MotoHawk Control Solutions

ECM-S12X-070-1001

Engine Control Module

- 70-pin platform
- Microprocessor: Freescale MC9S12XEP100, 50 MHz
- Memory: 1M Flash, 64K RAM,(13K of the 64K RAM is available to the application)
- + 32K D-Flash, 4K internal EEPROM, 64K serial FRAM
- Operating Voltage: 6.5–16 Vdc, 24 V (jump start), 5 V (crank)
- Operating Temperature: –40 to +85 °C (105 °C possible in some applications)

Inputs:

- 17 Analog
- 1 Oxygen Sensor
- 1 VR or Digital Encoder (Crank)
- 1 Digital Encoder (CAM)
- 1 Digital Frequency (Speed)
- 4 Switch to GND
- 1 E-STOP

Outputs:

- 4 Fuel Injector
- 3 Spark
- 9 Low Side Drivers
- 1 Tach Driver
- 1 Main Power Relay Driver
- 2 Sensor Supply (5 V) Outputs

Communications:

- 2 CAN 2.0B channels
- 1 RS-485 channel

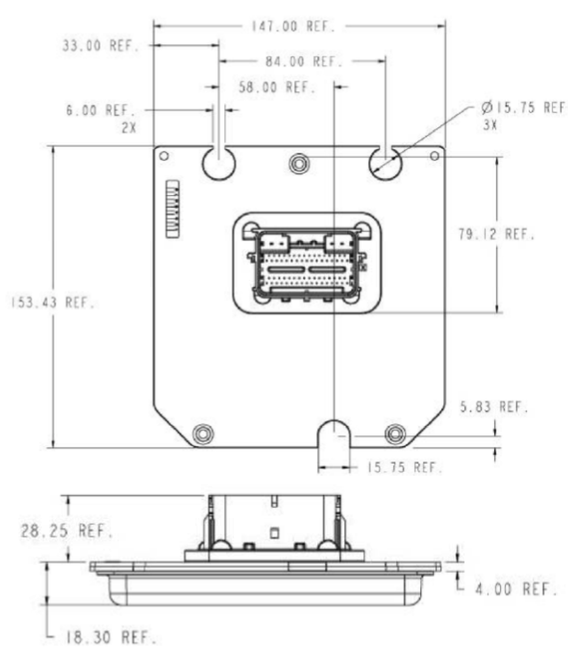
Description

The ECM-S12X-070-1001 Engine Control Module from Woodward's new MotoHawk Control Solutions product line. These rugged controllers are capable of operating in harsh automotive, marine, and off-highway applications. Numerous marine applications have proven the capability of this family. Based on the Freescale MC9S12 family of microprocessors, the ECM-S12X-070-1001 is capable of delivering complex control strategies. The onboard fixed-point unit and high clock frequency allow software to be executed in shorter times. The CAN 2.0B datalink ensures interoperability with other vehicle systems.

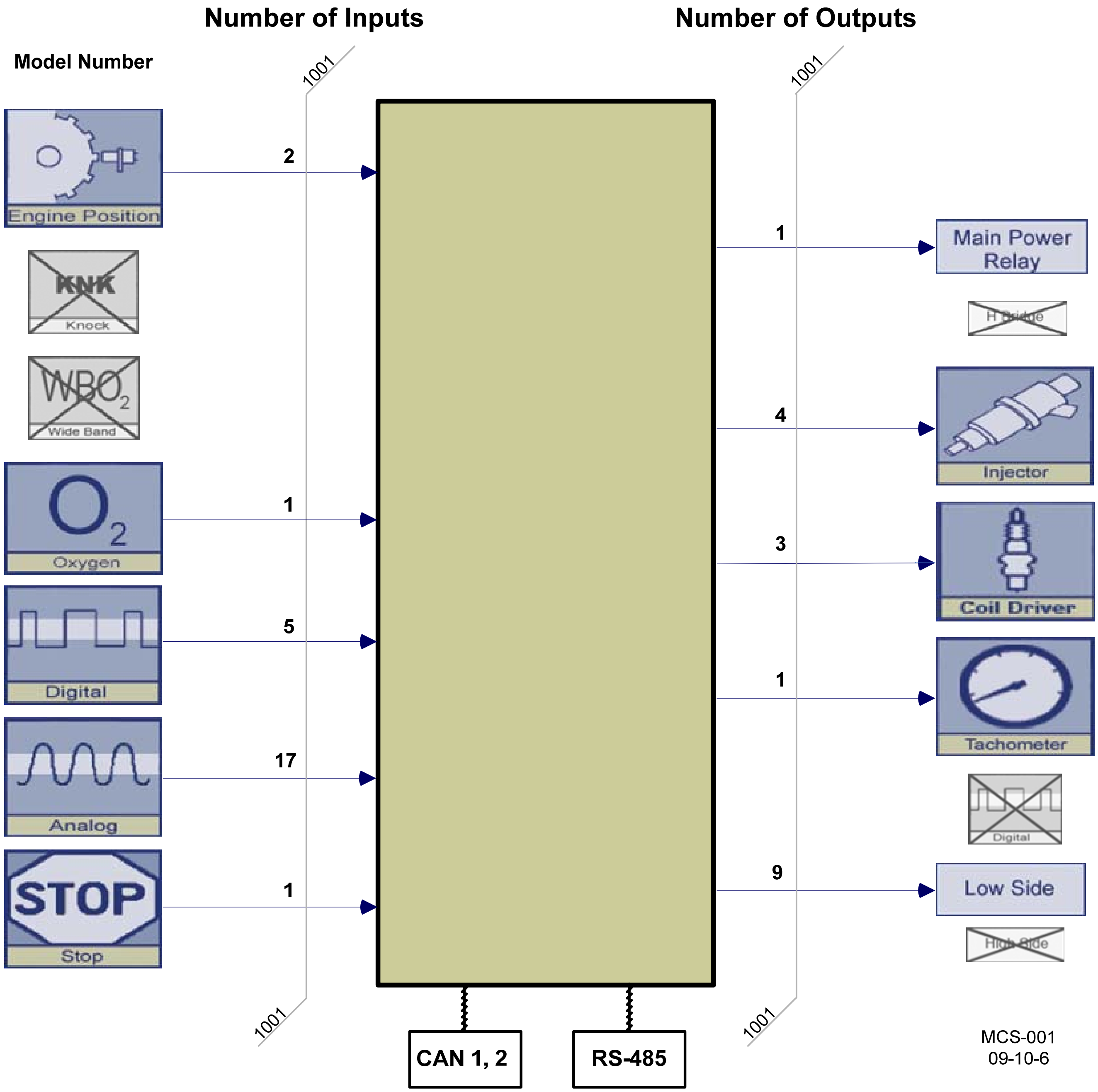
The ECM-S12X-070-1001 is part of the MotoHawk ControlCore® line of embedded control systems. The ControlCore operating system, MotoHawk® code generation product, and MotoHawk's suite of development tools enable rapid development of complex control systems.

This controller is only available in the 'C' (Calibratible) version. This module can be used for either production purposes or for prototyping/development. It can be calibrated in real time using MotoTune®.

Physical Dimensions



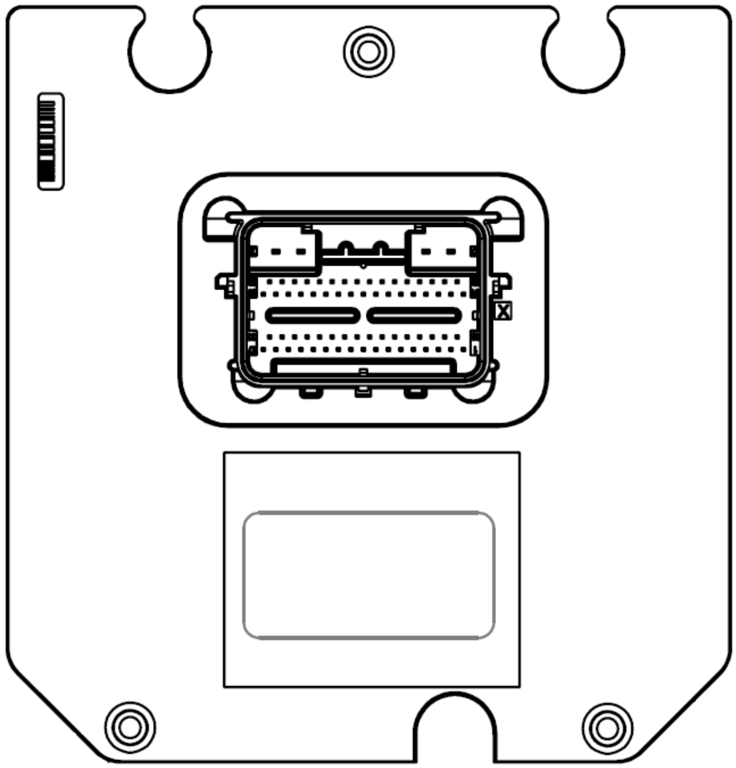
Simple Block Diagram



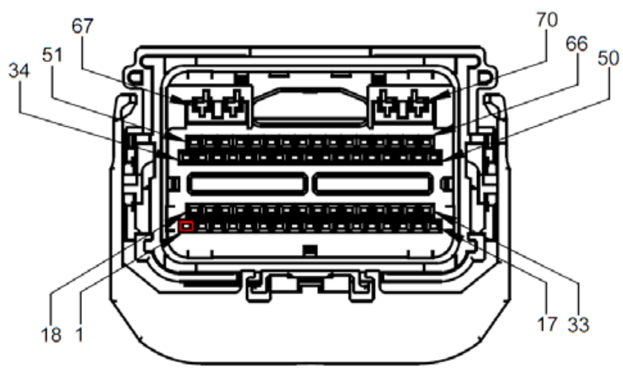
Ordering Information

Controller	Part No.	w/Mounting Hardware	Boot Key (P/N)	Boot Cable	Pigtail Harness	Development Harness	Desktop Simulator Harness (P/N)
ECM-S12X-070-1001-C00	1751-6466	8923-1640	N/A	5404-1144	5404-1141	5404-1143	5404-1207

Connector/Pocket Definitions



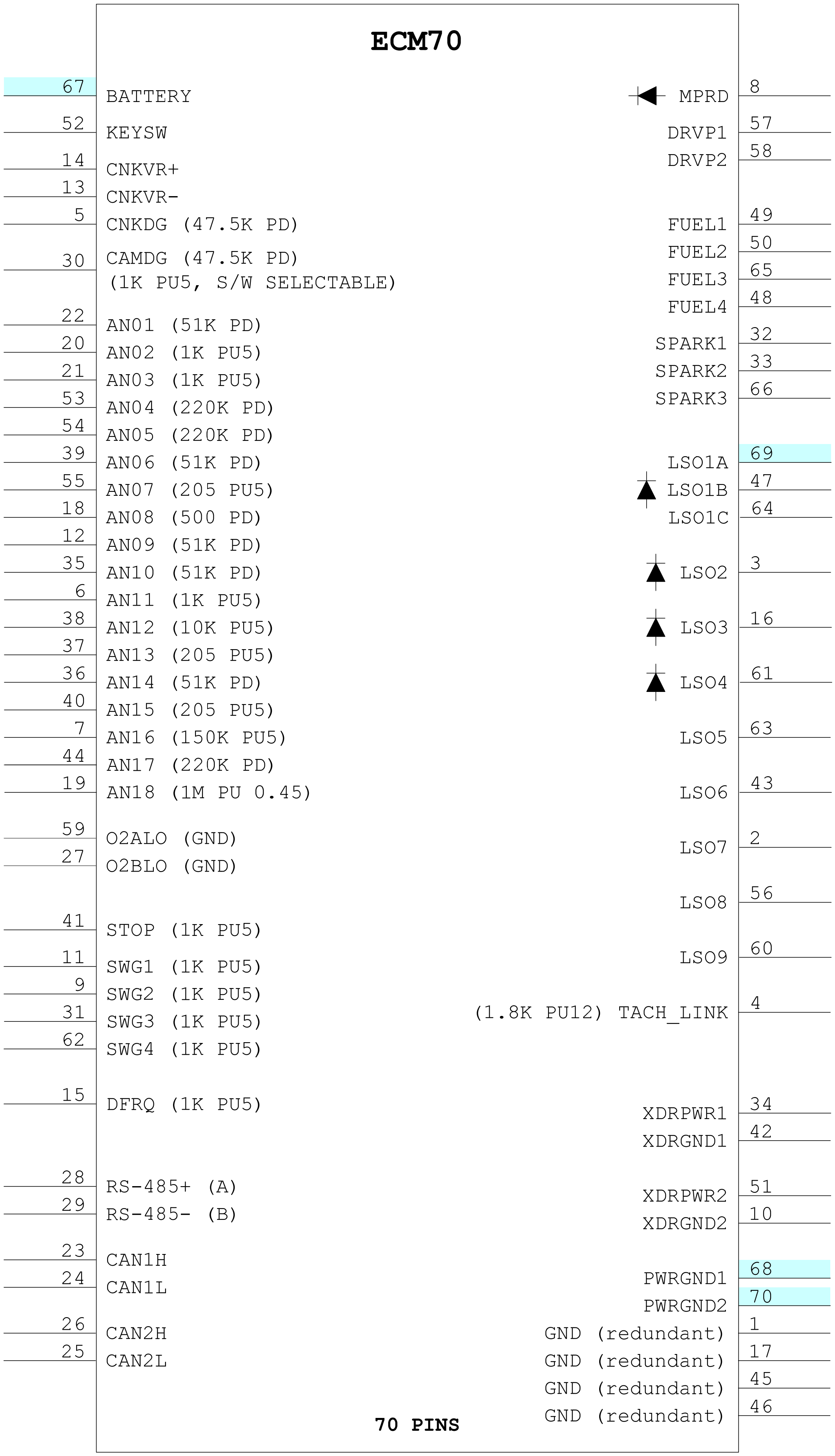
Connector viewed from wire insertion side:



Woodward P/N: 1635-1772

TYCO ELECTRONICS P/N: 1438136-1

Block Diagram



Signal Conditioning

Input Signal Conditioning	**Notes** (see Resource by Connector Pin table and/or block diagram for pull up/pull down resistor levels)
IMPORTANT—The ECM has been validated in an application using typical loads. Maximum loading is based on datasheet values. Actual capability is somewhere between typical (validated) and maximum (datasheet) and is dependent on ambient temperature, system voltage, and the state of all other inputs and outputs. In most cases it will not be possible for an application to use the maximum values. Please contact Woodward sales for more information.	
Power and Ground **BATTERY, ECUP (KEY SWITCH), DRVP1, DRVP2, PWRGND1, PWRGND2, XDRG1, XDRG2, O2ALO, O2BLO, GND**	**(Note—See Figure 1 in "Typical Circuit Schematics" section for Power and Ground Block Diagram)**
BATTERY(67) BATT is normally connected to battery via a fuse.	V_{BATT} (min) = 5 V (crank transient) and 6.5 V (continuous) V_{BATT} (nom) = 8-16 V I_{BATT} (key off, max) = 1 mA at V_{BATT} = 13 V (Battery drain when module is off)
ECUP (KEY SWITCH)(52) This input is the user interface to turn the module on and off.	V_{IL}(max) = 18 V V_{IH} (min)= 4 V V_{ADC} = 0.181 x V_{KEYSW} (10-bit resolution) τ = 1.8 ms
DRVP1 (57), DRVP2 (58) These pins are normally connected to the output of the main power relay, Driver Power (battery voltage). They provide a current path back to the load (e.g. controlled current) as well as a power source to the internal H-bridges.	V_{IN} = 0 to 18 V V_{ADC} = 0.181 x V_{KEYSW} (10-bit resolution τ = 1.8 ms **Note—**Unless otherwise specified, all low-side loads assume protection from reverse battery via the main power relay and DRVP.
PWRGND1(68), PWRGND2(70) These pins are the single point ground for the module.	**Note—**All DRVG terminals are internally connected (one electrical node).
XDRG1(42), XDRG2(10) Transducer Grounds	**Note—**These pins are signal return paths from analog sensors and or switch inputs
O2ALO(59), O2BLO(27) The O_2 sensors grounds	**Note—**These pins are signal return paths from oxygen sensors. Because the ECU ties these signal return paths to the single point ground, the O_2 sensor must be isolated.
GND (Redundant) (1,17,45,46)	**Note—**Internally, ECM70 uses a ground plane. These pins may be used as redundant grounds if necessary.

Input Signal Conditioning	**Notes** (see Resource by Connector Pin table and/or block diagram for pull up/pull down resistor levels)
CNKVR+(14), CNKVR– (13) Variable reluctance input	Vin (min) = 1 volt (peak-peak) at 24 Hz Vin (max) = 360 volts (peak-peak) at 3000 Hz F_{3dB} = 569 Hz **Note—**The frequency (min and max) are dependent on the input signal waveform and software processing of the conditioned signal.
CNKDG(5) This is a digital position input, normally used for crankshaft position.	V_{IL} (max) = 1.0 V V_{IH} (min) = 3.8 V V_{HYST} = 400 mV τ = 29 µs $R_{PULLDOWN}$ = 47.5 kΩ **Note—**Typical applications will use a 50% duty-cycle (half moon) sensor.
CAMDG(30) This is a digital position input, normally used for the camshaft. It includes a software selectable pull-up resistor and is suitable for 5-volt or open-drain type sensors.	V_{IL} (max) = 2.0 V V_{IH} (min) = 3.0 V V_{HYST} = 400 mV τ = 1 ms R_{PULLUP} = 1 kΩ to 5 V software selectable $R_{PULLDOWN}$ = 47.5 kΩ **Note—**Typical applications will use a 50% duty-cycle (half moon) sensor. No internal termination.
DFRQ(15) Digital frequency input.	V_{IL} (max) = 2.0 V V_{IH} (min) = 3.0 V V_{HYST} = 400 mV τ = 5 µs R_{PULLUP} = 1 kΩ to 5 V
Analog Inputs **AN01(22), AN02(20), AN03(21), AN04(53), AN05(54), AN06(39), AN07(55), AN09(12), AN10(35), AN11(6), AN12(38), AN13(37), AN14(36), AN15(40), AN16(7), AN17(44)** **See Figure 2 in "Typical Circuit Schematics" section.**	Vin = 0 to 5 volts $V_{A/D} = V_{IN}$ τ = 1 ms A/D Resolution: 10-bits A/D Accuracy: 0.6% **Note—**Short-to-ground and short-to-battery protected. The pull-up or pull-down values are specified in Block Diagram on page 4 and Connector Pinout descriptions on page 11.
AN08(18)	Normal Input voltage: 0–16 V $V_{A/D} = 0.181(V_{IN})$ A/D Accuracy: 5% (0–16 V)
AN18(19)	R_{PULLUP} = 13 MΩ, 5% to 5 V $R_{PULLDOWN}$ = 1.2 MΩ, 5% **Note—** Input designed for oxygen sensor, doesn't allow for any amplification. Software selectable pull-up 1 kΩ
Switch Inputs SWG1(11), SWG2(9), SWG3(31), SWG4(62).	R_{PULLUP} = 1.0 kΩ τ = 1 ms Vil (max) = 2.0 V Vih (min) = 3.0 V Vhyst (min) = 0.4 V **Note—** Short-to-ground and short-to-battery protected.

Input Signal Conditioning	Notes
STOP (41)	R_{PULLUP} = 1.0 kΩ to 5 V Analog Monitor: τ = 180 us $V_{A/D} = V_{IN}$ (analog monitor) A/D Resolution: 10-bits A/D Accuracy: 0.6% Digital Monitor: τ = 1 ms Vil (max) = 2.0 V Vih (min) = 3.0 V Vhyst (min) = 0.4 V

Output Signal Conditioning	Notes
See Figure 4 in "Typical Circuit Schematics" section.	Outputs are protected from shorts to battery and ground. Outputs have open circuit and short circuit detection. Low-side output drivers sink current and the maximum current must not exceed the specified value, Imax. Stored energy in an inductive load, E=0.5*L*(I^2), must not exceed the specified value, Emax. LSO3, LSO4, LSO5, and LSO8 are implemented as integrated outputs on the same IC. A short-to-battery on one of these outputs may also cause the other outputs to turn-off. LSO7 is not protected from a short to battery when the key is off and software is not operating.
XDRP1(34), XDRP2(51) 5-volt supply for analog sensors.	Vout: 5 V ± 0.5% Iout (max): 100 mA $R_{PULLDOWN}$ = 20 kΩ(monitor circuit) τ = 5 ms $V_{A/D} = 0.5(V_{IN})$ A/D Resolution: 10-bits A/D Accuracy: 4% (0–5.25 V) **Note—**XDRPx is on whenever the key switch is on. When the key switch is turned off, XDRPx remains on until software shuts the system down.
TACH – LINK(4) 0-12 volt pulsed output, implemented as low side output with pull-up resistor	R_{PULLUP} = 1.8 kΩ to key switch Isink (max) = 250 mA Isource (max) = 7 mA (at Vkeysw = 14 V) Trise (max) = 7 µs (@ external 200 ohm load to battery) Tfall (max) = 3 µs (@ external 200 ohm load to battery) **Note—**Short to battery and short to ground protected. Short to ground not detected. LINK is a "bit-banged" serial interface, enabled via software.
MPRD (8) Main power relay control output	I_{SINK} (max) = 500 mA Emax = 50 mJ **Note—**The high-side of the main power relay is normally connected to battery (fused). Reverse battery-protected via series blocking diode.

Output Signal Conditioning	Notes
SPARK1(32), SPARK2(33), SPARK3(66) Low-side output driver, IGBT	Imax = 10 A (peak) **Note—**Imax of 10 A directly implies that the average current during Ton is 5 A.
INJ1(49), INJ2(50), INJ3(65), INJ4(48) Low-side output driver	Imax = 1.4 A Lmax (load) = 12 mH Duty-cycle: 0 to 100% **Note—**Clamped at 47 V (nominal)
LSO1A(69),LSO1B(47),LSO1C(64), Low-side output with current monitor	I_{SINK} (max) = 12 A (discrete) or 3 A (PWM) τ = 220 µs (monitor circuit) $V_{A/D}$ = 0.255 (Iout) A/D Resolution: 10 bits A/D Accuracy: 20% @ 4 A, 10% @ 12 A **Note—**Implementation uses low-side drive with flyback (recirculation) diode to DRVP.
LSO2(3) Low-side output with PWM capability	Imax = 2 A Fmax = 500 Hz **Note—**The 500 Hz maximum frequency results from excess power dissipation during a short to battery. Implementation uses low-side drive with flyback (recirculation) diode to DRVP.
LSO3(16),LSO4(61) Low-side output with PWM capability	Imax = 1 A Fmax = 1000 Hz **Note—**The 1000 Hz maximum frequency results from excess power dissipation during a short to battery. Implementation uses low-side drive with flyback (recirculation) diode to DRVP.
LSO5(63),LSO8(56) Low-side output	Imax = 1 A Emax = 100 mJ Fmax = 1000 Hz **Note—**There is no flyback diode on this output. The 1000 Hz maximum frequency results from excess power dissipation during a short to battery.
LSO6(43), LSO9(60), Low-side output	Imax = 500 mA Emax = 50 mJ **Note—**There is no flyback diode on this output. Short to battery and short to ground protected. Short to ground not detected. Clamped at 45 V (nominal).
LSO7(2) Low-side output **Caution: Normally on (even with key off)**	Imax = 2 A Emax = 50 mJ **Note—**There is no flyback diode on this output. Short to battery and short to ground protected. Short to ground not detected. Clamped at 47 V (nominal).

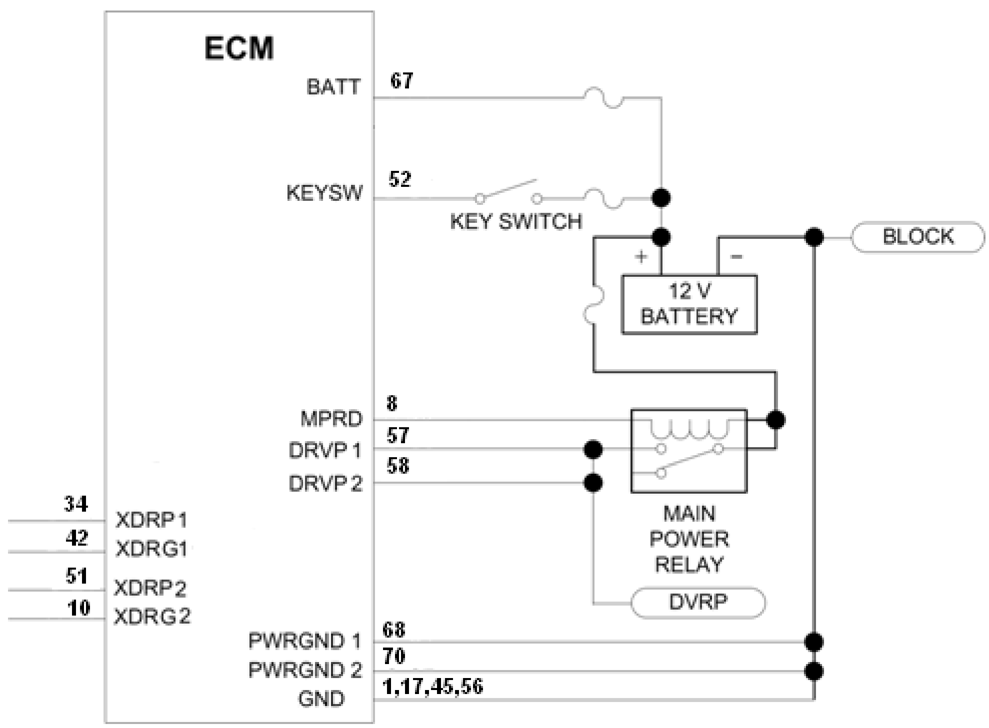
Communications	
CAN1Hi(23), CAN1Lo(24), CAN2Hi(26), CAN2Lo(25)	High-speed CAN 2.0B buses, no internal termination. 500 kps capable, validated to 250 kps
RS485+(28), RS485-(29)	RS-485 serial lines

Memory	
FLASH	Base 256K, Calibratible 1M
RAM	Base 16K, Calibratible 64K
EEPROM	4K EEPROM; serial

Typical Circuit Schematics

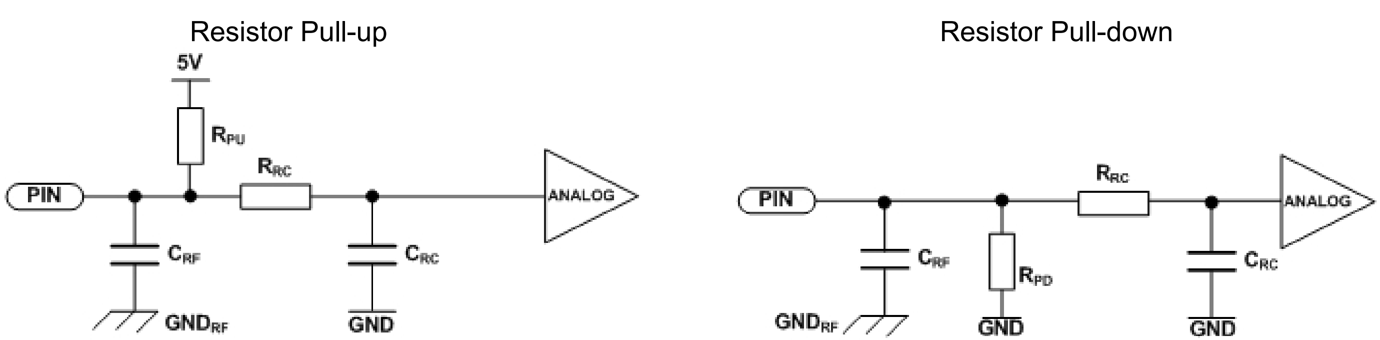
Power and Ground

Figure 1:



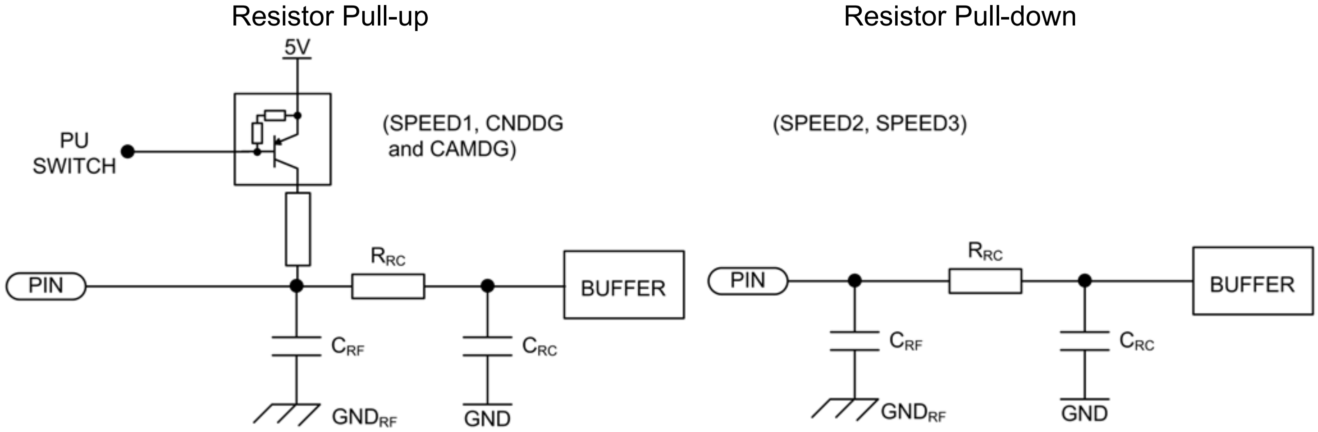
Analog Inputs

Figure 2:



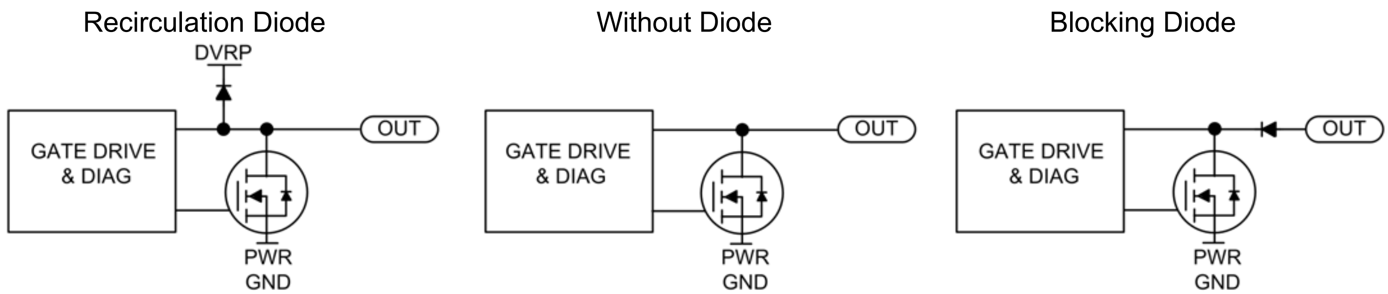
Digital Inputs

Figure 3:



Typical Outputs

Figure 4:

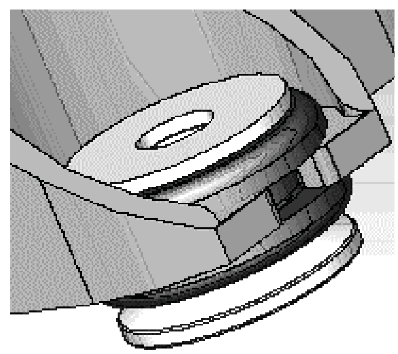


Connector Pinouts

Pin#		Pin#		Pin#		Pin#	
1	GND	19	AN18	37	AN13	54	AN5
	Ground		Analog input 18		Analog input 13		Analog input 5
			R_{PULLUP}=1 MΩ (O_2 sensor)		R_{PULLUP}=201 Ω, 1%		$R_{PULLDOWN}$=220 kΩ, 5%
2	LSO7	20	AN2	38	AN12	55	AN7
	Low Side Output 7		Analog input 2		Analog input 12		Analog input 7
	Normally on, 2 A, No diode		R_{PULLUP}=1.0 kΩ, 1%		R_{PULLUP}=10.0 kΩ, 1%		R_{PULLUP}=201 Ω, 1%
3	LSO2	21	AN3	39	AN6	56	LSO8
	Low Side Output 2		Analog input 3		Analog input 6		Low Side Output 8
	Recirc. diode, 2 A		R_{PULLUP}=1.0 kΩ, 1%		$R_{PULLDOWN}$=51.1 kΩ, 1%		No diode, 1 A
4	TACH_LINK	22	AN1	40	AN15	57	DRVP1
	Digital Output		Analog input 1		Analog input 15		Driver Power
	0/12 V, Isink 250 mA, Isource 7 mA, serial		$R_{PULLDOWN}$=51.1 kΩ, 1%		R_{PULLUP}=201 Ω, 1%		
5	CNKDG	23	CAN1H	41	STOP	58	DRVP2
	Digital Input		CAN Hi		Emergency Stop Input		Driver Power
	Rpulldown=47.5 kΩ		CAN2.0b		With Monitor, disables MPRD, R_{PULLUP}=1.0 kΩ		
6	AN11	24	CAN1L	42	XDRG1	59	O2ALO
	Analog input 11		CAN Lo		Transducer Ground		Oxygen Sensor Ground
	R_{PULLUP}=1.0 kΩ, 1%		CAN2.0b				
7	AN16	25	CAN2L	43	LSO6	60	LSO9
	Analog input 16		CAN Lo		Low Side Output 6		Low Side Output 9
	R_{PULLUP} = 150 kΩ		CAN2.0b		No diode, 500 mA		No diode, 500 mA
8	MPRD	26	CAN2H	44	AN17	61	LSO4
	Main Power Relay Driver		CAN Hi		Analog input 17		Low Side Driver 4
	Blocking diode, 500 mA		CAN2.0b		$R_{PULLDOWN}$=220 kΩ, 5%		Recirc. diode, 1 A
9	SWG2	27	O2BLO	45	GND	62	SWG4
	Switch-to-ground input		Oxygen Sensor Ground		Ground		Switch-to-ground input
	R_{PULLUP} = 1.0 kΩ		(for optional population)				R_{PULLUP} = 1.0 kΩ
10	XDRG2	28	RS-485+	46	GND	63	LSO5
	Transducer Ground		Serial communication		Ground		Low Side Driver 5
							No diode, 1 A
11	SWG1	29	RS-485-	47	LSO1B	64	LSO1C
	Switch-to-ground input		Serial communication		Low Side Output with monitor (same as 64,69)		Low Side Output with monitor (same as 47,69)
	R_{PULLUP} = 1.0 kΩ				Recirc. diode, 12 A (or 3 A PWM)		Recirc. diode, 12 A (or 3 A PWM)

Pin#		Pin#		Pin#		Pin#	
12	AN9	30	CAMDG	48	FUEL4	65	FUEL3
	Analog input 9		Digital input. Software selectable pull-up		Low-side output driver		Low-side output driver
	$R_{PULLDOWN}$=51.1 kΩ, 1%		Rpullup = 1.0 kΩ Rpulldown = 47.5 kΩ		Imax = 1.4 A		Imax = 1.4 A
13	CNKVR-	31	SWG3	49	FUEL1	66	SPARK3
	Differential Frequency Input		Switch-to-ground input		Low-side output driver		Low-side output driver, IGBT
			R_{PULLUP} = 1.0 kΩ		Imax = 1.4 A		Imax = 10 A
14	CNKVR+	32	SPARK1	50	FUEL2	67	VBATT+
	Differential Frequency Input		Low-side output driver, IGBT		Low-side output driver		Battery input
			Imax = 10 A		Imax = 1.4 A		
15	DFRQ	33	SPARK2	51	XDRP2	68	PWRGND1
	Digital Frequency Input		Low-side output driver, IGBT		Transducer Power		Power Ground
			Imax = 10 A		5 V Output		
16	LSO3	34	XDRP1	52	KEYSW	69	LSO1A
	Low Side Output 3		Transducer Power		Key switch		Low Side Output with monitor (same as 47,64)
	Recirc. diode, 1 A		5 V Output		$R_{PULLDOWN}$ = 500 Ω		Recirc. diode, 12 A (or 3 A PWM)
17	GND	35	AN10	53	AN4	70	PWRGND2
	Ground		Analog input 10		Analog input 4		Power Ground
			$R_{PULLDOWN}$=51.1 kΩ, 1%		$R_{PULLDOWN}$=220 kΩ, 5%		
18	AN8	36	AN14				
	Analog input 8		Analog input 14				
	$R_{PULLDOWN}$=500 Ω		$R_{PULLDOWN}$=51.1 kΩ, 1%				

Environmental Ratings

Environmental Ratings	Notes
The ECM is designed for automotive, under hood and marine industry environmental requirements. Validation tests include extreme operating temperatures, thermal shock, humidity, salt spray, salt fog, immersion, fluid resistance, mechanical shock, vibration, and EMC. The customer must contact Woodward and provide the intended environmental conditions in the application for verification of performance capability.	
Storage Temperature	–40 to +125 °C
Operating Temperature	–40 to +85 °C (105 °C applications possible)
Thermal Shock	–40 to +125 °C
Fluid Resistance	Two-stroke motor oil, four-stroke motor oil, unleaded gasoline, ASTM Reference 'C' fuel
Humidity Resistance	90% humidity at 85 °C for 1000 hours.
Salt Fog Resistance	500 hours. 5% salt fog, 35 °C.
Immersion	4.34 psi (29.92 kPa) test (simulated 10 feet/3 m), salt water, 20 minutes.
Mechanical Shock	50 G's, 11 ms, half sine wave.
Drop Test	Drop test on concrete from 1 meter.
Vibration This ECM family has been successfully deployed with on-engine mounting for small displacement engine applications with extreme vibrations. Electrical and mechanical isolation is achieved via Woodward mounting hardware (consisting of grommet, bushing, and washer) shown at the right. **IMPORTANT** **For prior verification of performance capability, contact Woodward and provide the vibration profile of the intended application.**	

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