can also be ac grounded at one end and hard grounded at the opposite end to improve shielding effectiveness.

Shield grounding can be a determinative process, specific applications and RF environments require different shield grounding schemes be followed. See Woodward application note 50532, *Interference Control in Electronic Governing Systems*, for more complete information.

Isolation

Figure 2-3 shows how the I/O is isolated with regard the input power supply and other I/O types. Each wiring diagram also shows how an input or output type is isolated in more detail.

This isolation diagram is shown so that the power and return wiring can be properly grouped and so that ground loops can be avoided. Isolation is not a substitution for proper grounding techniques. Each input and output section contains information regarding proper shielding and grounding for the specific I/O type. These guidelines must be followed in order to maintain compliance with the marked or certified standards as well as to provide high operating reliability. Do not defeat isolation by connecting returns of different isolation groups together.

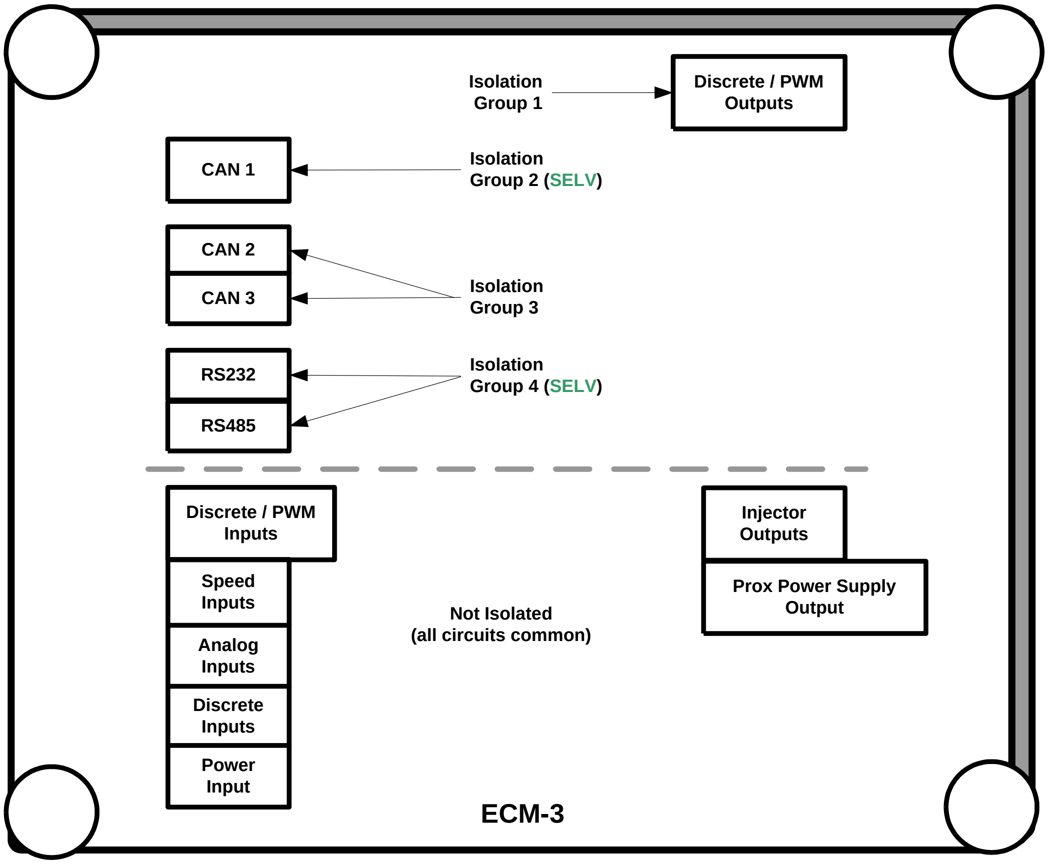


Figure 2-3. I/O Isolation

Harsh EMC Environmental Guidance

If the unit is to be installed in a harsh EMC environment or with noise generators (such as motor drives, ignition systems, and AVRs), additional precautions may be needed. Items like conduit, double shielding, and segregated cabling are discussed within this manual, and may be needed in harsh environments.

A harsh EMC environment example may be when an ignition control system is placed in the vicinity of the engine control system. Segregation of cabling, grounding, and power are especially critical in ignition systems. The ignition control system should be located at least 15 cm (6 inches) away from the ECM3 control, and cabling of the two systems should either be segregated by 15 cm (6 inches) or double shielding may work to segregate the cabling. Routing cabling against grounded metal frames and cable ways will help, but in systems such as these, noise can be significantly higher than the ECM3 validation tests.

Another harsh EMC environment example is high-current or high-voltage relays, both due to contact switching noise and to a lesser extent de-energizing the coils. Segregation similar to above is usually able to address this EMC noise except noise that is coupled to relay coil driver power. If the power supply for Discrete Inputs (DI) and Discrete Outputs (DO) is derived from the same source and is used to drive relays with high voltage or high current on the contacts, contact noise will typically couple to the relay driver source and contact's wiring. The noise level present will depend on the implementation but may be high enough to send false signals to the discrete inputs or other devices on the same power source as the relay driver. To avoid false signals, keep the power sources separate both in proximity and by electrical isolation.

ECM3 Wiring Diagrams

Terminal Locations

All connections are located on the top face of the ECM3. Signals are separated logically so that left and right banks of a Vee engine can be supplied by dedicated connectors thus simplifying the harness design. Power and I/O suitable for off-engine connection is provided on separate connectors.

See Figure 1-1 for reference of connector location.

Wiring Pinout

Table 2-2. J1 Pinout

Fuel Injection Drivers			
Injector 2 (+)	J1-14	Injector 14 (+)	J1-20
Injector 2 (–)	J1-15	Injector 14 (–)	J1-21
Injector 2 Shield	J1-32	Injector 14 Shield	J1-37
Injector 4 (+)	J1-16	Injector 16 (+)	J1-23
Injector 4 (–)	J1-17	Injector 16 (–)	J1-22
Injector 4 Shield	J1-34	Injector 16 Shield	J1-39
Injector 6 (+)	J1-10	Injector 18 (+)	J1-27
Injector 6 (–)	J1-9	Injector 18 (–)	J1-26
Injector 6 Shield	J1-8	Injector 18 Shield	J1-35
Injector 8 (+)	J1-30	Injector 20 (+)	J1-4
Injector 8 (–)	J1-31	Injector 20 (–)	J1-5
Injector 8 Shield	J1-38	Injector 20 Shield	J1-6
Injector 10 (+)	J1-25	Injector 22 (+)	J1-12
Injector 10 (–)	J1-24	Injector 22 (–)	J1-11
Injector 10 Shield	J1-33	Injector 22 Shield	J1-13
Injector 12 (+)	J1-2	Injector 24 (+)	J1-28
Injector 12 (–)	J1-3	Injector 24 (–)	J1-29
Injector 12 Shield	J1-1	Injector 24 Shield	J1-36
Speed Inputs			
MPU/Proximity 1 (+)	J1-62	MPU/Proximity 2 (+)	J1-49
MPU/Proximity 1 (–)	J1-61	MPU/Proximity 2 (–)	J1-41
MPU/Proximity 1 Shield	J1-60	MPU/Proximity 2 Shield	J1-59
Proximity 3 (+)	J1-40		
Proximity 3 (–)	J1-48		
Proximity 3 Shield	J1-58		
Analog Inputs			
Analog Input 4	J1-70	Analog Input 13	J1-44
Analog Input 5	J1-69	Analog Input 23	J1-68
Analog Input 6	J1-53	Analog Input 24	J1-67
Analog Input 10	J1-55	Analog Input 25	J1-66
Analog Input 11	J1-54	Analog Input 26	J1-65
Analog Input 12	J1-45	Analog Input 27	J1-64
Analog Input 28	J1-63		
Power Outputs			
Proximity Power (+)	J1-43, 50	Transducer Power (+)	J1-56, 57
Proximity Power (–)	J1-42, 51, 52	Transducer Power (–)	J1-46, 47

Table 2-3. J2 Pinout

Fuel Injection Drivers			
Injector 1 (+)	J2-41	Injector 13 (+)	J2-55
Injector 1 (–)	J2-40	Injector 13 (–)	J2-54
Injector 1 Shield	J2-33	Injector 13 Shield	J2-37
Injector 3 (+)	J2-59	Injector 15 (+)	J2-46
Injector 3 (–)	J2-60	Injector 15 (–)	J2-47
Injector 3 Shield	J2-58	Injector 15 Shield	J2-38
Injector 5 (+)	J2-69	Injector 17 (+)	J2-48
Injector 5 (–)	J2-68	Injector 17 (–)	J2-49
Injector 5 Shield	J2-70	Injector 17 Shield	J2-32
Injector 7 (+)	J2-57	Injector 19 (+)	J2-61
Injector 7 (–)	J2-56	Injector 19 (–)	J2-62
Injector 7 Shield	J2-39	Injector 19 Shield	J2-63
Injector 9 (+)	J2-43	Injector 21 (+)	J2-67
Injector 9 (–)	J2-42	Injector 21 (–)	J2-66
Injector 9 Shield	J2-35	Injector 21 Shield	J2-65
Injector 11 (+)	J2-50	Injector 23 (+)	J2-45
Injector 11 (–)	J2-51	Injector 23 (–)	J2-44
Injector 11 Shield	J2-34	Injector 23 Shield	J2-36
Analog Inputs			
Analog Input 1	J2-1	Analog Input 17	J2-16
Analog Input 2	J2-2	Analog Input 18	J2-26
Analog Input 3	J2-3	Analog Input 19	J2-4
Analog Input 7	J2-5	Analog Input 20	J2-17
Analog Input 8	J2-6	Analog Input 21	J2-27
Analog Input 9	J2-7	Analog Input 22	J2-18
Power Outputs			
Transducer Power (+)	J2-14, 15		
Transducer Power (–)	J2-24, 25		
Digital Outputs			
Digital Output 7	J2-31	Digital / PWM Output 11	J2-13
Digital Output 8	J2-30	Digital / PWM Output 12	J2-23
Digital Output 9	J2-29	Digital / PWM Output Return	J2-22
Digital Output Return	J2-28		
CAN Communications			
CAN 2 High	J2-10	CAN 3 High	J2-9
CAN 2 Low	J2-20	CAN 3 Low	J2-8
CAN 2 Common	J2-21	CAN 3 Common	J2-19
CAN 2 Shield	J2-12	CAN 3 Shield	J2-11

Table 2-4. J3 Pinout

Analog Inputs			
Analog Input 14 (+)	J3-34	Analog Input 15 (+)	J3-17
Analog Input 14 (–)	J3-33	Analog Input 15 (–)	J3-35
Analog Input 14 Shield	J3-24	Analog Input 15 Shield	J3-18
Current use Jumper (in)	J3-26	Current use Jumper (in)	J3-4
Current use Jumper (out)	J3-25	Current use Jumper (out)	J3-27
Analog Input 16 (+)	J3-15		
Analog Input 16 (–)	J3-2		
Analog Input 16 Shield	J3-1		
Current use Jumper (in)	J3-16		
Current use Jumper (out)	J3-3		
Digital Inputs			
Digital Input 1 (sourcing)	J3-60	Digital Input 8	J3-49
Digital Input 2	J3-61	Digital Input 9	J3-48
Digital Input 3	J3-62	Digital Input 10	J3-40
Digital Input 4	J3-63	Digital Input 11	J3-41
Digital Input 5	J3-52	Digital Input 12	J3-42
Digital Input 6	J3-51	Digital Input 13	J3-43
Digital Input 7	J3-50	Digital Input 14	J3-32
Digital Input Returns	J3-58, 59		
Digital / PWM Input 15 (+)	J3-8	Digital / PWM Input 16 (+)	J3-6
Digital / PWM Input 15 (–)	J3-9	Digital / PWM Input 16 (–)	J3-7
PWM Input 15 Shield	J3-19	PWM Input 16 Shield	J3-5
Key Switch Input			
Key Input (+)	J3-64		
Digital Outputs			
Digital Output 1	J3-70	Digital / PWM Output 5	J3-55
Digital Output 2	J3-69	Digital / PWM Output 5 Return	J3-45
Digital Output 3	J3-68	Digital / PWM Output 6	J3-56
Digital Output 4	J3-67	Digital / PWM Output 6 Return	J3-46
Digital Output 10	J3-57		
Digital Output Returns	J3-44, 47		
CAN Communications			
CAN 1 High	J3-10		
CAN 1 Low	J3-12		
CAN 1 Common	J3-11		
CAN 1 Shield	J3-13		
RS-485 Communications			
RS-485 (+)	J3-22		
RS-485 (–)	J3-21		
RS-485 Common	J3-20		
RS-485 Shield	J3-23		
Termination Jumper (+) in	J3-29		
Termination Jumper (+) out	J3-28		
Termination Jumper (–) in	J3-30		
Termination Jumper (–) out	J3-31		
RS-232 Communications			
RS-232 TX	J3-38		
RS-232 RX	J3-37		
RS-232 Common	J3-36		
RS-232 Shield	J3-39		

Table 2-5. J4 Pinout

Power Input	
Battery (+)	J4-1, 2, 3, 4
Battery (–)	J4-5, 6, 7, 8

NOTICE

The driver outputs are labeled as injection commands and are sequentially numbered from 1-24. Take great care to make sure that the correct firing order for the engine is obtained by wiring each injection command to the correct cylinder solenoid valve. The injection command 1 should be connected to the reference (No. 1) cylinder.

Input Power

The input to the power supply must be from large batteries such as used for engine cranking. An alternator or other battery-charging device is necessary to maintain a stable supply voltage.

NOTICE

Input power must be applied to the ECM3 control up to 5 seconds prior to expected use. The control must have time to run its power-up diagnostics to become operational. Failure of the diagnostics will disable control function.

⚠WARNING

The ECM3 must have all power removed before installing or removing any connectors or wiring.

This equipment is suitable for use in Class 1, Division 2, Groups A, B, C, and D, or non-hazardous locations only.

Wiring must be in accordance with Class I, Division 2 wiring methods and in accordance with the authority having jurisdiction.

Do not connect more than one power source to any one fuse or circuit breaker.

Injector power should only come from a battery stack with a charging system or a power supply implemented as explained below. The bus impedance from the source to the ECM3 is critical; it must be a low-impedance bus. The battery stack or power supply must be located within 30 m (100 feet) of wire length and the positive and negative wires twisted with approximately 1 twist per 5 cm (2 inches) or at least the wire jackets mostly touching along their length. If a distributed power bus is used, the bus inductance may be higher than desired, even with wires routing adjacent or touching.

It is recommended that a widely distributed power bus NOT be used for injectors. If distributed power must be used, bulk capacitors must be located close to the input connector on the ECM3, and the return connection to ground must be made at the frame ground local to the control area.

Bulk capacitance for a distributed power bus must be determined on an installation by installation basis. A minimum recommendation is 4800 µF rated at 200 V (dc).

Typically, polarized capacitors are used in this capacitance range. If polarized capacitors are used, negative transients or reverse biasing may damage the capacitors. Polarized capacitors used in conjunction with a distributed power bus must be protected from negative transients. A Schottky Diode of at least 150 V breakdown may be placed across the capacitance, blocking the positive rail (cathode to positive). In the forward conducting mode, for a negative transient, the diode should be able to handle 275 A or use multiple diodes. An example diode is STPS2150, which requires 3 diodes in parallel to handle a typical IEC 61000-4-5 negative surge. A bleed resistor across the capacitor is also recommended for safety.

Input Power Ratings

These ratings are based on using an engine with the following parameters:

- 24 outputs
- 4-cycle engine
- 1800 rpm
- 50 degree injection duration
- 11 A pull-in / 4 A hold-in current profile with CPD in 1.2 ms
- A full 10 meter 16 AWG wire length to injectors

Table 2-6. Power Input Specifications

Voltage Range	18–32 Vdc
Maximum Voltage	36 Vdc
Maximum Input Power	1300 W (during injector pull-in)
Average Input Power	260 W @ 24 Vdc
Reverse Polarity Protection	–32 Vdc
Hold Up Voltage	0 Vdc for 1 ms , 6 Vdc for 99 ms
Cranking Voltage	9 Vdc for 15 sec
Input Wiring Constraints	The ECM3 must be wired such that no other device receives power from the wiring between the ECM3 and the power supply source.
Input Wire Size	14 AWG (2.0 mm²)
Input Fuse Rating	30 A continuous at 85 °C 40 A for 30 seconds Time delay type with melting I^2t 5 A^2 sec), > 48 V capable

Significant inrush currents are possible when current is applied to the ECM3 control. The magnitude of the inrush current depends on the power source impedance, so Woodward cannot specify the maximum inrush current. Time-delay fuses or circuit breakers must be used to avoid nuisance trips.

Power Supply Grounding

The following guidelines must be observed for the ECM3 power source connections.

- The 24 V power supply negative lead should be bonded to protective Earth (PE) at only one point.
- This bond strap should be relatively short compared to the total length of the power leads, ≤1 m (39.4 in).
- The power supply should be bonded to the same PE structure as the control.
- The negative leads should not be bonded to PE at the control.
- The negative leads on the power supply should be bonded to PE relatively close to the supply or at the point the supply voltages arrive at the PE structure used for the control.

Note: Since the control has shielded wiring that requires grounding, care must be taken to provide proper installation. Specific requirements for this control are listed in the individual sections, i.e., proximity sensor, CAN, etc. Grounding and shield termination is application specific; see Woodward grounding document application note number 51204, Grounding and Shielding Termination. Application Note 51204 gives a general overview to help apply sound techniques to specific installations.

Input Power Wiring

It is required that the installation of this equipment includes over current protection between the power source and the ECM3. This over current protection may be accomplished by series connection of properly rated fuses or circuit breakers. Branch circuit protection of no more than 250% of the maximum ECM3 power supply input current rating must be provided. Maximum fuse rating must meet the 250% UL listing requirements. The use of properly sized UL class CC, J, T, G, RK1, or RK5 fuses is required to meet the requirements for branch circuit protection. Do not connect more than one ECM3 to any one fuse. Use the largest wire size possible for the chosen connectors that also meets local code requirements. Time delay fuses should be used to prevent nuisance trips. Maximum protection against damage to the control includes fusing on both the B+ wiring and the B– wiring.

IMPORTANT **The largest wire size that can be connected to the control power input connector is 2.0 mm² (14 AWG).**

Due to the relatively small wires size available for the main power input and the large currents drawn by the fuel injection, a large voltage drop is possible. Short wire lengths are recommended. To minimize the voltage drop, it is required to use the largest wire size possible which is 2.0 mm^2 (14 AWG) and four wire pairs to split the current.

The ECM3 input power wiring must be routed separately from all other wiring. Due to the large injection currents, these wires carry large amounts of noise that can interfere with sensitive equipment. If the wires must be routed together with other wires, shielding is recommended. The source "+" and return "-" wires between the power supply and the ECM3 should be bundled together and routed away from injector output wires. Twisting each of the four source and return wire pairs is an added measure to reduce unbalanced currents but is not required.

IMPORTANT **The control's power supplies are not equipped with input power switches. For this reason, some means of disconnecting input power to each main power supply must be provided for installation and servicing.**

Power Supply Monitoring Circuit

The input voltage level is monitored for the purpose of application diagnostics. In GAP, this value is found in the ECM3_STS block as "MON_24".

Table 2-7. Input Power Monitor Specifications

Maximum Voltage Measured	34 Vdc
Resolution in Volts	55 mVdc (10-bits)
Accuracy	±1% of full scale typical steady-state
Temperature Drift	±1% of full scale typical (±0.34 V) ±2.4% of full scale worst case (±1.33 V)
Filter Constant	1 pole at 0.6 ms

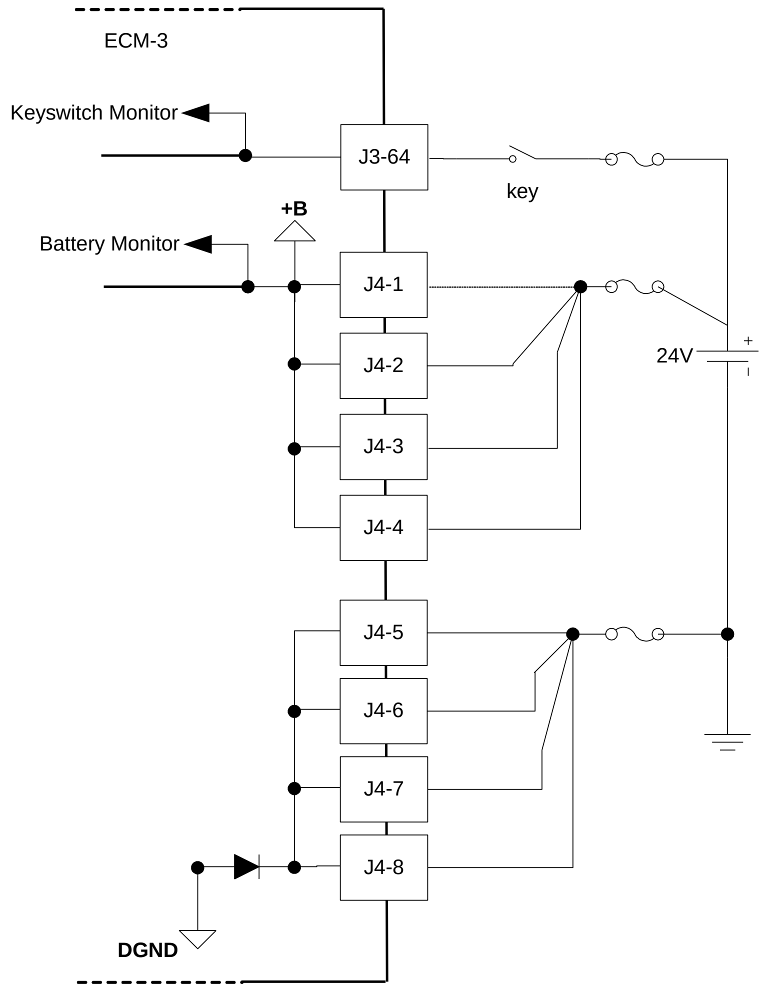


Figure 2-4. Input Power Wiring Diagram

MPU and Proximity Sensor Inputs

The ECM3 accepts passive magnetic pickup (MPU) sensors or active proximity probe (Hall effect) sensors. When proximity sensors are used, power for the sensor is provided by the ECM3.

The speed inputs can be used for detecting speed, angular position, or both with a missing tooth flywheel or camshaft gear. Detection of a single tooth, or a bolt head for angular position (TDC or Phase) must be done with a proximity sensor. Detection of a hole cast or drilled into a gear wheel for TDC or Phase is not recommended.

Proximity sensors can be prone to EMC susceptibility issues, for best results with Hall effect proximity sensors, use only Woodward proximity sensors. The Woodward proximity sensor is a “NPN-PNP” sensor meaning that it forces the return voltage to the supply (+) or supply (–) depending on the presence of a tooth. The supply voltage never gets pulled to the supply (+) or (–) using only pull-up/down resistors. The sensor also has built-in protection from mis-wiring and has been tested for EMC compliance. See Appendix C for sensor details.

Sensor P/N	Size
1689-1056	M16-1.5
1689-1058	5/8-18

For speed sensor application and selection, refer to Woodward publication 82510. The publication discusses sensor selection, application, and installation.

There are three inputs on the ECM3 dedicated to speed sensor signals. Two of the inputs can be used with either an MPU (passive VR sensor) or a proximity (active Hall effect) sensor. The third input accepts only a proximity sensor.

Table 2-8. Speed Input Specification

Input Frequency	10 Hz – 10 kHz (when used for general speed detection) 10 Hz – 6 kHz (when used for fuel injection) 5 Hz – 2 kHz (for third Proximity only input)
Input Amplitude	1.4–70 V peak-to-peak for MPU 5–28 Vdc for Proximity Probe “HIGH” 0–1 Vdc for Proximity Probe “LOW”
Input Impedance	10 kΩ
Isolation Voltage	None
Input Common Mode Range	±37 Vdc
Resolution	Dependent on frequency, 13 bit minimum at maximum speed
Accuracy	±0.08% full scale from –40 to +125 °C internal temperature
MPU Duty Cycle	1–99% up to 1 kHz 5–95% up to 5 kHz 10–90% up to 10 kHz
Prox Duty Cycle	10–90% up to 10 kHz 10 µs minimum period

In GAP, speed input #1 is found in the ECM3 Chassis block as “SS_1”. Speed input #2 is found in the ECM3 Chassis block as “SS_2”. The third input which is intended for TDC or Phase is found in the ECM3 Chassis block as “SS_3”. Any of the GAP blocks “AI_MPU_ENG”, “TDC”, or “PHASE” may be used with these inputs.

Sensing Gear Selection

A multi-tooth crankshaft flywheel with more than 60 teeth is the optimum location for a speed pickup. This sensor will be used for speed control and fuel injection timing. It is allowed for this sensor to have a single missing tooth to represent TDC (or TDC and Phase on a 2-cycle engine). Either a MPU or a Hall effect proximity sensor may be used in this application.

A multi-tooth camshaft gear with more than 120 teeth can be used as a backup or alternate location for a speed pickup. It is not as optimal for speed sensing as a crankshaft sensor due to gear train backlash but may produce acceptable results depending on the engine. It is allowed for this sensor to have a single missing tooth to represent Phase (or TDC and Phase together if correctly located). Either an MPU or a proximity sensor may be used in this application.

A single tooth or bolt on a crankshaft may be used to represent TDC (and Phase if a 2-cycle engine). In this case a proximity sensor must be used. A MPU sensor is not allowed.

A single tooth or bolt on a camshaft may be used to represent Phase. In this case a proximity sensor must be used. A MPU sensor is not allowed.

Operation of the speed inputs is described in Chapter 5. The description relates how the inputs are used in the EFI control algorithm and how redundancy can be accomplished.

The Duty Cycle specification in the Speed Input Specification Table (Table 2-8) indicates the ratio of tooth width to the gap width between teeth on the sensing gear wheel. See graphic below for a visual explanation.

$$Duty\_Cycle = \frac{Y}{X+Y} \bullet 100\%$$

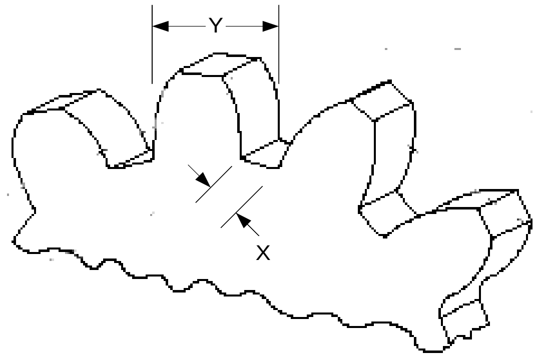


Figure 2-5 Duty Cycle

Speed Sensor Wiring

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 ECM3 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.

Best practice for speed sensors is not to share them with other controls. Each control should have its own speed sensors. If sharing of sensors is absolutely necessary, it is best to share proximity sensors rather than MPU sensors because the signal is not as heavily affected by the load applied within the ECM3.

For best signal protection, shielding for speed sensors must be carried through from the sensor to the ECM3 without interruption.

Most ignition systems ground the speed sensors. This technique eliminates common mode protection built into the ECM3 rendering the input much more susceptible to noise. For this reason it is best not to share speed sensors with any equipment that grounds the signal return.

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. In general, the most effective shield for a proximity or MPU sensor is carried through to the sensor body via the connector and also connected to the ECM3 shield pin. Unfortunately terminating both ends of the shield can create ground loops at lower frequencies. 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.

Shield grounding can be a determinative process, specific applications and RF environments require different shield grounding schemes be followed. See Woodward application note 50532, *Interference Control in Electronic Governing Systems*, for more complete information.

The following diagram shows how to connect a passive, magnetic pickup. Connection to speed input #1 is shown. Speed inputs #2 and #3 are similar. Each input has a dedicated shield connection. Connections are made to J1. Explanation for inverted wiring is given in the following section regarding missing tooth gears.

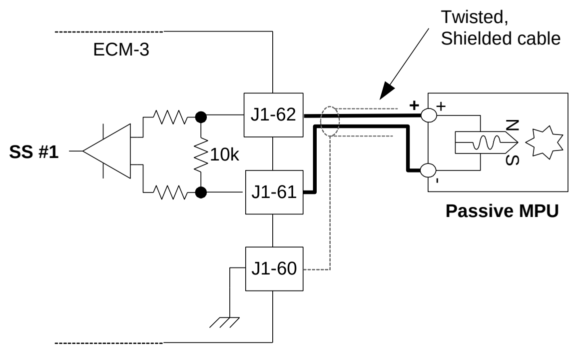


Figure 2-6. MPU Wiring Diagram

Table 2-9. Speed Sensor Connections

Connection	SS_1	SS_2	SS_3
Input (+)	J1–62	J1–49	J1–40
Input (–)	J1–61	J1–41	J1–48
Prox Power (+)	J1–43	J1–43	J1–50
Prox Power Common	J1–52	J1–51	J1–42
Shield	J1–60	J1–59	J1–58

The polarity of the MPU signals is important due to the way that the MPU input circuitry inside the ECM3 control functions. The rising and falling edges are used to “arm and trigger” the signal going to the CPU. The rising edge arms the event and the falling edge triggers the event. See below graphic.

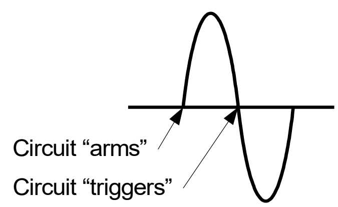


Figure 2-7. MPU Signal Arm and Trigger

If the sensor is wired with the (+) terminal connected to the (+) input of the ECM3, the center of the tooth will be the trigger. If the sensor is wired with inverse polarity, timing will be shifted from this point. Woodward recommends using inverse polarity by wiring the (–) terminal of the sensor to the (+) input of the ECM3. This is done to create a larger gap for detecting a missing tooth, but it does shift the timing from the normal location. Actual timing location will depend on the tooth shape and the sensor shape. Use timing instruments to calibrate the correct timing. Below is both an example of the correct (desired) relationship as well as an example of what happens when the speed sensor is wired incorrectly.

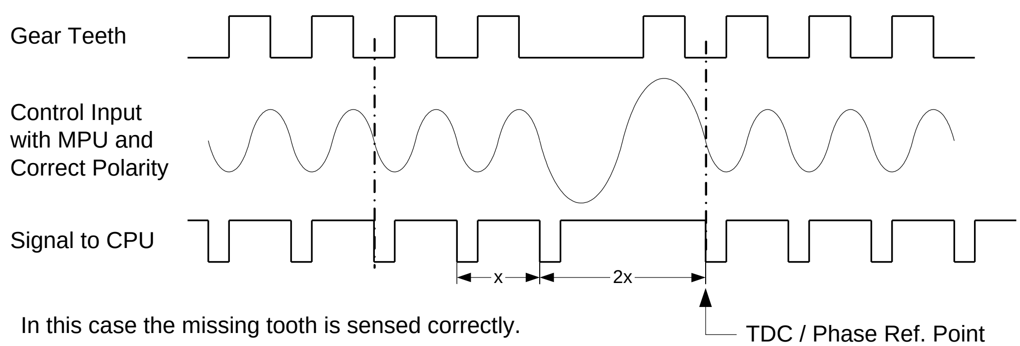


Figure 2-8. MPU Wired Correctly

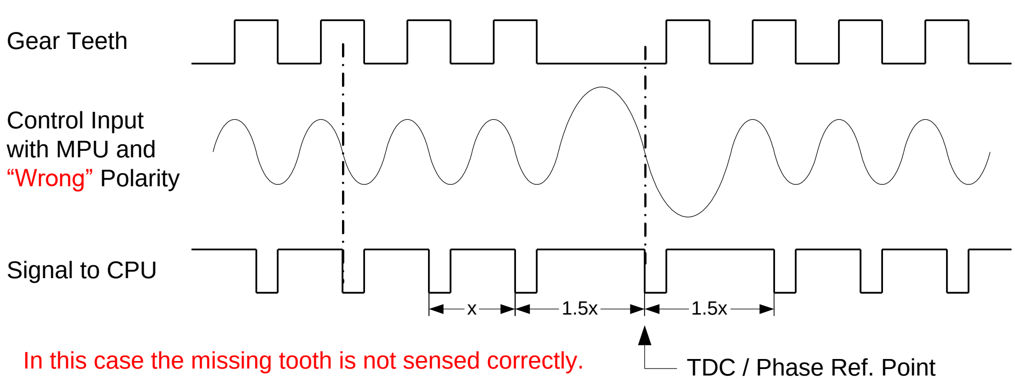


Figure 2-9. MPU Wired Incorrectly

The following diagram shows how to connect an active proximity sensor. Connection to speed input #1 is shown. Speed inputs #2 and #3 are similar. Each input has a dedicated shield connection. Connections are made to J1. See Table 2-11 for pinout of both speed sensor inputs. The Woodward active proximity sensor is shown. The ECM3 supplied proximity power should always be used for signal isolation. Multiple proximity sensor power output connections are also provided to ease wiring connections.

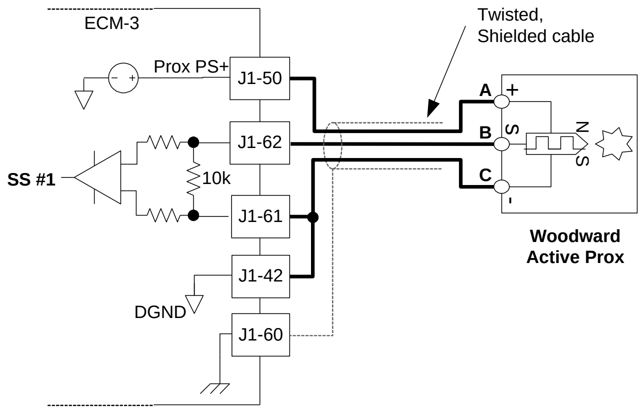


Figure 2-10. Proximity Sensor Wiring Diagram

Proximity Probe Power Supply

A power supply is provided for the proximity probes. This supply must be used to power the probes.

Table 2-10. Proximity Power Specifications

Output Type	Voltage Source
Output Voltage	11 Vdc ±10%
Output Current	30 mA
Protection	Output is protected from short circuit

Proximity Probe Power Supply Monitoring Circuit

The proximity probe power supply voltage level is monitored for the purpose of application diagnostics. In GAP this value is found in the ECM3_STS block as “MON_PRX”.

Table 2-11. Proximity Probe Power Monitor Specifications

Maximum Voltage Measured	34 Vdc
Measured Voltage Filter	1 pole at 0.6 ms
Resolution	10 bits (55 mVdc)
Accuracy	±1% of full scale typical steady-state
Temperature Drift	±1% of full scale (0.34 V) typical ±2.4% of full scale (1.33 V) worst case

General Purpose Analog Inputs

There are three inputs on the ECM3 dedicated to analog transducer signals. The Analog Inputs accept a 4–20 mA signal or a 1–5 Vdc signal. The Analog Inputs may be used with a two-wire ungrounded (loop powered) transducer or an isolated (self-powered) transducer. Use of current or voltage source transducers must be determined in advance and wired to the appropriate input pins. Wiring requirements are different between the two types of inputs.

Current Input

If interfacing to a non-isolated device that may have the potential of reaching over 20 Vdc with respect to the control’s common, the use of a loop isolator is recommended to break any return current paths, which could produce erroneous readings. Loop power must be provided from an external source. See transducer wiring below for typical wiring.

Loop power should always be fused with a 100 mA (or smaller) fuse. This fuse prevents damage to the sensor or to the ECM3 due to wiring errors or shorts.

Table 2-12. Current Input Specification

Input Type	4–20 mA
Max. Input Current	22 mA ±5%
Common Mode Rejection	56 dB typical 48 dB worst case
Input Common Mode Range	±20 Vdc
Input Impedance	200 Ω (±1%)
Anti-aliasing Filter	2 poles at 0.94 ms and 0.47 ms
Resolution	10 bits
Accuracy @ 25 °C	±0.5% of full scale typical ±1.3% of full scale worst case
Temperature Drift	±0.4% of full scale (0.08 mA) typical ±1.1% of full scale (0.22 mA) worst case

In GAP, the three general-purpose analog inputs are provided as analog inputs #14, #15, and #16. Each is found in the ECM3 Chassis block. The GAP block “AN_IN” or the GAP block “AI_SYNC” should be used with these inputs. When used as current inputs, the “IN_TYPE” configuration field should be set to “1” for 4–20 mA.

Application logic should be included to flag errors and take action when input current or any channel is below 4 mA or above 20 mA. The input will detect currents outside this valid range so that such diagnostics are possible.

Current Input Wiring

Wiring for analog inputs must be shielded cable with wire size of 16 or 18 AWG. Smaller wire diameters may not provide a strong crimp at the ECM3 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.

Shielding should be unbroken between the sensor and the ECM3. Shielding should not be grounded anywhere in the system along the cable length. The shield should be connected to the correct Analog Input shield pin on the ECM3. The shield may be connected to the sensor with an optional capacitor or left unconnected. It is best not to connect both ends of the shield without the use of a capacitor unless the sensor is completely floating with respect to ground.

To use the input as a current input, an external jumper must be put in place. The Current Jumper (+) and Current Jumper (–) terminals must be shorted together with a short external wire. The mA signal is applied across the Input (+) and Input (–) terminals.

Note that the control’s power supplies are not equipped with input power switches. For this reason, some means of disconnecting input power to the power supply must be provided for installation and servicing.

IMPORTANT	**External loop powered transducers must be individually protected with a 100 mA (or smaller) fuse on each channel.**

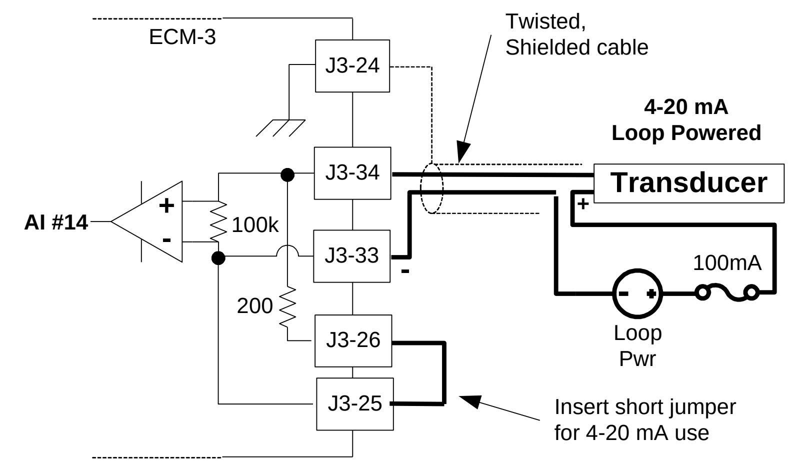


Figure 2-11. Current Input Wiring Diagram: Loop Powered

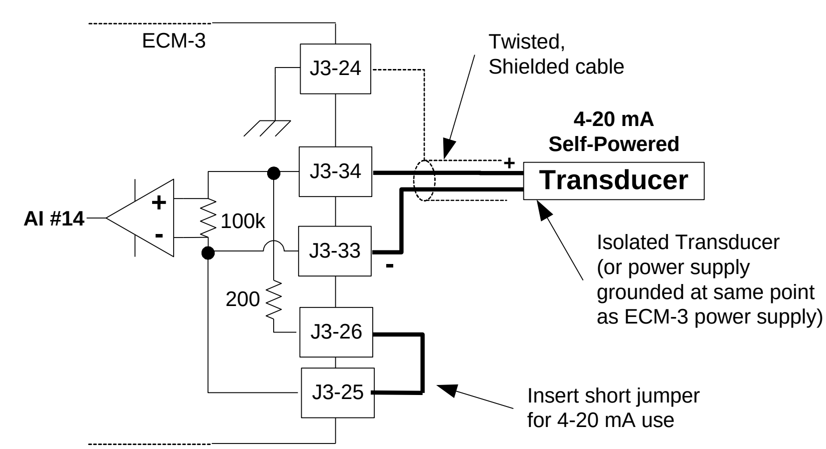


Figure 2-12. Current Input Wiring Diagram: Self-Powered

Table 2-13. Current Input Connections

Connection	AI_14	AI_15	AI_16
Input (+)	J3–34	J3–17	J3–15
Input (–)	J3–33	J3–35	J3–2
Current Jumper (+)	J3–26	J3–4	J3–16
Current Jumper (–)	J3–25	J3–27	J3–3
Shield	J3–24	J3–18	J3–1

Voltage Input

If interfacing to a non-isolated device that may have the potential of reaching over 20 Vdc with respect to the control’s common, the use of a signal isolator is recommended to break any return current paths that could produce erroneous readings. Transducer power must be provided from an external source. See transducer wiring below for typical wiring.

Table 2-14. Voltage Input Specification

Input Type	0–5 Vdc
Max. Input Voltage	5 Vdc
Common Mode Rejection	56 dB typical 48 dB worst case
Input common Mode Range	±20 Vdc
Input Impedance	17.5 kΩ (±1%)
Anti-aliasing Filter	2 poles at 0.94 ms and 0.47 ms
Resolution	10 bits
Accuracy @ 25 °C	±0.5% of full scale typical ±1.3% of full scale worst case
Temperature Drift	±0.4% of full scale typical ±1.1% of full scale worst case

In GAP, the three general-purpose analog inputs are provided as analog inputs #14, #15, and #16. Each is found in the ECM3 Chassis block. The GAP block “AN_IN” or the GAP block “AI_SYNC” should be used with these inputs. When used as voltage inputs, the “IN_TYPE” configuration field should be set to “2” for 0–5 Vdc or “3” for 1–5 Vdc.

Voltage Input Wiring

Wiring for analog inputs must be shielded cable with wire size of 16 or 18 AWG. Smaller wire diameters may not provide a strong crimp at the ECM3 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.

Shielding should be unbroken between the sensor and the ECM3. Shielding should not be grounded anywhere in the system along the cable length. The shield should be connected to the correct Analog Input shield pin on the ECM3. The shield may be connected to the sensor with a capacitor or left unconnected. It is best not to connect both ends of the shield without the use of a capacitor unless the sensor is completely floating with respect to ground.

To use the input as a voltage input, the external jumper used with current inputs must NOT be put in place. The Current Jumper (+) and Current Jumper (–) terminals must not have any connections. The voltage signal is applied across the Input (+) and Input (–) terminals.

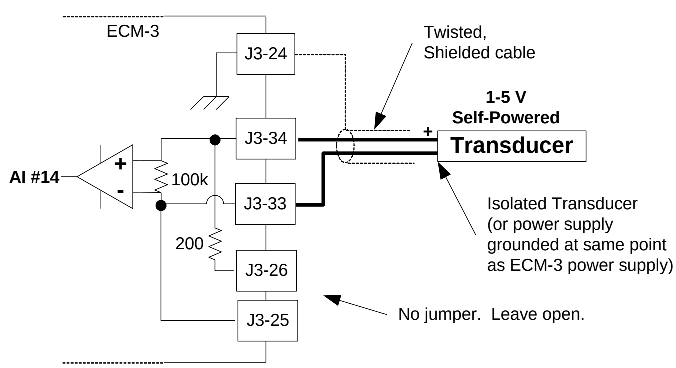


Figure 2-13. Voltage Input Wiring Diagram: Self-Powered

Table 2-15. Voltage Input Connections

Connection	AI_14	AI_15	AI_16
Input (+)	J3–34	J3–17	J3–15
Input (–)	J3–33	J3–35	J3–2
Current Jumper (+)	NC	NC	NC
Current Jumper (–)	NC	NC	NC
Shield	J3–24	J3–18	J3–1

Engine Sensor Analog Inputs

There are inputs on the ECM3 dedicated to on-engine analog transducer signals. The sensor inputs accept a 0–5 Vdc signal from devices such as pressure sensors. The input is single ended with a simple pull-down resistor to circuit ground (not battery ground). The sensor inputs should be used with three-wire ungrounded transducers powered by the ECM3. Use of ratiometric sensors or non-ratiometric sensors is supported. The power source from the ECM3 is a 5 Vdc source (typical for engine sensors).

Engine sensor analog inputs are pinned out on two separate connectors (J1 and J2). Half the inputs are provided via J1 and the other half are provided via J2. This is done to ease harness wiring and to support dedicating a connector for each bank of a Vee engine.

Table 2-16. Engine Sensor Analog Input Specification

Input Type	0–5 Vdc
Max. Input Voltage	32 Vdc (due to wiring failure)
Common Mode Rejection	0 dB (single ended)
Input Common Mode Range	0 Vdc
Input Impedance	Resistor to DGND (see Table 2-13)
Anti-aliasing Filter	1 pole at 1 ms
Resolution	10 bits
Accuracy @ 25 °C	Better than ±0.65% of full scale (±0.0325 Vdc) typical Better than ±2.0% of full scale (±0.10 Vdc) worst case
Temperature Drift	Better than ±0.75% of full scale (±0.0375 Vdc) typical Better than ±1.1% of full scale (±0.1125 Vdc) worst case

Currently, all inputs of this type on the ECM3 have the same input impedance as shown in the table below.

Table 2-17. Engine Sensor Analog Input Impedance

Connection	Input Impedance	Connector
AI_1	51.1 kΩ (±1%)	J2
AI_2	51.1 kΩ (±1%)	J2
AI_3	51.1 kΩ (±1%)	J2
AI_4	51.1 kΩ (±1%)	J1
AI_5	51.1 kΩ (±1%)	J1
AI_6	51.1 kΩ (±1%)	J1
AI_7	51.1 kΩ (±1%)	J2
AI_8	51.1 kΩ (±1%)	J2
AI_9	51.1 kΩ (±1%)	J2
AI_10	51.1 kΩ (±1%)	J1
AI_11	51.1 kΩ (±1%)	J1
AI_12	51.1 kΩ (±1%)	J1
AI_13	51.1 kΩ (±1%)	J1

In GAP, the engine sensor analog inputs are numbered 1—13. Analog input #1 is found in the ECM3 Chassis block as “AN_1”. Analog input #2 is provided as “AN_2” and so on. The GAP block “AN_IN” may be used with any of these inputs. The GAP block “AI_SYNC” may be used with analog inputs #1—#5 in order to achieve engine synchronous sampling.

Engine Sensor Analog Input Wiring

Shielding is not required for engine sensor analog input wiring but may be used if desired. If shielding is used, the shield should be continuous and ungrounded along its length. There is no connection at the ECM3 for the shield. The shield should be connected to the ECM3 mounting plate at the ground strap location.

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

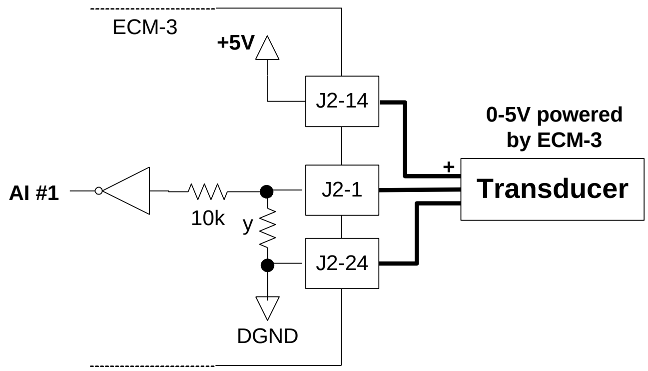


Figure 2-14. Engine Sensor Analog Input Wiring Diagram

For wiring ease, the transducer power supply is pinned out twice on each connector. The power output is the same physical source for a given connector but provided on two sets of pins.

The power source on J1 is a different power source than the one on J2. Two supplies are provided both for capacity reasons and to provide failure mode “limp home” capability in case one of the power sources gets shorted in the wiring harness. Careful thought should be given to which sensors are connected to each power source if “limp home” capability is desired in the case of a power supply wire short circuit.

All engine sensors must be wired to the same common connection. The common return for engine sensors is the same as used for engine temperature sensors (see next section). For wiring ease, the transducer power supply common (common return) is pinned out twice on each connector. All analog return connections share the same internal connection regardless of connector. Choice of pin is arbitrary and only one connection of the two is required.

Table 2-18. Engine Sensor Analog Input Connections

Connection	Signal Input	Power Outputs	Common Returns
AI_1	J2–1	J2–14, J2–15	J2–24, J2–25
AI_2	J2–2	J2–14, J2–15	J2–24, J2–25
AI_3	J2–3	J2–14, J2–15	J2–24, J2–25
AI_4	J1–70	J1–56, J1–57	J1–46, J1–47
AI_5	J1–69	J1–56, J1–57	J1–46, J1–47
AI_6	J1–53	J1–56, J1–57	J1–46, J1–47
AI_7	J2–5	J2–14, J2–15	J2–24, J2–25
AI_8	J2–6	J2–14, J2–15	J2–24, J2–25
AI_9	J2–7	J2–14, J2–15	J2–24, J2–25
AI_10	J1–55	J1–56, J1–57	J1–46, J1–47
AI_11	J1–54	J1–56, J1–57	J1–46, J1–47
AI_12	J1–45	J1–56, J1–57	J1–46, J1–47
AI_13	J1–44	J1–56, J1–57	J1–46, J1–47

Transducer Power Supply

Two transducer power supplies are provided. Transducer power A is provided on J1. Transducer power B is provided on J2. Each power supply is identical.

Table 2-19. Transducer Power Specifications

Output Type	Voltage source
Output Voltage	5 Vdc ± 5%
Output Current	200 mA each
Protection	Each output is protected from short circuit

Transducer Power Supply Monitoring Circuit

The two transducer power supply voltage levels are monitored for the purpose of application diagnostics or for ratiometric sensor biasing. In GAP these values are found in the ECM3_STS block as "XDCR_A_PS" and "XDCR_B_PS". Transducer power A is provided on J1. Transducer power B is provided on J2.

Table 2-20. Transducer Power Monitor Specifications

Maximum Voltage Measured	5 Vdc
Measured Voltage filter	1 pole at 0.6 ms
Resolution	10 bits (55 mVdc)
Accuracy	±1% of full scale typical steady-state
Temperature drift	±1% of full scale (0.34 V) typical ±2.4% of full scale (1.33 V) worst case

Temperature Sensor Analog Inputs

There are inputs on the ECM3 dedicated to on-engine analog temperature signals. The sensor inputs accept a 0-5 Vdc signal from resistive temperature sensors. The input is single ended with a simple pull-up resistor to 5 Vdc.

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

These inputs are not suitable for use with thermocouples. They may be used with thermistors or RTDs but careful selection of input impedance matched to sensor impedance range is required.

Temperature sensor analog inputs are pinned out on two separate connectors (J1 and J2). Half the inputs are provided via J1 and the other half are provided via J2. This is done to ease harness wiring and to support dedicating a connector for each bank of a Vee engine.

Table 2-21. Temperature Input Specification

Input Type	0–5 Vdc
Max. Input Voltage	32 Vdc (due to wiring failure)
Common Mode Rejection	0 dB (single ended)
Input common Mode Range	0 Vdc
Input Impedance	Resistor to +5 V (see Table 2-13)
Anti-aliasing Filter	1 pole at 1 ms
Resolution	10 bits
Accuracy @ 25 °C	Better than ±0.65% of full scale (±0.0325 Vdc) typical Better than ±2.0% of full scale (±0.10 Vdc) worst case
Temperature Drift	Better than ±0.75% of full scale (±0.0375 Vdc) typical Better than ±1.1% of full scale (±0.1125 Vdc) worst case

Currently, all inputs of this type on the ECM3 have the same input impedance as shown in the table below.

Table 2-22. Temperature Sensor Analog Input Impedance

Connection	Input Impedance	Connector
AI_17	1 kΩ (±1%)	J2
AI_18	1 kΩ (±1%)	J2
AI_19	1 kΩ (±1%)	J2
AI_20	1 kΩ (±1%)	J2
AI_21	1 kΩ (±1%)	J2
AI_22	1 kΩ (±1%)	J2
AI_23	1 kΩ (±1%)	J1
AI_24	1 kΩ (±1%)	J1
AI_25	1 kΩ (±1%)	J1
AI_26	1 kΩ (±1%)	J1
AI_27	1 kΩ (±1%)	J1
AI_28	1 kΩ (±1%)	J1

In GAP, the temperature sensor analog inputs are numbered 17—28 (27 for MHI). Analog input #17 is found in the ECM3 Chassis block as "AN_17". Analog input #18 is provided as "AN_18" and so on. The GAP block "AN_IN" may be used with any of these inputs.

Temperature Sensor Analog Input Wiring

Shielding is not required for engine sensor analog input wiring but may be used if desired. If shielding is used, the shield should be continuous and ungrounded along its length. There is no connection at the ECM3 for the shield. The shield should be connected to the ECM3 mounting plate at the ground strap location.

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

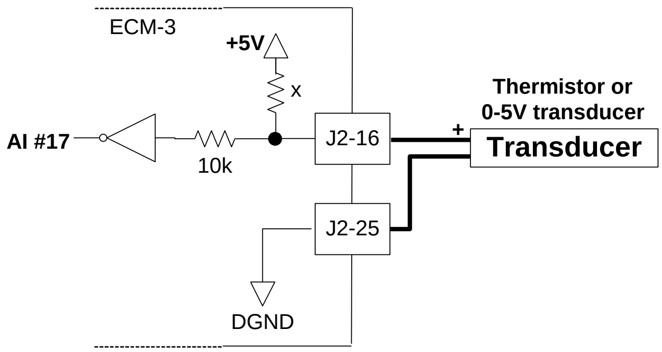


Figure 2-15. Temperature Sensor Analog Input Wiring Diagram

All temperature sensors must be wired to the same common connection. The common return for temperature sensors is the same as used for engine transducers. For wiring ease, the transducer power supply common (common return) is pinned out twice on each connector. All analog return connections share the same internal connection regardless of connector. Choice of pin is arbitrary and only one connection of the two is required.

Table 2-23. Temperature Sensor Analog Input Connections

Connection	Signal Input	Common Returns
AI_17	J2–16	J2–24, J2–25
AI_18	J2–26	J2–24, J2–25
AI_19	J2–4	J2–24, J2–25
AI_20	J2–17	J2–24, J2–25
AI_21	J2–27	J2–24, J2–25
AI_22	J2–18	J2–24, J2–25
AI_23	J1–68	J1–46, J1–47
AI_24	J1–67	J1–46, J1–47
AI_25	J1–66	J1–46, J1–47
AI_26	J1–65	J1–46, J1–47
AI_27	J1–64	J1–46, J1–47
AI_28	J1–63	J1–46, J1–47

Boolean and PWM Inputs

There are 2 discrete inputs that can be used as Boolean inputs or PWM inputs. Each is individually configured as a Boolean or PWM input. The inputs are differential to provide more EMI noise immunity than typical single ended inputs. A pull-up resistor is provided on each (+) input to maximize compatibility with external sending devices.

Table 2-24. Discrete and PWM Input Specification

Number of Channels	2
Input Type	Balanced differential input
Isolation	None
Input Common Mode Range	±50 Vdc
Input Thresholds	< 2 Vdc = "ON" > 7 Vdc = "OFF" (internal 10 k□ pull-up to +15 V)
Input Impedance	40 kΩ
Max Input Voltage	32 Vdc
PW Input Frequency	100–2000 Hz
PWM Duty Cycle	5–95% at 500 Hz 10–90% at 2000 Hz
PWM Resolution	Frequency dependent 11-bits at 2000 Hz 15-bits at 100 Hz
PWM Accuracy	±2% for both frequency and duty cycle determination
Temperature Drift	300 ppm/°C

In GAP, discrete input #15 is found in the ECM3 Chassis block as "DI_15". Discrete input #6 is "DI_16". The GAP block "BOOL_IN" should always be used with this input if it is to be used as a Boolean input. The GAP block "AI_PWM" should always be used with this input if it is to be used as a PWM input.

Signal Application

To understand the proper application of Boolean and PWM signals into the discrete inputs on the ECM3, it will help to understand how they are used. Since the input is a sinking input, the active condition is actually 0 volts as referenced to the return pin. This is the condition where the input is actively shorted to the return pin thus it is the active state. See the below diagrams for visualization.

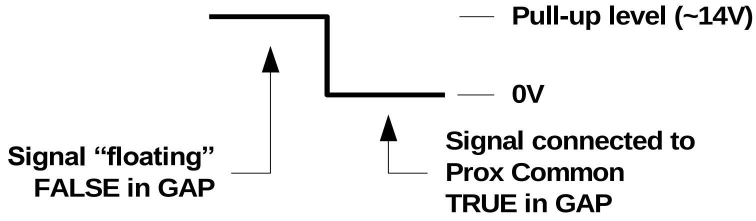


Figure 2-16. Boolean Usage

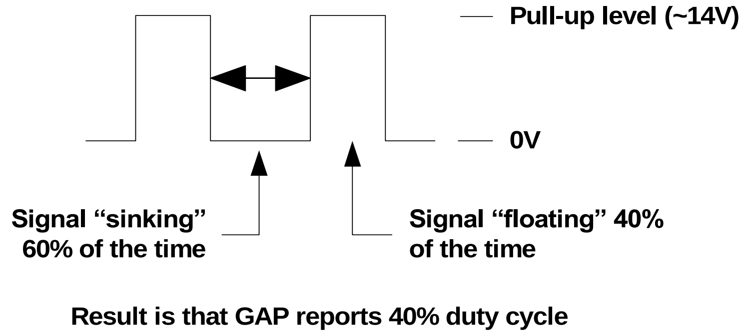


Figure 2-17. PWM Usage

The digital input return (DI_RTN) is provided on multiple pins for wiring convenience. Only one connection is required.

Table 2-25. Discrete and PWM Input Connections

Connection	DI_15	DI_16
Input (+)	J3–8	J3–6
Input (–)	J3–9	J3–7
DI Returns	J3–58, J3–59	J3–58, J3–59
Shield	J3–19	J3–5

PWM Wiring

The PWM inputs are intended for connection to devices such as speed references (foot pedal, etc.). However, they can be connected to other devices as well. Each input has identical circuitry. Wiring for discrete input #15 is shown below. Only the terminal numbers change for discrete input #16.

PWM signals may originate from a sensor or from another electronic control. The originating device must be powered or referenced to the same power source used on the input power pins of the ECM3.

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

PWM wiring should be done with twisted pair wiring with a shield. Shielding should be unbroken between the sensor / control device and the ECM3. Shielding should not be grounded along its length anywhere in the system. The shield should be connected to the appropriate dedicated PWM shield pin on the ECM3. The shield may be connected at the source device with a capacitor or left unconnected. It is best not to connect both ends without the use of a capacitor unless the source is completely floating with respect to ground.

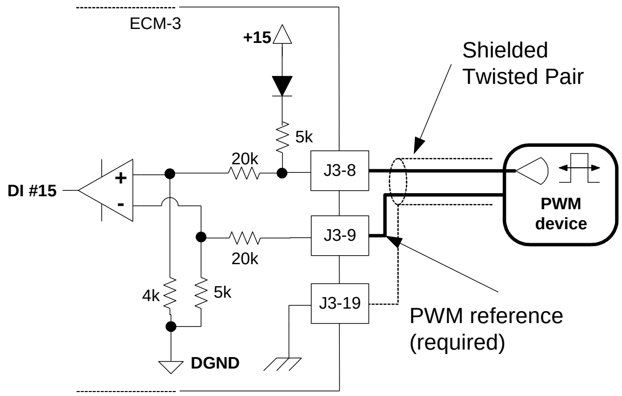


Figure 2-18. PWM Input Wiring Diagram

Boolean Input Wiring

Wiring to use an input in a Boolean operation is shown below. Each input has identical circuitry. Wiring for discrete input #15 is shown below. Only the terminal numbers change for discrete input #16.
When wiring one of these configurable inputs, the input (–) terminal must be permanently shorted to a DI_RTN pin in order to create the correct reference. This shorting can be done at the connector with a short jumper.

Boolean wiring is not intended to be shielded. Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

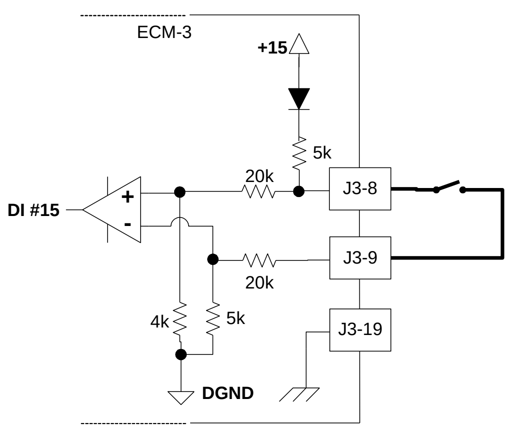


Figure 2-19. Boolean Input Wiring Diagram

Boolean Inputs

There are inputs on the ECM3 dedicated to Boolean signals. All inputs are un-isolated and are designed for use with nearby dry contacts. All but 1 input expects a connection to the return pin for an asserted state. The return pin is NOT the same as battery return. Making connections to battery return will not provide the desired results and will inhibit EMC compliance. DI_1 is a sourcing input that expects B+ to be applied for an asserted state.

Sourcing Input

Table 2-26. Sourcing Input Specification

Number of Channels	1
Input Type	Sourcing input
Isolation Voltage	None
Input Thresholds	> 7 Vdc = “ON” < 1 Vdc = “OFF”
Input Impedance	15 kΩ
Max Input Voltage	32 Vdc

In GAP, discrete input #1 is found in the ECM3 Chassis block as “DI_1”. The GAP block “BOOL_IN” should always be used with this input.

Sourcing Input Wiring

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

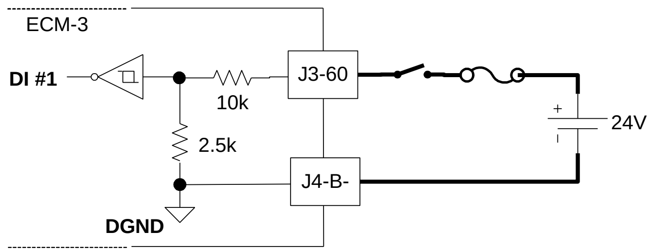


Figure 2-20. Sourcing Input Wiring Diagram

Sinking Inputs

Table 2-27. Sinking Input Specification

Number of Channels	13
Input Type	Sinking input
Isolation Voltage	None
Input Thresholds	> 7 Vdc = “OFF” (internal pull-up) < 1 Vdc = “ON”
Input Impedance	15 kΩ
Max Input Voltage	28 Vdc

In GAP, discrete input #2 is found in the ECM3 Chassis block as “DI_2”. Discrete input #3 is found as “DI_3” and so forth. The GAP block “BOOL_IN” should always be used with this input.

Sinking Input Wiring

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

Wiring to use an input in a Boolean operation is shown below. Each input has identical circuitry. Wiring for discrete input #2 is shown below. Only the terminal numbers change for the remaining discrete inputs.

The discrete input return should not be connected to any other devices. For best results, connect to the contact of a relay and do not share the contact with other devices. Redundant inputs and/or normally closed logic are recommended for critical functions. Two return pins are provided for wiring convenience. Both pins have the same internal connection and may be used interchangeably.

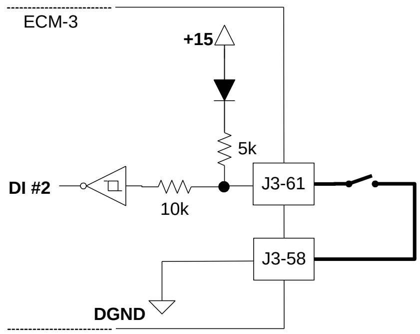


Figure 2-21. Sinking Input Wiring Diagram

The digital input return (DI_RTN) is provided on multiple pins for wiring convenience. Only one connection of the two is required.

Table 2-28. Discrete Input Connections

Connection	Signal Input	Common Returns
DI_2	J3–61	J3–58, J3–59
DI_3	J3–62	J3–58, J3–59
DI_4	J3–63	J3–58, J3–59
DI_5	J3–52	J3–58, J3–59
DI_6	J3–51	J3–58, J3–59
DI_7	J3–50	J3–58, J3–59
DI_8	J3–49	J3–58, J3–59
DI_9	J3–48	J3–58, J3–59
DI_10	J3–40	J3–58, J3–59
DI_11	J3–41	J3–58, J3–59
DI_12	J3–42	J3–58, J3–59
DI_13	J3–43	J3–58, J3–59
DI_14	J3–32	J3–58, J3–59

Boolean and PWM Outputs

There are 12 discrete outputs. Four of the outputs can be used as a Boolean output or as a low frequency PWM output. Two of the four PWM capable outputs have a higher current rating for direct control of proportional actuators. The PWM capability is useful as a controlling signal for some actuators in place of a 4–20 mA signal. Another common use is to drive an analog dashboard meter indicating pressure or temperature.

All outputs are individually optically isolated. However, all share a common power supply and return circuit.

Each output uses a protected MOSFET that will protect the ECM3 if a short circuit is detected. The output will be retried periodically until the short circuit is removed, allowing the output to operate normally again. Feedback is provided to the software application indicating the short circuit condition.

Table 2-29. Boolean and PWM Outputs Specification

Number of Channels	12
Output Type	Low-side driver with short circuit and over voltage protection
Current Drive Rating	500 mA on outputs #1 to #10 3 A on outputs #11 and #12
PWM Output Frequency	50–1000 Hz
PWM Duty Cycle	0–100%
PWM Resolution	12 bits
PWM Accuracy	±2% for both frequency and duty cycle determination from 5% to 95% duty cycle at 500 Hz
PWM Temperature Drift	±0.5% for both frequency and duty cycle over the operating temperature range
Isolation Voltage	500 Vac as a group

In GAP, discrete output #1 is found in the ECM3 Chassis block as “DO_1”. Discrete output #2 is “DO_2 and so forth. The GAP block “BOOL_OUT” should be used with this output when Boolean application is desired. The GAP block “AO_PWM” should be used with the output when PWM application is desired. This is not a current controlled output and no current feedback is provided.

PWM Wiring

When using discrete outputs as PWM outputs, there is not a pull-up resistor internal to the ECM3 output. Therefore, unless the receiving end has an internal pull-up resistor at the input, one must be provided in the wiring harness or at the terminals of the receiving device (not at the ECM3 terminals). The PWM output closes a connection between the PWM output pin and DO_RTN.

For best performance, the pull-up resistor should have a low resistance value considering power dissipation and the maximum rating of the PWM outputs. Lower resistance values result in faster output slew rates and better immunity to noise. A pull-up resistor value around 1 kΩ is recommended.

Woodward products that may be used with PWM position commands are listed here for reference:

- The Woodward L-series actuators and FCV (Diesel Common Rail Fuel Control Valve) have internal pull-up resistors that are activated using a software configuration parameter.
- Some Woodward Flo-Tech actuators have an internal resistor. Check the product documentation for your model.
- All Woodward ProAct Digital Plus actuators will require an external pull-up resistor at the terminals.

PWM outputs are provided on both J2 and J3. If driving a proportional actuator, only the PWM outputs on J2 have enough current drive capability.

Table 2-30. PWM Outputs

Connection	Output Current	Connector
DO_5	500 mA	J3
DO_6	500 mA	J3
DO_11	3 A	J2
DO_12	3 A	J2

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

Released

Twisted pair wiring is required for PWM wiring but shielding is optional. However, shielding is recommended for low current PWM wiring such as control signals to a Woodward actuator. Shielding should be unbroken between the ECM3 and the receiving device. Shielding should not be grounded anywhere in the system along the cable's length. The shield should be connected to the receiving device as required in the product manual for that device. Do not make any shield connections for the PWM outputs at the ECM3.

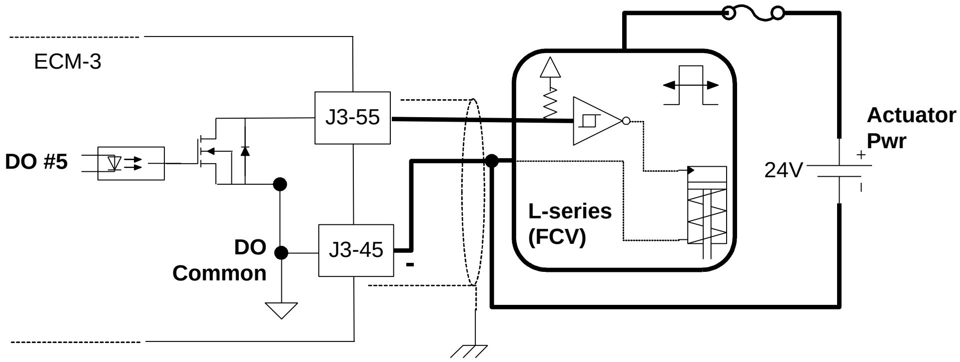


Figure 2-22. PWM Output Wiring Diagram for L-Series, FCV, Flo-Tech

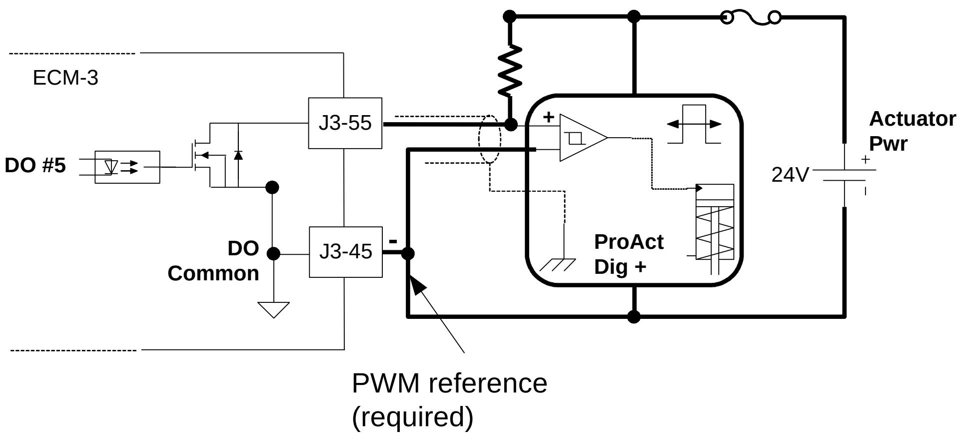


Figure 2-23. PWM Output Wiring Diagram for ProAct Digital Plus

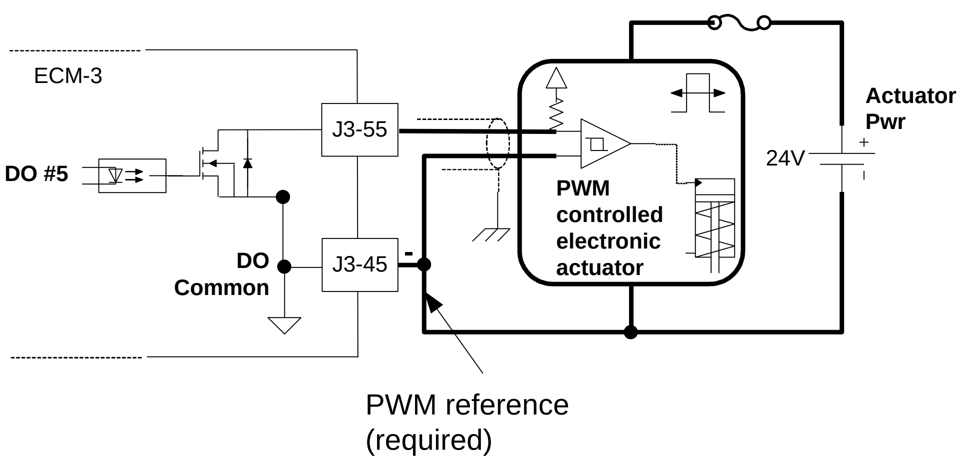


Figure 2-24. PWM Output Wiring Diagram for General Application

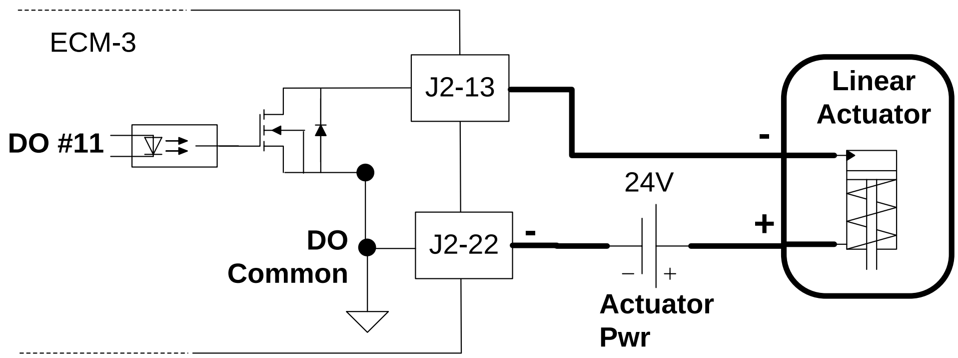


Figure 2-25. PWM Output Wiring Diagram for Linear Actuator

The digital output return (DO_RTN) is provided on multiple pins for wiring convenience. Only one return connection on each connector is required. However, when using high current PWM signals, it is best to use the separate return for those signals.

Table 2-31. PWM Output Connections

Connection	Signal Input	Common Returns
DO_5	J3–55	J3–44, J3–45, J3–46, J3–47
DO_6	J3–56	J3–44, J3–45, J3–46, J3–47
DO_11	J2–13	J2–22, J2–28
DO_12	J2–23	J2–22, J2–28

Note that since some discrete outputs can be used as PWM or Boolean outputs, take care on wiring the power source to avoid current loops.

Boolean Output Wiring

All discrete outputs can be used as Boolean outputs. Each output has identical circuitry. Wiring for digital output #1 is shown below. Only the terminal numbers change for the remaining discrete outputs.

The discrete outputs are generally designed for connection to a small indicating lamp (LED or incandescent) or a relay coil. The output cannot be synchronized to engine position (crank angle).

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

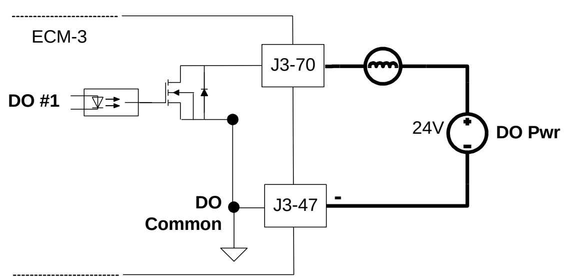


Figure 2-26. Boolean Output Wiring Diagram

The digital output return (DO_RTN) is provided on multiple pins for wiring convenience. Only one return connection on each connector is required. However, when using high current PWM signals, it is best to use the separate return for those signals.

Table 2-32. Discrete Output Connections

Connection	Signal Input	Common Returns
DO_1	J3–70	J3–44, J3–45, J3–46, J3–47
DO_2	J3–69	J3–44, J3–45, J3–46, J3–47
DO_3	J3–68	J3–44, J3–45, J3–46, J3–47
DO_4	J3–67	J3–44, J3–45, J3–46, J3–47
DO_5	J3–55	J3–44, J3–45, J3–46, J3–47
DO_6	J3–56	J3–44, J3–45, J3–46, J3–47
DO_7	J2–31	J2–22, J2–28
DO_8	J2–30	J2–22, J2–28
DO_9	J2–29	J2–22, J2–28
DO_10	J3–57	J3–44, J3–45, J3–46, J3–47
DO_11	J2–13	J2–22, J2–28
DO_12	J2–23	J2–22, J2–28

Note that since the discrete outputs can be used as PWM or Boolean outputs, take care on wiring the Discrete Output power source to avoid loops.

Fuel Injection Outputs

There are 24 fuel injection outputs internally grouped in sets of three. These groups are called injection groups. There are two boost supplies internal to the ECM3 that boost the 24 Vdc input voltage to 125 Vdc for fuel injection. Each boost supply provides power for 12 fuel injection outputs.

Injection groups can overlap, with simultaneous use, but with limitations. Two injection groups may simultaneously start injection as long as the injection groups are fed from opposite boost supplies. Two injection groups fed from the same boost supply may operate in an overlapping condition where the first is at the lower “hold-in” level when the second begins the “pull-in” event.

Each output has two pins on the connector labeled (+) and (–). Both connections are protected from over current and mis-wiring. In the case of a short circuit, causing an over current condition, the entire injection group (all 3 channels) will be disabled. Feedback is provided to the software application when an over current condition occurs. The software application can reset the lock out to allow the outputs to operate again. An over-current condition in one injection group will not affect the other injection groups.

Table 2-33. Fuel Injection Outputs Specification

Number of Channels	24
Output Type	Current controlled driver
Current Drive Rating	11 A maximum solenoid pull-in
Output Voltage	125 Vdc
Isolation Voltage	None

In GAP, injection output #1 is found in the ECM3_EFI Module block as “OUT_1”. Injection output #2 is “OUT_2”. This pattern repeats for all 24 outputs. The GAP block “EFI_OUTPUT” should always be used with this output.

Fuel Injection Wiring

Each injection group supports 3 fuel injectors. One injector of an injection group can be used at a time. See below graphic for an understanding of how injector outputs are combined in an injection group. The external connections to the ECM3 are marked as a box with a star inside.

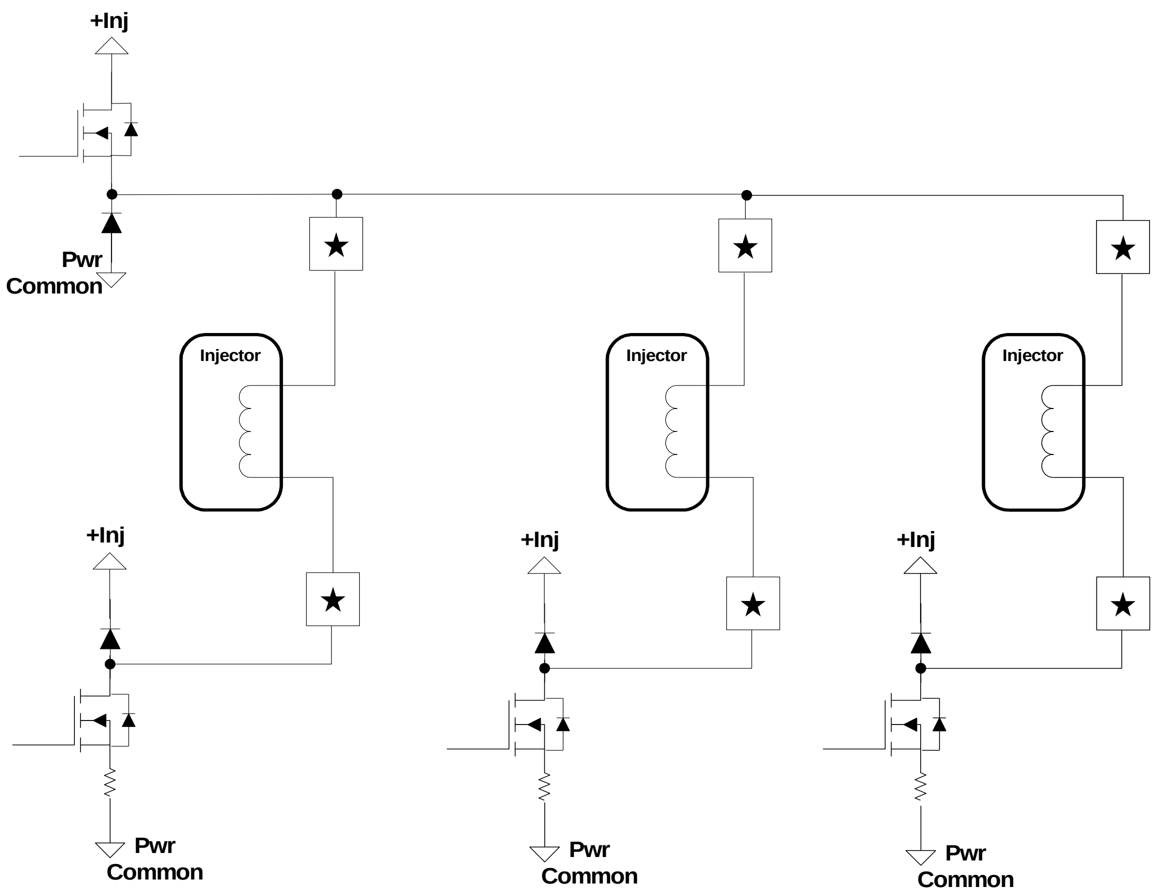


Figure 2-27. Fuel Injection Group Design

The injector outputs are ordered by counting through the first of each injection group followed by the second and last by the third. This is illustrated in Table 2-34. The purpose for this is to avoid conflicts of injection overlap within a group (where it is not possible to turn on multiple outputs simultaneously). Even numbered injectors are found on J1 and odd numbered injectors are found on J2.

Table 2-34. Fuel Injection Connections

Injector Group	Output #	Boost Supply	Connector	Coil (+)	Coil (–)	Shield
1	1	A	J2	J2–41	J2–40	J2–33
2	2	A	J1	J1–14	J1–15	J1–32
3	3	A	J2	J2–59	J2–60	J2–58
4	4	A	J1	J1–16	J1–17	J1–34
5	5	B	J2	J2–69	J2–68	J2–70
6	6	B	J1	J1–10	J1–9	J1–8
7	7	B	J2	J2–57	J2–56	J2–39
8	8	B	J1	J1–30	J1–31	J1–38
1	9	A	J2	J2–43	J2–42	J2–35
2	10	A	J1	J1–25	J1–24	J1–33
3	11	A	J2	J2–50	J2–51	J2–34
4	12	A	J1	J1–2	J1–3	J1–1
5	13	B	J2	J2–55	J2–54	J2–37
6	14	B	J1	J1–20	J1–21	J1–37
7	15	B	J2	J2–46	J2–47	J2–38
8	16	B	J1	J1–23	J1–22	J1–39

Table 2-34. Fuel Injection Connections (cont'd.)

Injector Group	Output #	Boost Supply	Connector	Coil (+)	Coil (–)	Shield
1	17	A	J2	J2–48	J2–49	J2–32
2	18	A	J1	J1–27	J1–26	J1–35
3	19	A	J2	J2–61	J2–62	J2–63
4	20	A	J1	J1–4	J1–5	J1–6
5	21	B	J2	J2–67	J2–66	J2–65
6	22	B	J1	J1–12	J1–11	J1–13
7	23	B	J2	J2–45	J2–44	J2–36
8	24	B	J1	J1–28	J1–29	J1–36

Like other signals on the ECM3, maximum wiring length is limited to less than 10 meters. All cabling should be 18 or 16 AWG for proper crimp strength at the ECM3 connector and for engine vibration durability.

All fuel injection outputs must be shielded to maintain EMC compliance. Shielding should be unbroken between the ECM3 and the linear actuator. Shielding must not be grounded anywhere in the system along the injector cables length. The shield must be connected directly to the ECM3 using the correct pin on the connector. Do not make any shield connections directly to ground or to the actuator (injector).

Boost Supply Monitoring Circuit

The boost supply monitoring circuit is used by the fuel injection algorithm as part of the injector valve calibration routine. There is a monitor for each boost supply. Each is also available to the application as a voltage monitor for diagnostic purposes. In GAP these values are found in the ECM3_STS block as "V1_INJ" and "V2_INJ". A filtered average of these two outputs is found in the EFI_CORE block as "COIL_VOLTS".

Table 2-35. Boost Supply Monitor Specifications

Maximum Voltage Measured	144.7 Vdc
Resolution in Volts	0.145 Vdc
Accuracy	2.5%
Temperature Drift	±1.0% of full scale typical (±1.50 V) ±2.1% of full scale worst case (±3.00 V)
Filter Constant	1 pole at 1.4 ms

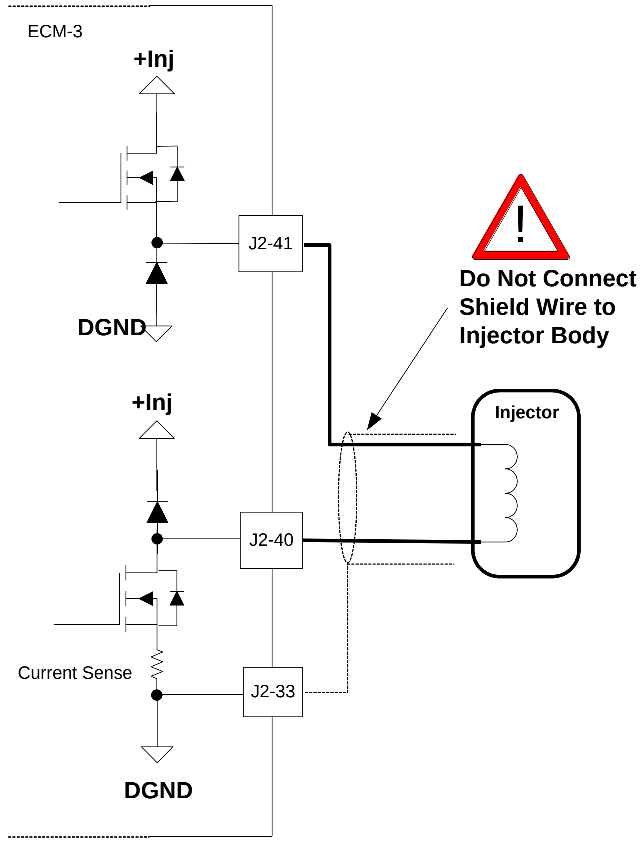


Figure 2-28. Fuel Injection Output Wiring Diagram

Serial Communication Ports

There are two serial ports on the ECM3. They may both be used simultaneously and may both be configured independently. Performance of any one port will depend on how many ports are in use and the port traffic.

Both serial ports share a common isolation. They are isolated from all other circuits, but not from each other. The isolation conforms with SELV Product Safety requirements. Since both ports are common, if they are to be used simultaneously at least one of the ports, at the receiving end, should be isolated from the other so that a ground loop is not created between the two communicating devices via the serial network.

These ports are 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.

RS-232 Configuration Port

RS-232 is an ANSI (American National Standards Institute) standard definition of electrical, functional and mechanical connections for communications between DTE (Data Terminal Equipment) and DCE (Data Communications Equipment) such as connection of a computer to a modem. It has gained wide usage in short-distance applications (15 m/50 ft). In practice, the standard is largely ignored beyond the most rudimentary implementation of electrical signals (±3 to ±15 volts). Woodward's implementation will support speeds up to 115 K baud. The actual specification allows 19.2K baud at up to 15 m (50 ft).

Table 2-36. RS-232 Specification

Transceiver Type	RS-232C
Isolation Voltage	500 Vdc SELV rated (common to the RS-485 port)
Baud Rates Supported	9.6, 19.2, 38.4, 57.6, 115.2 kbps
Protocols Supported	Woodward ServLink, Modbus RTU, Modbus ASCII

In GAP, the RS-232 port is found in the ECM3 Chassis block as “COMM_1”. One of the GAP blocks “SIO_PORT” or “MOD_PORT” should be used with this port. Use “SIO_PORT” for Woodward Servlink (service tool) application. Use “MOD_PORT” for Modbus protocols.

RS-232 Serial Wiring

The connected wiring should meet the requirements of EIA RS-232. This standard states a maximum cable length of 15 m (50 ft) with a total capacitance less than 2500 pF and a data rate not exceeding 56 kbps. The ECM3 serial port may be configured for data rates up to 115200 bps. Wiring length should be limited to 10 meters.

Since this port is the only serial port that can be used to download application code, we recommend that this port be used exclusively as a Woodward ServLink port. Its intended primary purpose is for configuration using a PC. ServLink is a proprietary Woodward service tool protocol. Configuration can be done using a PC with Woodward’s Watch Window or Merlin service tools. However, it may also be connected to a PC based Human Machine Interface (HMI) for local configuration and monitoring. The port configuration is defined in the GAP program and sets configuration for kbps, parity, data, and stop bits as well as protocol choice.

PC’s usually tie the RS-232 signal common to chassis and protective earth; this can allow an unintended current loop to be formed and defeat the protective isolation in the control. Occasionally the current path formed by connecting signal common to chassis can cause damage to the control, or to the un-isolated PC. The typical problems encountered are noise sources, such as surges, or broken power returns damaging the PC. For this reason, the RS-232 signal common is isolated in the ECM3; however, if RS-485 is used, the signal common may also be grounded at another device on the RS-485 link. If the RS-485 port is being used, it is recommended that an isolator or careful consideration of the system wiring be used prior to connecting a PC to the control.

When not in use, the cable should be disconnected from this port. The RS-232 transceiver has temperature limitations and cannot be used when the ECM3 is at full operating temperature on a hot engine. Disconnecting the serial cable allows the transceiver to shut down so it is not damaged from the high temperature.

NOTICE	**The RS-232 serial cable must be disconnected when not in use or when the ECM3 is used at full operating temperature. This is also critical for on-engine applications. Failure to disconnect the cable can result in damage to the RS-232 transceiver inside the ECM3.**

Interface Cable Characteristics

Please refer to “Interface Cable Characteristics” in the RS-485 Serial Port section below.

Shielding

Shielded RS-232 cable is required between the ECM3 and any other devices. Unshielded or improperly shielded cables are likely to cause communication problems and unreliable control operation.

The shield must always be ac-coupled (connected through a capacitor) at one end and connected directly to earth on the opposite end for proper operation. Improper shield termination to ground can also cause communication problems and unreliable control operation.

The ECM3 has been constructed so that the serial port shield connections are ac coupled to chassis ground (chassis ground must be tied directly to earth). Devices connected to the opposite end of the cable must provide for the direct ground shield connection or a direct ground must be applied at the ECM3, external to the control's shield connector pin.

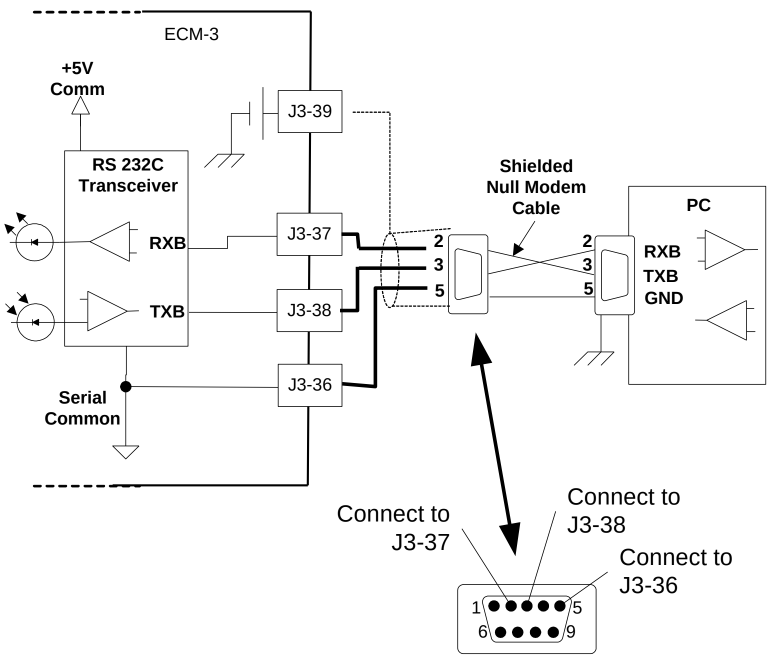


Figure 2-29. RS-232 Wiring Diagram

RS-485 Serial Port

RS-485 is also an ANSI standard definition of electrical connections for communications between devices. Because it uses balanced drivers, it can communicate over long distances (900 m/3000 ft) at high baud rates (115K). This protocol is implemented identically to "RS-422" with the exception that only one twisted pair is required. Both transmitted and received data use the same pair of wires. A common wire is still required since the output ground is isolated. The port supports up to 32 devices as a half-duplex, multi-drop communications network. This allows more than one device to be connected to the common bus with a single master requesting data. It requires one twisted pair and common to operate.

This port may be used as a Modbus RTU, Modbus ASCII, or ServLink port. All messaging can be independent from the RS-232 port above. This port supports multi-drop communications on all protocols.

Table 2-37. RS-485 Specification

Transceiver Type	RS-485 half duplex
Isolation Voltage	500 Vdc SELV rated (common to the RS-232 port)
Baud Rates Supported	9.6, 19.2, 38.4, 57.6, 115.2 kbps
Protocols Supported	Woodward Servlink, Modbus RTU, Modbus ASCII

In GAP, the RS-485 port is found in the ECM3 Chassis block as "COMM_2". One of the GAP blocks "SIO_PORT" or "MOD_PORT" should be used with this port. Use "SIO_PORT" for Woodward Servlink (service tool) application. Use "MOD_PORT" for Modbus protocols.

Interface Cable Characteristics

When choosing a cable for RS-485, it is necessary to examine the required distance of the cable run and the data rate of the system. Beyond the obvious traits such as number of conductors and wire gauge, cable specifications include a handful of less intuitive terms.

Characteristic Impedance (ohms)—A value based on the inherent conductance, resistance, capacitance, and inductance of a cable that represents the impedance of an infinitely long cable. When the cable is cut to any length and terminated with this Characteristic Impedance, measurements of the cable will be identical to values obtained from the infinite length cable. Therefore, termination of the cable with this impedance gives the cable the appearance of being infinite length, allowing no reflections of the transmitted signal. When termination is required in a system, the termination impedance value should match the Characteristic Impedance of the cable.

Shunt Capacitance (pF/ft)—The amount of equivalent capacitive load of the cable, typically listed in a per foot or per meter basis (1 pF/ft = 3.28 pF/m). One of the factors limiting total cable length is the capacitive load. Systems with long lengths benefit from using low capacitance cable.

Propagation velocity (% of c)—The speed at which an electrical signal travels in the cable. The value given typically must be multiplied by the speed of light (c, $3x10^8$ m/s) to obtain units of meters per second. For example, a cable that lists a propagation velocity of 67% gives a velocity of 0.67 x $3x10^8$ = $2.01x10^8$ m/s. The higher the percentage, the smaller the signal delay.

General recommendations for serial cable are listed in the table below.

Table 2-38. Serial Cable Requirements

Impedance	100 Ω ±20%
Cable Capacitance	49.2 pF/m (15.0 pF/ft) at 1 kHz
Propagation Velocity	67.0%
Data Pairs	0.8 mm² (18 AWG) tinned copper
Signal Attenuation	6.0 dB maximum

Network Construction

While there are a number of different ways to physically connect devices on a network, for best performance, Woodward recommends that multi-drop networks be constructed using a “daisy chain” configuration or a “backbone with stubs”.

In a daisy chain configuration, wires are run from device one to device two to device three, etc.

In a backbone with stubs configuration, a main trunk line is run between the two devices that are physically farthest apart and have the physically longest cable. Stub lines are run from the intermediate devices to the trunk line. Stubs should be kept as short as possible. See Figure 2-36 for a graphical representation.

The RS-485 specification states that a common wire is needed if there is no other ground path between units. The preferred method for isolated ports is to include a separate common wire in the cable that connects the circuit commons together.

Non-isolated nodes may not have a signal common available. If a signal common is not available, use the alternate wiring scheme of connecting all circuit commons of isolated nodes to the shield, and connecting the shield to earth ground at a non-isolated node.

Termination

To achieve best performance with RS-485 serial communication networks, it is necessary to terminate the network to prevent interference caused by signal reflections. (RS-232 networks are short enough that termination is not required.)

Woodward has provided, built-in, network termination resistors for the RS-485 serial port to ease network setup and configuration. The resistor network used is a special design intended to provide maximum noise immunity. The same design should be used at the opposite end of the network. See the circuit diagram (Figure 2-30). This termination network is necessary due to limitations of the Modbus protocol.

To activate the termination resistors, external jumpers must be placed at the connector. See Figure 2-30 for jumper locations.

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 on the two units that are at the physical ends of the network. Terminating more than two units can overload the network and put it into a cyclic thermal shutdown mode.

Shielding

Shielded RS-485 cable is required between the ECM3 and any other devices. Unshielded or improperly shielded cables are likely to cause communication problems and unreliable control operation.

The shield must always be ac-coupled (connected through a capacitor) at one end and connected directly to earth on the opposite end for proper operation. Improper shield termination to ground can also cause communication problems and unreliable control operation.

The ECM3 has been constructed so that the serial port Shield connections are ac coupled to chassis ground (chassis ground must be tied directly to earth). Devices connected to the opposite end of the cable must provide for the direct ground shield connection or a direct ground must be applied at the ECM3, external to the control's termination connector pin.

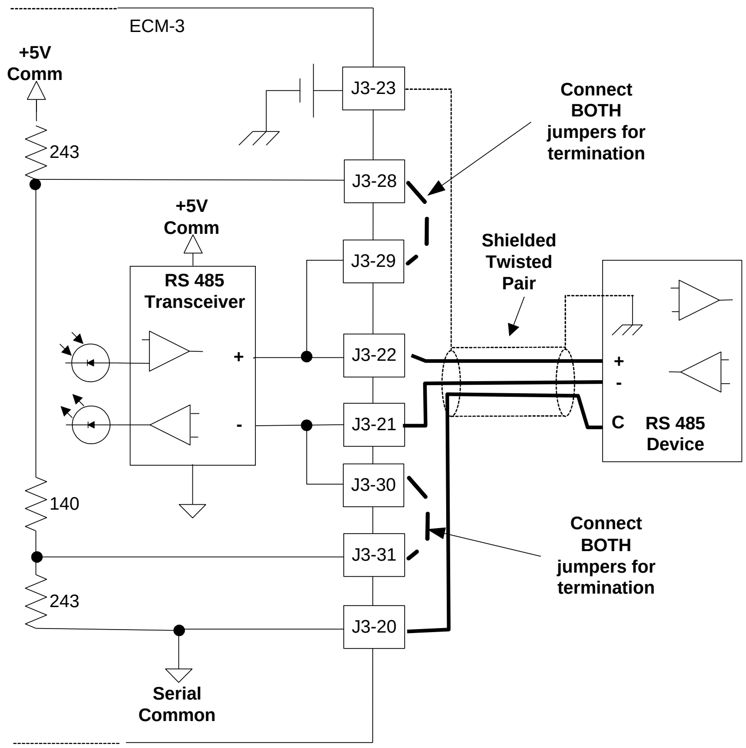


Figure 2-30. RS-485 Wiring Diagram

CAN Communication Ports

There are 3 CAN ports for distributed I/O, distributed control, and Human Machine Interface (HMI) purposes. Each port operates independently. Communications is controlled via GAP rate groups and is deterministic. Care should be given to the choice of devices used on each network. HMI devices should generally not be put on distributed control networks with real time control requirements.

Port 1 is electrically isolated from all other circuits in the ECM3. It may be used for on-engine or off-engine communications. Isolation used on this port is SELV rated with respect to product safety requirements.

Ports 2 and 3 are isolated as a single group; both CAN ports share a common isolation. They are isolated from most other circuits but not from each other. The isolation does NOT conform to product safety SELV requirements and is considered to be hazardous live. Neither port should be used for communication off the engine. They are designed for on-engine distributed control.

Each of the 3 ports support SAE J1939 and CiA CANopen network protocols. Either protocol may be used on any port.

Table 2-39. CAN Specification

Transceiver Type	CAN 2.0B
Isolation Voltage	500 Vdc SELV rated (port #1) 500 Vdc hazardous live rated (ports #2 and #3)
Baud Rates Supported	125, 250, 500, and 1000 kbps
Protocols Supported	CANopen, SAE J1939

In GAP, the CAN ports are found in the ECM3 Chassis block as “CAN1_PORT”, “CAN2_PORT”, and “CAN3_PORT” respectively. The GAP block “CAN_PORT” must be used with these ports.

Recommended Bulk Cable

Use shielded CAN compatible cabling for all CAN networks. DeviceNet cable is a good example of CAN cable for use with isolated CAN ports, but caution should be used as most DeviceNet cables are not rated for on-engine temperatures. It is typically suitable for wiring between switchgear cabinets and an engine junction box where the temperatures are lower. Also, both the “thick” and “thin” DeviceNet cables have wire insulation and wire size that is not compatible with the ECM3 connectors.

When using DeviceNet cables outside a vibration damped enclosure, use the “Thick” or “Trunk” cable. The “Thin” or “Drop” cables have very small wire sizes that fatigue easily. Below are two DeviceNet CAN cables that are compatible with isolated CAN use off engine.

Belden 7896A	PVC, 18 AWG shielded data pair, 16 AWG shielded power pair. NEC/UL TC-ER, CSA I/II, A/B
Lapp Cable 2710-250	Halogen free, 18 AWG shielded data pair, 15 AWG shielded power pair. UL and CSA approved

“J1939” cable is a good example of CAN cable for use with un-isolated CAN ports and for on-engine use. This cable does not include the extra wire used to carry the common reference. It is suitable for use with CAN2 and CAN3 on the ECM3. It can also be used with CAN1 (the isolated port) if an extra wire is used for CAN common. Raychem makes a compatible cable as do many other manufacturers.

Raychem 2019D0301	Cheminax, J1939-11, 0.75 mm^2, 120 Ω characteristic impedance, 10.5 pF/ft mutual capacitance, 74% velocity of propagation

The basic cable requirements are listed below. When selecting other cables, be sure they meet these requirements.

Table 2-40. Cable Specification

Data Pair Impedance	120 Ω ±10% at 1 MHz
Cable Capacitance	12 pF/ft at 1 kHz (nominal)
Capacitive Unbalance	1200 pF/1000 ft at 1 kHz (nominal)
Propagation Delay	1.36 ns/ft (maximum)
DC Resistance	6.9Ω / 1000 ft @ 20°C (maximum)
Data Pair	0.75 mm^2 to 1.0 mm^2 corresponds to 20 AWG to 18 AWG, individually tinned, 3 twists/foot
Power Pair (DeviceNet only)	0.75 mm^2 to 1.5 mm^2 corresponds to 20 AWG to 16 AWG, individually tinned, 3 twists/foot
Drain / Shield Wire	0.75 mm^2 to 1.0 mm^2 Tinned Copper drain wire inside a braid or foil shield
Signal Attenuation	0.13 dB/100 ft @ 125 kHz (maximum)
	0.25 dB/100 ft @ 500 kHz (maximum)
	0.40 dB/100 ft @ 1000 kHz (maximum)

Figure 2-31 illustrates what the DeviceNet cables will look like including shielding. There is a foil tape around each conductor pair as well as a braided shield around the entire group of conductors. J1939 cables will not include the dc power pair and related extra shielding.

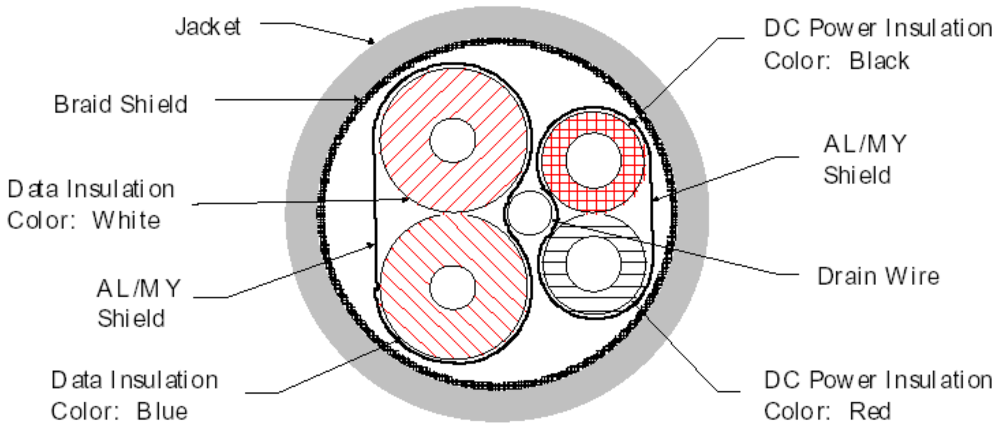


Figure 2-31. CAN Cable Cross-Section

Network Construction

There are a number of different ways to physically connect devices on a CAN network. Woodward recommends that multi-drop networks be constructed using either a "daisy chain" configuration (also called zero length drop line) or a "backbone" with very short drop lines for best performance.

In a daisy chain configuration, wires are run from one device to the next device without drop lines.

In a backbone with stubs configuration, a main trunk line is run between the two devices that are physically farthest apart and have the physically longest cable. Stub lines are run from the intermediate devices to the trunk line. Stubs should be kept as short as possible and may never exceed 6 m (20 ft). As shown in Figure 2-36, it is acceptable to mix both methods on the same network.

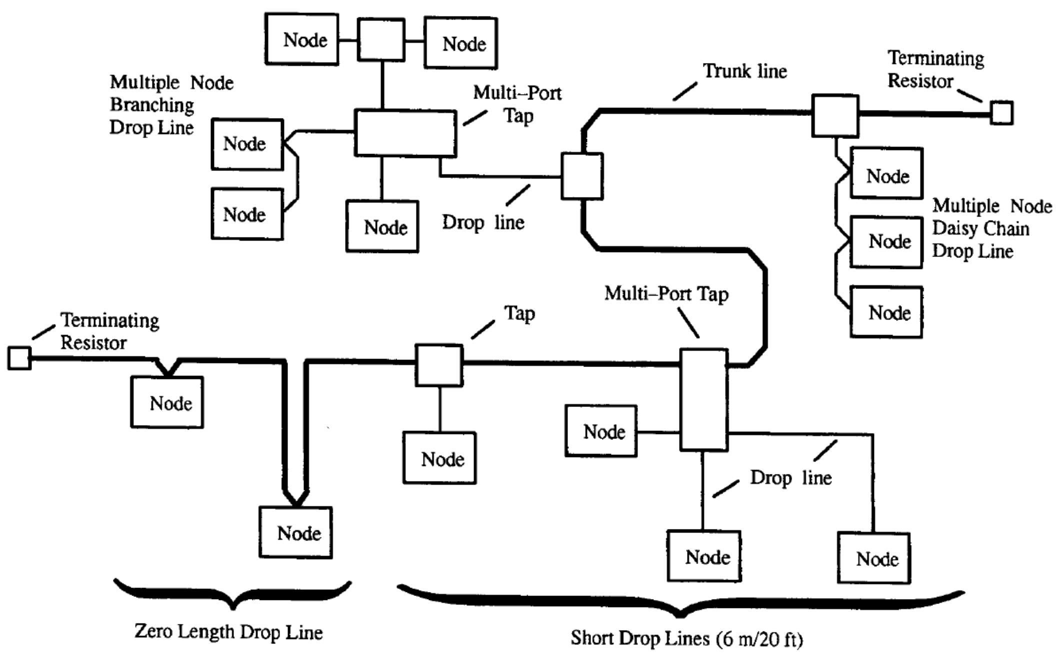


Figure 2-32. CAN System Wiring Example

A daisy chain (zero drop length) connection is not feasible at the ECM3 connection due to the sealed connector design. The next best alternative is to use a very short drop line from the trunk into the ECM3. Special ‘T’ connectors (Tap in the diagram above) are available from multiple manufacturers to ease the wiring harness manufacture. Also available from the same manufacturers, are termination resistors that plug directly into the ‘T’ connectors for the network ends.

Due to the port isolation on port 1, a common wire is needed between all units on the network. The preferred method for isolated ports is to include a separate wire within the CAN cable. This keeps the communications and ground reference at the same potential at all times. The DeviceNet cables listed in this manual have the common wire feature.

Non-isolated nodes may not have a signal common available for connection. If a signal common is not available, use the alternate wiring scheme of connecting the CAN ground wire from the isolated nodes to the B- terminal at a non-isolated node. B- is typically the signal reference for CAN if isolation is not provided.

The CAN common wire should not be grounded. The only exception to this rule is if one of the devices on the link is not isolated, then connecting CAN common to B- on that device may create a connection to the B- power supply ground, assuming the power supply has a connection to ground. Otherwise, no other connections to ground or physical earth should be provided.

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.

In order to allow the possibility of removing and inserting a unit onto a running network, the CAN termination network is not included inside the ECM3 control. An external CAN termination network must be provided.

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, ¼ 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 required between the ECM3 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 (ac-coupled: connected through a capacitor). Additionally, a single direct network shield ground location may be provided in some situations. Typically, the direct shield grounding location does not have to be at a unit connector, it can be any convenient place in the system.

The ECM3 has been constructed so that the CAN port #1 shield connection is ac coupled to chassis ground, chassis ground must be tied directly to earth ground.

The ECM3 has been constructed so that the CAN ports #2 & #3 shield connection is directly coupled to chassis ground, chassis ground must be tied directly to earth ground.

CAN port #1 may also have the CAN cable’s shield tied directly to ground, but care must be taken in how this is accomplished, see Figure 2-37 below. It is expected that each network has one direct connection to chassis ground. The chassis grounding point should be chosen for its proximity to ground noise generators and node connections.

CAN Port 1 Wiring

CAN Port #1 may be used for off-engine wiring to control rooms. It is electrically isolated from all other circuits in the ECM3. Isolation used on this port is SELV rated for product safety requirements.

Wiring length restrictions depend on the baud rate used. Table 2-41 is appropriate for CANopen, at the 4 supported baud rates. The “Trunk” is the length between the two units that are at the physical ends of the network. The “Cumulative Drop” is the added length of all drop wires from the trunk to the devices. This only applies to “backbone” type networks since Daisy chain networks do not have drops. The “Maximum Drop” is the maximum allowed for any 1 drop. Any network configured for 1000 kbps should use the daisy chain topology to reduce the possibility of reflections.

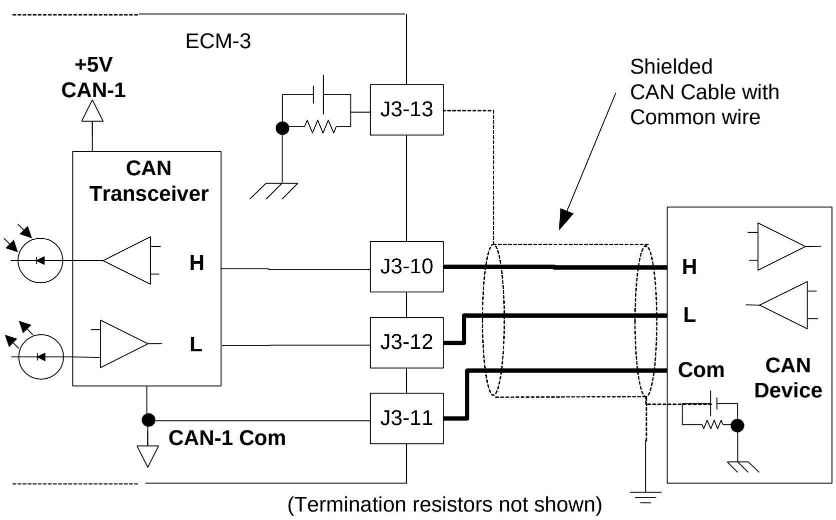
SAE J1939 protocol is restricted to 250 kbps and the SAE J1939 standard limits wiring distances to 40 meters, when un-isolated controls are connected on the link.

The limits below are the maximum allowed by the CAN standard. To maintain a high level of reliability in practice, shorter lengths are highly recommended.

Table 2-41. CAN-1 Wiring Limitations

Baud Rate	Trunk Length	Cumulative Drop	Maximum Drop
125 kbps	500 m (1640 ft)	156 m (512 ft)	6 m (20 ft)
250 kbps	250 m (820 ft)	78 m (256 ft)	6 m (20 ft)
500 kbps	100 m (328 ft)	39 m (128 ft)	6 m (20 ft)
1000 kbps	25 m (82 ft)	Not recommended	Not recommended

Wiring used on the engine must be rated for the engine environment. This typically means that no cable is available with a common wire integrated into it. However, wiring selected for off-engine use may have a lower temperature rating. Such cable is available with a common wire integrated into it (DeviceNet cable). All wiring off the engine should be done with the DeviceNet type cable in order to provide a shielded common connection with the CAN wiring pair.



Optimal solution where appropriate wire can be used

Figure 2-33a. CAN-1 Wiring Diagram

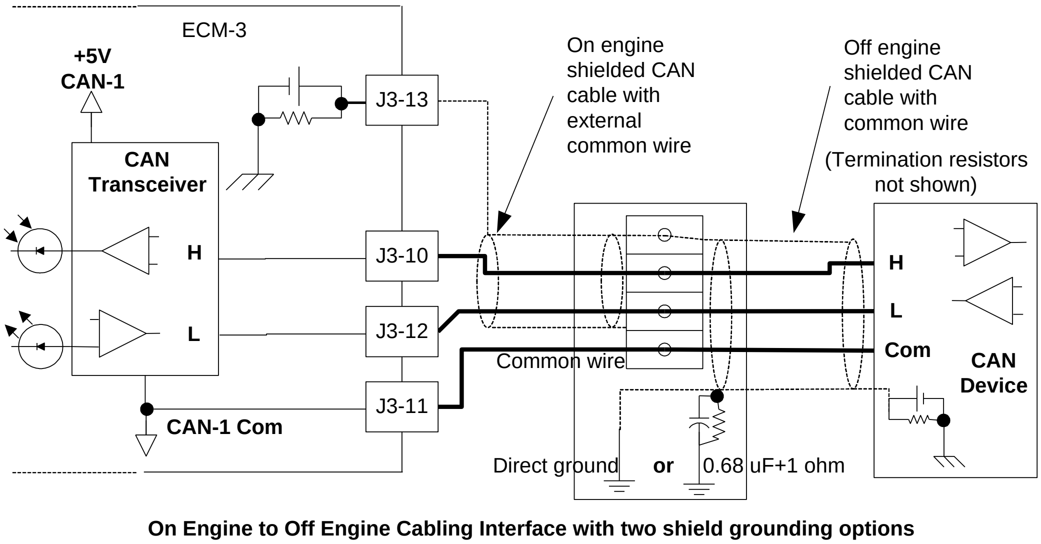


Figure 2-33b. CAN-1 Wiring Diagram—On and Off Engine

CAN Ports 2 and 3 Wiring

CAN Ports 2 and 3 are isolated as a common group. They are isolated from most other circuits but not from each other. The isolation does not conform to SELV product safety requirements and is considered to be hazardous live. Neither port should be used for communication off the engine. They are designed for on-engine distributed control.

As a result of the isolation style for these ports, they must be limited to 10 meters or less wiring length between the two devices at the physical ends of the network.

Both CAN port #2 and CAN port #3 have identical circuit designs. Only the pinout for CAN port #2 is shown. The pinout for CAN port #3 is similar except with different terminal numbers. To improve immunity to noise, CAN common (B–) can be routed with the shielded signal cable. This is particularly useful when connecting to isolated devices.

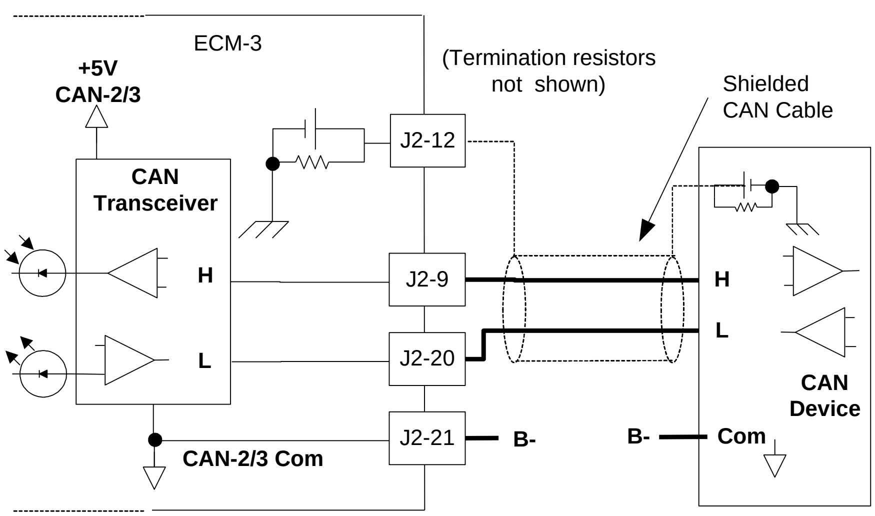


Figure 2-34a. CAN-2 and CAN-3 Wiring Diagram

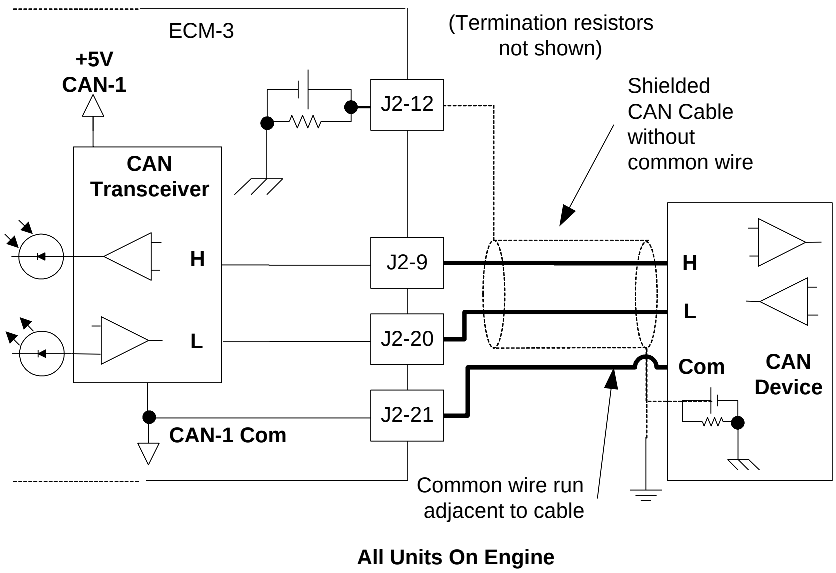


Figure 2-34b. CAN-2 and CAN-3 On Engine Enhanced Wiring Diagram

Table 2-42. Engine CAN Connections

Connection	CAN_2	CAN_3
CAN High	J2–10	J2–9
CAN Low	J2–20	J2–8
CAN Common	J2–21	J2–19
Shield	J2–12	J2–11

Chapter 3.
Serial Communications

Modbus Communication

The ECM3 can communicate with plant distributed control systems (DCS) and/or CRT-based operator control panels through Modbus communication ports. These ports support communications using ASCII or RTU MODBUS transmission protocols. Modbus uses a master/slave protocol. This protocol determines how a communication network's master and slave devices establish and break contact, how a sender is identified, how messages are exchanged, and how errors are detected.

The ECM3 supports two Modbus transmission modes. The mode defines the individual units of information within a message and the numbering system used to transmit the data. Only one mode per Modbus network is allowed. The supported modes are ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). These modes are defined in Table 3-1.

Table 3-1. ASCII vs. RTU Modbus

CHARACTERISTIC	ASCII	RTU
Coding System	Hexadecimal (uses ASCII printable binary characters: 0-9, A-F)	8-bit binary
Start Bits	1	1
Data Bits per Char	7	8
Parity	Even, odd, or none	Even, odd, or none
Stop Bits	1, 1.5, or 2	1, 1.5, or 2
Baud Rate	110, 300, 600, 1200,1800, 2400, 4800, 9600,19200, 38400, or 57600	110, 300, 600, 1200,1800, 2400, 4800, 9600, 19200, 38400, or 57600
Error Checking	LRC (Longitudinal Redundancy Check)	CRC (Cyclical Redundancy Check)

In the RTU mode, data is sent in 8-bit binary characters and transmitted in a continuous stream. In the ASCII mode, each binary character is divided into two 4-bit parts (high order and low order), changed to be represented by a hexadecimal equivalent, then transmitted, with breaks of up to 1 second possible. Because of these differences, data transmission with the ASCII mode is typically slower (see Figure 3-1).

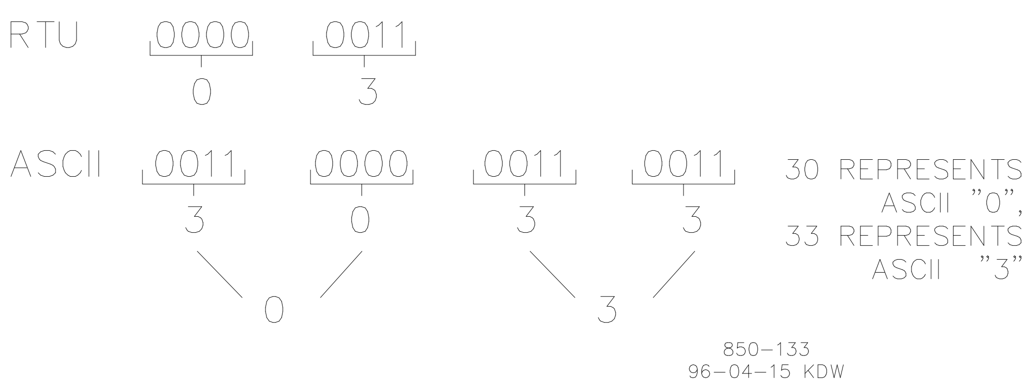


Figure 3-1. ASCII/RTU Representation of 3

The Modbus protocol allows one master and up to 247 slaves on a common network. Each slave is assigned a fixed, unique device address in the range of 1 to 247. With the Modbus protocol, only the network master can initiate a transaction. A transaction consists of a request from the master to a slave unit and the slave's response.

The ECM3 can directly communicate with a DCS or another Modbus supporting device on a single communications link, or through a multi-dropped network. If multi-dropping is used, up to 246 devices (ECM3 or other devices) can be connected to one Master device on a single network.

Each message to or from a master has a defined structure called the message "frame". A frame consists of the slave device address, a code defining the requested data, and error checking information (see Figure 3-2).

Table 3-2. Modbus Frame Definition

	Beginning of Frame	Slave Address	Function Code	Data	Error Check Code	End of Frame
ASCII		2 chars 8 bits	2 chars 8 bits	4 bits data per char	2 chars 8 bits	CR LF
RTU	3-char dead time	1 char 8 bits	1 char 8 bits	8 bits data per char	2 chars 16 bits	3-char dead time

The Modbus function code tells the addressed slaves what function to perform. Table 3-2 lists the function codes supported by this control.

Modbus Function Codes

Table 3-3. Modbus Function Codes

Code	Definition	Reference Address
01	Read Digital Outputs (Raise/Lower and Enable/Disable commands)	0XXXX
02	Read Digital Inputs (Status Indications / Alarms and Trips)	1XXXX
03	Read Analog Outputs	4XXXX
04	Read Analog Inputs (speed, setpoint, etc)	3XXXX
05	Write Single Discrete Output (Raise/Lower and Enable/Disable commands)	0XXXX
06	Write Single Register (enter setpoint directly)	4XXXX
08	Loopback Diagnostic Test (supports subfunction 0 only)	N/A
15	Write Digital Outputs	0XXXX
16	Write Analog Outputs	4XXXX

When a Modbus message is received, it is checked for any errors or invalid data. If there is invalid data in the message, an error code is sent back to the master and the master issues an alarm message. The error codes are defined in Table 3-4.

Modbus Slave Exception Error Codes

Table 3-4. Modbus Error Codes

Code	Error Message	To Master	Description
0	No Error	0	No Error
1	Bad Modbus function	1	The specified function is not supported for this control
2	Bad Modbus data address	2	The Modbus value address is not valid for this control
3	Bad Modbus data value	3	Too many values requested or the on/off indicator in function code 5 is invalid
9	Bad Modbus checksum	None	Message checksum did not match
10	Bad Modbus message	None	Message could not be decoded
n/a	Lost Modbus link	None	No messages received for the configured time-out period

Port Adjustments

Before the ECM3 will communicate with another device, the communication parameters must be verified. These values are set in the GAP program, and the GAP programmer may also make these values tunable if desired.

Table 3-5. Modbus Communication Port Adjustments

Parameter	Adjustment Range
Baud Rate	110 to 57600
Parity	None, odd, or even
Stop Bits	1 to 2
Driver	RS-232, RS-422, or RS-485

Chapter 4.
Programming and Service Tools

Introduction

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

Two program download and service tools are available for the ECM3 control. The Woodward Toolkit is the primary service software. The alternate service software is the Woodward Watch Window system. Both software tools run on a PC that is connected to the control with a RS-232 serial cable. When Watch Window is used, also running on the same PC is the Woodward Servlink server software that allows Watch Window to access selected application variables that were generated in the GAP application program. The details of the specific GAP application programming are beyond the scope of this manual, but Woodward publication number 80018 is available to assist the application engineer in this process.

Two versions of Toolkit are available for use with the ECM3:

1. Toolkit Professional is a licensed software tool that enables the application engineer to modify or create new screens for service configuration. At the point of creating new screens, Toolkit Professional is used to:
   - Configure the control software to the specific site or application needs
   - Monitor and tune system variables that were selected in the GAP application program
   - Trend variables
   - Upload and download all tunable and configuration variables from the control
2. The standard Toolkit is a software tool that does not have the capability to modify screens. Otherwise, it provides the same functionality as Toolkit Professional.

Two versions of Watch Window are available for use with the ECM3:

1. Watch Window Professional is a licensed software tool that enables the GAP-generated application program to be downloaded into the control. Watch Window Professional is used from the point a GAP-generated program is downloaded to:
   - Configure the control software to the specific site or application needs
   - Monitor and tune system variables that were selected in the GAP application program
   - Upload and download all tunable and configuration variables from the control
2. Watch Window Standard is a software tool that does not have the capability to download application software. Otherwise, it provides the same functionality as Watch Window Professional

This chapter covers the following procedures:

- Connecting the ECM3 to a PC
- Loading the Watch Window System or Toolkit software on the PC
- Applying power to the control
- Opening communications with the control
- Downloading the GAP-generated application software to the ECM3
- Using software to view variables and to tune the control
- Uploading and downloading tunable and configuration variables from/to the ECM3

Connecting the ECM3 to a PC

Connection of a generic PC to the ECM3 is required in order to load application software and view/tune within that software application. Figure 4-1 shows the connection details.

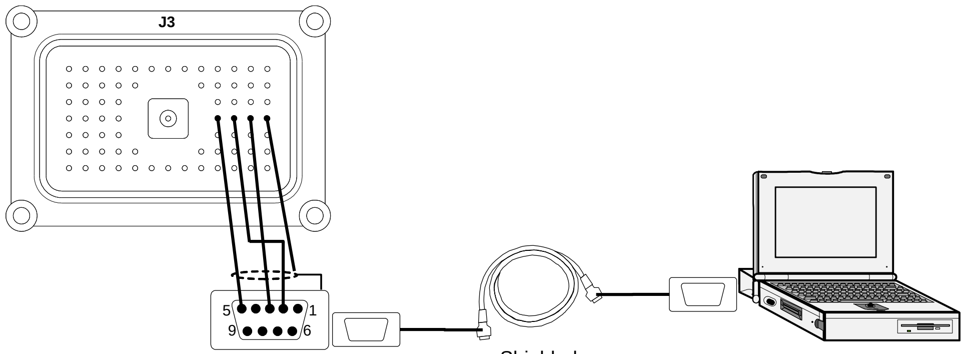


Figure 4-1. Connecting the ECM3 to a PC

Loading Woodward Software Tools on the PC

Woodward's Toolkit, Watch Window Standard, and Watch Window Professional tools may be downloaded from the Woodward website (**www.woodward.com/software/**). Alternatively, a Toolkit CD Install Kit or Watch Window CD Install Kit may be purchased from your Woodward distributor. Once downloaded, the kit's Setup.exe program will guide the user through the installation of Toolkit or Watch Window and ServLink software on the PC hard drive.

Applying Power to the ECM3

At power-up, the ECM3 runs through its boot-up routine and performs a set of initial diagnostics to verify CPU, memory, and bus health. When boot-up is complete, the application program (if loaded) will begin running, the control's outputs will be enabled, and system control will begin.

Toolkit Software Instructions

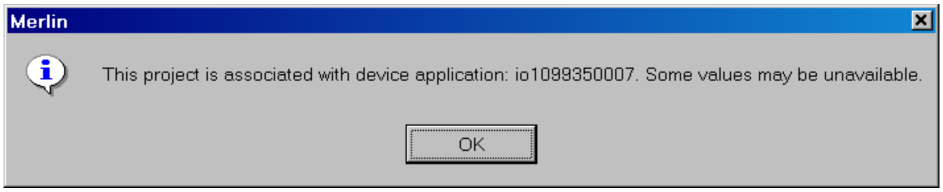
Establishing Communications with the ECM3

Step 1 – Opening a Project File

Before communications can begin between the Toolkit software and the ECM3, a Project File should be opened. To open a project file, select Open Project in the File menu. Toolkit project files have a .WPRJ file extension. The file browser will open in your default location for projects as configured in Toolkit Defaults. You do not need to be connected to a control to open a project file.

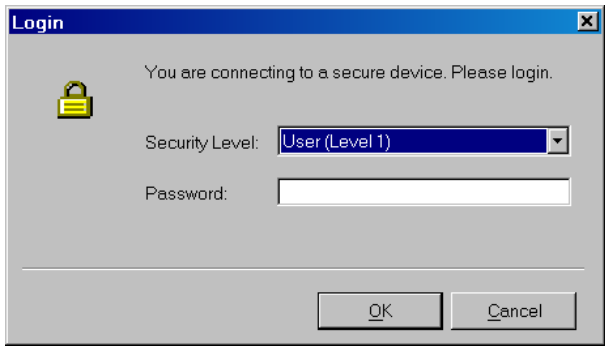
Step 2 – Connecting to the ECM3

1. Make sure that all other programs or devices that may access your computer's communication port are shut down.
2. Select Connect from the Communication menu in Toolkit. The user must select the COM port (unless the correct port is configured as the default in the Options… dialog of the Tools menu). Toolkit automatically detects the baud rate of the control.
3. Once connected to the control, the project association (SID file version) will be compared to the application in the control. The default project association file is automatically loaded with the Project File in step 1. If the default SID file does not match the application in the control, a warning similar to the following will be displayed.

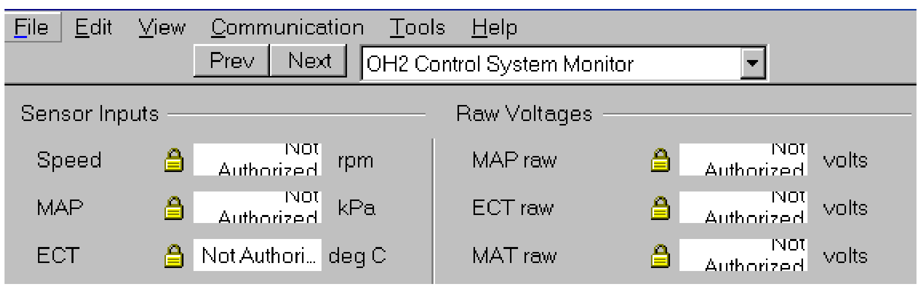


For proper operation, open the correct Project File from the File menu.

4. If connection is successful, the login window may be opened. If no password requirements are set in the control, the login window will not appear.



5. If the login prompt is canceled or the login level used does not have sufficient security level to view a parameter, a lock symbol will appear next to the secure parameters with the words “Not Authorized” in the field.



Downloading the GAP Application Code

The ECM3 may be shipped from the factory with a default GAP program. If no application is loaded or a new application needs to be loaded, the application can be downloaded by selecting the option Load Application from the File menu. This will start the Load Application Wizard.

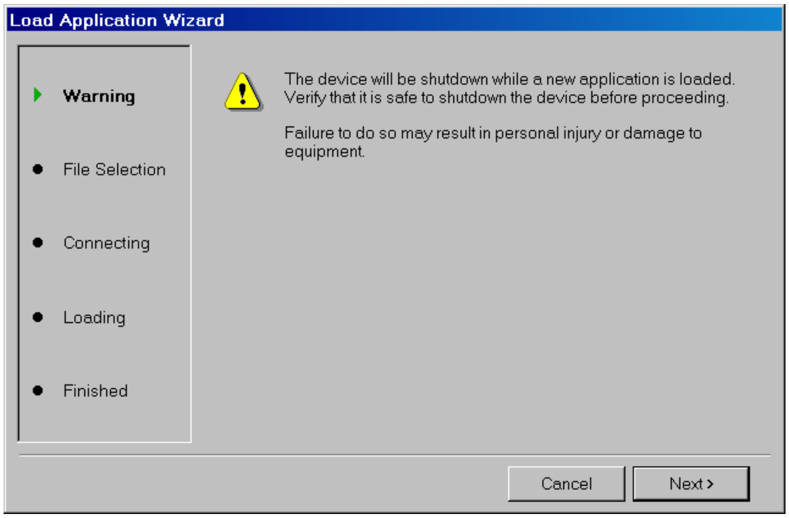
Toolkit will prompt the user to make a connection to the control if one does not already exist.

If any changes to the settings in the control have been made that should be saved, they should be saved before performing the application download. All settings will be modified to what is stored in the application file with the download. After the download is complete the user can then reload the proper settings.

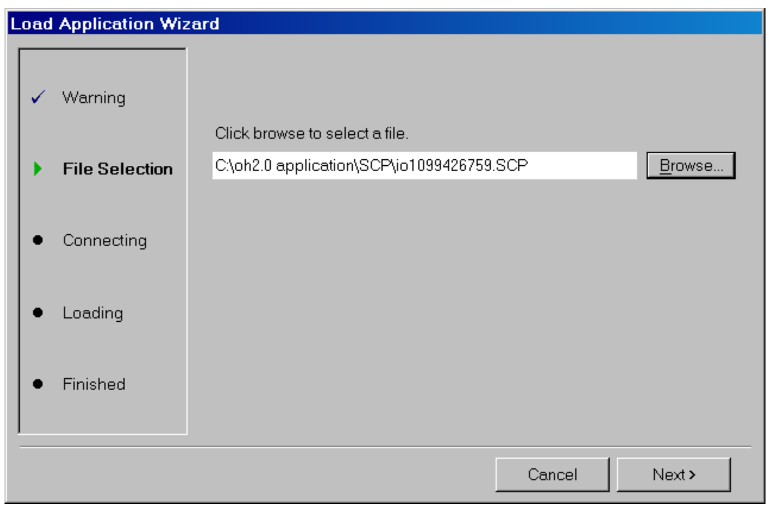
⚠WARNING	**The engine must be shut down prior to starting download of a new application.**

Download the Application File

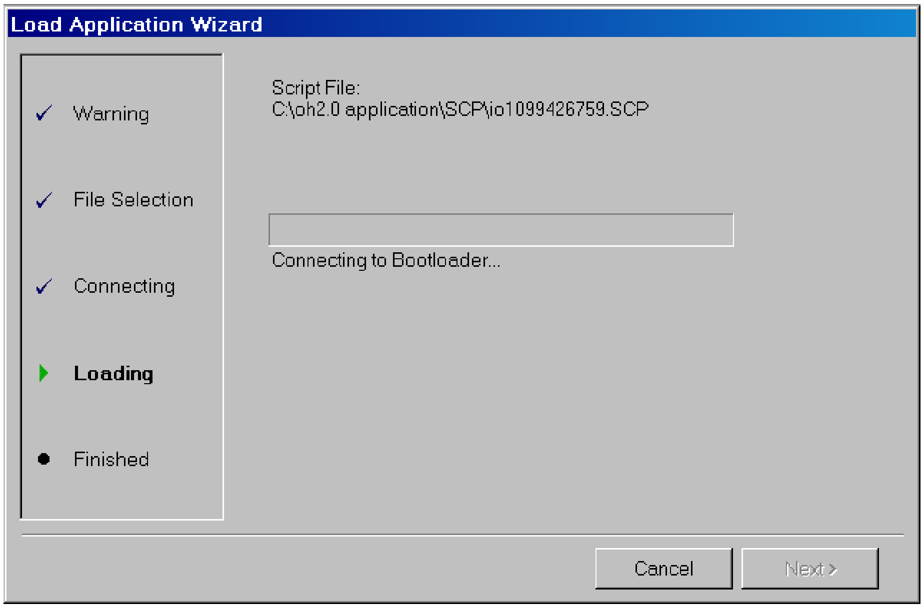
1. Select the option Load Application from the File menu.



2. A warning screen will ask that the user make sure the prime mover is shut down before downloading. When the warning screen has been addressed by clicking Next >, the application file (SCP) to load into the ECM3 must be selected.

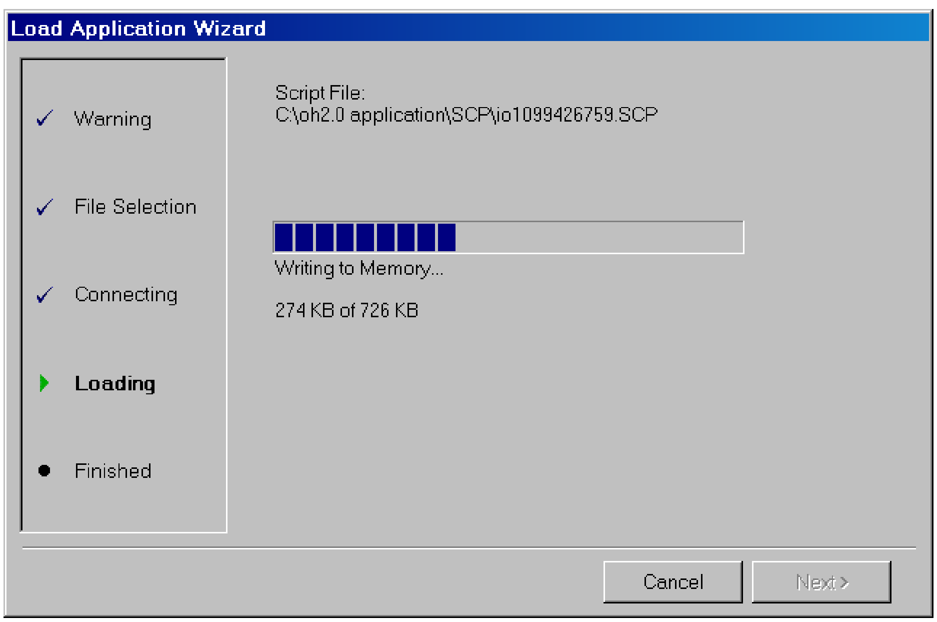


3. Once the file is selected, click Next > to begin the download. The ECM3 will automatically reboot and start a boot loader to accept the new program.



After the new connection is established (automatically) the new application download will begin. A progress meter indicates the download status.

The download should not be interrupted or canceled. If it is, there will be no valid application in the ECM3. Another attempt to download will be possible, but the previous application version will not be available for use.



4. When downloading is complete, the control will reboot automatically. When reboot is completed, the control will begin execution of the new application program.
5. After downloading an application, the user may desire to reload the application settings (if applicable). See the online help in Toolkit for instructions on using settings files.

⚠WARNING **Be sure the engine is shut down before downloading. Damage to the engine or other serious problems can result if the engine is running during the download procedure.**

Using Toolkit

Here are brief instructions for using the Toolkit to view and tune the variables for your ECM3. These instructions are meant to be introductory. Full on-line help is available in Toolkit.

There are three basic types of control parameters within Toolkit. These are:

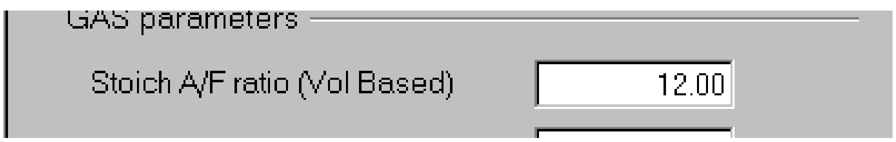
- Non-adjustable parameters
- Adjustable parameters
- Adaptive parameters

Non-adjustable Parameter

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.

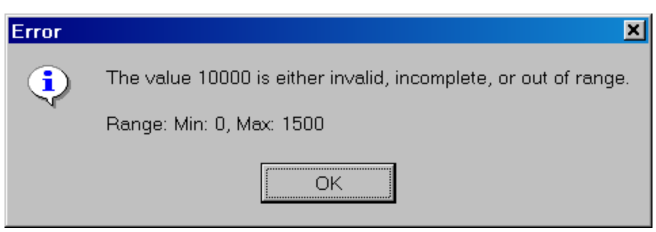
Adjustable Parameter

Adjustable control parameters come in three types: calibration, tunable, and configurable. These three types of adjustable parameters appear the same. 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.



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. This sample parameter has a minimum limit of 100 and a maximum limit of 800.

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



When a value is modified the change immediately takes effect in the control. To save the changes permanently, select Save Values from the Device menu.

A configurable parameter is a special type of parameter that is changed but not used until the next reboot. When the ECM3 is rebooted, the new value will take effect.

Adaptive Parameter
The third type of control parameter is an adaptive point. This is a special tunable that can be modified by the control software and the user simultaneously.

Watch Window Software Instructions

Opening Communications with the ECM3

Initial ECM3 Communications

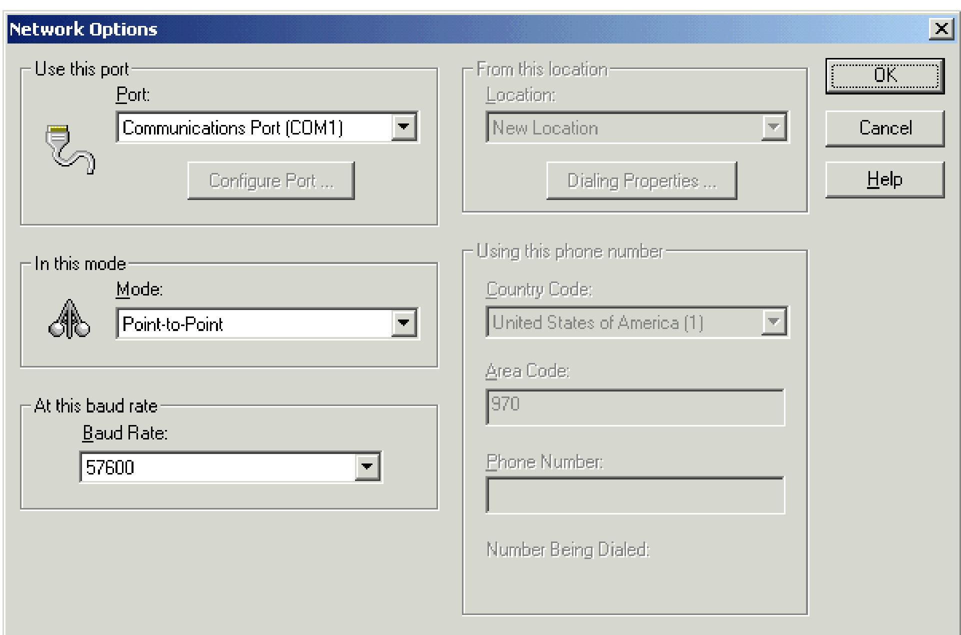
Before communications can begin between the Watch Window software and the ECM3, a Network Definition file must be created. Once this file is created and saved, it never has to be recreated unless a new GAP application program is installed.

Create the Network Definition File

1. Make sure that all other programs that may access your computer's communication port are shut down and you know which comm port the control is located on.
2. Start the ServLink software by selecting Start> Programs> Woodward> Watch Window Professional (or Watch Window Standard)> ServLink Server on the PC. Then select File> New on the ServLink dialog window. In the dialog window (shown below) select the proper COM port for your computer, select POINT TO POINT communications mode, and set the baud rate to 38400. This is the factory default baud rate. If the control has been re-programmed after leaving the factory, the user may need to contact the entity that supplied the new program to determine the correct baud rate.

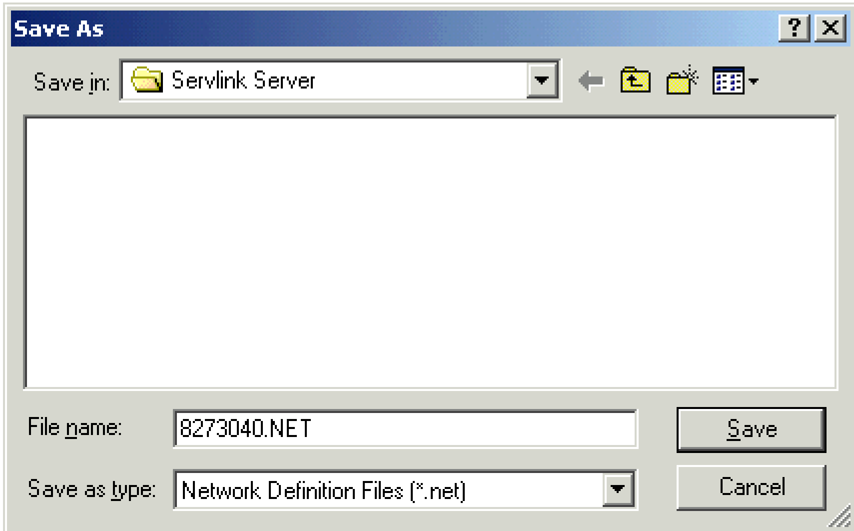
IMPORTANT

If a previous download activity was interrupted before completion of the download, the control will have no installed program. In this instance, after the control is reset and the boot-up period has elapsed, the control will continuously scan COM1 port at 57600 and 115200 baud looking for a connection to ServLink. The user may have to hit <Retry> a few times until the control and ServLink baud rates are matched and communications are established.

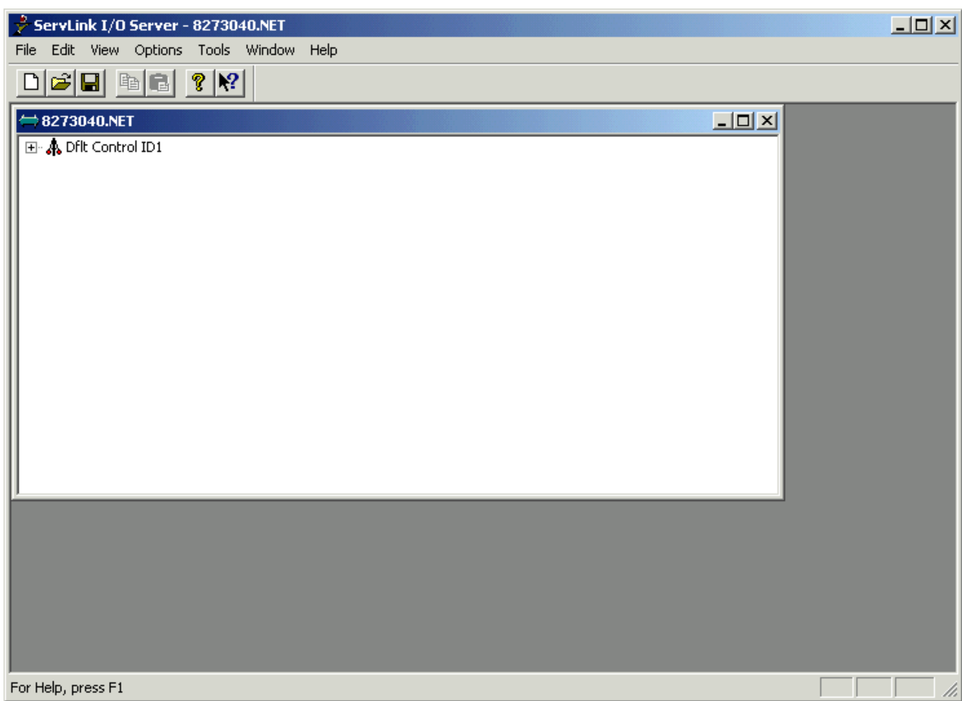


3. Select OK. If everything is working correctly there will be an animated graphic of a string of "1"s and "0's flying from the control to the PC on the screen. Once this transfer is completed, a Network Definition file whose default name is NET1.NET will have been generated. This file should be saved by using the 'File> Save As' feature on the PC. Link this name to the control part number since it will

only work with that application. For example, if the control part number is 8273-040, one can save the Network Definition file as 8273040.NET. See example below. Do not disconnect the server.



4. In the ServLink window there will be another dialog window entitled “your filename.NET”. Unless the user has given the control a serial number (or name) with the SLSN.EXE program, this name will display as “<unidentified>”. The user should note this name. See example below.



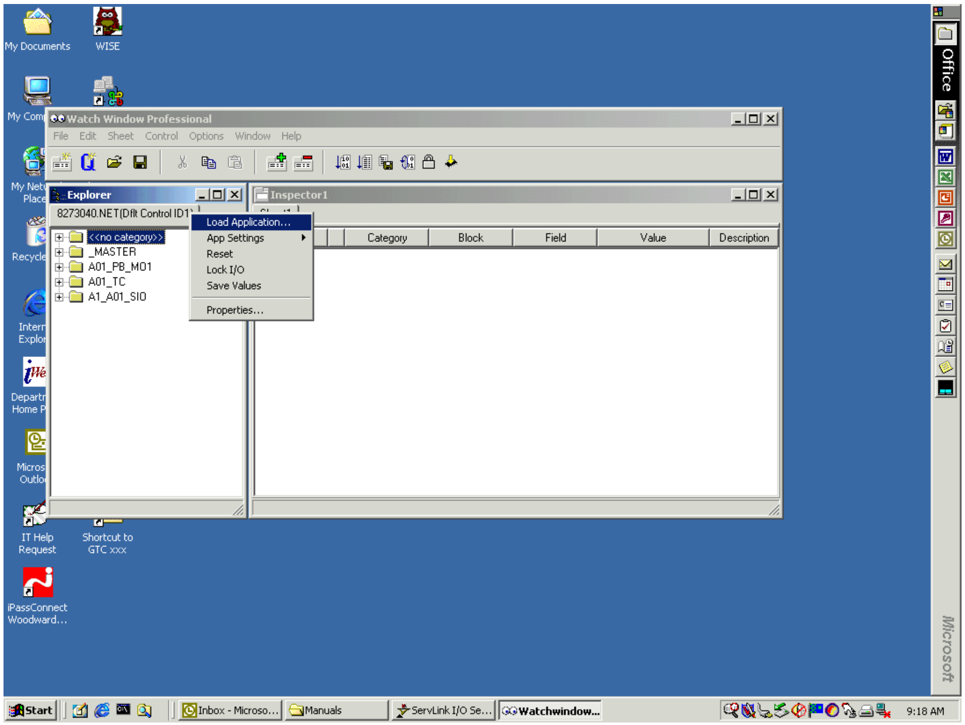
Downloading the GAP Application Code

The ECM3 may be shipped from the factory with a default GAP program. In order to download a new GAP-generated application program it is necessary to use the Watch Window Professional service tool. The following steps are required for this program downloading process.

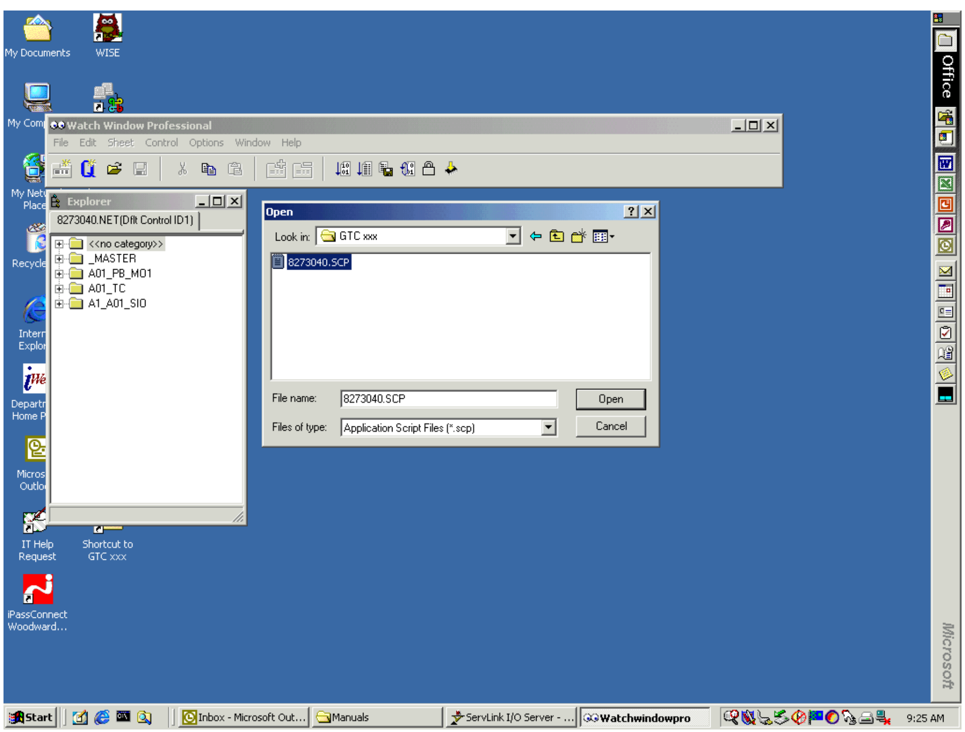
Download the Application File

1. Start the Watch Window program by selecting Start> Programs> Woodward> Watch Window Professional> Watch Window Professional on the PC. It will ask for a .NET file that corresponds with the application in the control. Open the previously saved file. Under the title bar in the Explorer section of the screen, a tab with the Network Definition filename and the Control ID will be displayed.

Right click on this tab to display a pop-up menu and select LOAD APPLICATION. See example screen below.



2. Once the Load Application selection has been made, the Inspector window will close and a new window will appear. In this new window the user enters the name of the file that is to be downloaded into the control. Once the filename is correct, click on the Open button. See example below



3. A warning screen will ask that the user make sure the prime mover is shut down before downloading. When the warning screens have been addressed, the downloading will commence automatically. This may take several minutes depending on the size of the application. When

downloading is complete, the control will reboot automatically. When reboot is completed control will begin execution of the new application program. All associated settings, actuators etc. must be ready to execute the new software.

4. At the end of the download process, an Information window will appear in Watch Window (see below) to alert the user to the fact that a new Network Definition file must be created that matches the new program that has been downloaded. The same procedure that was used initially to create a Network Definition file can be used again.

WARNING **Be sure the engine is shut down before downloading. Damage to the engine or other serious problems can result if the engine is running during the download procedure.**

Using Watch Window

Here are brief instructions for using the Watch Window in conjunction with ServLink to view and tune the variables for your ECM3. These instructions are meant to be introductory. Full on-line help is available in each application. It is assumed that you already have ServLink and Watch Window installed. The default installation location can be found by clicking the START icon (Microsoft Windows 95 or later) on the main menu bar and then clicking the PROGRAMS menu item. Look for an icon called WOODWARD WATCH WINDOW.

1. Make sure that all other programs that may access your computer communications port are shut down and you know the communication port connected to the control.
2. Start the ServLink server and open a new file. Select the proper COM port for your PC, verify that POINT TO POINT communications mode is selected, and verify that the baud rate matches the baud rate of the ECM3 control. See the on-line help file if you have been changing the port settings of your control.
3. Select OK. If everything is working right, you should see an animated picture of a string of “1”s and “0”s flying from the control to the PC on your screen. You now have a network definition file whose default name is NET1. You should save this file as “your filename.net” (use FILE/SAVE AS). Link this name to your control part number since it will work only with that application. For instance, if the upper level control number is 8273-040, you could save the file as 8273040.NET. Do not disconnect the server.
4. In the ServLink window you will now have another dialog window titled “your filename.net”. In this window you will see a ballhead icon and a control identifier name. Unless you have given the control a serial number (or name) with the SLSN.EXE program, this name will display as “<unidentified>”.
5. Start the Watch Window application. When Watch executes, you will have a screen displaying three windows entitled Watch Window, Explorer, and Inspector.
6. The Explorer window will have two groups displayed, SERVICE and CONFIGURE. Double clicking on either of these will expand them to show groups of values. Explorer is used only to locate a tunable or monitor value. In order to change a value or monitor a value, you must drag and drop a value from the Explorer window into the Inspector window.
7. Once a value is displayed in the Inspector, you can see several blocks of information. The most important blocks for a tunable value are the FIELD and VALUE blocks. The FIELD block is used to identify a particular value, and the VALUE block displays the current value of a variable. There are two types of values available in Watch. One is a monitor value, which is marked in the INSPECTOR window with a pair of glasses. This means it may only be looked at. The other value is a read/write value, which is marked with a pencil. The read/write type may be modified using the up and down arrows in the value block.

Chapter 5.
Speed and Position Sensing

The ECM3 has a total of 3 inputs that can be used for speed sensing for a variety of purposes. The following sections will explain the options.

Speed Sensing for Fuel Injection

The fuel injection algorithms need to know the engine speed and position relative to a known reference. This is necessary in order to schedule the fuel injections for each cylinder. Both 2-cycle and 4-cycle engines are possible.

In the drawings below the gray symbol is for a TDC or Phase sensor and indicates that the sensor used MUST be a proximity sensor. It cannot be an MPU. The black symbol for a Speed sensor indicates that either a MPU or a Proximity sensor may be used.

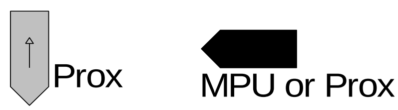


Figure 5-1. Sensor Symbol Key

2-Cycle Engine

In this application, both speed and Top Dead Center (TDC) of cylinder #1 are needed. Speed and (TDC) can be provided by one or two sensors.

GAP Options in EFI_CORE block
PATTERN 1 = Teeth on Crank, TDC on Crank pin for 2 Cycle
PATTERN 4 = Missing Tooth on Crank for 2 Cycle

Table 5-1. 2-Cycle Sensor Application Options

Usage	Location	Sensed Element	Sensor Type	Pattern
Speed	Crankshaft	Flywheel with 60+ teeth	MPU or Prox	1, 4*
TDC	Crankshaft	Single pin	Prox	1
	Crankshaft	Flywheel with 60+ teeth and a missing tooth	MPU or Prox	4*

(*) Pattern 4 uses one sensor. Both measurements are made with the same sensor.

If a two-sensor system is to be used, the speed sensor should be located on the crankshaft flywheel. This provides the largest sensing wheel with the most teeth and no gear train movement to affect the speed accuracy. A minimum of 60 teeth is required on the flywheel to maintain the desired fuel injection accuracy. All fuel injection scheduling is performed based on the flywheel speed sensor teeth.

The second sensor is used to pick up a single tooth (or pin) that represents TDC for cylinder #1. The sensor does not need to be located exactly at the TDC point. A software offset is available to compensate for actual sensor location. The sensor may be located to detect a pin on the crankshaft flywheel or it can be located to detect a tooth or pin on a camshaft gear (not shown – still illustrated by pattern 1). The TDC indication is used to reset the tooth count from the crankshaft speed sensor. The next fuel injection event, after this reset, causes the control to start over again with injection output #1.

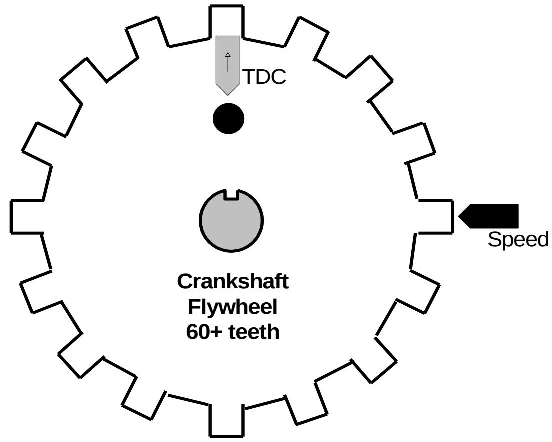


Figure 5-2. Pattern 1

If a single-sensor system is to be used, a gear wheel on the crankshaft is preferred so that gear train movement can be eliminated. A minimum of 60 teeth is required on the gear to maintain the desired fuel injection accuracy. A single missing tooth on the gear is used to indicate TDC. The first tooth after the missing tooth will be the TDC point. As with pattern 1 above, the actual location of TDC can be different from the missing tooth. The same software TDC offset used for pattern 1 above can be used in this scenario as well. This option is represented below as pattern 4.

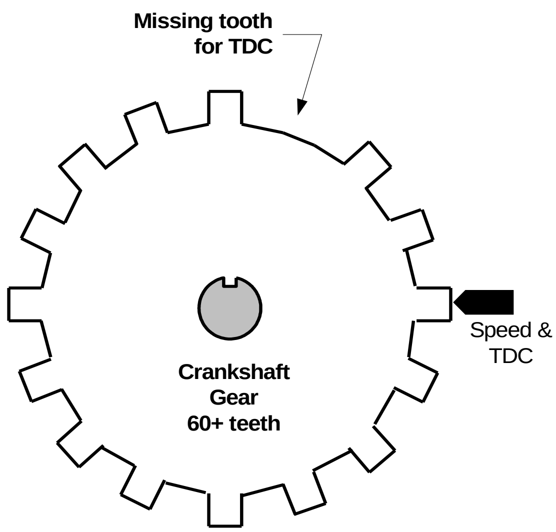


Figure 5-3. Pattern 4

2-Cycle Engine – Redundant Sensors

If either the speed sensor, the TDC sensor, or the wiring to either sensor fails, the engine will be stopped because fuel injection is no longer possible. However, redundant sensors can be used to avoid engine shutdown in critical applications where it is very undesirable to unexpectedly stop the engine. In these applications it is preferred to have a backup for Speed and TDC sensing.

When redundancy is used, the sensors are grouped. Either of the above patterns may be used for the primary group. The primary group is the group that will be used by default. If any one sensor in the primary group fails, the ECM3 will switch over to the backup sensor group. Again, either of the above patterns may be used for the backup group. It is not necessary to use the same pattern type for the primary and the backup groups. No sensor can be shared between groups. A switchover delay of up to one engine cycle may occur before the backup sensor group can be used.

Because there are only 3 inputs available for EFI speed sensing, one of either the primary or the backup group must use pattern 4.

4-Cycle Engine

In this application, both speed and Top Dead Center (TDC) of cylinder #1 are needed as well as the engine phase. This can be provided by one, two, or three sensors. Engine phase must provide the beginning of the combustion cycle for cylinder #1.

GAP Options in EFI_CORE block
PATTERN 2 = Teeth on Crank, TDC on Crank pin, Phase on Cam pin for 4 Cycle
PATTERN 3 = Teeth on Crank, TDC on Cam pin for 4 Cycle
PATTERN 5 = Missing Tooth on Cam for 4 Cycle
PATTERN 6 = Missing Tooth on Crank Phase on Cam pin for 4 Cycle
PATTERN 7 = Missing Tooth on Crank Phase on Missing Tooth on Cam for 4 Cycle
PATTERN 8 = Teeth on Crank, TDC on Crank pin, Phase on Missing Tooth on Cam for 4 Cycle
PATTERN 9 = Teeth on Crank, TDC from Missing Tooth on CAM for 4 Cycle

Table 5-2. 4-Cycle Sensor Application Options

Usage	Location	Sensed Element	Sensor Type	Pattern
Speed	Crankshaft	Flywheel with 60+ teeth	MPU or Prox	2, 3*, 8, 9††
	Crankshaft	Flywheel with 60+ teeth and a missing tooth	MPU or Prox	6†, 7†
	Camshaft	Gear with 120+ teeth and 1 missing tooth	MPU or Prox	5**
TDC	Crankshaft	Single pin	Prox	2, 8
	Crankshaft	Flywheel with missing tooth	MPU or Prox	6†, 7†
	Camshaft	Single tooth or pin	Prox	3*
	Camshaft	Multi-tooth gear with missing tooth	MPU or Prox	5**, 9*
Phase	Camshaft	Single tooth or pin	Prox	2, 3*, 6†
	Camshaft	Multi-tooth gear with missing tooth	MPU or Prox	5**, 7†, 8, 9††

(*) Pattern 3 uses two sensors total. Both TDC and phase measurements are made with the same sensor.
(**) Pattern 5 uses a single sensor. All measurements are made with the same sensor.
(†) Pattern 6 and Pattern 7 use two sensors total. Both speed and TDC measurements are made with the same sensor.
(††) Pattern 9 uses two sensors total. Both TDC and phase measurements are made with the same sensor.

If a three-sensor system is to be used, the speed sensor should be located on the crankshaft flywheel. This provides the largest sensing wheel with the most teeth and no gear train movement to affect the speed accuracy. A minimum of 60 teeth is required on the flywheel to maintain the desired fuel injection accuracy. All fuel injection scheduling is performed based on the flywheel speed sensor teeth.

The second sensor of a three-sensor group is used to pick up a single pin that represents TDC for cylinder #1. The sensor does not need to be located exactly at the TDC point. A software offset is available to compensate for actual sensor location.

The third sensor of a three-sensor group is used to pick indicate the engine Phase. One of two options is available. The sensor may be located to detect a tooth or pin on a camshaft gear (pattern 2) or the sensor may be located to detect a missing tooth on a camshaft gear (pattern 8). This sensor is used to reset the tooth count from the crankshaft speed sensor. The next fuel injection event after this reset starts over again with injection output #1. The sensor does not need to be located exactly at the TDC point for the engine phase. A software offset is available to compensate for actual sensor location. These options are represented below as patterns 2 and 8.

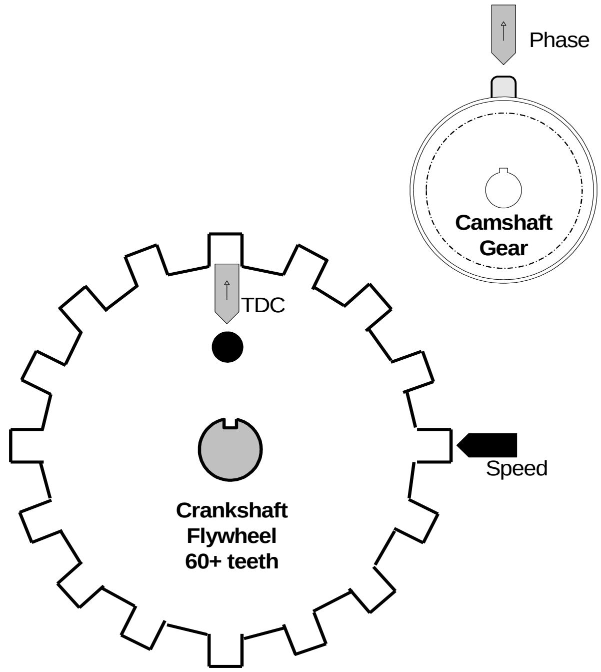


Figure 5-4. Pattern 2

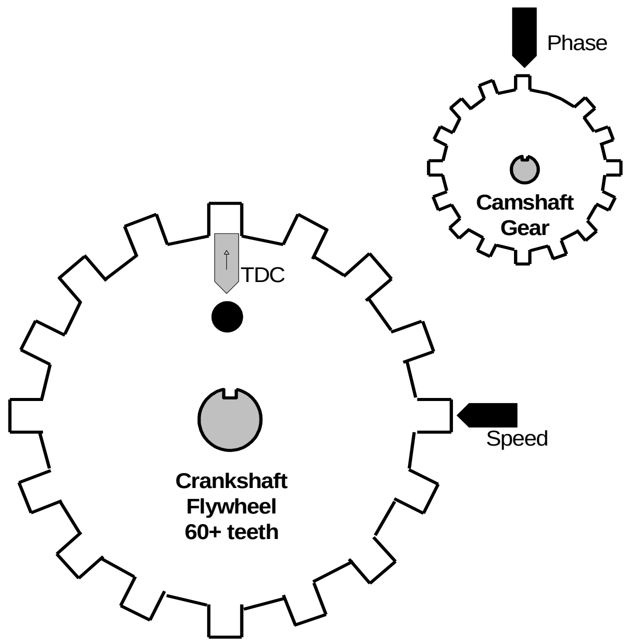


Figure 5-5. Pattern 8

Many varieties of two-sensor system are possible. In all cases, speed is measured from a sensor located on the crankshaft flywheel. This provides the largest sensing wheel with the most teeth and no gear train movement to affect the speed accuracy. A minimum of 60 teeth is required on the flywheel to maintain the desired fuel injection accuracy. All fuel injection scheduling is performed based on the flywheel speed sensor teeth.

A second sensor is located on a camshaft gear. This sensor is used to detect engine Phase. A single tooth or pin can be used to provide the engine phase detection (patterns 3 and 6). Alternatively, a missing tooth gear wheel can be used where the missing tooth indicates the engine phase (pattern 7). The next fuel injection event after this reset starts over again with injection output #1. The sensor does not need to be located exactly at the TDC point for the engine phase. A software offset is available to compensate for actual sensor location.

If the crankshaft flywheel has a missing tooth to represent TDC, then the TDC indication will be done with the speed sensor (patterns 6 and 7). However, if TDC cannot be done via the speed sensor, it will be done via the Phase sensor regardless of what the sensor uses to detect phase (patterns 3 and 9). When the engine phase sensor must provide TDC information, the software will only be aware of TDC for cylinder #1 ever other time it happens (at the beginning of a combustion cycle). No matter how TDC is detected, a software offset is available to compensate for actual sensor location.

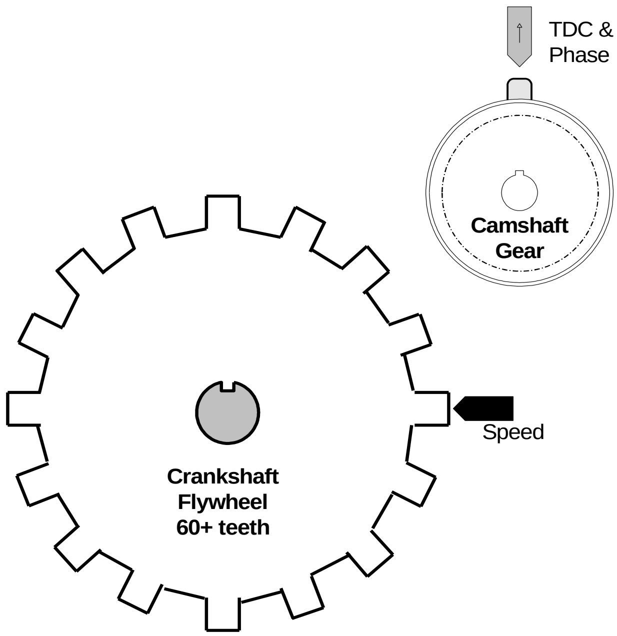


Figure 5-6. Pattern 3

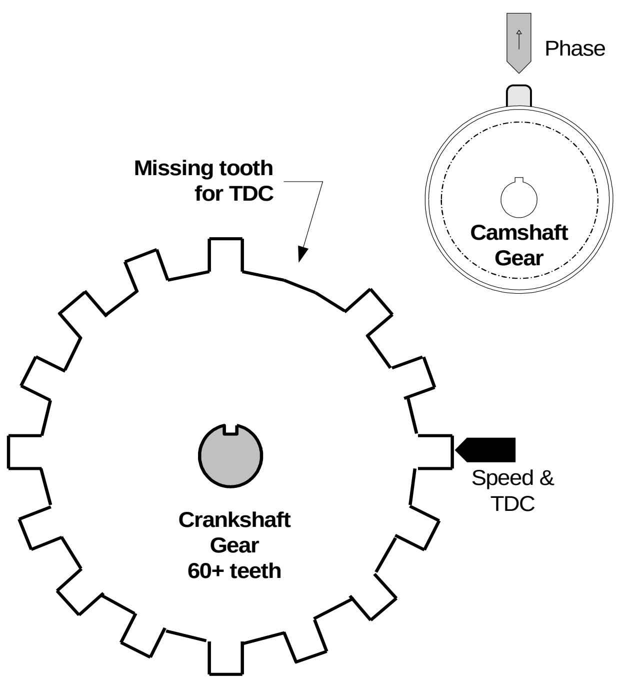


Figure 5-7. Pattern 6

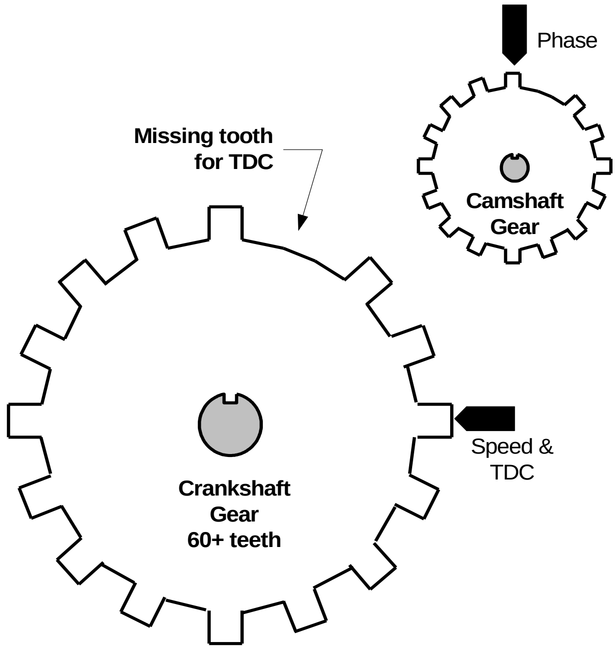


Figure 5-8. Pattern 7

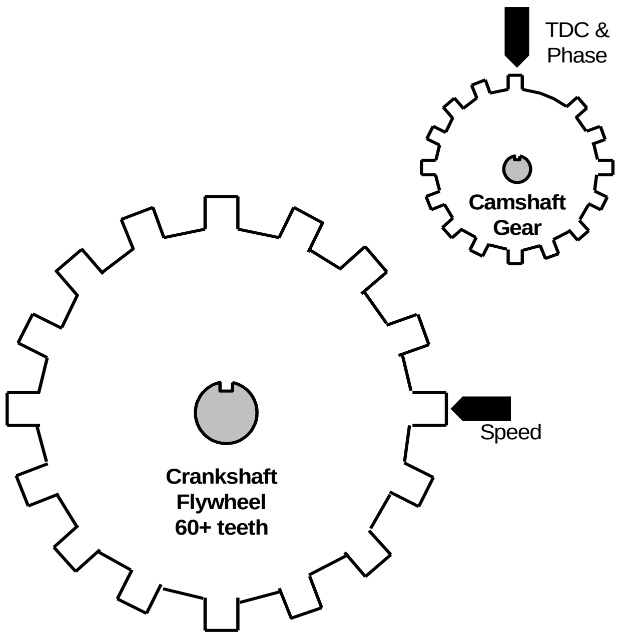


Figure 5-9. Pattern 9

If a single-sensor system is to be used, a gear wheel on the camshaft is the only choice. A minimum of 120 teeth is required on the gear to maintain the desired fuel injection accuracy. A single missing tooth on the gear is used to indicate both TDC and engine Phase. The first tooth after the missing tooth will be the TDC/Phase point. As with other patterns, the actual location of TDC can be different from the missing tooth. A software offset is used to adjust the location. This option is represented below as pattern 5.

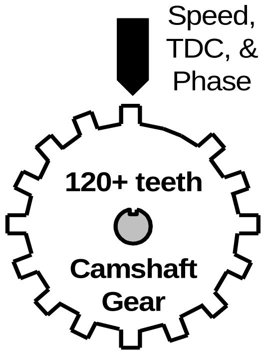


Figure 5-10. Pattern 5

4-Cycle Engine – Redundant Sensors

If either the speed sensor, the TDC sensor, the engine Phase sensor, or the wiring to one of these sensors fails, the engine will be stopped because fuel injection is no longer possible. However, redundant sensors can be used to avoid engine shutdown in critical applications where it is very undesirable to unexpectedly stop the engine. In these applications it is preferred to have a backup for Speed, TDC, and Phase sensing.

When redundancy is used, the sensors are grouped. Any of the above patterns may be used for the primary group. The primary group is the group that will be used by default. If any one sensor in the primary group fails, the ECM3 will switch over to the backup sensor group. Again, any of the above patterns may be used for the backup group given the limitation of 3 total sensor inputs. It is not necessary to use the same pattern type for the primary and the backup groups. No sensor can be shared between groups. A switchover delay of up to one engine cycle may occur before the backup sensor group can be used.

Chapter 6
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. Connector Information

The ECM3 is not shipped with mating connectors because many applications may have a standard wiring harness, or it is desirable to have the mating connectors in advance for wiring harness wiring. However, for service and convenience, Woodward also carries an ECM3 connector kit that contains all of the mating terminal blocks used on the ECM3.

A single kit provides all the necessary parts for the ECM3. The kit part number is 8928-7138. Contents of the kit include:

- J1 mating connector
- J2 mating connector
- J3 mating connector
- J4 mating connector
- 220 hand crimp sockets for 16–18 AWG (1.0–0.75 mm^2) wire
- 8 hand crimp sockets for 14–18 AWG (2.0–1.0 mm^2) wire
- 1 removal tool
- 50 sealing plugs for all unused terminals

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 Deutsch.

Table A-1. Deutsch Harness Component Part Numbers

Component	Part Number	Notes
J4 Mating Connector	DT06-08SA	Key A, 8 sockets
J4 Mating Connector Locking Wedge	W8S	For J4 only
Sealing Plugs in Bulk	114017	Suitable for all connectors
14–18 AWG (2.0–0.75 mm^2) Stamped Terminals on a Reel	1062-16-0722	Suitable for all connectors
Automated Production Crimping Tool	HDP-400	For mating connector stamped terminals on a reel
Removal Tool	0411-204-1605	

The 70-pin connectors must be purchased through Woodward. Woodward part numbers are:

- J1 mating connector: 1635-1442
- J2 mating connector: 1635-1443
- J3 mating connector: 1635-1444

The sealed connectors on the ECM3 are not designed for removal by hand. After input power is disconnected, the connectors can be removed using a 4 mm Allen head driver. When reinstalling the connectors, use 6.0 ±0.1 N·m (53.1 ±0.9 lb-in) torque for the jackscrew. Using the correct torque is required to both 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. In practice, we have found that it is necessary to use the correct crimping tool to avoid damaging the terminals and to get a good crimp. The hand crimping tool is available from Woodward as part number 8992-557.

Individual wires can be removed using an extraction tool. If a wire must be removed from the connector, a removal tool is necessary to avoid damage to the connector. One extraction tool (8996-2084) is provided with each connector kit. Using the wrong removal tool will very likely result in damage to the internal connector retaining clip. Insert the tool and twist about 90 degrees then pull the wire and tool out together.

Each wire seals within the connector body individually to protect against dust and water intrusion into the connector. In order to make a proper seal, the wire insulation diameter on the 70-pin connectors must be between 2.26 and 3.94 mm (0.089 and 0.155 inch). Likewise, the wire insulation diameter on the 8-pin power connector must be between 2.24 and 3.68 mm (0.088 and 0.145 inch).

Recommended Wire Size and Types

The Society of Automotive Engineers (SAE) has a standard for on-engine cabling called J1128. It covers many wire sizes and types. For individual wiring, the TXL, GXL, and SXL wire types are common. TXL is Thin Wall, Cross Linked Polyolefin Insulated and has the thinnest insulation. GXL is General Purpose, Cross Linked Polyolefin Insulated and has a medium size insulation thickness. SXL is Special Purpose, Cross Linked Polyolefin Insulated and has a very thick insulation layer. Each type has different characteristics. In relation to the connector on the ECM3, the important characteristic difference between these cable types is the insulation thickness.

The 70-pin connectors accept wire sizes of 14–18 AWG (2.0–0.75 mm^2). In order to seal properly within the connector, the wire insulation diameter must be greater than 2.26 mm (0.089 inches) but less than 3.94 mm (0.155 inches).

The 8-pin power connector should always be used with a 14 AWG (2.0 mm^2) wire size. In order to seal properly within the connector, the wire insulation diameter must be greater than 2.24 mm (0.088 inches) but less than 3.68 mm (0.145 inch). SXL, GXL, and TXL wire all fit within this range for 14 AWG wire.

Table A-2. Wire Sizes

Gauge (AWG)	Type	Use
14	TXL, GXL or SXL, stranded, unshielded	Power supply inputs
16–18	GXL or SXL, stranded, unshielded	Discrete I/O
16–18	Two- conductor, shielded	4–20 mA, MPU, Prox, PWM, injectors
16–18	Two- or three-conductor stranded, twisted, shielded, 100 Ω impedance	RS-232 RS-485
16–18	Two-by-two conductor stranded, twisted, shielded, 121 Ω impedance	CAN

Wire Gauge—AWG to Metric Comparison

Table A-3 is intended as a guide for determining the wire size that will fit into the ECM3 connector(s). The wire size must also be evaluated for the maximum current rating for each connection. Most places in this manual refer to various AWG sizes as being equal to common metric sizes. For example, 18 AWG is noted the same as 0.8 mm^2. Though they are not exactly the same physical sizes, their use is interchangeable.

Table A-3. Wire Gauge Comparison

Circ. Mils	Equivalent Circ. Mils	AWG Size	Metric Wire Size mm^2	Stranding/ Wire Dia. per Strand		Approximate Overall Copper Diameter	
				in	mm	in	mm
1620	—	18	0.8	1 / 0.0403	1 / 1.02	0.040	1.02
1620	—	18	0.8	7 / 0.0152	7 / 0.386	0.046	1.16
—	1974	—	1.0	1 / 0.045	1 / 1.14	0.045	1.14
—	1974	—	1.0	7 / 0.017	7 / 0.432	0.051	1.30
2580	—	16	—	1 / 0.0508	1 / 1.29	0.051	1.29
2580	—	16	—	7 / 0.0192	7 / 0.488	0.058	1.46
—	2960	—	1.5	1 / 0.055	1 / 1.40	0.055	1.40
—	2960	—	1.5	7 / 0.021	7 / 5.33	0.063	1.60

Appendix B.
Commissioning Procedure

The procedures below relate specific block input and output names for clarity. A specific customer application may use different names for the same functions due to inclusion of interface blocks. This procedure should be re-written by the engineer who creates the customer specific application in order to be appropriate documentation.

Control I/O Commissioning

In order to verify correct installation wiring and safe starting and stopping capability, it is necessary to check all control I/O functionality.

Verify wiring using current injection, digital multi-meters, visual inspection, and any other means necessary. Verify wiring polarity as well.

Verify that each output point is connected to the correct device by using test modes in the software and verifying correct actuator / relay movement.

Verify that each input point is connected to the correct device by using current or voltage injection in place of the devices for analog and digital inputs. Communications networks will require special communications equipment to validate.

EFI Valve Commissioning

Refer to Woodward Application Note 51275, *In-Pulse II and ECM3 Engine Commissioning Procedure*.

Appendix C. Proximity Sensors

Table C-1. Proximity Sensor Specifications

Type	Active, near zero speed, input voltage following
Operating Voltage Range	6–28 Vdc
Normal Operating Current	16 mA
Frequency Range	0.2–20 kHz
Output Impedance	200 Ω typical
Mis-wiring Protection	Protected from damage for any combination of the 3 wires incorrectly connected
Air Gap	0 to 0.030 typical for 20 pitch gear 0 to 0.100 typical for 8 pitch gear Where air gap is optimized based on tooth thickness 1.5708/dp and dp (diametral pitch) is (number of teeth+2)/od
Logic	No tooth = +300 mV max at output Tooth present = approx. Supply Voltage at output
Temperature Range	–40 to +105 °C (–40 to +221 °F)
Material	Stainless steel Sensor is sealed and potted internally making it oil and moisture resistant

- Transient voltage protection for CE and marine spec levels provided internally.
- The connector on the sensor mates with Woodward part number 1631-002 (MS3106A-10SL-3S).

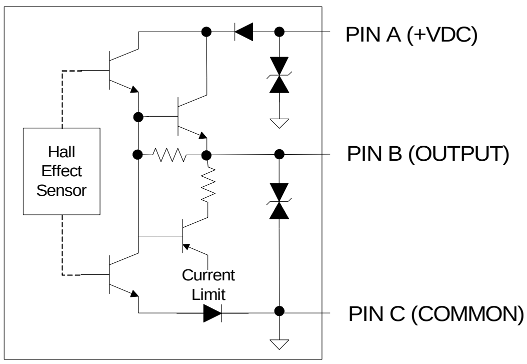


Figure C-1. Prox Sensor Schematic

Metric Proximity Sensor

Woodward part number: 1689-1056

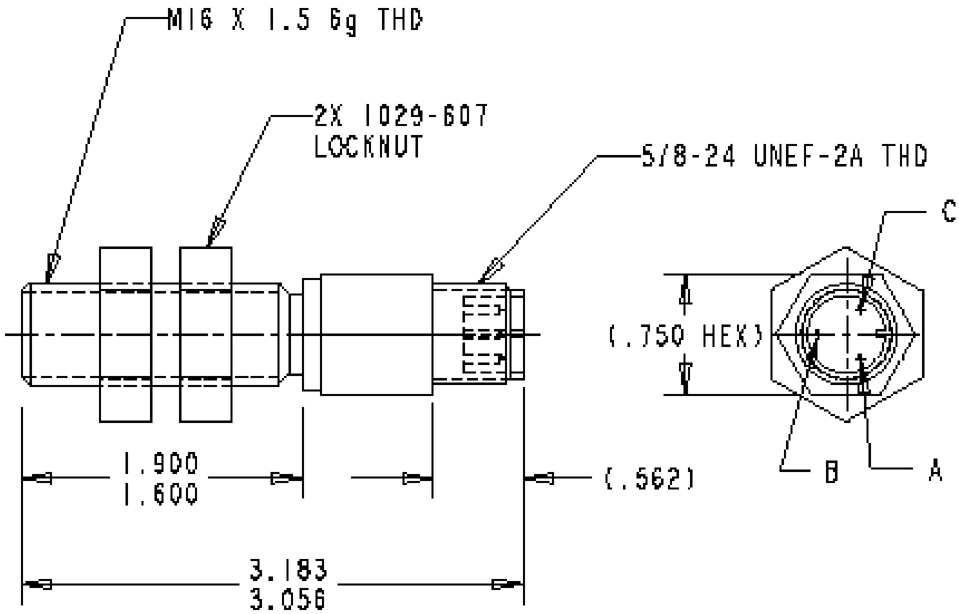


Figure C-2. Metric Proximity Sensor

SAE Proximity Sensor

Woodward part number: 1689-1058

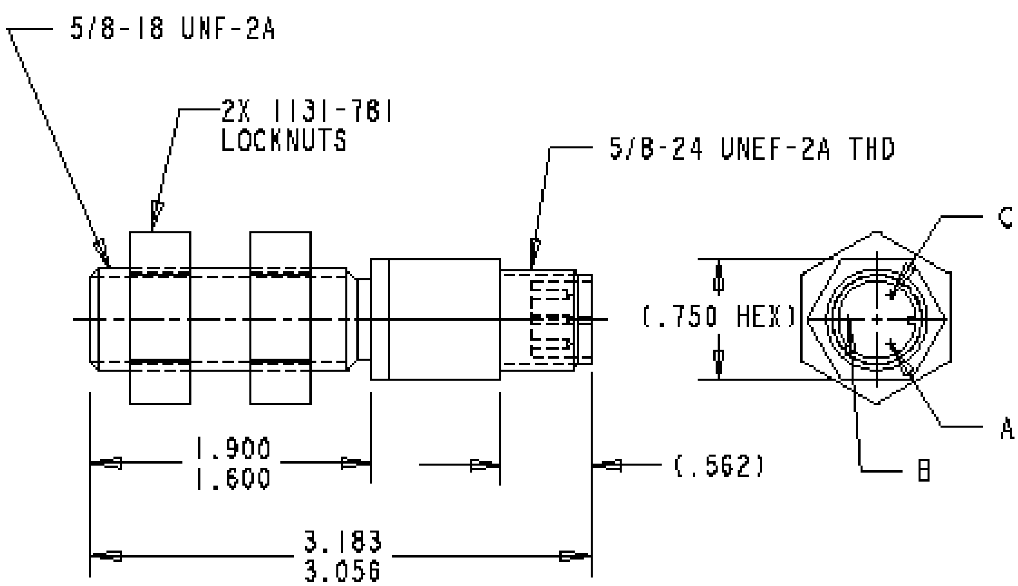


Figure C-3. SAE Proximity Sensor

Appendix D
Technical Specifications

Table D-1. ECM3 Control Specifications

	Input Power
Voltage	18–32 Vdc (24 Vdc nominal)
Power Consumption	Application-specific
	Speed Signal Inputs
Speed Input Voltage	Magnetic Pickup: 1.4–70.0 V peak-to-peak Proximity Switch: 5–28 Vdc
Speed Input Frequency	10 Hz to 10 kHz
Proximity Input Duty Cycle	10–90% to 10 kHz
	Discrete Inputs
Type	2 inputs configurable for PWM or Boolean 14 inputs are dedicated Boolean inputs
Discrete Input Type	Sinking with internal pull-up
Impedance	15 kΩ for Boolean inputs 40 kΩ for PWM inputs
PWM Frequency/Duty Cycle	100 Hz to 2 kHz; 10–90% duty cycle
	Analog Inputs
Type	0–5 Vdc, 4–20 mA, transducers externally powered
Input Impedance	17.5 kΩ for 0–5 Vdc input 200 Ω for 4–20 mA input
Resolution	10 bits
Accuracy	0.5% of full scale typical (1 sigma) 1.3% of full scale maximum (3 sigma
	Temperature Inputs
Type	Resistive sensor
Input Impedance	1 kΩ
Resolution	10 bits
Accuracy	2% of full scale
	Engine Sensor Inputs
Type	Analog voltage sensor
Input Impedance	51.1 kΩ
Resolution	10 bits
Accuracy	2% of full scale
	Boolean/PWM Outputs
Type	4 outputs configurable as either Boolean or PWM 8 outputs dedicated as Boolean outputs All 12 are isolated outputs sinking to a dedicated return
Max Output Current	500 mA for the first 10 outputs 3 A for the last 2 outputs
PWM Frequency Range	50–1000 Hz (configurable)
	Proximity Probe Power Output
Voltage Level	11 Vdc, isolated
Current Limit	30 mA
	Injector Outputs
Voltage Level	125 Vdc
Current Limit	11 A pull-in (peak current)
Type	Totem pole driver

Table D-1. ECM3 Control Specifications (cont'd.)

Environmental	
Max Operating Temperature	On-engine mounting with application-defined temperature limits
Storage Temperature	–40 to +120 °C (–40 to +248 °F)
Humidity	95% @ +60 °C (+140 °F)
Mechanical Vibration	US MIL-STD 202F, Method 214A, TC(B)
Mechanical Shock	US MIL-STD 810C, Method 516.2, Procedure I
CE Compliant	EMC Directive
Enclosure Protection	IP-66

Revision History

Changes in Revision E—

- Regulatory Compliance
    - Updated EMC Directive to 2014/30/EU specifications
    - Removed ATEX Directive
    - Removed "The ECM3 is suitable for use in European Zone 2, Group II environments per self-declaration to EN 60079-15."
    - Removed reference to European Zone 2 in wiring methods specification
    - Removed Special Conditions for Safe Use sections
- Chapter 2
    - Removed reference to European Zone 2 from WARNING box in Input Power section
- Technical Specifications
    - Removed ATEX Directive (Zone 2, Group II) in Table D-1
- Declaration of Conformity
    - Updated to remove ATEX compliance

Changes in Revision D—

- Updated Regulatory Compliance information and Declarations
- Updated Warnings & Notices section
    - Added IOLOCK warning
- Chapter 2
    - Added installation warnings
    - Updated "IMPORTANT" note
    - Updated shield grounding paragraph
    - Updated bulk capacitance paragraph
    - Corrected Input Threshold "OFF" voltage in Table 2-20
- Chapter 4
    - Added trained personnel warning

Changes in Revision C—

- Chapter 2
    - Added additional severe EMI environment information

Declarations

EU DECLARATION OF CONFORMITY

EU DoC No.:	00330-04-EU-02-01
Manufacturer's Name:	WOODWARD INC.
Manufacturer's Contact Address:	1041 Woodward Way Fort Collins, CO 80524 USA
Model Name(s)/Number(s):	ECM3
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)
Markings in addition to CE marking:	
Applicable Standards:	EN 61000-6-2:2005, EN 61000-6-2:2005/AC:2005: EMC Part 6-2: Generic Standards - Immunity for Industrial Environments EN 61000-6-4:2007, EN 61000-6-4:2007/A1:2011: EMC Part 6-4: Generic Standards - Emissions for Industrial Environments

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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

Dave Petruska

Full Name

Engineering Manager

Position

Woodward, Fort Collins, CO, USA

Place

13-Dec-2021

Date

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We appreciate your comments about the content of our publications.

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Please reference publication 26348.

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