



ETAC: Electronic Transmission Automotive Control

User's Manual



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Information contained in this document is subject to change without notice. Performance values are typical values. Customers are responsible for selecting products for their applications using normal engineering methods.

General

Eaton Corporation is a diversified industrial manufacturer. Eaton is a global leader in electrical systems and components for power quality, distribution and control; fluid power systems and services for industrial, mobile and aircraft equipment; intelligent truck drivetrain systems for safety and fuel economy; and automotive engine air management systems, power train solutions and specialty controls for performance, fuel economy and safety.

Eaton Corporation is a global diversified industrial manufacturer. Eaton is a leader in:

- Fluid power systems
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Electronic Transmission Automotive Control

(ETAC™)

Electronic Transmission Automotive Control (ETAC) systems provide many cost and operating benefits. Applications can include lift trucks, telehandlers, railway maintenance equipment, utility vehicles, and compact wheel loaders. Within the ETAC system, the electronic controller is integrated with the engine throttle management system, as well as a closed circuit pump. It drives high performance proportional valves and uses electronic swashplate feedback to provide precise, dynamic system control.

Automotive control of a hydrostatic drive allows large vehicles to be operated in a way similar to a standard automobile with an automatic transmission. A single throttle pedal controls the engine and transmission, giving output speed and torque as needed for vehicle operating systems.



Single 350 Pump
(Shown with proportional control and electronic swash position sensor.)

Series 2 Variable Displacement Pump
(Shown with proportional control and electronic swash position sensor.)



MAESTRO

Design features and benefits:

- **Adjustable performance** – Within the capabilities of the engine, vehicle responsiveness (aggressive vs. smooth) can be adjusted relative to changes in engine speed. The settings affect both acceleration and deceleration modes of operation.
- **Anti-stall** – ETAC's scalable anti-stall sensitivity enables maximum engine loading and allows use of maximum available engine power over the full speed range. The response rate and load profile is adjustable to specific engine characteristics.
- **Operator Interfaces** – Specifications and recommendations are provided for all system components, including the foot pedal, forward/neutral/ reverse selector switch, inching pedal, and interlock switches (parking brake and operator presence).
- **Safety** – The safety features ensure pump displacement is maintained at mechanical neutral by interrupting power to the pump control. Other safety interrupts include parking brake release and operator presence switches.
- **Hydrostatic braking** – ETAC uses full capacity of the hydrostatic system for slowing vehicles, which reduces the demands on service brake systems. Hydrostatic-braking greatly reduces the need for frequent brake servicing and associated vehicle downtime. It is initiated by simply releasing the throttle pedal. More aggressive braking action can also be obtained by depressing the inching pedal.
- **Inching control** – With this option, a second foot pedal allows the user to destroke the pump, allowing the engine to maintain speed in a loaded condition. Inching control is useful when precise positional control is required or when engine speed must be increased independent of travel speed to support other machine work functions such as raising a load on a forklift.
- **Electronic Control Module** – The brain of the system is the MAESTRO Electronic Control Module. This unit can be configured, by means of software, to perform a wide range of functions.
- **Performance** – The ETAC system offers more consistent performance compared to hydromechanical (automotive drive) systems. Performance is not impacted by temperature effects on oil viscosity because engine speed is measured electronically. The use of electronic control offers the capability to more precisely match transmission performance relative to engine power. The ETAC's control delivers greater maximum vehicle performance, reduced fuel consumption and faster cycle times resulting in reduced overall vehicle operating cost.
- **Hot shifting** – This feature allows the transmission to be rapidly shifted from forward to neutral to reverse (or vice versa) without damage to the vehicle powertrain system. Hot shifting improves productivity compared to mechanical systems by simplifying operation and reducing operator fatigue.
- **Temperature stability** – The system's electronic swashplate position (ESP) technology makes system control insensitive to temperature and/or oil viscosity. This ensures positive neutral – even under extreme cold start conditions – without the complexities of extra valves. The control in turn, provides smooth, precise, reliable, and repeatable operation with predictable performance.
- **Setup** – The operator must size the HST transmission, including pumps and motors, when setting up the system design software. From those calculations, many details can be tailored for the needed system applications, including:
 - vehicle parameter settings
 - vehicle speed vs. travel pedal profile
 - engine speed vs. travel pedal profile
 - pump displacement vs. engine speed, and
 - engine torque curve.

Electronic Transmission Automotive Control

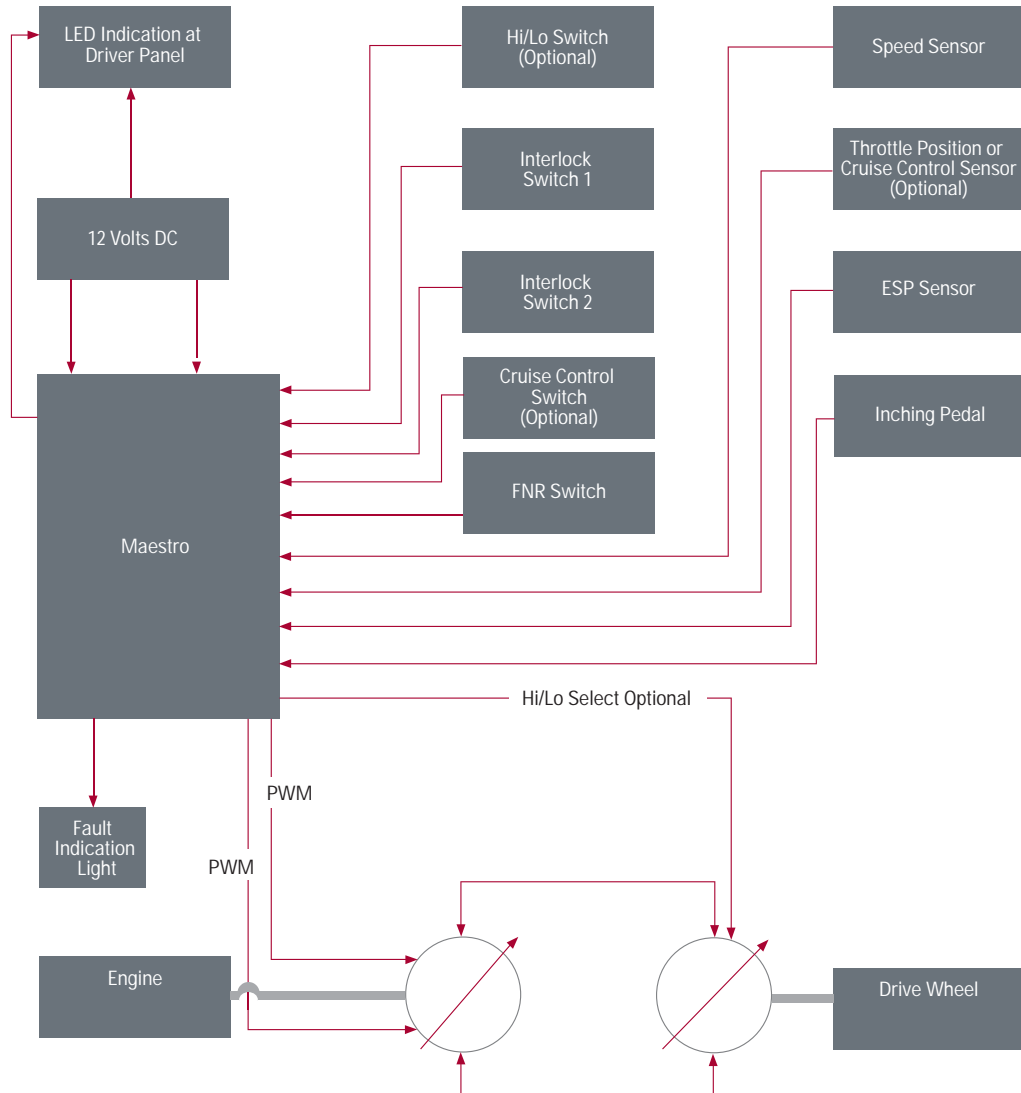
(ETAC)

ETAC™

- Tailored performance improves productivity over a wide range of operator skill levels.
- ETAC™ matches engine power to the work requirement, for quieter operation and reduced fuel consumption.
- Inching function maximizes productivity by allowing smoother, more manageable operation of work hydraulics.
- The anti-stall feature enables maximum use of available engine power.



Schematic Diagram



Key Platforms

- Compact Wheel Loaders
- Fork Lift Trucks
- Telehandlers
- Utility Vehicles

Optional Control System Upgrades

Throttle Position Sensor

- Provides improved Anti-Stall Response

Cruise Control Sensor

- Provides constant pump displacement while engine speed varies

Motor Shift (Hi/Lo)

- Expands power and speed range with integrated motor control.
- Choose between automatic or operator selectable operation.

ETAC and Pump Control Selection

MAESTRO:

EATON PART NUMBER	OPERATING VOLTAGE	MAX MODULE OUTPUT
800-0029-001	9 – 32 VDC	4 Amps

Pump Control Selection:

Series 2, HD Control Options

This control is compatible with Series 2 pumps containing the proportional control with electronic swash position feedback sensor.

PUMP CONTROL MODEL CODE	CONTROL DESCRIPTION
SE	Solenoid control 12 volt with non-contact feedback sensor with electrical connectors per DIN 43650
SG	Solenoid control 24 volt with non-contact feedback sensor with electrical connectors per DIN 43650

Series 1, HD Control Options

This control is compatible with Series 1 pumps containing the proportional control with electronic swash position feedback sensor.

PUMP CONTROL MODEL CODE	CONTROL DESCRIPTION
SC	Solenoid control 12 volt with non-contact feedback sensor with electrical connectors per DIN 43650
SD	Solenoid control 24 volt with non-contact feedback sensor with electrical connectors per DIN 43650

MD Control Options

This control is compatible with MD pumps containing the proportional control with electronic swash position feedback sensor.

PUMP CONTROL MODEL CODE	CONTROL DESCRIPTION
MD-72400 Series SK	Proportional Solenoid Control 12 Volt With Non-Contact Feedback Sensor With 4 Pin Metri-Pack Connector
350 Series Single Pump SA	Solenoid Control 12 Volt With Non-Contact Feedback Sensor With Metri-Pak Electrical Connectors

Pump Control Orifice Selection

A plate orifice installed in the control valve regulates the speed that displacement can be changed. The plate orifice can be changed to meet desired size to meet the application requirements.

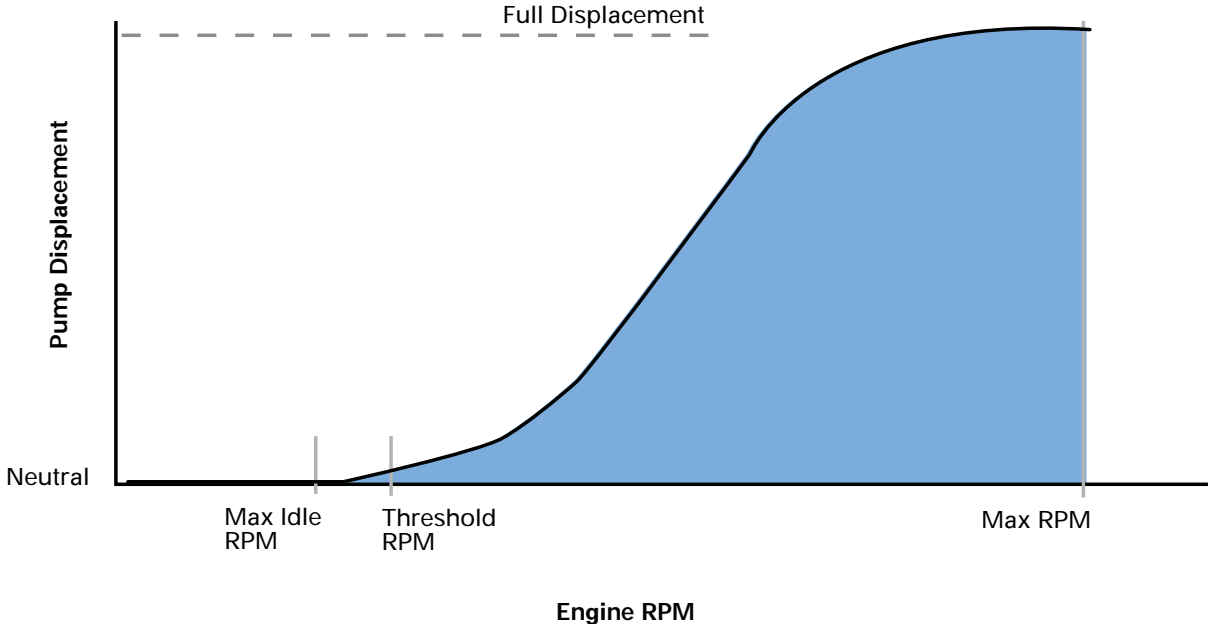
Refer to either MD pump catalog (11-06-0611) or HD series 1 catalog (11-882) for further information on stroke speeds.

- Control orifice supply (P) (affects on-stroke time). Code "0" recommended as the pump stroke ramp rate may be adjusted by the GUI software
- Control orifice S1 & S2 (affects on and off-stroke times) Code "M" 0.102 inches [2.59 mm] Recommended as

maximum size available to ensure for proper pressure override (POR) function in HD series 2 pumps.

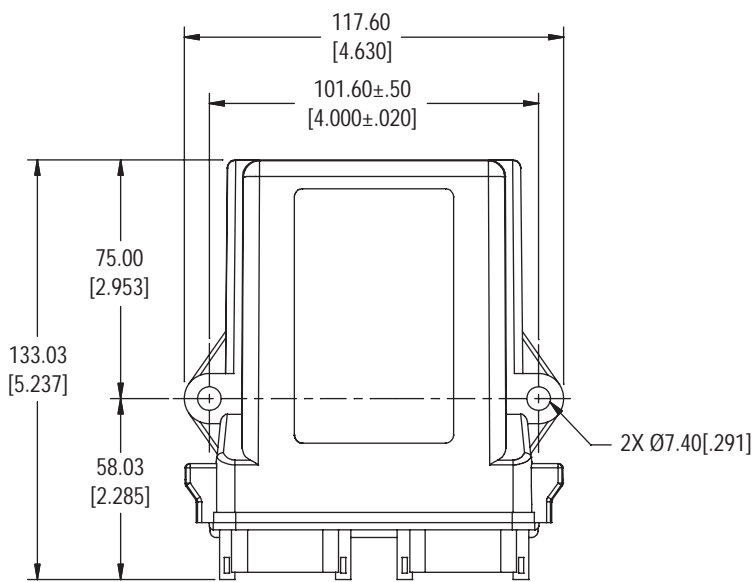
Autodrive Performance Curve

Typical Autodrive Performance Curve



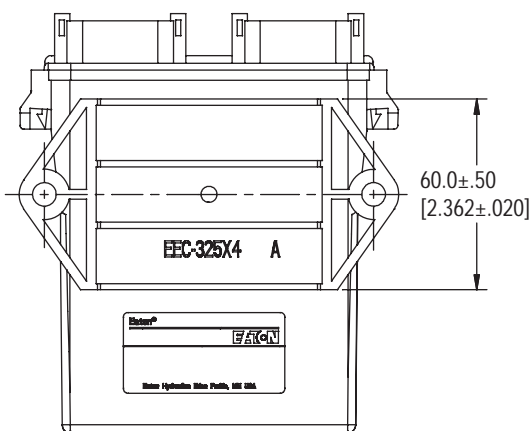
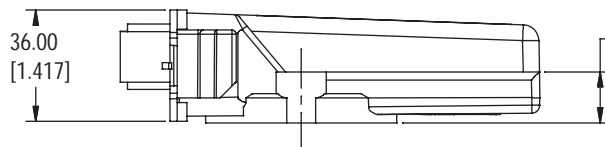
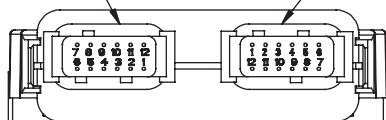
Note: The performance curve is adjustable by the end user thru the GUI (Graphical User Interface).

MAESTRO Installation Requirements



Sleeve Color Grey
Mating Connector
Deutsch DTM06-12SA

Sleeve Color Black
Mating Connector
Deutsch DTM06-12SB



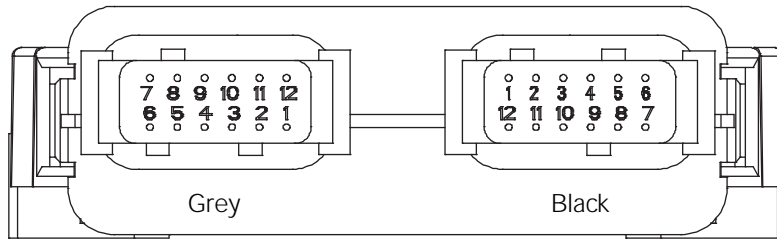
Controller Installation guidelines

- Electronic control should be mounted in a "protected" location. Mount the maestro in a protected location keeping it from pressure washing or steam cleaning. Mount the MAESTRO according to the specifications in the installation drawing. Avoid locations where vehicle wash down or exposure to "water" is likely. If the MAESTRO is mounted in a splash location it is recommended to orient the MAESTRO with connectors down to help drain away water. Leave it accessible to change the MAESTRO if necessary.
- Not intended for direct mounting on pump or near the engine.

Note

- Mount ECM using two 1/4 inch, grade 2 bolts torqued to $5.2 \pm \text{N m}$ [$46 \pm 5 \text{ lbf in}$]. Use washer with nominal O.D. of .620 or customer may use alternate bolting options if a thread locking is employed.

Connector



Connector Pin Detail

GREY CONNECTOR PIN	ETAC TYPICAL APPLICATION A	ETAC TYPICAL APPLICATION B
1A	ESP	ESP
2A	Cruise Control signal (optional)	Throttle pedal (optional)
3A	Inching pedal	Inching pedal
4A	FNR switch	FNR switch
5A	FNR switch	FNR switch
6A	Supply	Supply
7A	Ground	Ground
8A	CAN shield	CAN shield
9A	Pump speed	Pump speed
10A	Sensor Supply	Sensor Supply
11A	CAN HI	CAN HI
12A	CAN LO	CAN LO

BLACK CONNECTOR PIN	ETAC TYPICAL APPLICATION A	ETAC TYPICAL APPLICATION B
1B	PWM Ground	PWM Ground
2B	PWM Ground	PWM Ground
3B	PWM Ground	PWM Ground
4B	PWM Ground	PWM Ground
5B	Neutral start relay	
6B	Cruise control switch (optional)	Interlock Switch 1
7B	Interlock Switch 2	Interlock Switch 2
8B	Motor speed switch	Motor speed switch (future)
9B	Pump coil 1	Pump coil 1
10B	Pump coil 2	Pump coil 2
11B	Motor speed select	Motor speed select (future)
12B	LED	LED

Mating Connector

Connector: Deutsch P/N DTM06-12SA, Qty. 1

Connector: Deutsch P/N DTM06-12SB, Qty. 1

Terminal: Deutsch P/N 1062-20-0122, Qty. A/R

Wedge Lock: Deutsch P/N WM-12S, Qty. 2

Wiring Guidelines

- It is recommended to use 18AWG wire per SAE J1128
- Appropriate wiring practices should be used for installation to avoid abrasion, strain, damage, and EMI (electromagnetic interference). Do not route ETAC harness wires in the same bundle as other power wires (example, powering motors and actuators).
- External circuits must not be connected to the sensor or solenoid wires.
- All sensor supply and ground wires must be spliced together within 8 inch wire length of the MAESTRO controller. All ground wires should be connected to a center point.
- All switch supply wires should be spliced together within 8 inch wire length of the MAESTRO controller.

- Provide switched 12 or 24 volts with a 6-amp fast blow fuse. Provide an emergency stop switch.
 - As practical, route the wires in bundles and enclose the bundles in sleeve material such as convoluted tubing, mesh or heat shrink tubing. Be sure to choose temperature appropriate material. This will help prevent wire failure due to abrasion, accidental nicking or cutting.
 - Avoid routing wires around sharp corners or rough edges. Use grommets as appropriate. Avoid making sharp turns with the harness, for this may increase stresses.
 - Secure the wire bundles in channels or use wire ties to secure harness to frame. Securing the harness will help prevent wire fatigue and accidental damage from moving parts or maintenance work. Avoid long stretches of unsupported harness.
- Allow the harness to move as the frame will move in the application.
- Avoid high temperature sources such as exhaust systems and engine blocks.
 - Avoid routing wires on sources of high vibration.
 - When possible locate connectors shielding them from direct spray. Use manufacture connector boots, if available, to help prevent high-pressure spray directly on a connector where the wires enter. Do not locate connectors, or wire slices, in troughs that can retain water and leave the connector submerged in water or other chemicals.
 - Use wire routing to prevent similar connectors from being mistakenly connected by adjusting wire length so only the correct connector can be engaged.

Graphical User Interface

The Graphical User Interface (GUI) walks the system engineer through the tuning process, using real-time graphical feedback to clearly indicate the system's response to each parameter change. You define the performance characteristics that give your vehicle it's competitive advantage.

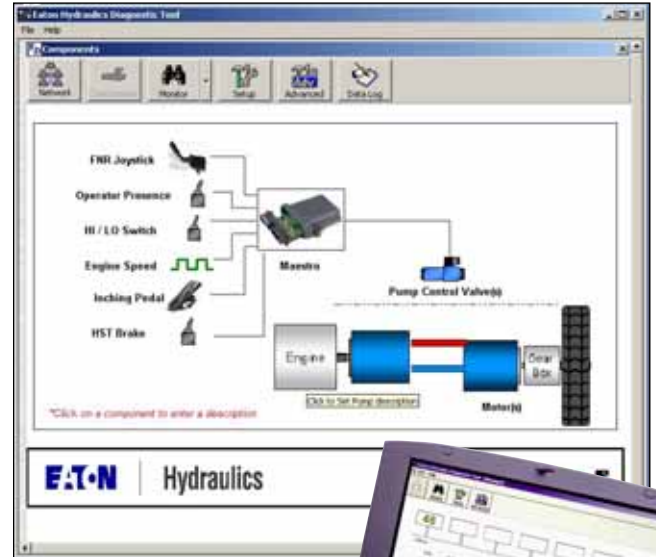
The Eaton MAESTRO offers the ability to interface with the control for advanced diagnostics and/or set-up of basic parameter settings. The GUI software P/N 5995409-001 is available via download for installation on a PC and must be used in conjunction with a ValueCAN interface device via USB port connection with PC for control communications.

GUI Adjustable Parameters:

- EDC Module address
- Command source address
- Neutral start enable/disable

GUI User's Guide

A detailed GUI User's Guide may be obtained by requesting Eaton document ATS-524.



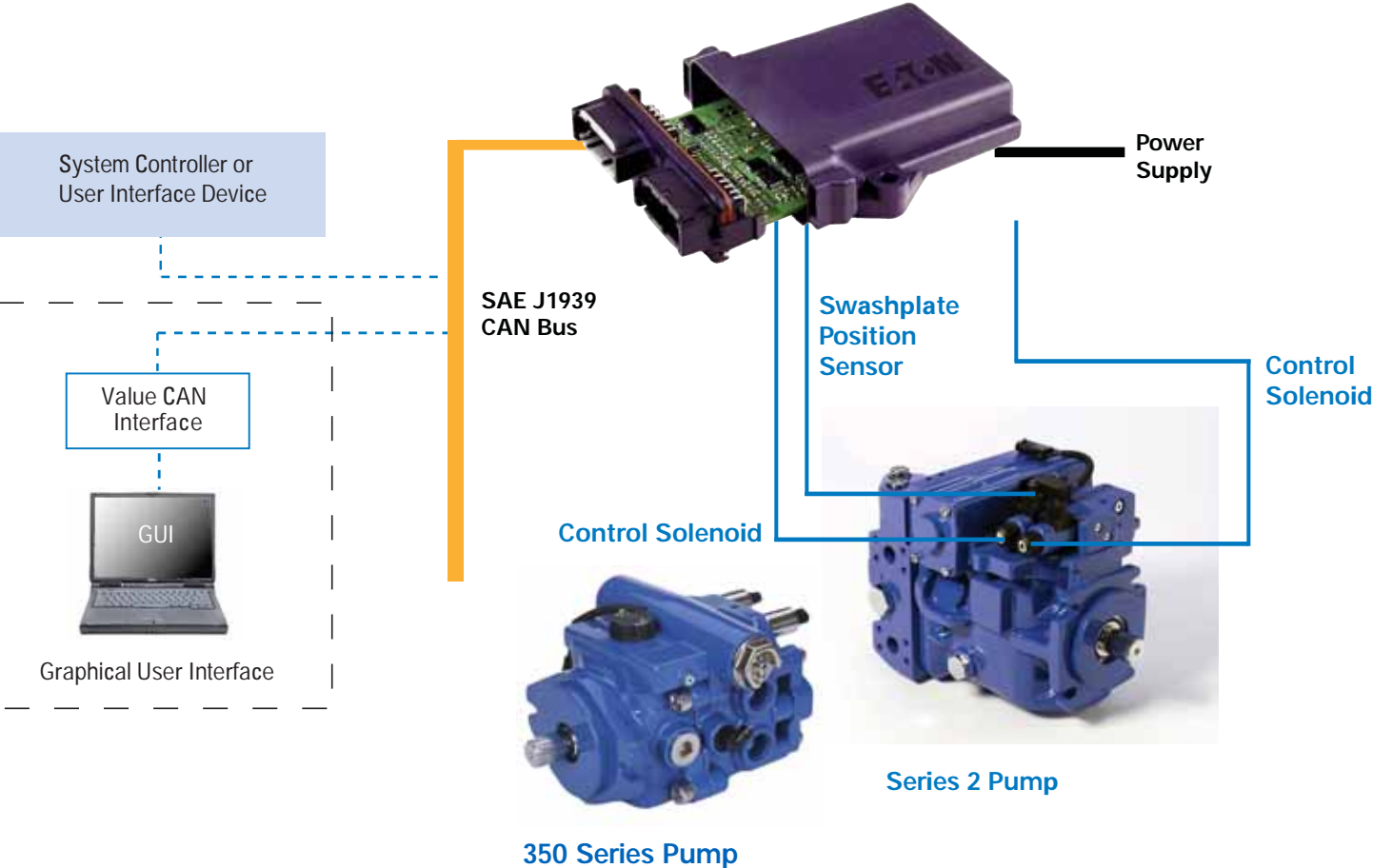
ValueCAN Interface



Parameterization Tool

- ValueCANTM (DWCAN) interface
- Order direct from Intrepid Control Systems, Inc.
- <http://www.intrepidtools.com/main/>

Graphical User Interface Interconnect Diagram





MAESTRO

Vehicle Battery

- 9-32 VDC
- The proper (12V or 24V) solenoid must be used

Communication Protocols

- SAE J1939 CAN-bus vehicle network
- SAE J1939 communication with GUI

Mechanical

- Polymer enclosure
- (2) Mounting flanges

Inputs

- (3) 0-5 VDC for potentiometer sensors
- (1) Speed input
- (5) 0-40 VDC for switches

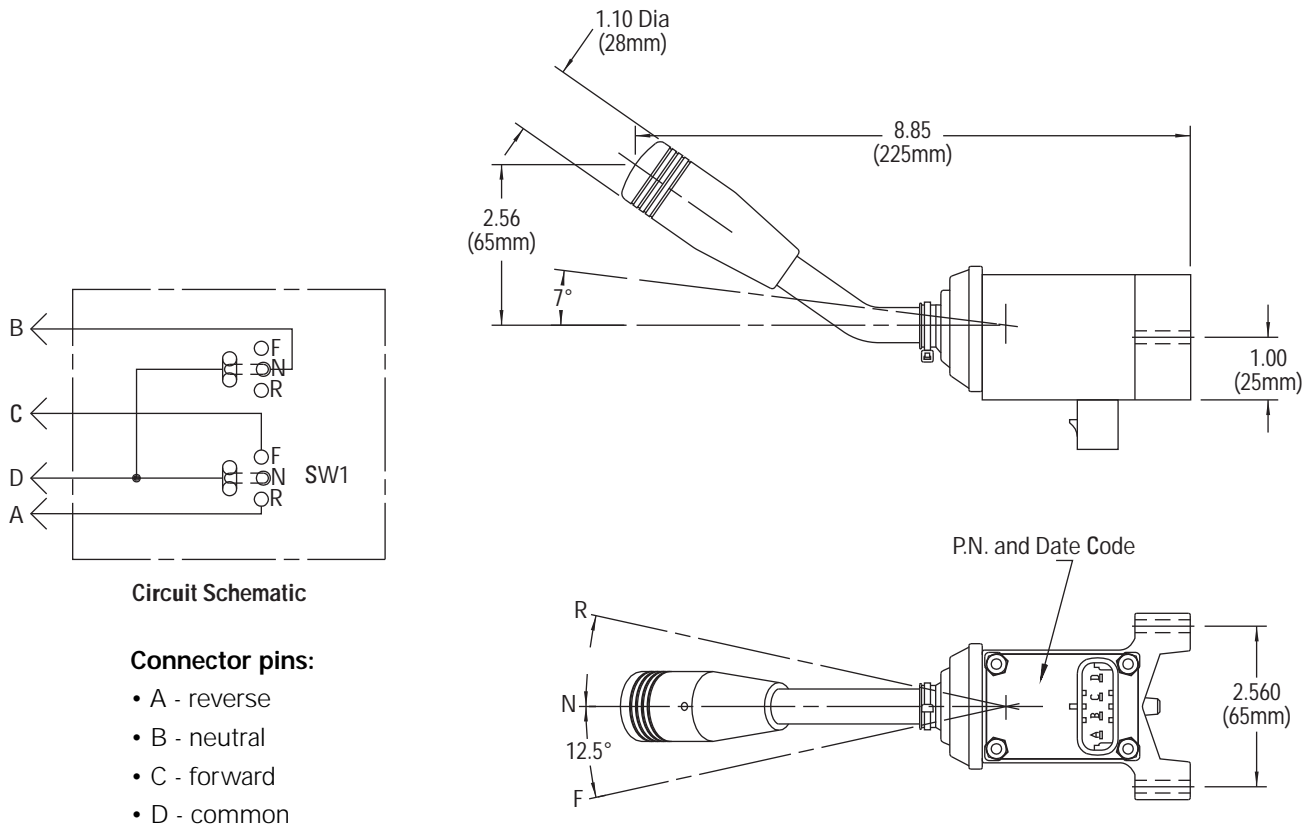
Environmental

- Meets EMC standards EN 13309-2000 (Construction machinery) ISO 13766-1999 (Earth moving machinery)
- CE marked for EMC
- Reverse battery and load dump protection
- Input/output short circuit protection
- UV resistant
- Random vibration 5.8 Grms
- Shock: 50 G
- The max ambient temp is -40°C to 70°C (158°F)

Outputs

- (1) Sensor power supply Regulated 5 VDC
- (2) MAESTRO PWM outputs – 3 Amps peak
- (2) MAESTRO PWM outputs – 2 Amps peak
- (1) Digital output max 50mA/150mA for 12/24V vehicle
- 4 Amps max MAESTRO module output

Shifter Assy (F-N-R)



*A. Mating Connector – Packard P.N. 15300029

*B. Typical Mating Terminal – Packard P.N. 12077411

*C. Typical Cable Seal – Packard P.N. 12015323

ITEM	P/N	DESCRIPTION
1	5995414-001	FNR Switch and Clamp for a 1.50 inch diameter column
2	5995414-002	FNR Switch and Clamp for a 1.75 inch diameter column

* Customer Supplied

Inching Pedal

*Mating Connector C:

Packard Electric "Weather Pack": Connector
 Connector, Key Index P/N 12010717
 Terminal Pin (Male) P/N 12089040
 Wire Seal P/N 12015323
 *Cavity Plug: P/N 12010300



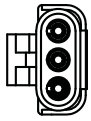
PIN A---ORANGE---APS 2 SIGNAL
 PIN B---BLUE---APS 2 GROUND
 PIN C---GREEN---APS 2 SUPPLY (5V)

* Connector C is not used for ETAC.
 If not used elsewhere, install cavity plug instead of terminal pin and wire seal.

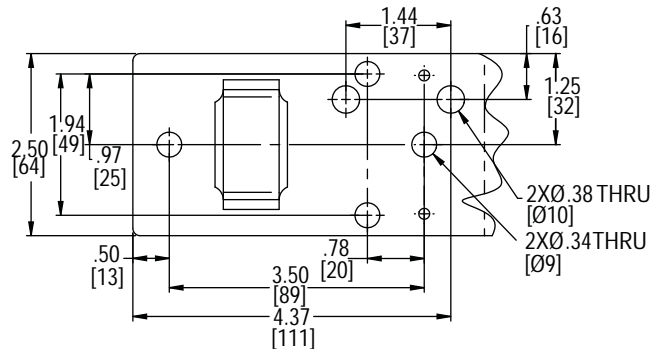
Mating connection to be customer supplied.

*Mating Connector B:

Packard Electric "Weather Pack": Connector
 Connector, Key Index P/N 12015793
 Terminal Pin (Female) P/N 12089188
 Wire Seal P/N 12015323



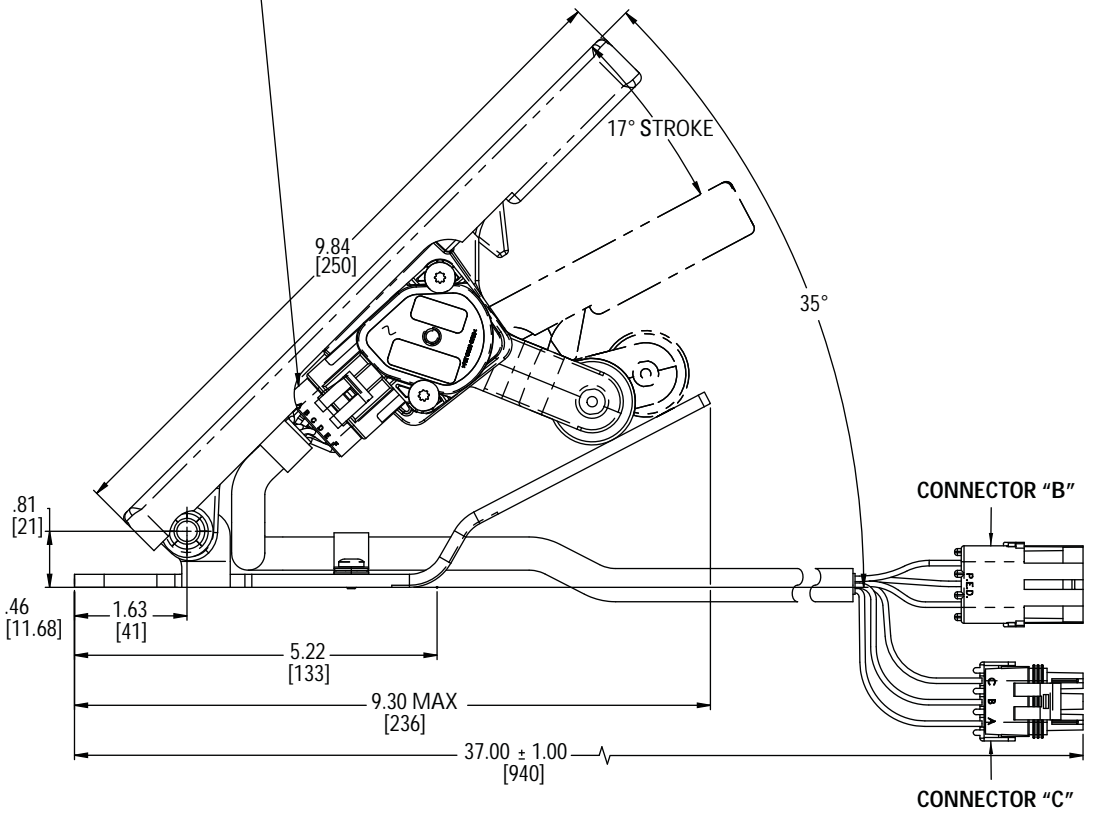
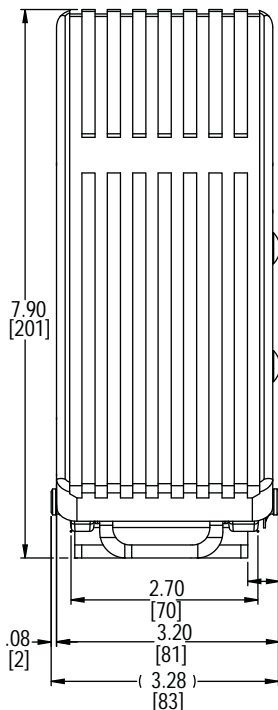
PIN A---RED---APS 1 SUPPLY (5V)
 PIN B---BLACK---APS 1 SIGNAL (5V)
 PIN C---WHITE---APS 1 GROUND



Connector A:

Packard Electric "Metri Pack": Connector
 Connector & Seal
 Terminal (Female)

PIN	COLOR	FUNCTION
A	BLACK	APS 1 SIGNAL
B	WHITE	APS 1 GROUND
C	RED	APS 1 SUPPLY (5V)
D	GREEN	APS 2 SUPPLY (5V)
E	BLUE	APS 2 GROUND
F	ORANGE	APS 2 SIGNAL



Dimensions in inch (mm)

Eaton p/n 5995413-001

ETAC Installation Guidelines

General Guidelines

- The system integrator must understand the issues of Electromagnetic Compatibility (EMC) and verify that the installation and use of the complete system complies with all governmental regulations.
- Appropriate industry practices must be followed to prevent damage of and shorting of electrical and electronic components caused by environmental hazards and application specific hazards. Typical hazards that damage the wiring harnesses or other components are abrasion, moving objects, and heat from the engine or exhaust system. Moisture and/or chemical exposure can damage poorly sealed connectors and/or components, causing short or open circuits and other problems like corrosion.
- All the electrical connections to the electronic module must be disconnected prior to performing any electrical welding on the vehicle or machine. The electrical module, sensors, and/or the hydraulic components are not to be used as a connection point for electrical welding equipment.
- During initial start-up and/or checkout of the system after service, care should be taken to avoid the hazards of inadvertent operation (machine activation, unintended movement, etc.) from improper installation, system problems, and/or component failure.
- Switches need to be protected from contamination that may cause a short across the switch.

ETAC Diagnostic Codes

ENGINE	FNR SWITCH	STATUS LIGHT	NOTES
ON	Forward, neutral or reverse	Solid – No Fault	Flashing - Fault Turn off engine and provide power to the MAESTRO to examine flash codes
OFF – MAESTRO Powered	Neutral	Solid – ESP Sensor in calibration Flashing – ESP Sensor out of calibration	Follow the ESP sensor calibration routine to correct this problem
OFF – MAESTRO Powered	Forward	Solid – No Fault Flashing – Fault codes will flash	See the fault codes table for an interpretation
OFF – MAESTRO Powered	Move forward to neutral to forward to neutral to forward within 3 seconds	Flashing fault code will cease and light will be on solid	This operation clears the present fault code

Fault Codes

Four possible faults can be displayed. The flash count determines which combinations of faults exist on the vehicle.

FLASH COUNT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Position Fault	X		X		X		X		X		X		X		X
Solenoid Fault		X	X			X	X			X	X			X	X
Inching Fault				X	X	X	X					X	X	X	X
FNR Fault								X	X	X	X	X	X	X	X

These four fault conditions are general indicators for many possible fault conditions.

Position Fault

Position Error – the pump swashplate feedback position is not within 5 degrees of the commanded swashplate position.

Neutral Range – pump neutral position is not within 2 degrees of expected neutral.

Speed Reading – speed sensor reported engine speed exceeds the user-defined maximum.

ESP Range – the pump swashplate feedback position reading is outside the acceptable range.

Sensor Supply – the sensor supply (power for the ESP Sensor) is outside of its expected voltage range.

Solenoid Fault

Positive Solenoid Coil – the positive coil circuit has an open or short condition.

Negative Solenoid Coil – the negative coil circuit has an open or short condition.

Positive Solenoid Offstate – the positive coil circuit is incapable of measuring current accurately.

Negative Solenoid Offstate – the negative coil circuit is incapable of measuring current accurately.

Inching Fault

Inching Pedal Range – the inching pedal position reading is outside the acceptable range.

FNR Fault

FNR Switch – the FNR switch Forward and Reverse inputs are reading active at the same time.

Typical ETAC Installation

Operator Interface Information:

Inching Pedal Specifications:

Eaton p/n 5995413-001, 35 degree Electronic Floor Pedal Assembly without Idle Validation Switch, or equivalent. Powered by MAESTRO Controller.

FNR switch specifications:

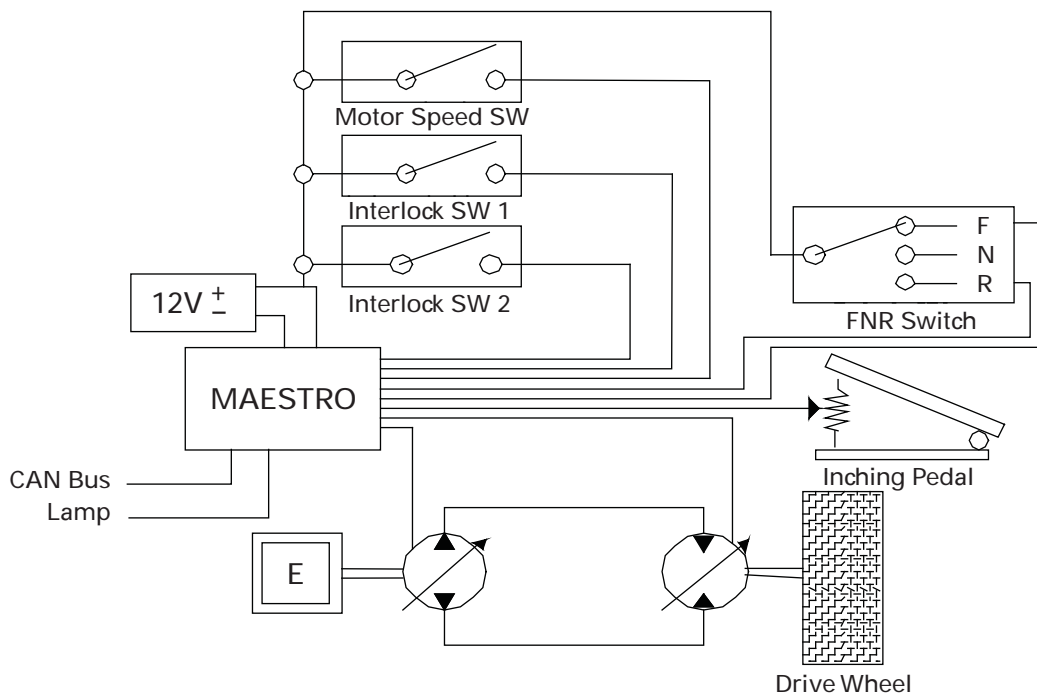
Eaton p/n

ITEM	P/N	DESCRIPTION
1	5995414-001	FNR Switch and Clamp for a 1.50 inch diameter column
2	5995414-002	FNR Switch and Clamp for a 1.75 inch diameter column

Controller Inputs for vehicle interlocks:

1. Operator presence interlock switch, for example, seat, seatbelt, roll cage (1)
Please describe your operator presence interlock:

2. Parking brake interlock switch (1)



General information, operator interface devices: foot pedals, joysticks, buttons, switches:

It is the customer's responsibility to determine the suitability of these items for the customer's specific vehicle. Operator interfaces are electrical mechanical devices which have a finite life. Only the customer can ensure that appropriate vehicle design, installation,

guarding and/or fail-safe devices will protect users' safety and comply with applicable federal, state, local and industry safety and health regulations, codes and standards. We ensure compatibility of recommended or equivalent products with the suggested Eaton electronic controller and software configuration. We can advise of the attributes of the suggested

products and obtain test units for prototyping. However, due to the unlimited variety of machines, vehicles, equipment and system designs in which these devices may be used, it is impossible for Eaton to guarantee the suitability of a given operator interface for a specific application. Ultimately, our customers' engineering departments

must be the qualified experts for their vehicle. If these devices will be used in a safety critical application, the customer must undertake appropriate testing, evaluation, and fail safe measures to prevent injury to the ultimate user.

Questionnaire:

Application Data Sheet

ETAC is an electronic hydrostatic drive control which enables a vehicle to be driven in a manner similar to an automobile with automatic transmission. Pump displacement is related to engine RPM.

ETAC is a propulsion system with anti-stall for off-road vehicles such as fork lift trucks and utility vehicles that are not equipped with boom and bucket work circuits. Inching capability is an available option which may not be needed if propulsion is the only hydraulically powered function.

Eaton Account Manager:

Office Phone:

Cell Phone:

e-mail address:

Distributor Name:

Location:

Distributor Salesman:

e-mail address:

OEM Name:

Address:

Project Name:

Date Prototypes Reqd:

Design Freeze Date:

Pilot Build:

Production Start Date::

OEM Engineering Contact:

Name:

Title:

Phone:

e-mail address:

MPS number(s):

MSS number:

Production Volume:

Year one:

Year two:

Year three:

Mature year qty:

Vehicle Information:

Vehicle, application Description:

Please provide schematics, photos, customer catalogs, etc. as available

Manufacturer's Model or Number:

Vehicle Power (battery voltage):

Voltage (Vdc):

Vehicle Weight, Unloaded:

Unloaded (16) kg:

Vehicle Weight, Laden:

Loaded (16) kg:

Max. Weight on Drive Wheels, Front:

Front lb(kg):

Max. Weight on Drive Wheels, Rear:

Rear lb(kg):

Vehicle Ground Speed, Working Range:

Working Range mph (kph):

Vehicle Ground Speed, Road Range:

Road Range mph (kph):

Maximum Drawbar or Tractive Effort:

Tractive Effort lb (kg):

Gradeability:

Maximum (%):

Coefficient of Traction (adhesion):

(0 -1.0)

Coefficient of Rolling Resistance:

(0 -1.0)

Questionnaire:

Application Data Sheet

Engine Information:

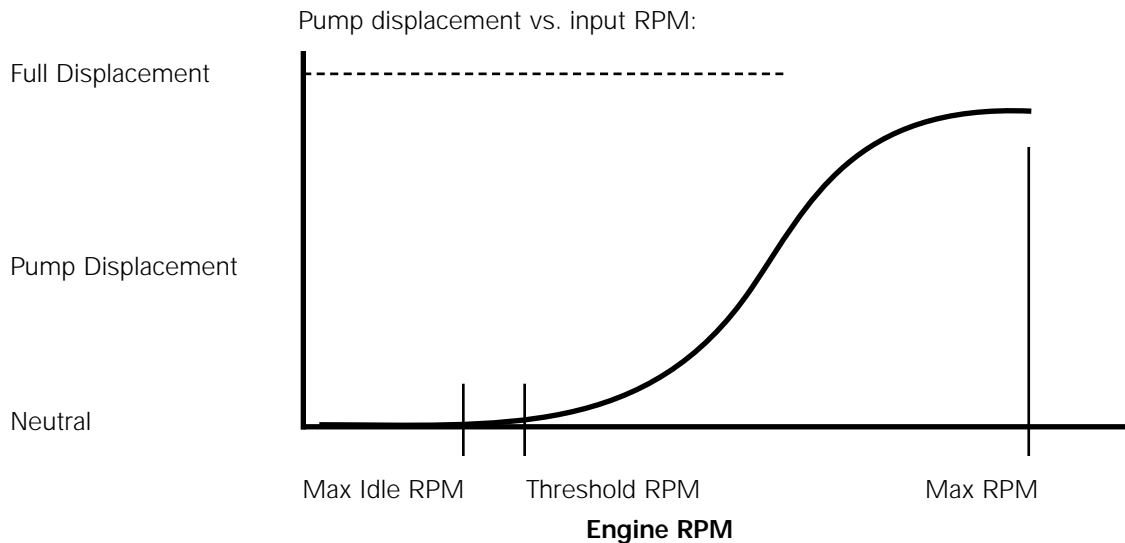
Make, fuel type:		
Model:		
Rated power:	Power	hp (kW):
RPM at Rated power:	(RPM)	
Peak torque:	Torque	ft-lb (N-m):
RPM at peak torque:	(RPM)	
Maximum low Idle RPM:	(RPM)	
Maximum RPM:	(RPM)	
Engine performance:	Please provide curve of Torque vs. Engine RPM	

Drive Line Data:

Fixed drive motor displacement:	Fixed (CID)cc:	
Variable drive motor displacement	Variable - low CID(cc):	
	Variable - high CID(cc):	
Gearbox Ratios (if applicable):	1st gear:	3rd gear:
	2nd gear:	4th gear:
Final Drive Reduction Ratio:		
Wheel or Track drive:		
Driven tire rolling radius:	Radius inch(mm):	

Automotive Drive Performance:

RPM at which vehicle begins to move:	(Engine RPM):	<i>"Threshold Speed" ...greater than max idle RPM</i>
Pump RPM at full displacement:	(Engine RPM):	<i>Typically less than max engine RPM, and greater than peak torque RPM</i>
Pump input-speed ratio to engine RPM:		



Please provide curve of pump displacement vs. engine or input shaft RPM

Eaton
Hydraulics Operations USA
14615 Lone Oak Road
Eden Prairie, MN 55344
USA
Tel: 952-937-9800
Fax: 952-294-7722
www.hydraulics.eaton.com

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Fax: +41 (0) 21 811 4601

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Fax: 86-21-6335-3912

