# Eaton Medium-Duty UltraShift® PLUS Transmissions TRIG0996 EN-US

September 2014

Eaton UltraShift® PLUS PV Performance Transmissions

EO-11E406B-PV EO-11E406B-PVER





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## **Introduction and General Information**

## **Warnings and Cautions**

This symbol is used throughout this manual to call attention to procedures where carelessness or failure to follow specific instructions may result in personal injury and/or component damage.

Departure from the instructions, choice of tools, materials and recommended parts mentioned in this publication may jeopardize the personal safety of the service technician or vehicle operator.



**Warning:** Failure to follow indicated procedures creates a high risk of personal injury to the servicing technician.

**Caution:** Failure to follow indicated procedures may cause component damage or malfunction.

**Important:** Highly recommended procedures for proper service of this unit.

**Note:** Additional service information not covered in the service procedures.

**Tip:** Helpful removal and installation procedures to aid in the service of this unit.

## **Important Notice**

Any reference to brand name in this publication is made as an example of the types of tools and materials recommended for use and should not be considered an endorsement. Equivalents may be used, unless otherwise stated.

The description and specifications contained in this service publication are current at the time of printing.

Eaton reserves the right to discontinue or modify its models and/or procedures and to change specifications at any time without notice.

#### **About this Manual**

This Eaton<sup>®</sup> publication is intended to be a reference guide for the installation of the Eaton UltraShift<sup>®</sup> *PLUS* PV transmission. General vehicle and transmission information is provided to cover the wide range of applications. This information benefits the OEM installer by providing the correct installation procedures to ensure the utmost in satisfactory operation and long service life. For additional transmission information, see the Suggested Tools section in this manual. For specific engine information contact the engine OEM.

Failure to adhere to Eaton Installation Requirements may affect transmission performance and/or warranty coverage.

Eaton UltraShift® *PLUS* PV is compatible with electronically governed engines equipped with a J-1939 data link and certified by Eaton. Transmissions installed at OEM facilities shall meet and be approved by Eaton Application Engineering. Contact Eaton Application Engineering or your OEM Application Engineering department for the proper Application form. All applications shall be submitted for approval.

## **OEM Design Responsibility**

OEM facilities shall submit a design package to Eaton OEM Engineering Support Group for approval prior to any OEM build. A design package consists of the following information:

- Battery power and ground Detailed drawing of battery power and ground scheme.
- **Individual harness drawings** Construction detail of individual wiring harnesses including harness routing location and clipping points.
- Wiring schematic High-level schematic of how this transmission interfaces with the vehicle.

## **Application Approval**

Eaton UltraShift *PLUS* PV model transmission systems installed at OEM facilities must meet the requirements and be approved using the Eaton Transmission Application Approval Form. Please contact Eaton Application Engineering or your OEM's Application department for the latest Application form.

- **Driveline Torque Requirements** Driveline angular acceleration and driveline torque shall not exceed requirements stated in Eaton Application Guideline specification TRAG2600.
- Applications and PTO Applications- refer to Application Guidelines Manual TRAG2600 and PTO Torque Limits TMIB0127 for PTO application guidelines.

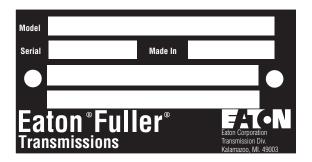
Every effort has been made to ensure the accuracy of the information contained in this manual. However, Eaton makes no warranty, either expressed or implied, based on the information provided. With each new application, engine manufactures should be contacted to make sure desired engines are compatible with these systems.

## **Transmission Identification Tag**

All UltraShift transmissions are supplied with component identification tags. All tags are located on the bottom, right rear corner of the transmission.

Care should be taken not to damage the identification tag during the installation process.

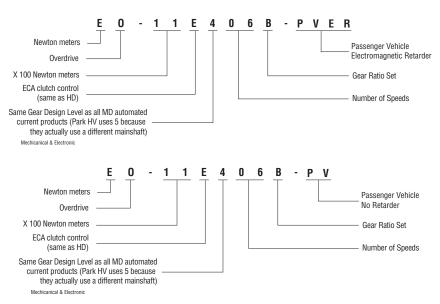
#### Do not remove the identification tag.



## **Product Identification**

#### **Nomenclature**

#### Eaton UltraShift® PLUS PV Performance Transmissions



## **Product Familiarization**

## Similarities and Differences Compared to Current Automated Products

Note: In all cases where differences have been identified, see the respective installation requirements for details.

# Similarities with Eaton UltraShift $^{\!(\!R\!)}$ PV Products compared to UltraShift $^{\!(\!R\!)}$ HV Products

- Identical PTO locations and PTO fit up requirements.
- Identical shift device options.
- Utilizes Gen 3 ECU and electrical connections
- Includes advanced Gen 3 diagnostic capabilities.
- Identical reverse switch option and locations.

#### Differences and Features with Eaton UltraShift PLUS PV Products

- A MEIIR circuit is not required for the Eaton UltraShift *PLUS* PV Transmissions.
- New 12/24 Volt capable Electric Clutch Actuator (ECA) to manage clutch engagement for improved transmission shifting. This requires the OEM to connect a power harness and ground.
- New ECA Clutch which is automatically adjusted at the OEM prior to vehicle being driven.
- A zerk fitting for the ECA cross shaft is easily accessible on the outside of the clutch housing for servicing. The cross shaft is pre-lubed by Eaton.
- Transmission rear supports are required with transmission mounted retarder.
- An intelligent start gear selection system automatically selects appropriate gear based on percent grade, vehicle weight
  and engine torque. The OEM is required to perform a grade sensor calibration procedure upon initial vehicle start up to
  support this system.
- A PTO input is available on this transmission. The OEM is recommended to provide a connector and wiring from the transmission ECU 38-way with the PTO wires installed.
- A High Capacity Inertia Brake (HCIB) is located on the transmissions PTO opening. This device is installed by Eaton. Therefore, a clutch brake is not required to be installed by the OEM.
- This system requires passive sealing on the clutch housing to ensure no foreign debris enters the clutch area. This requires the OEM ensure that all openings in the flywheel housing are plugged.
- A 10 tooth 1 3/4 inch spline on the input shaft is standard for the PV transmission.
- An auto neutral feature is required with this transmission which forces neutral in all instances when the parking brake is applied. This requires the OEM to install and connect a pressure switch in the parking brake valve circuit. Starting with the release of software #5569892, a data link signal will be an acceptable substitute for the pressure switch requirement.
- A direction sensor is a new device for this transmission which integrates the speed and directional signal into one sensor, thereby requiring only one opening (12 o'clock position) on the rear bearing cover.
- A 12 or 24 volt electrical system with a minimum of 1800 CCA is required.
- Product-specific J1939 messaging.
- The OEM is required to install a flywheel speed sensor.

# General Information

# **Suggested Tools/Publications**

## O.E. Tool & Equipment Group/Kent-Moore SPX Corporation 1(800) 520-2584

Kent-Moore Part no.	Description
5505027	Volt/Ohm Meter (Standard commercially available VOM)

## O.E. Tool & Equipment Group/Kent-Moore SPX Corporation 1(800) 328-6657

Kent-Moore Part no.	Description
J-43318	Eaton Test Adapter Kit
J-49111	Clutch Alignment Tool

## Liberty Circuits Corporation (269) 226-8743

Part No.	Description
500-432	Pull-To-Neutral Box
500-442	Grade Sensor Calibration Box

## Deutsch 951-765-2250

Part No.	Description
DTT-20-02	Hand Crimping Tool - Low Power Pins (size 20)
DTT-12-00	Hand Crimping Tool - High Power Pins (size 12)

#### **Service Publications**

TRSM0930	Service Manual for External components
TRTS0930	Troubleshooting Guide
TRDR1110	Drivers Instructions

## **Dearborn Group Technology**

Part No.	Description
DG-DPA IV PLUS	Protocol Adaptor

## Nexiq Technologies

Part No.	Description
104004	Pro-link GRAPHIC Scan Tool
6006001	HD Scan Tool Kit

For more information contact your OEM quality representative.

## **Vendor List**

#### **Eaton Vehicle Controls Business Unit**

J1939 Auto Shift Display

Contact Phone Number: 919 202 5220 http://commercialcontrols.eaton.com

#### **BELDEN WIRE AND CABLE**

(HIL and J-1939 Cable)

P.O. Box 1980

Richmond, IN 47375

(317) 983-5200

Fax (765) 983-5294

www.Belden.com

#### **BRAND-REX CO.**

(J-1939 Cable)

300 Brickston Square

Andover, MA 01801

(978) 933-5100

www.brand-rex.com

#### **CHAMPLAIN CABLE CO.**

(J-1939 Cable)

12 Hercules Dr.

Colchester, VT 05446

(802) 655-2121

Fax (802) 654-4224

www.champcable.com

#### **DEUTSCH**

(Connectors)

**Industrial Products Division** 

3850 Industrial Ave.

Hemet, CA 92545

(951) 765-2250

Fax (951) 765-2255

www.deutschipd.com

insidesales-ipd@deutsch.net

www.laddinc.com (Ladd Industries)

#### **Delphi Connection Systems**

(Connectors)

1265 North River Rd. MC. 11C

Warren, OH 44483 USA

(330) 373-3630

Fax (330) 373-7774

www.delphi.com

#### **RAYCHEM**

(Wire)

**Electronics OEM Components Division** 

300 Construction Drive

Menlo Park, CA 94025-1164

1-800-260-9909

Fax United States (800) 260-9999

Fax Worldwide (650) 361-5579

www.raychem.com

#### LIBERTY CIRCUITS CORPORATION

630 East Walnut

Kalamazoo, MI 49007

(269) 226-8743

#### **DELFINGEN**

(Conduit)

840 W. Long Lake Road, Suite 120

Troy, MI 48098

(248) 519-0534

Fax (248) 519-0093

www.delfingen.com

## Telma

#### United States:

Telma Retarder Inc. 870 Lively Boulevard Wood Dale, IL 60191 1-800-797-7714 www.telmausa.com

#### China:

Telma Vehicle Braking System Co., Ltd No. 9 factory 533 Yuanzhong Rd. Nanhui Shanghai, China 210300 +86 13818963597 www.telma-retarder.com.cn

# **Vehicle Space Claim**

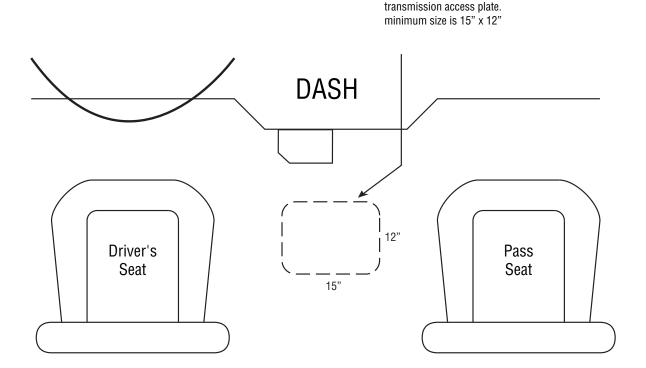
## **Cab Floor Access Plate Requirements**

Note: Access plate requirement applies to any vehicle configuration even though only a front engine configuration is shown.

Easily accessible and removable

Note: During chassis layout adequate space is required for ECA removal and maintenance.

Note: Refer to the "Transmission Component Temperature Requirements" on page 22.

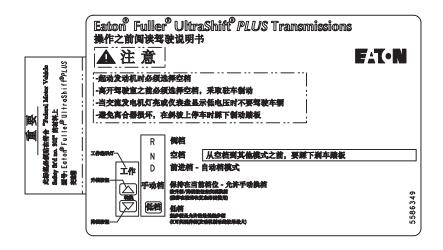


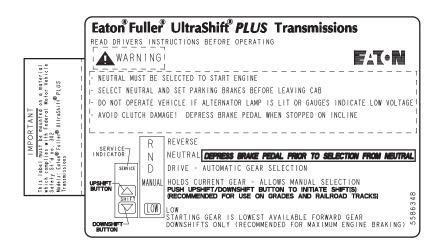
## **Cab Floor Access Plate Requirements**

- 1. A cab floor access plate is required for access and removal of components from the transmission top. Plate size (minimum: 15"x12") shall be sufficient to allow removal of the Transmission Electronic Control Unit or the Electric Shifter.
- 2. Access plate requirement applies to any vehicle configuration even though only a front engine configuration is shown.

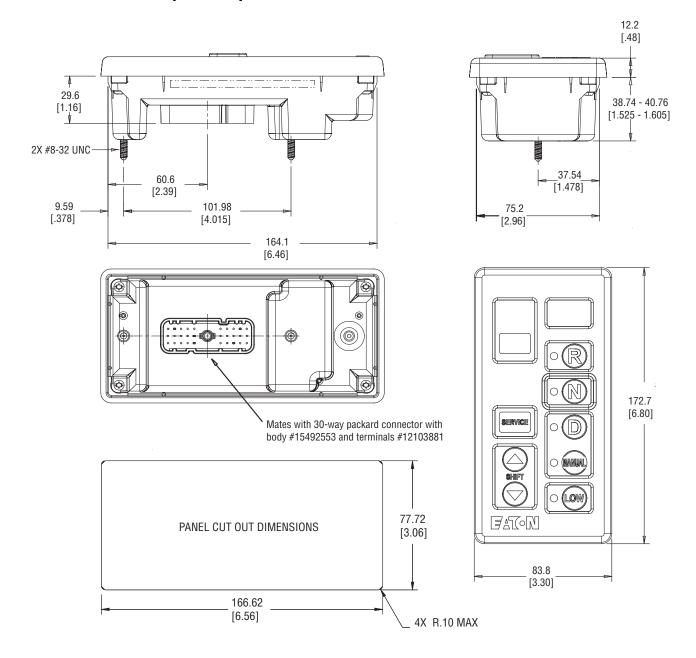
## **Shift Label Requirements**

- 1. The shift label should be located in the cab so that it is visible in the driver seat.
- 2. Shift labels are available for shift devices in Chinese and English.
- 3. The OEM must match the label with the installed shift device.

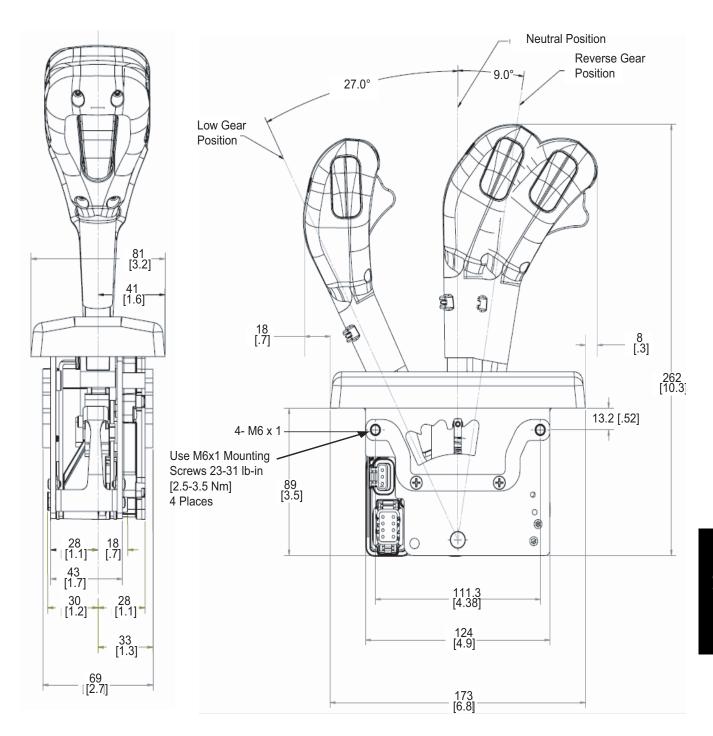




# **Eaton Shift Console Space Requirements**



# **Eaton Shift Lever and Tower Space Requirements**



## **Clutch Interface**

## **Pilot Bearing Specifications**

The OEM is responsible for the design and selection of pilot bearings to mate with our product. Eaton recommends high quality pilot bearings procured from Original Equipment Manufacturers. Significant decrease in life may occur with the use of generic brand pilot bearings.

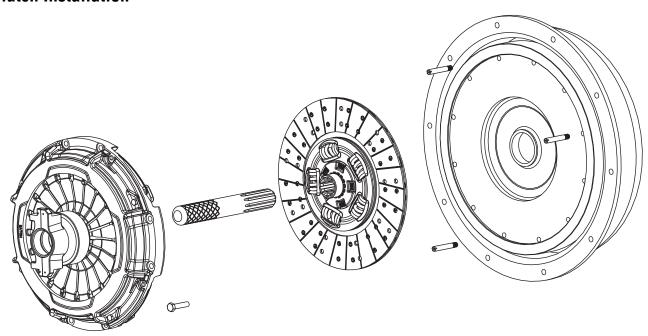
The following pilot bearings are currently the minimum Eaton Clutch Division recommends. The operating temperature that the pilot bearing sees has increased in the last several years. This creates operating conditions that are no longer acceptable to the standard pilot bearings and grease. In addition, the life of the clutch has increased. The use of high temperature grease and Viton seals are now mandatory to ensure adequate bearing life. Pilot bearing failure usually results in a warranty claim for drag or clutch noise. This results in a claim against Eaton Clutch.

Below is a list of the recommended Pilot Bearings. All of these bearings have Viton seals and a high temperature grease in addition to a C3 fit. It is acceptable to use synthetic high temperature grease and a C5 fit if desired.

If the supplier specific bearing is no longer available, contact the supplier for an equivalent alternative bearing.

Vendor	Seal Type	Bearing Series 6205	Bearing Series 6206	Bearing Series 6306	Bearing Series 6006
NTN	Viton	6205 LLUA1/C3	6206 LLUA1	6306 LLUA1/C3	6006 LLUA1 C3/LX16
КОҮО	Viton	6205 2RKF-S2/C3	6206 2RU	6306 2RKF-S2/C3	-
NSK	Viton	6205 DDU7/C4 ENS	6206 2RS2	6306 DDU7/C4 ENS	6006 DDWA18A C4/ENSS
SKF	Viton	6205 2RS2/C3	6206 2RSJ	6306 2RS2/C3	-
FED-MOG	Viton	6205 VV/C3	206 VV	6306 VV/C3	-
PEER	Viton	6205-2VRLD-C3	-	6306-2VRLD-C3	6006-2VRLD-C3

#### **Clutch Installation**

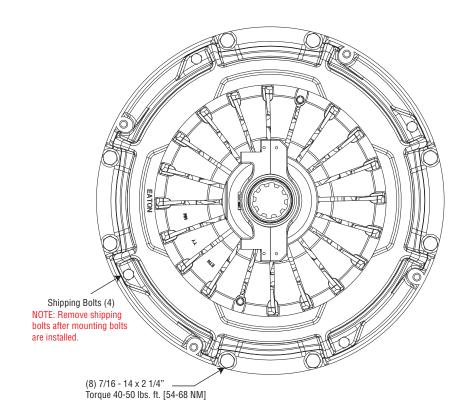


Note: Eaton supplied 395mm clutch must be used.

## 395 Clutch Installation Requirements

- 1. Install two guide studs into mounting holes.
- 2. Install disc onto aligning tool. Follow the orientation instructions on the disc.
- 3. Put aligning tool with disc into flywheel. Verify aligning tool pilot is through the pilot bearing.
- 4. Slide clutch assembly over aligning tool and two guide studs.
- 5. Install lock washers and (8) 7/16-14 x 2" grade 5 or better mounting bolts finger tight. Replace studs with lock washers and bolts. Progressively tighten bolts in a crisscross pattern starting with a lower bolt. Torque the 395mm to 40–50 lb-ft. [54–68 Nm].
- 6. Remove (4) yellow shipping bolts.
- 7. Remove aligning tool.

## 395mm Mounting Bolts and Shipping Bolts

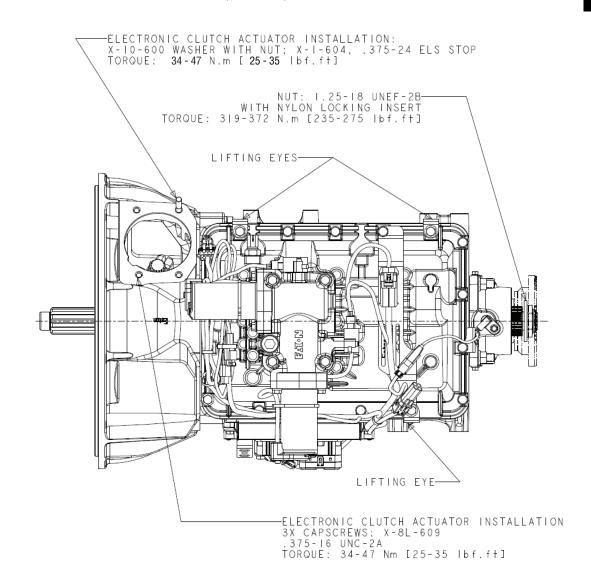


#### **ECA Assembly Instructions**

The ECA will be shipped as a loose part.

#### ECA Installation:

- Apply anti-seize compound to the bore of the ECA.
- The ECA will need to be rotated to line up a locating pin with a notch in the housing in order to install the ECA into the clutch housing.
- Install the ECA onto the housing, while matching the splines of the ECA motor to the shaft.
- Install (1) 3/8"-24 nylon lock nut or nut with washer to secure the ECA to the housing. Torque to 25 35 ft lb (34 47 Nm).
- Install (3) 3/8"-16 cap screws. Torque to 25–35 ft-lb (34–47 Nm).



#### **ECA Removal Instructions**

If transmission removal is necessary the ECA must first be released from the clutch by one of two methods.

The first method is to use ServiceRanger:

- 1. Once connected with Service Ranger go to Service Routines.
- 2. Click the "Start" button located next to "Clutch Service Utility". This page will give instructions for a variety of operations.
- 3. Select Service Position on the upper left corner of the screen, carefully follow the instructions on the screen. This will rotate the clutch fork to the open position so the transmission can be pulled back from the engine with out damaging the clutch.
- 4. Make sure the shipping bolts are installed before removing the clutch or clutch damage will occur.

The other option is to remove the ECA by using the following Instructions. Refer to the following procedure in the event the Electronic Clutch Actuator assembly requires removal and replacement:

#### **ECA Removal:**

- 1. Cut tie straps which secures the ECA harness (if applicable).
- 2. Disconnect the harness to the ECA.
- 3. Remove the (1) 3/8"-24 nylock nut that secure the ECA to the housing.
- 4. Remove the (4) 3/8"-16 capscrews that secure the ECA to the housing. Remove the ECA.
- 5. The ECA will need to be rotated to line up a locating pin with a notch in the housing in order to remove the ECA from the clutch housing.
- 6. Make sure the shipping bolts are installed before removing the clutch or clutch damage will occur.

## **Transmission Interface**

## **Handling**

Handle the transmission carefully to avoid damage to the transmission components and surrounding vehicle components.

• Use a hoist or transmission jack that permits precise control of the transmission movement during installation.

## **Transmission Preparations**

**Note:** Eaton has provided several brackets that can be used for clipping vehicle components to. ECU, sensor, and lifting eye fasteners are not to be used for securing additional OEM brackets under any circumstances. This includes cap screws used to fasten the shift bar housing, rear housing, bearing covers, and PTO covers. Removal of these can compromise transmission system operation and overall system reliability.

**Note:** No mechanical speedometer. The rear bearing cover will offer three (3) push-in sensor openings at 3, 9, and 12 o'clock positions. The 12 o'clock position is reserved for Eaton for the direction and speed sensor assembly. The 3 and 9 o'clock positions are reserved for the OEM to install a speed sensor. The tone wheel has 16 teeth, as standard.

#### **Reverse Switch**

#### **Reverse Switch Option**

Reverse switch opening is standard on all medium-duty Eaton transmissions. The transmission will be shipped with plug this opening, unless a switch is ordered by the OEM and pre installed by Eaton.

#### **Reverse Switch**

Location: Opening is located at the right front corner of the shift bar housing. See top view drawings for location.

Switch type: Normally open ball type switch. See Electrical System Interface for electrical requirements.

Thread size: 0.5625-18 UNF-2B.

Mating Connector: Options are screw terminals or Weather Pack.

## **Mounting Transmission to Engine**

Use the two transmission lifting eyes provided. The lifting eye position shall not be changed on the transmission. Do not remove the Electric Shifter at any time.

- Use a two point lift chain or transmission jack with a minimum capacity of 1500 lbs.
- Inspect the engine to transmission mating surfaces for damage or debris prior to installation. Make sure the engine flywheel housing face, transmission clutch housing face, input shaft, etc. are free of paint, debris, rust, and any type of damage before installation.
- The transmission is shipped in gear until the vehicle is powered up with the key switch. Use a Pull-to-Neutral-Box to disengage the transmission or rotate the axles to align the transmission prop shaft.
- Input Shaft To Clutch Alignment the transmission is shipped from Eaton with the transmission in gear. The transmission shall be in gear in order to rotate the input shaft by turning the output shaft/yoke. The transmission will automatically reset to the neutral position as soon as the vehicle is powered up (key switched on). In the event that the transmission is not received in gear, the input shaft will have to be manually indexed to mate up with the clutch splines.
- Adjust the lift chain or transmission jack to obtain the same relative angle as the engine. The face of the engine flywheel
  housing and the face of the transmission clutch housing shall be parallel during installation. Rotate the output shaft/
  yoke while sliding the input shaft into the clutch to line up the splines. If the transmission is properly aligned and the
  clutch splines are properly aligned, very little force is required to slide the input shaft through the clutch and into the
  pilot bearing.
- If interference is encountered, move the transmission away from the engine to investigate the cause. The use of excessive force to overcome misalignment may cause damage to the transmission input shaft and the clutch.
- The clutch/yoke will remain in the released position during the entire transmission installation. At key on the ECA will rotate the clutch/yoke to its proper position.
- Once the transmission is seated against the engine flywheel housing, align the clutch housing bolt holes with the engine flywheel housing bolt holes and install all capscrews and tighten finger tight.

**Note:** The clutch housing shall be flush against the engine flywheel housing before tightening any capscrews. Do not use the capscrews to seat housing.

**Note:** Do not tighten any mounting capscrews until all capscrews have been installed and are finger tight. Do not remove the transmission support chain or iack until all mounting bolts have been tightened.

• The ECA and ECA cover will be shipped as a loose part to the OEM. This requires the OEM to install the ECA after the transmission has been attached to the engine.

#### **Using Rear Supports**

Transmission rear supports are required for all Eaton UltraShift *PLUS* PV model installations that have a Telma retarder. The OEM is responsible for nodal and rear support design. Refer to OEM for rear support fastener torque specifications.

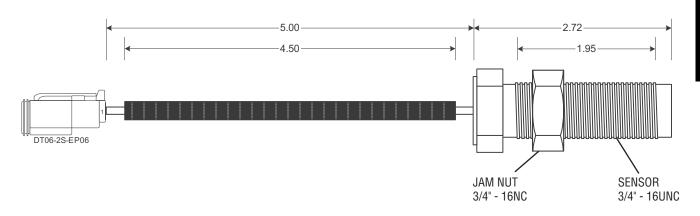
## **ECA Engine Speed Sensor Requirements**

The OEM is required to install a dedicated engine speed sensor in this product. The use of the J1939 data bus engine speed signal is not a substitute for this sensor.

The ECA engine speed sensor is directly connected to the ECA and mounted in the engine flywheel housing.

**Note:** The ECA Engine Speed Sensor requires a port in the engine flywheel housing. The preferred location of the port is either between 3 and 5 o'clock or 7 and 9 O'clock positions, for serviceability and to prevent road debris damage.

#### Eaton Part Number 4308074

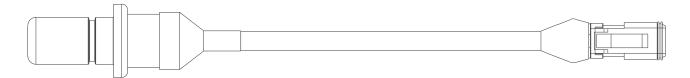


#### **Threaded Engine Speed Sensor Installation Requirements**

- Thread speed sensor into the engine bellhousing until it touches the flywheel then back sensor out approximately 1/2 turn to set gap.
- Set gap between sensor and flywheel to 0.055 inches +/- 0.020".
- Hold the sensor in place and tighten the 3/4"-16 jam nut to 15 lbs.ft. [20.3 Nm].
- Connect engine speed sensor connector to the mating connector on the transmission and fasten harness to the ECA cover.

#### **Push in Engine Speed Sensor Installation Requirements**

- Install push in speed sensor and secure by proper means that sensor shall not rotate or vibrate.
- Gap between sensor and flywheel must be 0.055 +/- 0.020".
- Connect engine speed sensor connector to the mating connector on the transmission and fasten harness to the ECA cover.



P/N 4306660

## **Lubrication Requirements and Specifications**

#### Eaton UltraShift PLUS PV Transmission Gear Box Lubrication Requirements

Eaton requires the use of a transmission lubricant that meets PS-164 rev 7 specification.

A list of approved lubricants and suppliers can be found in the Approved Lubricant Supplier Manual, TCMT0020.

Not using the required lubricant will result in degraded performance and shortened life of the product. Refer to the Lubrication Manual, TCMT0021, for the latest information regarding lubrication requirements.

**Note:** Eaton recommends the use of Eaton Roadranger Lubricants. Roadranger SAE 50 Synthetic Lubricant and Eaton PS-164 rev 7 are the only approved synthetic lubricants.

Note: Failure to adhere to Eaton installation requirements may affect the transmission performance and / or warranty coverage.

#### **Transmission Gear Box Required Lubricant**

Eaton Roadranger SAE 50 Synthetic Lubricant or PS164 Rev 7 approved lubricant

#### **Warnings and Cautions**

- Before working on a vehicle, place transmission in neutral, set brakes, and block wheels.
- Do not introduce additives and / or friction modifiers. Additives of any kind added later to the oil can result in unpredictable consequences. No liability of any kind will be accepted by Eaton for any damage resulting from the use of such additives.
- · Do not mix lubricants of different grades.
- Use clean containers when transferring lubricant from the bulk storage to the transmission. Containers used for antifreeze or water should be cleaned prior to use.
- Do not re-use lubricant.
- Failure to use the required lubricant will affect the transmission performance and the warranty coverage.
- SAE 15W-40 viscosity grades are not allowed in Eaton transmissions.

#### **Operating Temperatures**

Transmissions must not be operated at temperatures above 250 °F (121 °C.) Operation at temperatures above 250 °F (121 °C) causes loaded gear tooth temperatures to exceed 350 °F (177 °C) which will ultimately destroy the heat treatment of the gears.

The following conditions in any combination can cause operating temperatures over 250 °F (121 °C.)

- Operating consistently at high loads / slower speeds
- High ambient temperatures
- Restricted air flow around transmission
- Exhaust system too close to the transmission

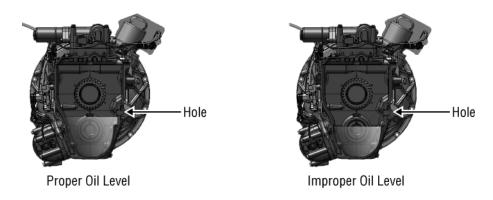
#### **Transmission Oil Level**

Transmission Capacity (Approximate)				
PV	20.75 pints (9.8 liters)			

- 1. Place vehicle on level ground.
- 2. Turn engine off.
- 3. Remove fill hole plug.
- 4. Lubricant must be level with the bottom of the fill hole (+/- 3mm).
- 5. Reinstall the fill hole plug and torque to recommended torque value.
- 6. Clean off any oil residue.

Make sure that the transmission lubricant is level with the bottom of the fill opening (+/-3mm).

**Note:** Being able to reach the lubricant with your finger does not indicate that the lubricant is at the proper level. (On heavy-duty transmissions, one inch of lubricant equals about nine pints of oil.)

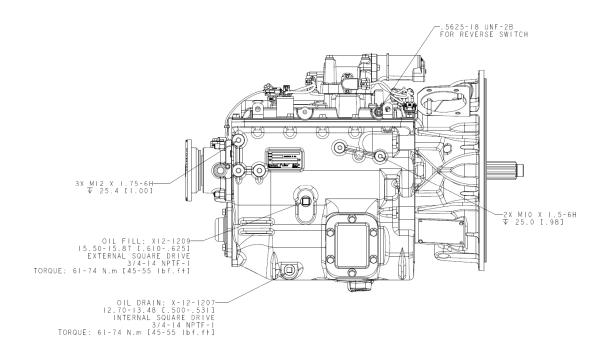


**DO NOT** remove the Electric Shifter (XY Shifter) to fill the transmission with oil. Transmission must be filled through the fill hole.

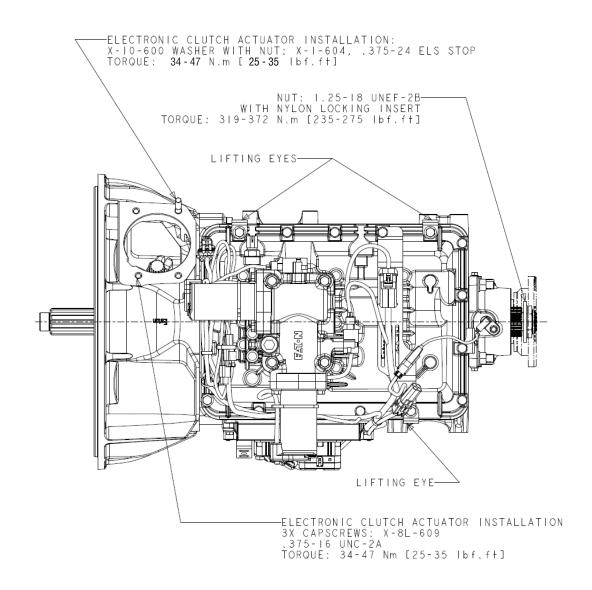
# **Transmission Component Temperature Requirements**

The temperature limit for all electrical and air system components is 250 °F (121 °C). Do not exceed. If sufficient air gap between the heat source and these transmission components cannot be achieved, the OEM must provide proper methods of heat shielding to ensure this limit is not exceeded. The components and systems to be protected would include, but not limited to, the Shift Motors, Sensors, Solenoids, Inertia Brake, Wire Harness, Transmission Controller, ECA, and the Transmission Case.

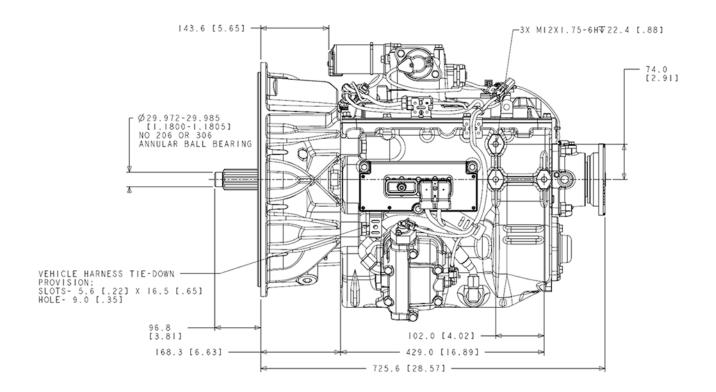
## **Right Side View**



## **Top View**



## **Left Side View**



# **Electrical System Interface**

## **Definitions**

**Vehicle Power** - Refers to both Battery Positive and Battery Negative supply

**Battery Positive** - Any connections to the vehicle battery pack positive rail

Battery Negative - Any connections to the vehicle battery pack negative rail

Switched Ignition - Ignition signal (power) from vehicle key-switch

**PBSC** - Push Button Shift Control (a.k.a. Eaton Shift Console)

**TCM** - Transmission Control Module

**ECA** - Electric Clutch Actuator

**ECM** - Engine Control Module

Vehicle Design - Implementation of a vehicle design to produce a defined functional output

**Vehicle Function** - Verification that a design produces a defined functional output

Service Lamp - Diagnostic Lamp to indicate transmission fault detection to the operator

Shift Control Power - Power supplied from the TCM to either the PBSC or Eaton Shift Lever (a.k.a. Cobra)

**Eaton Shift Lever** - Eaton resistive ladder shift device (a.k.a. Cobra)

**Resistive Ladder Shift Device** - OEM resistive ladder shift device (same interface as Eaton Shift Lever, but supplied by OEM)

AWG - American Wire Gauge

SAE - Society of Automotive Engineers

**ISO** - International Standards Organization

FMVSS - Federal Motor Vehicle Safety Standards - United States of America

**LED** - Light Emitting Diode

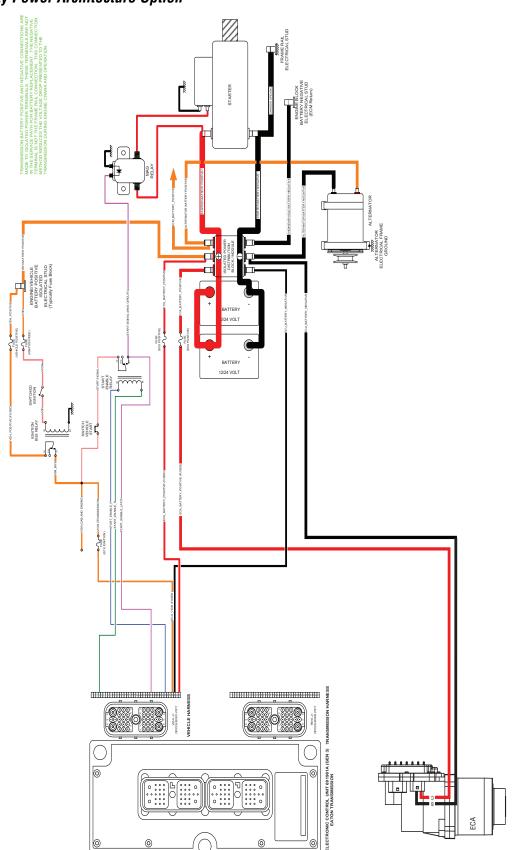
## **Power Requirements and Recommendations**

**Note:** *Italicized* requirements are critical to reliable vehicle operation.

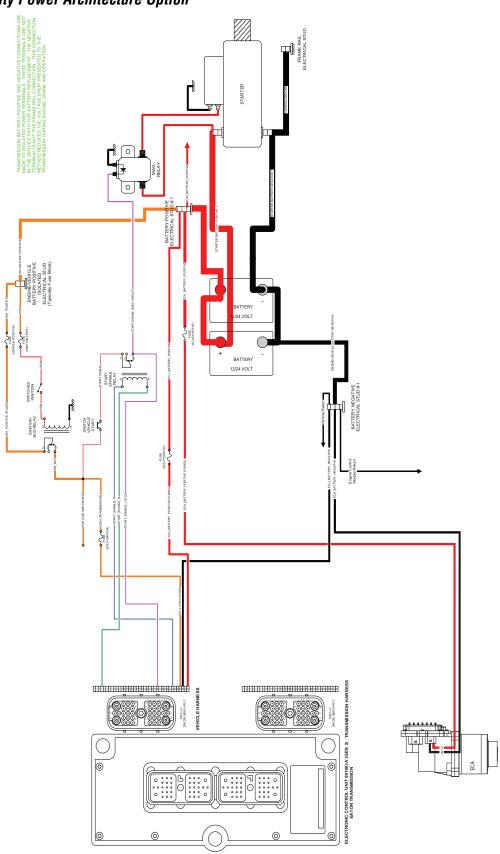
#### **Battery Power Requirements and Recommendations**

- The vehicle shall have a negative ground power system.
- The vehicle primary power system shall be either of the following types: 12 or 24 volt.
- The vehicle power system shall be designed such that if both the TCM and the ECA lose power due to a single point disconnect, the same disconnect simultaneously removes power from the ECM.
- The ECU battery power terminations shall not be made on the battery, frame rail, or starter posts. This applies to Battery Positive and Battery Negative.\*
- The ECA battery power terminations shall not be made on the battery, frame rail, or starter posts. This applies to Battery Positive and Battery Negative.\*
- If a disconnect switch is used for the ECM, it shall be configured such that it also removes power to the TCM and ECA simultaneously.
- For full TCM sub-system operation, the vehicle power system shall provide minimum of 9.0 volts DC at a steady state load of 30 amps for a nominal 12 volt vehicle power system (18.0 volts DC at a steady state load of 30 amps for a nominal 24 VDC system) at the ECU connector.
- For full TCM sub-system operation, the vehicle shall provide an electrical system, that, at 120 °C, the conductors between the TCM and the vehicle primary power system shall have no more than 0.05 ohms between TCM and Battery Positive and no more than 0.05 ohms between TCM and Battery Negative (0.1 ohms total).
- For full ECA sub-system operation, the vehicle shall provide minimum of 9.0 volts DC at a steady state load of 30 amps for a nominal 12 volt vehicle power system (18.0 volts DC at a steady state load of 30 amps for a nominal 24 VDC system) at the ECA connector.
- For ECA optimal shift quality, the vehicle shall provide a minimum of 11.0 volts DC at steady state load of 30 amps at the ECA connector.
- For full ECA subsystem operation, the vehicle power system shall provide and electrical system, that, at 120 °C, the conductors between the ECA and the vehicle primary power system shall have no more than 0.040 ohms between ECA and Battery Positive and no more than 0.040 ohms between ECA and Battery Negative (0.080 ohms total) to vehicle battery.
- The electrical power supply shall not exceed crank profile defined in ISO 16750-2 Third Edition (March 15, 2010) section 4.6.2.3 during crank for full transmission system operation. Contact your Eaton OEM Engineering Support Group for additional information.
  - The ECA function will not be affected if the crank profile is exceeded.
  - The TCM has been designed to allow cranking to continue for limited excursion outside of crank profile. Other TCM functions may not function when the crank profile is exceeded.
- The OEM shall supply power to the TCM and ECA that does not exceed a steady state voltage of 32 volts DC.
- The OEM shall provide Switched Ignition power signal such that the differential voltage (TCM Negative subtracted from Switched Ignition) shall exceed 9.0 volts DC at a steady state load of 10 amps.
- Vehicle Power and Switched Ignition to the TCM shall not be switched off during the engine start process.
- Frame Rail shall not be used as a return path for Battery Negative Vehicle Power.
- Vehicle Power shall be configured as shown in one of the accepted power electrical architectures indicated below.\*
  - \* Additional options may be available with approval from your Eaton OEM Engineering Support Group.

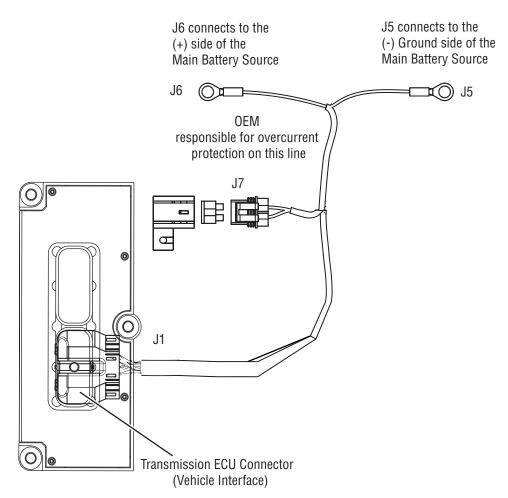
# **Medium Duty Power Architecture Option**



## **Medium Duty Power Architecture Option**

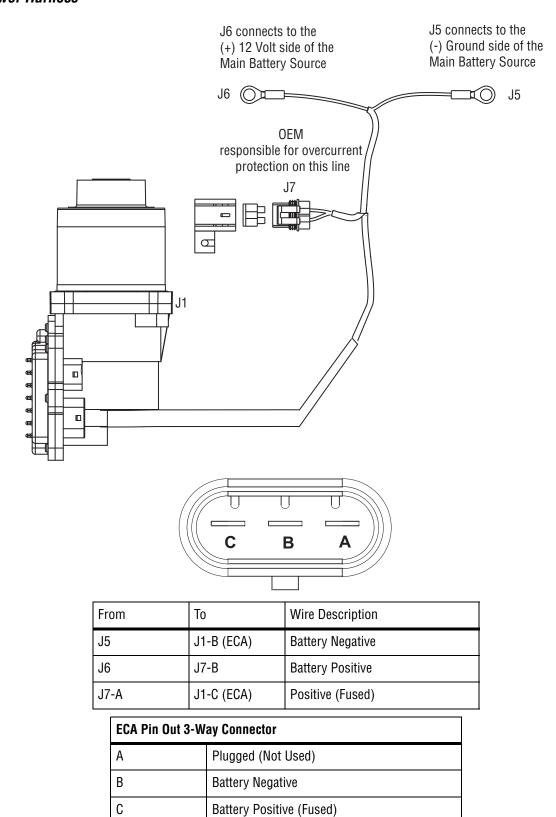


## Electrical Harnessing Integration Examples



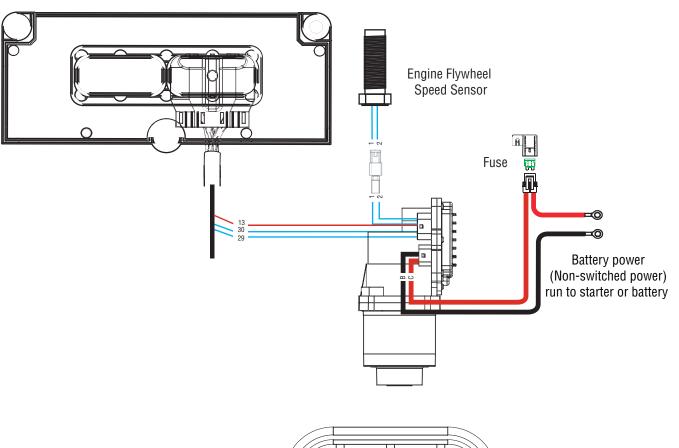
From	То	Wire Description
J5	J1-36	Battery Negative
J6	J7-B	Battery Positive
J7-A	J1-38	Positive (Fused)

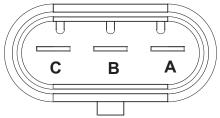
#### ECA Power Harness



# Typical ECA Circuit

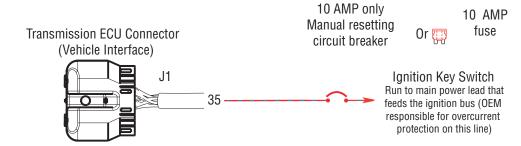
# Transmission ECU



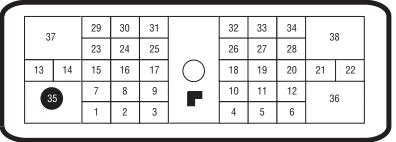


ECA Pin Out 3-Way Connector		
Α	Plugged (Not Used)	
В	Battery Negative	
С	Battery Positive (Fused)	

# Typical TCM Circuit



Front View Transmission ECU Connector (Vehicle Interface)



From	То
J1-35	VIGN

# **Electrical Current Requirements and Recommendations**

# **Operating Conditions over Temperature for 24-Volt Systems**

- For vehicles required to meet United States of America Federal Motor Carrier Safety Administration Regulations, the following shall apply: The OEM shall comply with vehicle wire installation and over current protection per Federal Motor Carrier Safety Administration Regulations Sections 393.27 Wiring specifications; 393.28 Wiring to be protected; 393.29 Grounds; 393.31 Overload protective devices; and 393.33 Wiring, installation.
- The fusing device for the TCM branch of Battery Positive Vehicle Power shall be identified at the termination.
- The fusing device for the TCM branch of Switched Ignition power shall be identified at the termination.
- The fusing device for the ECA branch of Battery Positive Vehicle Power shall be identified at the termination.
- The vehicle power system shall be designed to support the following operating current characteristics for the TCM:
  - Active Shifting Current: 30 amps
  - Maintaining current gear: 6 to 15 amps
  - Power down sequence: 6 to 30 amps
- The vehicle power system shall be designed to support the following operating current characteristics for the ECA: Peak Vehicle Power to the ECA: 30 amps for 200 ms.
- The fusing device for the TCM Vehicle Power shall have a nominal break current of 30 A or greater.\*
- Recommend use of 30 Amp Fuse (ATO or equivalent) for the TCM connection to Vehicle Power.
- The fusing device for the TCM Vehicle Power shall be dedicated to the TCM Vehicle Power interface.
- The fusing device for the ECA Vehicle Power shall have a nominal break current of 40 A or greater.\*
- Recommend use of 40 Amp Fuse (ATO or equivalent) for the ECA connection to Vehicle Power.
- The fusing device for the ECA Vehicle Power shall be dedicated to the ECA Vehicle Power interface.
- The fusing device for TCM Switched Ignition shall have a nominal break current of 10 A or greater.\*
- Recommend use of 10 Amp Fuse (ATO or equivalent) for Switched Ignition power to the TCM.
- The fusing device for TCM Switched Ignition shall be dedicated to the TCM Switch Ignition.
- The fusing devices for TCM Vehicle Power, ECA Vehicle Power, and TCM Switch Ignition shall not be self-resetting.
- The fusing devices shall be protected against the environment to prevent loss of function due to environmental factors including vibration and corrosion.
- Recommend environmentally sealed fuse block for ECU and ECA fuses. If in-line fuse holders are used, locate away from battery box and road splash; and that fuse holder be mechanically mounted in an orientation to best prevent water ingress into fuse holder.
- \* A properly sized fusing device for distribution of power to sub-circuits such as TCM Vehicle Power, ECA Vehicle Power, and TCM Switched Ignition may be used.

## **OEM on Transmission Routed Components**

#### **Routable Component Requirements**

- OEM routable components shall not be tie wrapped to transmission electrical harnesses
- OEM routable components shall not interfere with oil filler plug
- OEM routable components shall not interfere with oil sight glass
- OEM routable components shall not interfere with manufacturing fixtures, such as lifting eyes.

# **Mating Connector and Terminal Requirements**

#### **TCM**

- The OEM harness TCM mating connector shall be Deutsch DRC26-38S01-P017.
- The OEM harness TCM mating harness cable (wire) diameters shall be compliant with the following insulation diameter requirements:

SAE J1128 Wire Range Reference Table for TCM						
Seal Range Diameter (mm) / (in)	Contact Size	Description	TCM Pin Number	TXL <sup>1</sup> AWG	GXL <sup>1</sup> AWG	SXL <sup>1</sup> AWG
1.02-2.41 /0.040-0.095	20	Signal	J1-1 - J1-34	18	18	Ø
3.40-4.95 /0.134-0.195	12	Power	J1-38	Ø	12	Ø
3.40-4.95 /0.134-0.195	12	V-Ignition	J1-35	Ø	12	14
3.40-4.95 /0.134-0.195	12	Ground	J1-36	Ø	12	Ø

<sup>&</sup>lt;sup>1</sup> Typical. Manufacturer's insulation diameter should be confirmed to meet stated insulation diameter

- The TCM Deutsch connector shall strain relieve the harness by use of one of the following back-shells:
  - Manufacture: Deutsch | Style: Standard right angle | P/N: 0528-004-3805
  - Manufacture: Deutsch | Style: Low profile right angle | P/N: 0528-005-3805
- The TCM Deutsch connector's size 12 pins shall be nickel plated terminals.

**Note:** These circuits are power circuits.

The TCM Deutsch connector's size 20 pins shall be gold plated terminals.

Note: These circuits are signal level circuits.

- The TCM Deutsch connector's terminal shall be compliant with Deutsch's terminal requirements for the DRC26-38S01-P017 connector body.
- The TCM Deutsch connector's terminal shall have unused cavities filled with Deutsch P/N 0413-2014-2005 for size 20 contact cavities, and P/N 114017 plug for size 12 cavities.
- Mating torque for the 38-way TCM jackscrew shall conform to torque requirements found in the Appendix under Torque Specifications.

#### **ECA**

- The OEM harness ECA mating connector shall be Delphi Metri-Pack 12124685.\*
- The OEM harness ECA mating harness cable (wire) diameters shall be compliant with the following insulation diameter requirements:

SAE J1128 Wire Range Reference Table for ECA					
Seal Range Diameter (mm) / (in)	Contact Size	Description	TXL <sup>1</sup> AWG	GXL <sup>1</sup> AWG	SXL <sup>1</sup> AWG
4.40-5.15 /0.173-0.202	10	Power	Ø	Ø	10

<sup>&</sup>lt;sup>1</sup> Typical. Manufacturer's insulation diameter should be confirmed to meet stated insulation diameter

- The ECA mating connector shall use Delphi Metri-Pack 12052456 terminals.\*
- The ECA mating connector shall use the Delphi P/N 12045699 TPA.
- The ECA mating connector shall use Delphi P/N 12059255 wire filer.
- \* Additional options may be available with approval from your Eaton OEM Engineering Support Group.

#### **Engine Speed Sensor Interface**

Note: The speed sensor harness is supplied by Eaton and this information is for reference.

- The OEM harness connecting to the engine speed sensor shall consist of the following connector system components:
  - The OEM shall use the Deutsch DT04-2P series connector body.
    - Eaton recommends Deutsch part number DT04-2P-E003.
  - The OEM shall use the Deutsch W2PA wedge.
  - The OEM shall use Deutsch Size 16 gold plated contacts.
    - Eaton recommends Deutsch part number 1060-16-0144.
  - The insulation outside diameter of the connector shall comply with Deutsch requirements for the selected connector shell.
  - The wire gauge shall comply with the Deutsch requirements for the selected contact.

SAE J1128 Wire Range Reference Table for ECA Engine Speed Sensor Harness					
Seal Range Diameter (mm) / (in)	Contact Size	Description	TXL <sup>1, 2</sup> AWG	GXL <sup>1, 2</sup> AWG	SXL <sup>1, 2</sup> AWG
2.24-3.68 /0.088-0.145	16	Signal	14	14-18	14-20

<sup>&</sup>lt;sup>1</sup> Typical. Manufacturer's insulation diameter should be confirmed to meet stated insulation diameter

<sup>&</sup>lt;sup>2</sup> Different contact part numbers are needed to accommodate different sizes of wires

## **Electrical System Interface**

#### **PBSC**

- The OEM harness PBSC mating connector shall consist of one of the following connector systems:
  - Delphi:
    - Connector Body P/N 15492553
    - Terminal P/N 12103881 (18-20 AWG)
    - Plug P/N 12034413
  - Cinch:
    - Connector Body P/N 581 01 30 027
    - Terminal:
      - P/N 425 00 00 872 (18-20 AWG)
      - P/N 425 00 00 873 (16-18 AWG)
    - Plug P/N 581 00 00 011
- The OEM PBSC mating harness cable (wire) diameters shall be compliant with the following insulation diameter requirements:

Seal Range Diameter (mm) / (in)	Contact Size	Description	TXL <sup>1</sup> AWG	GXL <sup>1</sup> AWG	SXL <sup>1</sup> AWG
2.00-2.40 / 0.079-0.094	12103881	Signal	Ø	18-20	Ø
1.96-2.64 / 0.077-0.104	425 00 00 872	Signal	16-18	16-20	20
1.96-2.64 / 0.077-0.104	425 00 00 873	Signal	16-18	16-20	20

<sup>&</sup>lt;sup>1</sup> Typical. Manufacturer's insulation diameter should be confirmed to meet stated insulation diameter

• Mating torque for the 30-way PBSC jackscrew shall conform to torque requirements found in the Appendix under Torque Specifications.

#### Eaton Shift Lever

- The OEM harness shift lever mating connector shall consist of the following connector systems:
  - The OEM harness Eaton Shift Lever mating connector system shall comprise of:
    - Deutsch P/N DTM06-08SA Connector Body
    - Deutsch P/N WM-8S Wedge-Lock
    - Deutsch gold plated Size 20 contacts for use with the DTM06-08SA connector body
    - Deutsch P/N 0413-204-2005 Filer Plug (optional for in-cab environments)
- The insulation outside diameter of the connector shall comply with Deutsch requirements for the selected contact.
- The OEM harness Eaton Shift Lever mating harness cable (wire) diameters shall be compliant with the following insulation diameter requirements:

Seal Range Diameter (mm) / (in)	Contact Size	Description	TXL <sup>1</sup> AWG	GXL <sup>1</sup> AWG	SXL <sup>1</sup> AWG
1.35-3.04 / 0.053-0.120	20	Signal	16-20	16-20	18-20

<sup>&</sup>lt;sup>1</sup> Typical. Manufacturer's insulation diameter should be confirmed to meet stated insulation diameter

# **General Requirements**

- For connector systems that contain transmission signals or power sources, unused connectors shall have sealed mating connectors connected to the unused connector or the unused connector shall be plugged with a sealed plug.
- For connector systems that contain transmission signals or power sources, unused terminal cavities shall be plugged with cavity plugs (filler plugs) for out of cab environments.
- No anti-seize, lubricating, or foreign compound shall be applied to the connector jackscrew threads, including NyoGel 760G. Rational: The use of such compounds may affect jackscrew torque and prevent proper sealing of the connector.
- Minimum wire gauge of 18 AWG shall be used for transmission signals except where mechanical reliability of 20 AWG wire harnessing can be demonstrated.
- All crimp contacts for connectors mating with Eaton components shall meet the supplier of the connector system's crimp requirements.
- For OEM harnesses that tie to transmission attachment points, tie wrap application and tightness shall conform to Section 14.1.1 of IPC/WHMA-A-620 Requirements and Acceptance for Cable and Wire Harness Assemblies, January 2002 revision or later.
- For OEM harnesses that tie to transmission attachment points, tie wrap application shall meet the Target and Defect of a Class 3 product per IPC/WHMA-A-620.
- All electrical power and signals referenced in italics shall be routed through an environmentally protected electrical system to end point(s) of the signal.

**Note:** The intent is that all signal connections are sealed where they may be exposed to water. Observation of proper wire sizing and connector sealing practices should be followed.

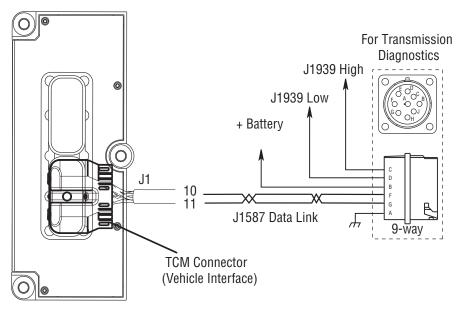
## **Network Communications Requirements**

- When the Eaton PBSC is used, the Controller Area Network (CAN) communications link between the PBSC and the TCM is a proprietary communications link but shall follow SAE J1939/15 physical layer requirements.
- The SAE J1939 bus physical connection to the TCM shall follow SAE J1939 specifications for either SAE J1939/11 or SAE J1939/15. All nodes on the bus must conform to the applicable bus architecture (SAE J1939/11 or SAE J1939/15).
- If a J1587 data link is provided on the vehicle, it shall conform to SAE J1708 physical layer requirements.
- During all normal operation conditions, the voltage potential between all J1939 node reference grounds shall not exceed 2.0 volts DC.

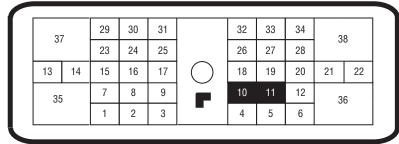
**Note:** A J1939 node reference ground shall be considered the Battery Negative connection to an electronic control at the electronic control's connector.

The vehicle shall provide a SAE J1939/13 compliant On-Board Diagnostic Connector.

# Typical System Wiring for SAE J1939/13 Diagnostic Connector

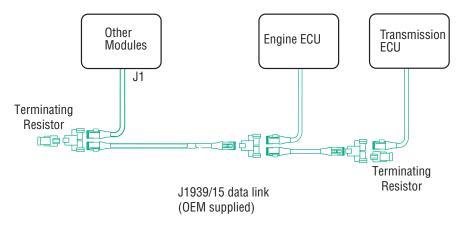


Front View TCM Connector (Vehicle Interface)

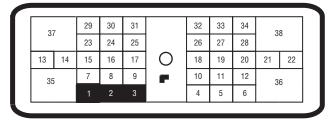


From	To 9-Pin	Description
J1-10	F	J1587 +
J1-11	G	J1587 -
	В	BATTERY +
	А	GROUND -
	С	J1939 HIGH
	D	J1939 LOW

# Typical System Wiring for SAE J1939/11 and SAE J1939/15



TCM Connector (Vehicle Interface)



From	То	Description
J1-2	В	J1939 Low
J1-3	Α	J1939 High
J1-1	С	J1939 Shield (used only for SAE J1939/11)

### **Vehicle Service Requirements for Electronics**



**Caution:** Battery Positive and Battery Negative must be disconnected prior to any type of electric welding on any Fuller<sup>®</sup> Automated transmission equipped vehicles.

- Battery Negative must be disconnected prior to removal or installation of TCM harness connectors.
- Removal and/or replacement of a battery shall not disturb the terminating connectors of the TCM and ECA

#### **Electrical/Electronic Vehicle System Hardware Requirements**

#### Start Enable Relay Requirements and Recommendations

The following requirements apply to vehicle systems that do not employ a SAE J1939 based start enable function:

- The OEM shall provide a normally open starter relay that will prevent engine crank unless energized.
- Startability shall meet United States of America FMVSS Standard 102, Section 3.1.3: "The engine starter shall be inoperative when the transmission shift lever is in a forward or reverse direction position."
- TCM J1-32 shall provide signal to the high side of the relay coil.
- TCM J1-4 shall provide signal to the low side of the relay coil.
- TCM J1-26 shall provide signal from the relay contact providing power to the Starter Solenoid Relay.
- This signal shall not be interrupted by the vehicle system between the Start Enable Relay and the Starter Solenoid Relay.
- For vehicles required to meet United States of America FMVSS requirements, the Vehicle Design and Vehicle Function shall be verified to FMVSS Standard 102, Section 3.1.3.

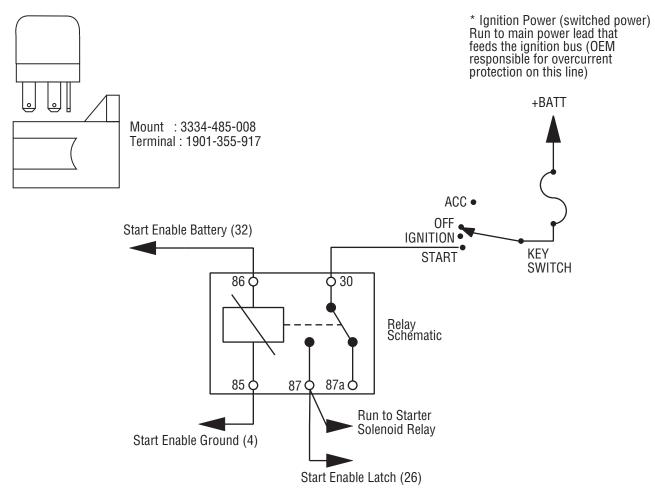


## J1939 Start Enable Requirements

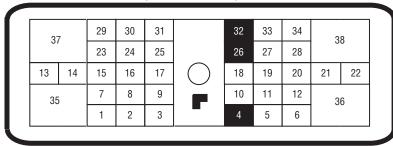
**Important:** J1939 Start Enable Type – The J1939 ETC7 SPN 2900 Transmission Crank Enable message may be used to enable cranking without a relay. This feature can be configured with VEPS or ServiceRanger 4.

It is acceptable to configure a vehicle for a J1939 Start Enable Type in place of a Start Enable Relay. A configurable Start Enable Type supports "Relay" or "J1939" control. The J1939 ETC7 SPN 2900 Transmission Crank Enable message may be used to enable cranking without a relay. This feature can be configured with VEPS or ServiceRanger 4.

# Typical Start Enable Circuit

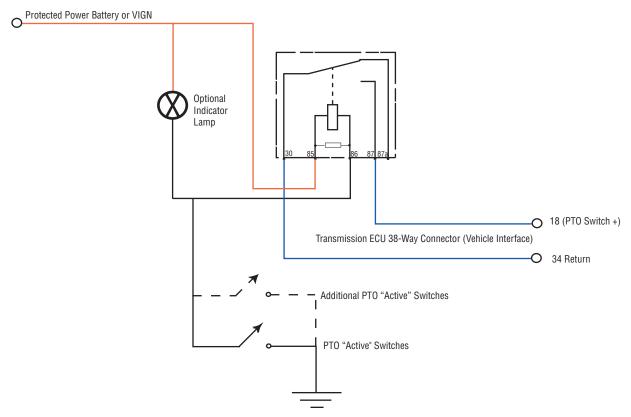


Front View Transmission ECU Connector (Vehicle Interface)



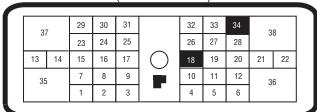
From Pin	To Relay Pin	Description
J1-32	86	Start Enable Battery
J1-26	87	Start Enable Latch
J1-4	85	Start Enable Ground

#### Typical Relay Isolated PTO Input



Battery Negative or Frame Ground

#### Front View Transmission ECU Connector (Vehicle Interface)



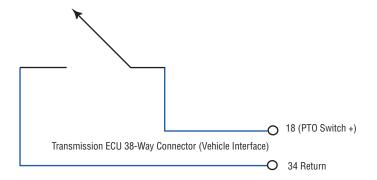
Pin Side View

From	Description
J1-18	PTO Signal Input
J1-34	PTO Return

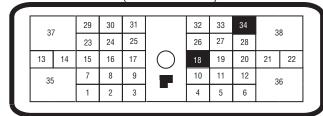
## **PTO Switch Input Requirements**

- When a PTO is installed on a vehicle, the vehicle shall provide a "PTO active" input to the transmission ECU.
- A Switch or Relay closure is required for the "PTO active" input.
- If a relay is used, the relay shall be a normally open.
- TCM J1-18 shall be connected to the signal side of switch or relay.
- TCM J1-34 shall be connected to the return side of switch or relay.
- The return side shall be isolated from vehicle ground.
- Switch or Relay contacts shall be able to reliably make contact with wetting current of 5 mA and a contact closure voltage of 4.5 volts.

#### Typical Switched PTO Input



Front View Transmission ECU Connector (Vehicle Interface)



Pin Side View

From	Description
J1-18	PTO Signal Input
J1-34	PTO Return

## **Auto Neutral Switch Requirements**

- Switch shall be a normally closed switch.
- Switch closed state indicates to TCM that Neutral should be commanded.
- TCM J1-19 shall be connected to the signals side of the switch.
- TCM J1-33 shall be connected to the return side of the switch.
- The return side shall be isolated from vehicle ground.
- Switch or Relay contacts shall be able to reliably make contact with wetting current of 5 mA and a contact closure voltage of 4.5 volts.

**Note:** Contact the brake manufacturer for additional pressure switch requirements.

#### Typical Auto Neutral Switch Input

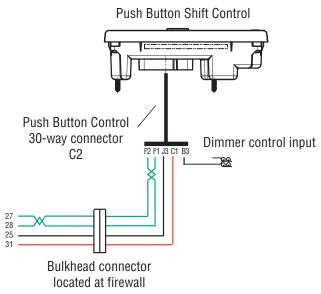
Description	From	То
Auto Neutral Signal	Pin 19	Signal Wire
Auto Neutral Return	Pin 33	Return Wire

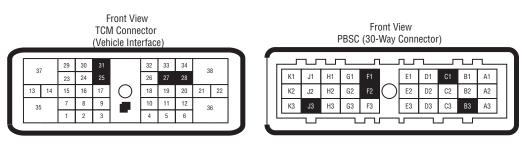
## **Eaton PBSC Installation Requirements**

- Wiring for HIL (TCM J1-27 and J1-28 to PBSC C2-F2 and C2-F1) shall meet Network Communications Requirements in this section.
- Electrical connections for PBSC interface shall conform to intent in Section 5 Typical System Wiring with Eaton PBSC.

**Note:** See "Dimmer Control Input Requirements for PBSC and Eaton Shift Lever" in this section for additional requirements.

#### Typical System with Eaton PBSC





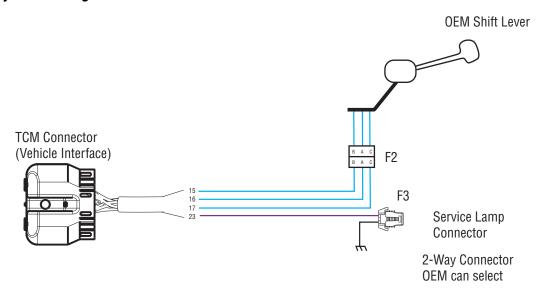
From	To	Description
J1-27	C2-F2	HIL LOW (Proprietary CAN)
J1-28	C2-F1	HIL HIGH (Proprietary CAN)
J1-25	C2-J3	Shift Control Power Minus
J1-31	C2-C1	Shift Control Power Plus
C2-B3		Dimmer Control Input

## **Eaton Shift Lever and Resistive Ladder Shift Device Requirements**

- Electrical connections for Resistive Ladder Shift Device interface shall conform to intent in Section 5 Typical System with OEM supplied Resistive Ladder Shift Device.
- Electrical connections for Eaton Shift Lever shall to intent in Section 5 Typical System with Eaton Shift Lever.

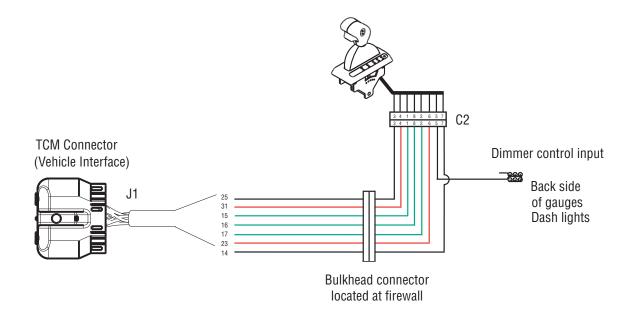
**Note:** See "Dimmer Control Input Requirements for PBSC and Eaton Shift Lever" in this section for additional requirements.

#### Typical System Wiring with OEM Resistive Ladder Shift Device

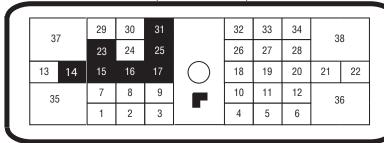


From	То	Description
J1-15	F2-B	Shift Control Input (Mode Auto)
J1-16	F2-A	Shift Control Input (Mode Manual)
J1-17	F2-C	Shift Control Input (Mode Common)
J1-23	F3-A	Service Lamp Output
F3-B		Ground

## Typical System Wiring with Eaton Shift Lever



Front View Transmission ECU Connector (Vehicle Interface)



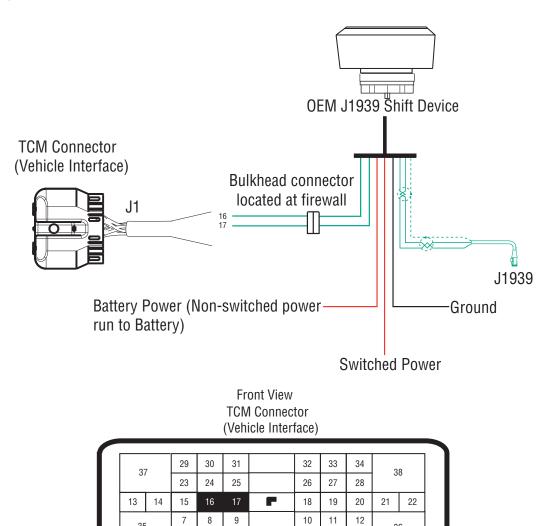
From	То	Description
J1-15	C2-1	Shift Control Input (Mode Auto)
J1-17	C2-2	Shift Control Input (Mode Common)
J1-25	C2-3	Shift Control Power Minus
J1-31	C2-4	Shift Control Power Plus
	C2-5	Dash Lights
J1-23	C2-6	Service Light Output
J1-16	C2-8	Shift Control Input (Mode Manual)
J1-14	C2-7	Shift Control Input (Mode Common 2)

#### **OEM J1939 Based Shift Devices**

- OEM shift device shall connect to the vehicle's J-1939 communications bus.
- OEM shift device shall provide separate indication of a requested neutral state via TCM pins J1-16 and J1-17.
- The OEM shall indicate neutral request to the TCM by bringing a  $5 \pm 10\%$  volt signal through a 1000 ohm resistor to less than 1.2 VDC at TCM pin J1-16 with respect to J1-17.
- The OEM shall indicate a non-neutral state request by providing an impedance of 10,000 ohms ± 1% across TCM J1-16 and J1-17.

#### Typical System Wiring with OEM SAE J1939 Shift Input Device

35



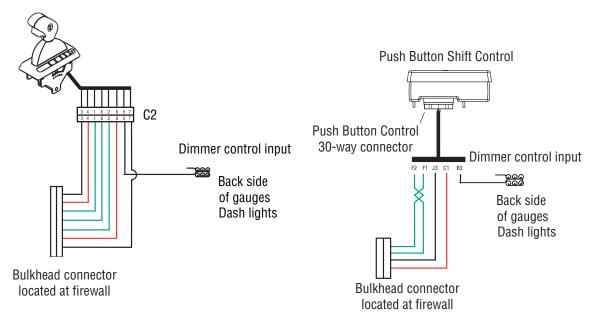
36

### **Dimmer Control Input Requirements for PBSC and Eaton Shift Lever**

The vehicle system cab dimming system shall provide dimmer control input (aka VDASH) to meet OEM dimming function system operation requirements for the following operation conditions:

- This input will dim the lights on the shift device when the lights are on based on the voltage supplied to the VDASH input.
- When VDASH input is less than 20% of shift device power voltage, the lights on the shift device may be on full.

#### Typical Eaton Shift Device System Wiring for Dimmer Control Input Control



**Note:** Connect VDASH to the dash lights. This input will dim the lights on the shift device when the lights are on. When VDASH input is off, the lights on the shift device will be on full.

Shift Control	From	То
Cobra Lever	C2-5	VDASH
Push Button	B3	VDASH

# **Service Lamp Requirements**

#### Service Lamp TCM Connection Requirements

**Note:** This section refers to Service Lamps powered from J1-23 of the TCM.

• Wiring for Service Lamp wiring shall provide power for up to a 1 watt to an incandescent lamp load at nominal vehicle battery voltage.

**Note:** An LED indicator may also be used.

- TCM J1-23 shall be connected to the source side of the Service Lamp.
- The return side of the lamp shall be connected to vehicle ground.

**Note:** The voltage supplied to the service lamp shall follow vehicle battery voltage.

#### Service Lamp SAE J1939

Data message structure must meet requirements outlined in "SAE J1939 Data Link Received Messages" section of this document.

### **Eaton Installed Reverse Switch Electrical Requirements and Recommendations**

- Maximum incandescent DC lamp load current on 12 V nominal Vehicle Power: 4.2 A.
- Maximum incandescent DC lamp load current on 24 V nominal Vehicle Power: 2.1 A.
- · Maximum resistive load current: 10 A.
- Minimum wetting current: 200 ma.\*
- Wetting current must be provided at switch make.
- Recommend use of no more than 2 typical incandescent lamps on a reverse switch. Additional lamps should be controlled through a relay.
- Multiple relays may be driven from a switch.
- Multiple LED reverse lamps may be driven from a switch.

Note: Some switches have extended limits.\*\*

- Minimum whetting current is based on environmental temperature profile and how often the switch is actuated. The value is a conservative estimate based on historical use of ball switches. Typically, less whetting current is required for proper operation. Environmental validation is required to determine actual minimum whetting current.
- \*\* Contact your Eaton OEM Engineering Support Group for additional information.

# **Vehicle Electrical/Electronic System Component Recommendations**

#### **Relay Recommendations**

- Relays shall be sized for the application. This includes design considerations for wetting current and voltage across contacts at closure.
- · Recommended Relays:
  - Bosch: 0332-209-151 (+12 volt)
  - Bosch: 0332-204-203 (+24 volt)
  - Siemens: W28-15F24-S01 (+12 volt)

## Harness Design, Routing, and Attachment Recommendations

#### **Mating Connector and Terminal Recommendations**

Recommend gold plated contacts are used for signal circuits. This recommendation does not supersede requirements stated within this document.

#### **Electrical Sealing Recommendations**

All electrical junctures outside of the cab should be sealed per SAE J-2030 standards.

**Note:** Future transmission systems will require SAE J-2030 compliance for above recommendation with exception of certain power connections.

#### **Harness Design Recommendations**

- Tie wraps should not pull on the harness so that connector cable seals are distorted.
- Allow individual conductors to exit connector body with out pulling on the connector.
- An anchor point should be no further than 6 in. [15.24 cm] (Recommended 3 in. [7.62 cm]) from a connector. The minimum distance to the tie point is based on two factors:
  - The ability to remove the connector without cutting tie wraps.
  - The ability for the tie-wrap to only bind the harness sheath (as opposed to individual wires going into the connector shell).
- The length of an unanchored section of harness should be no more than 12 in. [30.48 cm].
- Eaton has provided several harness routing brackets that can be used for clipping vehicle routed components. These harness routing brackets identification and use are shown in figure [TBD].
- Recommend use of the fixed clip points on OEM harness Fir trees, J-clips, P-clips.

#### **Harness Routing Recommendations**

- A bend radius of six times the harness diameter is recommended.
- Recommend routing clear of transmission lifting eyes to prevent damage during installation into vehicle chassis
- Recommend harness routing to ease service of transmission components such as:
  - XY Shifter
  - TCM
  - Transmission sensors
- Harnesses should not be routed over sharp edges.
- Recommend that split convoluted conduit not be routed where water and road debris can collect within the conduit.
   The debris causes damage to electrical conductor insulation.

#### **Harness Attachment Recommendations**

- Tie wrap application and tightness should conform to Section 14.1.1 of IPC/WHMA-A-620 "Requirements and Acceptance for Cable and Wire Harness Assemblies, January 2002 revision or later. Tie wrap application should meet the Target and Defect of a Class 3 product per IPC/WHMA-A-620.
- Use tie wraps on harness covering only, not on individual wires.
- Do not anchor harness with tie wraps in contact with wire insulation.
- Harness and in-line connectors shall be anchored to prevent free movement.
- Harnesses should not be tie-wrapped to against a sharp edge
- Recommend tension control device tie wrap attachment for vehicle routing and harness construction.

#### **Contact Lubrication Recommendation**

Eaton recommends the use of (NyoGel 760G) on all electrical contacts. The preferred method of application is to use a metered dispensing mechanism that places the material on the socket of the connector. It is also preferred that the material be placed immediately prior to connector mating to reduce the probability of contamination.

**Note:** Contact your Eaton OEM Engineering Support Group for additional information.

# **Additional Harness Design Recommendations**

- Recommend the distance of the SAE J-1939 bus between the TCM and ECM should be short as possible.
- Recommend wiring types for the Deutsch connector (DRC26-38-S01)\*:
  - 18 AWG GXL max /18 AWG TXL min. for Communication and control wires
  - 12 AWG GXL or 14 AWG SXL for Power Supply wires
  - 12 AWG GXL or 14 AWG SXL for V-Ignition wires
- Recommend cable for the 3-Way Metri-Pack connector\*:
  - 10 AWG SXL for Power Supply wires to ECA
- Recommend cable for the 8-Way Metri-Pack connector\*:
  - 18 AWG GXL max 18 AWG TXL min. for communication and control wires to ECA
  - 18 AWG GXL for V-Ignition wires
- Recommend splices be ultrasonically welded per IPC/WHMA-A-620 and encapsulated and sealed to meet SAE J-1455.
- Recommend convoluted conduit have a service temperature of at least 257 °F (125 °C).
- Recommend braided loom shall have a service temperature of at least 280 °F (138 °C). Coverage: A minimum of 10 / maximum of 12 picks per inch.
- Recommendation for twisted wires (applies to 16 and 18 AWG wire only)
  - 2 Wires = 10 Twists / 25.4 cm
  - 3 Wires = 8 Twists / 25.4 cm
- Recommend all harnesses with mission critical functionality have a production test method to guarantee contacts fully seated.
- Recommend convoluted conduit not be constructed with glass fill. Glass fill causes abrasion of wire insulation
  over time.
  - \* Indicated wire gauges and insulation types ensure proper connector sealing and current carrying capacity.

- Recommend that all sources of SAE J-2011 wire be qualified, as actual abrasion resistance varies significantly amongst manufactures.
- Recommend that conduit systems be qualified not to cause wire abrasion.
- Recommend environmental testing for mission critical harnessing systems. This would include indirect pressure wash, salt spray, splash, etc.
- Conduit recommendation for TCM mating connector back shell options. Generic conduit recommendations for exiting Deutsch back shells:
  - Size 13 mm [.500]; 125 °C or higher temperature rating.

#### **Recommended Conduit**

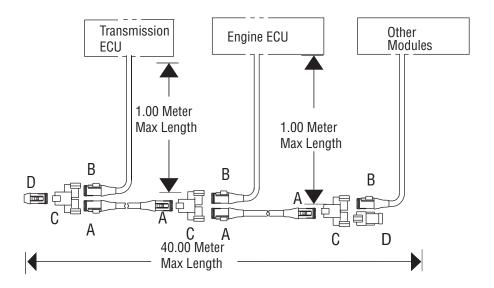
	Deutsch 0528-004-3805 Back Shell	Deutsch P/N 0528-005-3805 Low Profile Backshell
Conduit/OEM	Delfingen	Delfingen
Conduit P/N	R-69246 (round)	R-69246 (round) R-72506 (profile)

#### Recommended SAE J-1939/15 Cable

Recommended	Cable Part	Round	J-1939 (+)	J-1939 (-)
Cable Manufacturer	Number		(PIN "A") Color	(PIN "B") Color
Champlain	15-07353	Yes	Yellow	Green

#### Recommended SAE J-1939/15 Bus Connector System

Ref.	Body	Signal Terminals (Qty.)	Wedge	Function
Α	DTM-06-2S	0462-201-2031 (2)	WM-2SB	Through Connector
В	DTM-06-2S	0462-201-2031 (2)	WM-2S	Stub Connector
С	DTM04-2P-P007	N/A	N/A	"T" Receptacle
D	DTM06-2S-EP10	N/A	N/A	120 Ohm Termination



#### **Electrical Juncture Recommendations**

- Recommend not using more than three (3) ring terminals per mounting stud.
- Terminals such as ring, bullet, spade, etc., should be sized for the correct current capacity of the circuit as stated by the manufacturer.
- Terminals should be plated and non-insulated. Plating materials of metallic mechanical connections points should have metallurgical compatibility.
- Recommendation relative to use of shrink tubing to seal crimp junctures
  - Terminal sleeves should be insulated with a double wall adhesive lined shrink tubing.
  - Cable construction for use of shrink tube should only a single conductor per barrel.
  - Barrels should be closed ended or sealed as part of the terminal insulator design.
  - Multiple wires in same barrel do not seal.
  - Design should be demonstrated to operate in SAE J-1455 environment.
- Highly recommend over-molded battery cable terminals.
- Sealing Dielectric grease over the surface of the ring terminals is recommended.
- Recommend that split ring or star lock washers not be used for electrical contact surfaces. Mechanical retentions system should not damage plating integrity.
- Recommend all sealed connectors be vacuum tested to assure all wires and wire filers are in place and functioning.
- Recommend all electrical distribution studs have manufacturing torque control in place.
- Recommend corrosion protectant be applied to all exposed electrical distribution study and associated ring terminals.
- Minimize the number of mechanical connection points to Eaton transmission components and other critical components such as ABS system, and Engine Control system.

# **Troubleshooting Recommendations**

### Harness Troubleshooting and Test Equipment Design Recommendations

- Opening a switch contact or the main power link is the recommended method of interrupting power.
- Recommend not removing fuses as the method of disconnecting power to the TCM or ECA. This causes fuse holder contact damage, and weakening of the contact spring-force.



**Caution:** Making and breaking a circuit through tin plated terminals (e.g. ring terminals, fuses, and most connectors) will destroy the plating on the terminal.



**Caution:** Recommend that OEM harness insulation is not punctured for diagnostics purposes. Damage to the wire insulation can lead to immediate or future failures of the harness or electronic control unit due to short circuits, water entry, or corrosion.

• If a connection to the harness or TCM is required before vehicle installation, Eaton recommends the use of a connector with a spring loaded contact rather than a standard mating connector. The spring loaded contact is intended to make the electrical connection with the tip of the terminal without touching the mating surface. This will protect the terminal plating, contact lubricant, and retain the original durability and reliability of the connector system.

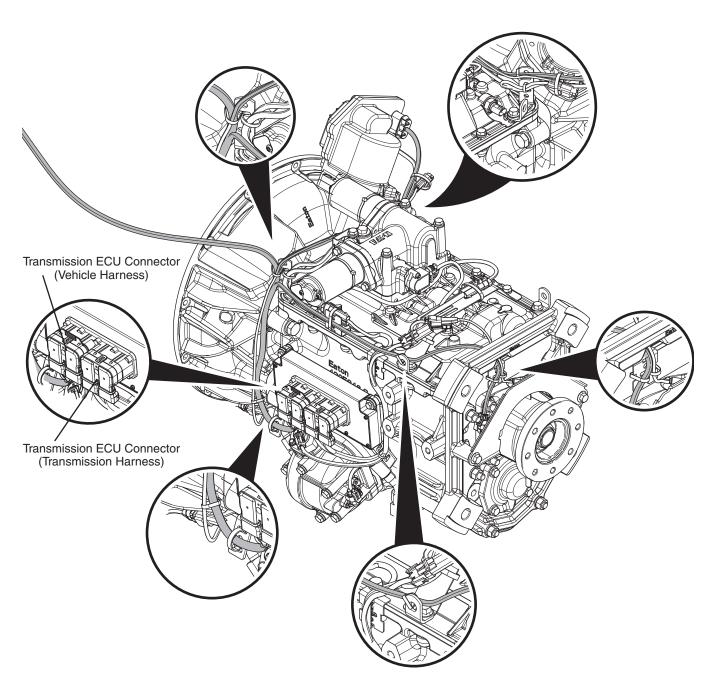
**Note:** Contact your Eaton OEM Engineering Support Group for additional information.

#### **Vehicle Service Recommendations for Electronics**

Recommend disconnecting all electronic controls when electric welding is performed on the vehicle. Rational: Ground path differentials can cause overvoltage to electronic control I/O even if the battery plus and minus are disconnected.

# **Electrical Reference Diagrams**

# **Routing Attachment Points**



Note: The above routing and attachment points are recommended for best transmission reliability.

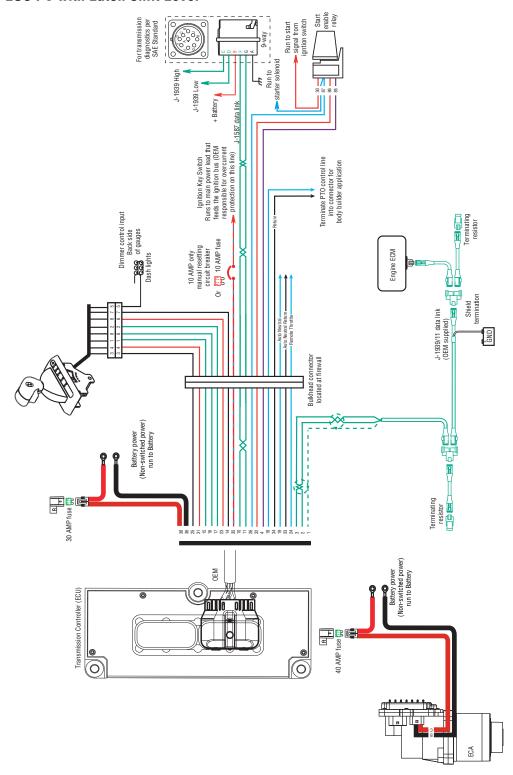
**Caution:** To prevent damage to the harness, ties need to be made after the transmission is placed into the frame.

# **SAE Cable Insulation Outside Diameter Reference**

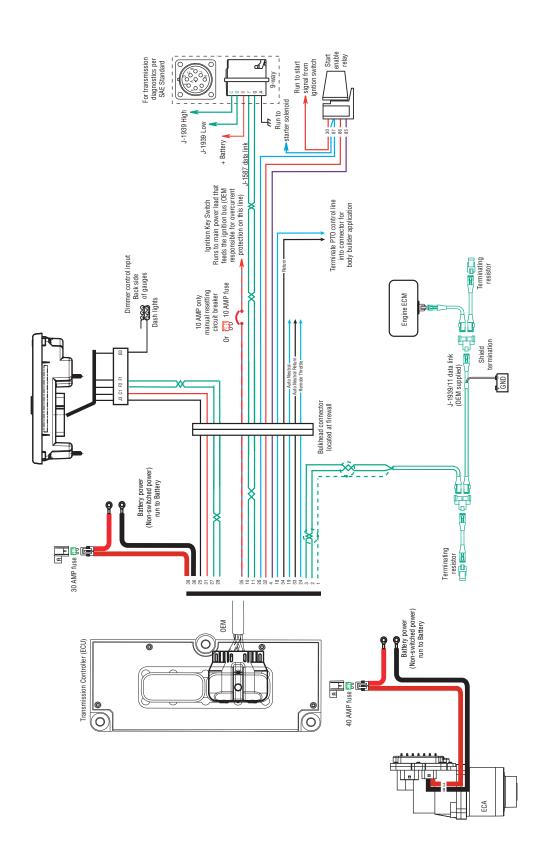
SA	E Wire	Non	Nominal Outside Diameter (mm)		Nominal Outside Diameter Inch		
Size mm²	Size No.	TXL	GXL	SXL	TXL	GXL	SXL
0.8	18	1.98	2.39	2.72	0.08	0.09	0.11
1	16	2.24	2.59	3.05	0.09	0.10	0.12
2	14	2.62	2.97	3.58	0.10	0.12	0.14
3	12	3.25	3.63	4.14	0.13	0.14	0.16
5	10	3.96	4.45	4.95	0.16	0.18	0.20

# Wiring Diagram - OEM Responsibility

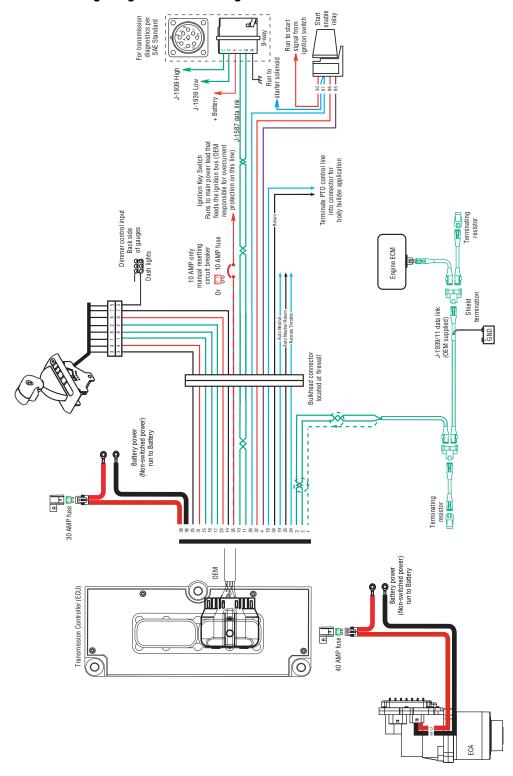
# UltraShift PLUS PV with Eaton Shift Lever



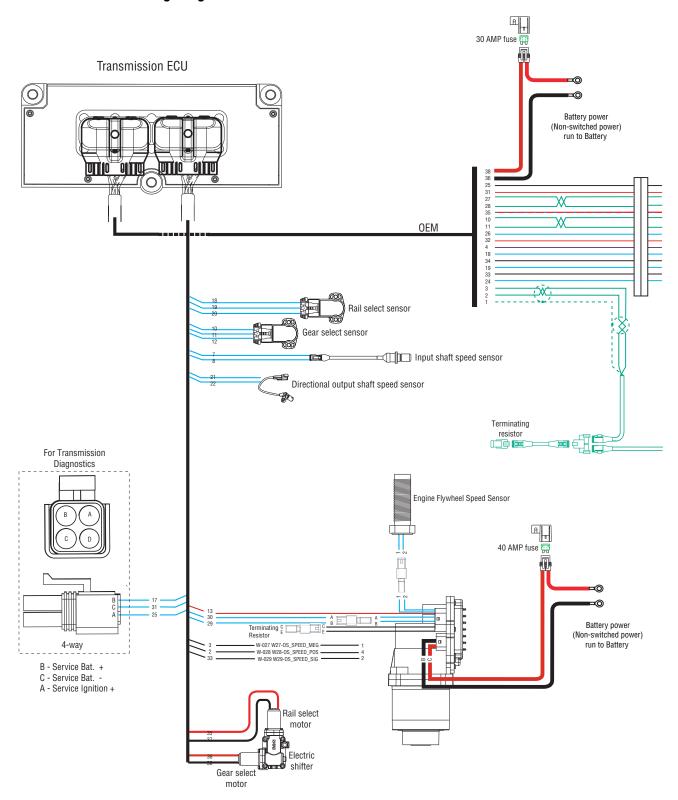
#### UltraShift PLUS PV with Eaton PBSC

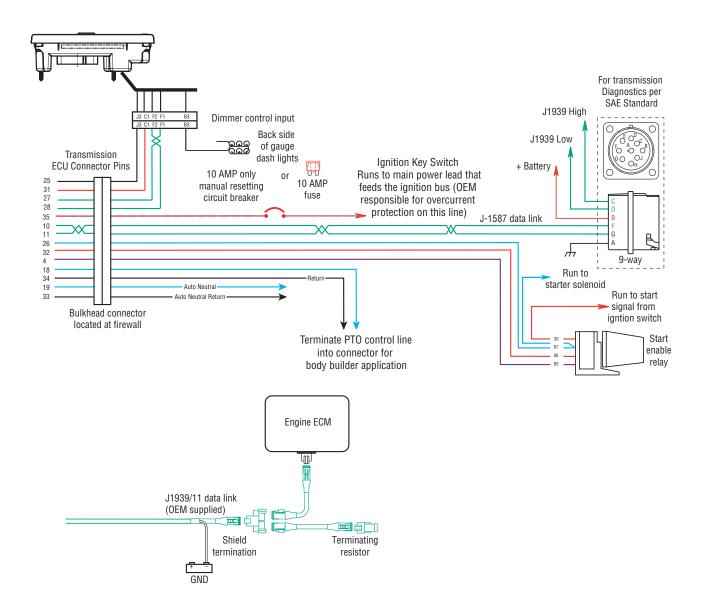


## **UltraShift PLUS PV Wiring Diagram with Analog Shifter**



## **UltraShift PLUS PV Wiring Diagram with PBSC Shifter**





# lectrical System Interface

# **Connector Pin Descriptions**

# Transmission Controller 38-Way (Vehicle Interface Connector)

38-Way	Description
1	J1939 Shield (CAN)
2	J1939 Low (CAN)
3	J1939 High (CAN)
4	Start Enable Relay Minus
5	Plugged
6	Plugged
7	Plugged
8	Plugged
9	Plugged
10	J1587 Plus
11	J1587 Minus
12	Aux trans signal
13	Aux trans return
14	Shift Control Input (Mode Common/Neutral Return 2)
15	Shift Control Input (Mode Auto)
16	Shift Control Input (Mode Manual/ Neutral Signal)
17	Shift Control Input (Mode Common/Neutral Return)
18	PTO Signal Input
19	Auto Neutral Signal Input

38-Way	Description
20	Plugged
21	Plugged
22	Plugged
23	Service Light Output
24	Remote Throttle Output
25	Shift Control Power Minus
26	Start Enable Latch
27	HIL Low (Proprietary CAN)
28	HIL High (Proprietary CAN)
29	Plugged
30	Plugged
31	Shift Control Power Plus
32	Start Enable Relay Plus
33	AutoNeutral Return
34	PTO Return
35	Ignition
36	Battery Minus
37	Plugged
38	Battery Plus

# **Electrical System Interface**

# **Cobra Lever 8-way Connector**

8-Way	Description
1	Shift Control Input (Mode Auto)
2	Shift Control Input (Mode Common)
3	Shift Control Power Minus
4	Shift Control Power Plus
5	Dash Lights
6	Service Light Output
8	Shift Control Input (Mode Manual)
7	Shift Control Input (Mode Common 2)

# Electric Clutch Actuator (ECA) 3-way Connector

3-Way	Description
Α	No Connection (Plugged)
В	Ground
С	Battery

# **PBSC 30-Way Connector**

From	То	Description	
J1-27	C2-F2	HIL LOW (Proprietary CAN)	
J1-28	C2-F1	HIL HIGH (Proprietary CAN)	
J1-25	C2-J3	Shift Control Power Minus	
J1-31	C2-C1	Shift Control Power Plus	
	C2-B3	Dimmer Control Input	

# **SAE J1939 Data Link Broadcast Messages**

Eaton UltraShift *PLUS* PV model interface with many different components installed on the vehicle such as engine, shift input device, gear display, and service lamp. SAE J1939 and J1587 data links are standard means to transfer data to other components. Successful system integration is essential to ensure the utmost satisfactory operation of the vehicle. The following sections summarize the system integration requirements.

SPNs listed below are standard on Eaton UltraShift *PLUS* PV model. Unused data in a PGN is broadcast as "Not Available." The inability the transmission control unit to broadcast valid data will result in "Error Indicator" or "Not Available" being broadcast. For specific message formatting and broadcast rate see SAE J1939-71 and SAE J1939-73.

Active Diagnostic Trouble Codes (DM1)	PGN 65226
Source Address: 3 (Transmission #1)	
Parameter Name	SPN
Malfunction Indicator Lamp Status	1213
Red Stop Lamp Status	623
Amber Warning Lamp Status	624
Protect Lamp Status	987
Flash Engine Malfunction Indicator Lamp	3038
Flash Engine Red Stop Lamp	3039
Flash Engine Amber Warning Lamp	3040
Flash Engine Protect Lamp	3041
Suspect Parameter Number	1214
FMI	1215
SPN Conversion Method	1706
Occurrence Count	1216

Previously Active Diagnostic Trouble Codes (DM2)	PGN 65226
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Malfunction Indicator Lamp Status	1213
Red Stop Lamp Status	623
Amber Warning Lamp Status	624
Protect Lamp Status	987
Flash Engine Malfunction Indicator Lamp	3038
Flash Engine Red Stop Lamp	3039
Flash Engine Amber Warning Lamp	3040
Flash Engine Protect Lamp	3041
Suspect Parameter Number	1214
FMI	1215
SPN Conversion Method	1706
Occurrence Count	1216

Electronic Transmission Controller 1 (ETC1)	PGN 61442
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Transmission Driveline Engaged	560
Transmission Shift In Process	574
Transmission Output Shaft Speed	191
Engine Momentary Overspeed Enable	606
Progressive Shift Disable	607
Transmission Input Shaft Speed	161

Electronic Transmission Controller 2 (ETC2)	PGN 61445
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Transmission Selected Gear	524
Transmission Actual Gear Ratio	526
Transmission Current Gear	523
Transmission Requested Range	162
Transmission Current Range	163

Electronic Transmission Controller 7 (ETC7)	PGN 65098
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Transmission Ready for Brake Release	3086
Transmission Engine Crank Enable	2900
Transmission Requested Gear Feedback	3289
Transmission Warning Indicator	5344

Torque / Speed Control 1 (TSC1) Engine	PGN 0
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Engine Override Control Mode	695
Engine Requested Speed Control Conditions	696
Override Control Mode Priority	897
Engine Requested Speed / Speed Limit	898
Engine Requested Torque / Torque Limit	518
Message Counter	4206
Message Checksum	4207

Torque / Speed Control 1 (TSC1) Retarder	PGN 0
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Engine Override Control Mode	695
Engine Requested Speed Control Conditions	696
Override Control Mode Priority	897
Engine Requested Torque / Torque Limit	518
Message Counter	4206
Message Checksum	4207

# **Broadcast On Request To Transmission**

Component Identification (CI)	PGN 65259
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Make	586
Model	587
Serial Number	588
Unit Number (Power Unit)	233

Electronic Transmission Controller 3 (ETC3)	PGN 65223
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Transmission Shift Finger Gear Position	59
Transmission Shift Finger Rail Position	60
Transmission Shift Finger Rail Actuator 1	772
Transmission Shift Finger Gear Actuator 1	773
Transmission Range High Actuator	768
Transmission Range Low Actuator	769
Transmission Splitter Direct Actuator	770
Transmission Splitter Indirect Actuator	771
Transmission Inertia Brake Actuator	787

Electronic Transmission Controller 4 (ETC4)	PGN 65221
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Transmission Synchronizer Brake Value	54

Software Identification (SOFT)	PGN 65242
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Number of Software Identification Fields 965	965
Software Identification 234	234

ECU Identification Information (ECUID)	PGN 64965
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
ECU Part Number	2901
ECU Serial Number	2902
ECU Location	2903
ECU Type	2904
ECU Manufacturer Name	4304

Vehicle Electrical Power 1 (VEP1)	PGN 65271
Source Address: 3 (Transmission # 1)	
Parameter Name	SPN
Battery Potential / Power Input 1 168	168
Keyswitch Battery Potential 158	158

# **SAE J1939 Data Link Received Messages**

Eaton UltraShift *PLUS* PV model will interface with many different components installed on the vehicle such as engine, shift input device, gear display, and service lamp. SAE J1939 and J1587 data links are standard means to transfer data to other components. Successful system integration is essential to ensure the utmost satisfactory operation of the vehicle. The following sections summarize the system integration requirements.

For specific message formatting and broadcast rate see SAE J1939-71 and SAE J1939-73.

Cruise Control / Vehicle Speed (CCVS)	PGN 65265
Source Address: 49 (Cab Controller - Primary), 0 (Engine #1), 17 (Cruise Control), 23 (Instrument Cluster #1), 33 (Body Controller)	
Note: First Source Address supported with valid data is latched for power cycle. Source Address sending valid Brake Switch data will be monitored for valid Clutch Switch and Parking Brake Switch data. Wheel-Based Vehicle Speed can be sent from a different Source Address then that sending Brake Switch data.	
Parameter Name	SPN
Parking Brake Switch	70
Wheel-Based Vehicle Speed	84
Brake Switch	597

Component Identification (CI)	PGN 65259
Source Address: 5 (Shift Console – Primary)	
Note: The accepted CI shall be defined as Model type "RNDML". "RNDML" shall be the first Model characters received by the requester. Additional Model information shall be separated by a dash (RNDML-XXXX).	
Parameter Name	SPN
Make	586
Model	587
Serial Number	588
Unit Number (Power Unit)	233

STOP START BROADCAST (DM13)	PGN 57088
Source Address: Global	
Parameter Name	SPN
Current Data Link	1230

Electronic Brake Controller 1 (EBC1)	PGN 61441
Source Address: 11 (Brakes - System Controller)	
Parameter Name	SPN
ASR Engine Control Active	561
ASR Brake Control Active	562
Anti-Lock Braking (ABS) Active	563
ABS Off-Road Switch	575
ASR Off-R0ad Switch	576
ASR "Hill Holder" Switch	577

Electronic Brake Controller 5 (EBC5)	PGN 64964
Source Address: 11 (Brakes - System Controller)	
Parameter Name	SPN
Hill Holder Mode	2912

Engine Configuration 1 (EC1)	PGN 65251
Source Address: 0 (Engine #1)	
Parameter Name	SPN
Engine Speed At Idle, Point 1	188
Engine Percent Torque At Idle, Point 1	539
Engine Speed At Point 2	528
Engine Percent Torque At Point 2	540
Engine Speed At Point 3	529
Engine Percent Torque At Point 3	541
Engine Speed At Point 4	530
Engine Percent Torque At Point 4	542
Engine Speed At Point 5	531
Engine Percent Torque At Point 5	543
Engine Speed At High Idle, Point 6	532
Engine Reference Torque	544
Engine Maximum Momentary Override Speed, Point 7	533

Electronic Engine Controller 1 (EEC1)	PGN 61444
Source Address: 0 (Engine #1)	
Parameter Name	SPN
Engine Torque Mode	899
Driver's Demand Engine - Percent Torque	512
Actual Speed - Percent Torque	513
Engine Speed	190

Electronic Engine Controller 2 (EEC2)	PGN 61443
Source Address: 49 (Cab Controller - Primary), 0 (Engine #1), 17 (Cruise Control), 23 (Instrument Cluster #1), 33 (Body Controller)	
Parameter Name	SPN
Accelerator Pedal Position 1	91
Estimated Pumping - Percent Torque	5398

Electronic Engine Controller 3 (EEC3)	PGN 65247
Source Address: 0 (Engine #1)	
Parameter Name	SPN
Nominal Friction - Percent Torque	514
Engine's Desired Operating Speed	515
Engine's Desired Operating Speed Asymmetry Adjustment	519
Estimated Engine Parasitic Losses - Percent Torque	2978

Electronic Retarder Controller 1 (ERC1)	PGN 61440
Source Address: 15 (Retarder – Engine), 41 (Retarder, Exhaust, Engine #1)	
Parameter Name	SPN
Retarder Enable - Brake Assist Switch	571
Actual Retarder - Percent Torque	520

Engine Temperature 1 (ET1)	PGN 65262
Source Address: 0 (Engine #1)	
Parameter Name	SPN
Engine Coolant Temperature	110

Retarder Configuration (RC)	PGN 65249
Source Address: 15 (Retarder – Engine), 41 (Retarder, Exhaust, Engine #1)	
Parameter Name	SPN
Reference Retarder Torque	556

Transmission Control 1 (TC1)	PGN 256
Source Address: 5 (Shift Console - Primary) Interfacing with J1939 Driver Input Device requires TC1.	
Parameter Name	SPN
Transmission Requested Gear	525

# **System Integration Specifications**

Shutdown (SHUTDN)	PGN 65252
Source Address: 0 (Engine #1)	
Parameter Name	SPN
Engine Protection System has Shutdown Engine	1110
Engine Protection System Approaching Shutdown	1109

Vehicle Distance (VD)	PGN 65248
Source Address: Global	
Parameter Name	SPN
Total Vehicle Distance	245

# **Received On Request From Transmission**

Time / Date (TD)	PGN 65254
Source Address: Global	
Parameter Name	SPN
Seconds	959
Minutes	960
Hours	961
Month	963
Day	962
Year	964
Local minute offset	1601
Local hour offset	1602

# **SAE J1587 Data Link Broadcast Messages**

Note: All messaging protocol shown on this page are new to this product family.

**Note:** Unused data in a PID is broadcast as "Not Available." Reference SAE J1587 for complete specification.

Broadcast Period	Parameter Name	PID
100 ms	Transmission Output Shaft Speed	191
400 ms	Text Message to Display Note: PID 226 controls the tone. Cadence of the tone is controlled by Gen 3.	
500 ms	Transmission Range Selected	162
	Transmission Range Attained	163
1.0 s	Battery Potential (Voltage)	168
Upon change or 15 s while fault active	Transmitter System Diagnostic Code and Occurrence Count Table	194
On Request	Clutch Cylinder Position	33
	Transmission Synchronizer Brake Value	54
	Transmission Actuator Status #2	57
	Shift Finger Actuator Status	58
	Shift Finger Gear Position	59
	Shift Finger Rail Position	60
	Transmission Actuator Status #1	63
	Vehicle Enabling Component Status	66
	Shift Request Shift Status	67
	Battery Potential (Voltage) - Switched	158
	Transmission Main Shaft Speed	160
	Transmission Input Shaft Speed	161
	Engine Speed	190
	Multi-Section Parameter	192
	Diagnostic Data Request/Clear Count	195
	Diagnostic Data/Count Clear Response	196
	Software Identification	234
	Component Identification Parameter	243
	Total Vehicle Hours	246

### **Gear Display**



The OEM is responsible for supplying the Gear Display, wiring, and its location per FMVSS.

Note: Gear Display is NOT part of any Eaton shift device.

Gear display is required for proper operation of Eaton UltraShift *PLUS* PV models. Gear Display shall interface with any Eaton product by either SAE J1939 (ETC2) or J1587 (PID 226). The gear display offers real-time information pertaining to current engaged gear, engagement status during gear shifting, transmission synchronization during shifting, transmission fault status, diagnostic code information.

Gear display shall adhere to the following requirements.

- As a minimum, gear display shall support two character alphanumeric messages with the addition of two sets of display arrows (up and down) either side of the numerals.
- As a minimum, gear display shall be able to display all two character numeric combinations and alphanumeric
  combinations listed in the following table. It is preferred that the gear display support all uppercase letters to support
  product enhancements.
- For J1587, display time of a message shall be set to 5 seconds to avoid display blanking during heavy bus loads.
- Driver shall be able to clearly see the display from the normal driving position continuously during vehicle operation.
- Gear Display shall be capable of displaying messages within 2 seconds of ignition key-on.
- In order to provide real-time feedback of the selection/shifting/engagement process of transmission, the device shall be able to display the received message within 75 Milliseconds.
- Whenever bus communications are active and anytime ETC2/PID 226 message is not received within 5 seconds of the
  last valid message or message received contains a character not supported, the display shall be blank.
- Whenever bus communications are not active, a "\*\*" shall be displayed.

Note that the alphanumeric character in byte 7 is to be displayed to the left of the alphanumeric character in byte 8. If only one character is required, then byte 7 shall contain an ASCII space. Byte 8 shall contain the single character.

#### **Defined Control Characters**

When a control action is sent, the display characters shall not change. For example, if a '4' was shown prior to an arrow being displayed, then a '4' will remain on the display while the request for an arrow is given.

Control Type	Byte 7	Byte 8 Bits	8	7	6	5	4	3	2	1
Up / Down Arrow	0x00	No Arrow Up Arrow Down Arrow Up Arrow & Down Arrow	- - -	- - -	- - -	- - -	- - -	- - -	0 0 1 1	0 1 0 1
Tone (Cadence controlled by Generation 3)	0x00	Tone Off Tone On Undefined Undefined	- - -	- - -	- - - -	- - - -	0 0 1 1	0 1 0 1	- - -	- - - -
Reserved	0x00	Default Unused State	1	1	1	1	-	-	-	-

# **Minimum Gear Display Alphanumeric Combinations**

Display	First Character (dec./hex/char)	Second Character (dec./hex/ char)	Comments
R4	82 / 52 / "R"	52 / 34 / "4"	"R" = "reverse"
R3	82 / 52 / "R"	51 / 33 / "3"	"R" = "reverse"
R2	82 / 52 / "R"	50 / 32 / "2"	"R" = "reverse"
R1	82 / 52 / "R"	49 / 31 / "1"	"R" = "reverse"
N	32 / 20 / " "	78 / 4E / "N"	"N" = "neutral"
1	32 / 20 / " "	49 / 31 / "1"	
2	32 / 20 / " "	50 / 32 / "2"	
3	32 / 20 / " "	51 / 33 / "3"	
4	32 / 20 / " "	52 / 34 / "4"	
5	32 / 20 / " "	53 / 35 / "5"	
6	32 / 20 / " "	54 / 36 / "6"	
7	32 / 20 / " "	55 / 37 / "7"	
8	32 / 20 / " "	56 / 38 / "8"	
9	32 / 20 / " "	57 / 39 / "9"	
10	49 / 31 / "1"	48 / 30 / "0"	
11	49 / 31 / "1"	49 / 31 / "1"	
12	49 / 31 / "1"	50 / 32 / "2"	
13	49 / 31 / "1"	51 / 33 / "3"	
14	49 / 31 / "1"	52 / 34 / "4"	
15	49 / 31 / "1"	53 / 35 / "5"	
16	49 / 31 / "1"	54 / 36 / "6"	
17	49 / 31 / "1"	55 / 37 / "7"	
18	49 / 31 / "1"	56 / 38 / "8"	
F	32 / 20 / " "	70 / 46 / "F"	"F" = "fault"
CA	67 / 43 / "C"	65 / 41 / "A"	"CA" = "clutch abuse"
L	32 / 20 / " "	76 / 4C / "L"	"L" = "low gear"
ST	83 / 53 / "S"	84 / 54 / "T"	"ST" = "snap shot"
PD	80 / 50 / "P"	68 / 44 / "D"	"PD" = "product diagnostic"
-	32 / 20 / " "	45 / 2D / "-"	
GI	71/47/ "G"	73/49/ "I"	"GI" = "grease interval"
PS	80/50/ "P"	85/83/ "S"	"PS" = "product service"
	•	•	•

#### **System Integration Specifications**

#### **Auto Neutral**

Starting with the release of software # 5569892 it will be acceptable to use a J1939 Park brake signal in place of the switch. Refer to the table in the section SAE J1939 Data Link Received Messages. An auto neutral feature is provided with this transmission which forces the transmission into neutral in all instances when the parking brake is applied. This requires the OEM to "T" a normally closed pressure switch into the existing air line to the parking brake valve. Contact the brake manufacturer for pressure switch requirements.

#### **Shift Input Device**

UltraShift PLUS PV Transmissions will work with analog, PNL or J-1939 Shift Input Devices.

Contact Eaton OEM engineering representative for Shift Input Device design and interface requirements.

#### **Engine**

**Engine Configuration** - The engine ECU shall contain the proper configuration settings. For the proper engine configuration settings required for Eaton Automated Transmission operation refer to TRIG0910, the "*Engine Configuration Settings Installation Guide*" on roadranger.com under the literature center.

**Fan Drive Requirements** - The required practice is for the engine fan to be wired into the engine ECM, this includes the manual fan override switch. The OEM should use fan clutches that can be controlled by the engine (i.e. electromechanical). Failure to comply with this recommended practice can cause Eaton transmissions to inhibit shifts when the engine fan is on.

Contact Eaton OEM Engineering representative for engine interface requirements.

#### **J1939 Start Enable Functionality**

The J1939 ETC7 SPN 2900 Transmission Crank Enable message may be used to enable cranking without a relay. This feature can be configured with VEPS or ServiceRanger 4.

#### **Alert Tone**

The OEM is responsible for supplying the tone module with the Eaton Shift Lever or OEM Driver Interface Device. The tone module is supplied in the Eaton push button shift control.

Alert tone shall be required for proper operation of Eaton UltraShift PLUS PV model. The alert tone shall be used to:

- Inform the operator that the transmission has not yet confirmed a neutral request.
- Inform the operator that an invalid/improper request or operation was initiated.
- Implement the shift prompt for AutoSelect fallback mode.
- Warn of a clutch abuse situation.

The required tone information shall be conveyed from Eaton UltraShift *PLUS* PV model via SAE J1939 (ETC2) and J1587 (PID 226).

Alert tone shall adhere to the following requirements:

- Driver shall be able to clearly hear the tone from the normal driving position continuously during vehicle operation.
- Alert tone shall be capable of responding to a message within 2 seconds of ignition key-on.
- In order to provide real-time feedback of the selection/shifting/engagement process of transmission, the device shall respond to the received message within 75 milliseconds.
- Whenever bus communications are active and anytime ETC2/PID 226 message is not received within 5 seconds of the last valid message, annunciator shall be silent.
- Whenever bus communications are not active, annunciator shall be silent.

#### **Service Lamp**

Eaton UltraShift *PLUS* PV model provides a wired service lamp output at J1-23. This output is designed to drive an incandescent lamp of 1.0 watt or less. An alternate LED indicator may be used. The service lamp output will supply a positive voltage equal to the vehicle battery voltage to turn the service lamp on. The OEM shall supply the service lamp ground connection.

Note: If the shift device used does not provide a service lamp one must be added to the dash.

#### **OEM Vehicle Equipment Programming Station (VEPS)**

The following parameters will impact the VEPS operation at the OEM and will be defined by the Eaton OEM Engineering representative:

- Max start gear
- Default start gear
- Shift calibration

## **PTO Inputs and Configurations**

#### **PTO Inputs**

In any case a PTO is used, regardless of PTO style, Eaton requires the OEM provide a "PTO active" input to the transmission ECU. The vehicle interface harness shall be pre-populated at the ECU 38-way connector with wiring and a connector needed to connect the PTO. This connector will contain the input and return wire necessary to support the input function.

**Important:** If a Split Shaft PTO device is used the PTO input switch must be located on the Split Shaft PTO.

#### **PTO Configurations**

Countershaft PTOs may be used in conjunction with a Split Shaft PTO device, however the configuration must be set to Split Shaft PTO.

#### ▲ WARNING

The transmission ECU contains configuration software for PTO mode. The default mode is set to "Countershaft PTO" operation which also supports "Through-Shaft PTO" operation. If the application requires use of a "Split Shaft PTO", the transmission ECU configuration software shall be changed to reflect "Split-Shaft PTO". The Eaton ServiceRanger tool is the recommended interface for changing the configuration setting.

# ine Inspection ind End of Line

#### **Line Inspection and Road Test Instructions**

The checklist was developed as an installation tool for line personnel to ensure the correct operation of each vehicle and to assist the vehicle OEM to identify transmission quality related issues as well as OEM line quality issues. Used correctly, this checklist identifies transmission issues and aids in tracking the problem until corrected.

#### The recommended use of the checklist is as follows:

- 1. A separate checklist should be filled out for each vehicle built with Eaton transmissions. If these checks and information can be combined with an existing form, the Line Inspection form does not need to be used.
- The section identified as PRE-START CHECKS should be performed prior to the initial start-up of the vehicle. This section ensures the transmission has the correct power supplies, sufficient lubricant, and correct transmission shift tables.
- 3. Perform any necessary corrective action prior to the dyno or road testing.
- 4. The DYNO/ROAD TEST section is used to verify that all transmission systems are functional and the Drivers Manual and Shift Label are supplied in the cab.
- 5. With a record of transmission related information and repairs made to each unit, the OEM is able to track and correct repeated quality issues.
- 6. A copy of the checklist should be recorded for installation history. OEM line personnel should become familiar with the checklist for the transmission prior to a scheduled build. Eaton OEM Engineering Support Group can coordinate training and information to expedite this process.

This checklist represents a generic system which can be tailored to the individual OEM to achieve the best possible method of transmission installation verification. Eaton recommends the use of this system to maintain the utmost in satisfactory operation and long service life.

Each transmission system installed at the OEM shall pass the line checklist requirements per the Eaton Line Inspection Form prior to shipment from the OEM plant.

#### **Line Inspection**

This transmission is equipped with a neutral interlock system that when properly installed prevents the engine from cranking with the transmission in-gear.



Failure to perform installation pre-start checks may result in the engine cranking immediately when ignition is moved to the "START" position or to the "ON" position.

To prevent undesired vehicle movement for new installations, always set the parking brake prior to turning the ignition key "ON" and also prior to attempting "START".



Improper installation of the OEM Start Enable Circuit could result in enabling the vehicle to be started in gear.

#### **Pre-Start Inspection and Initial Starting Requirements**

#### **Pre-Start Inspection**

Verify the transmission has been filled with the correct amount and type of lubricant before starting the engine. Failure
to add sufficient lubricant could damage the transmission. See Lubricant Requirement section in this manual for details.

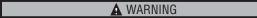
#### **Before Cranking Engine**

- Verify Neutral is selected on the shift input device.
- Turn the ignition key to the "On" position and visually observe the power up procedure.



During the initial power up of this transmission, the gear display will show an alternating "N" and "F". This is a normal occurrence on all Eaton UltraShift<sup>®</sup> *PLUS* equipped transmissions. This condition will persist until the initial clutch adjustment and grade sensor calibrations are completed. See following procedures.

- The alternating "N" indicates the transmission has verified neutral.
- The alternating "F" is an indication of an active fault code.
- It is normal for this system to detect an active fault code 27 (clutch adjustment fault) and active fault code 68 (grade sensor calibration fault) during initial power up.
- If the system detects active faults other than 27 and 68, refer to the diagnostic procedure in this manual.



Once the engine has been started, the transmission automatically initiates a clutch adjustment procedure.

- During the clutch adjustment procedure, the operator will be unable to select an active operating mode for the transmission. The shift input device will be locked out from operator request.
- The clutch adjustment procedure could take up to 35 seconds to complete.
- The clutch adjustment procedure will continue even if the engine is shut off.

**Note:** Once the clutch adjustment is complete, Eaton requires the grade sensor be calibrated prior to dyno. Refer to the following procedure.

#### ▲ WARNING

Failure to calibrate the grade sensor prior to dyno may lead to unsatisfactory shift performance. This condition could be misinterpreted as a product defect and could lead the operator to unnecessary repair.

#### **Grade Sensor Calibration**

#### **Process Requirements:**

- Vehicle must be on level ground before initiating the grade sensor calibration.
- Ground surface must be within +/-0.5% grade (.28 degrees) level.

#### ▲ WARNING

Failure to adhere to ground surface conditions may lead to unsatisfactory shift performance. This condition could be misinterpreted as a product defect and could lead the operator to unnecessary repair.

- · Verify the suspension is fully aired.
- Verify the suspension is set to proper ride height.
- Engine shall not be running during the grade sensor calibration.

There are three options for completing the grade sensor calibration. The process for each option is listed below. Your OEM may implement any of these processes.

#### **Grade Sensor Calibration Tool**

- 1. Key On.
- 2. Engine shall not be running.
- 3. Plug grade sensor calibration tool into 9-pin diagnostic connector.
- 4. Push the button on top of tool.
- 5. Observe the pass/fail indicator on top of tool:
  - If indicator is green, the calibration was successful.
  - If indicator remains red, the calibration failed.

#### ▲ WARNING

If the grade sensor fails to calibrate, refer to the diagnostic procedure in this publication.

# ine Inspection and End of Line

#### **Shift Input Device Combination**

- 1. Begin with the ignition key off.
- 2. Turn the ignition to the ON position but do not start engine.
- 3. Select "L" on the shift input device. At this point, do not press the brake pedal.
- 4. Press the "Up" arrow once, the gear display should change to 0.
- 5. Press the "Up" arrow five times, the gear display should change to 6.
- 6. Depress the accelerator all the way to the floor and hold until down arrow is shown in the gear display, may take approximately 2 seconds.
- 7. Release the accelerator, the gear display should revert back to 0.
  - Note: At this point, the grade sensor offset should be calibrated.
- 8. Select "N" on the shift input device, the gear display should no longer be flashing an "F".

#### ServiceRanger (PC-based Diagnostic Tool)

- 1. Turn ignition switch to On.
- 2. Plug 9-pin connector into dash port.
- 3. Click on ServiceRanger icon to launch program.
- 4. Click on "Go To" and select "Service Routines".
  - **Note:** All available Service Routines will be shown.
- 5. Click on the "Start" button next to Grade Sensor Calibration.

**Note:** Read the on screen instructions and ensure that the vehicle meets the requirements for Grade Sensor Calibration.

- 6. Click on the "Calibrate" button.
- 7. Wait until the message "Successful: The Grade Sensor Calibration was successful."
- 8. Verify that Fault Code 68 FMI 13 has gone inactive.
- 9. Click on "Disconnect" and close Service Ranger, then disconnect computer from dash port.

**Note:** If Fault Code 68 is active, see Troubleshooting Guide TRTS0940.

10. Turn ignition switch to Off.

#### Line Inspection Form - Eaton UltraShift PLUS PV Models

**Note:** The service brake input is required while selecting a starting gear. If the service brake is not applied while selecting a starting gear, the initial start gear will not be found and the driver will have to re-select neutral and press the brake while re-selecting the desired mode.

**Note:** When testing on a dynamometer which decelerates quickly, the display module may not appear to function correctly. Should this occur, drive the vehicle off the dynamometer and note how the display functions. If it functions correctly when driving, the problem is that the dynamometer decelerates too quickly.

Eaton UltraShift <i>PLUS</i> PV model		OEM:					
		Chassis S/N:					
Line In:	Line Inspection Trans Model:			Trans S/N:			
Descrip	otion		Yes	No	Corrected		
Pre-Sta	ırt Checks						
1.	Ignition Bus Check: Does service light turn on and to	ne sound?					
2.	Power Supply check: (manual reset type) or fuse						
	30 amp Main Power for Transmission ECU						
	40 amp Main Power for Transmission ECA						
3.	Power up procedure: System powers up and "N" on	Gear Display					
DYNO/	Road Test Checks						
1.	Verify the engine doesn't crank in any position other	than neutral					
2.	Verify forward and reverse gear not obtained without	t service brake applied					
3.	Verify all forward and reverse gears are obtained with	h engine control					
4.	Verify engine ECU contains proper configuration settings						
5.	Verify transmission temperature gauge is functional - if equipped						
6.	Verify gear display module works correctly						
7.	Verify shift input device panel lights are functional						
8.	Verify no transmission oil leaks or residue						
9.	Verify the transmission diagnostic connector is accessible						
10.	Verify correct Shift Label						
11.	Verify lubricant type and brand label affixed to transmission fill plug						
12.	Oil Fill - With engine off, verify proper lubrication level. Refer to Lubrication Requirements section of this manual.						
13.	Clear Fault Codes and verify diagnostic connector functions						
14.	Prior to shipment of Eaton Automated Transmission Systems installed at OEM plants, the engine ECU shall contain the proper configuration settings. For the proper engine configuration settings required for Eaton Automated Transmission operation refer to the "Engine Configuration Settings Installation Guide" on roadranger.com under the literature center.						
Comme	ents:						
Final I	nspection Date:						
Signati	ire:						

# Line Inspection and End of Line

## **Line Inspection Form - OEM Wiring Connector/Harness**

**Note:** Eaton requires the following checklist items to be incorporated into the OEM control plans.

Description	Yes	No	Corrected
Deutsch Connector to Transmission ECU 25 +/- 3 in-lb [2.82 +/-0.33 Nm]			
Packard Connector to Push Button Controller 10 +/- 3 in-lb [1.1 +/-0.33 Nm]			
NyoGel 760G lubricant is recommended on connector contacts			
No lubricant or foreign material on connector jackscrew			
No contaminants on connector contacts			
Harness anchor points within 6 in. [15.24 cm] of connectors			
No unanchored length of harness greater than 12 in [30.48 cm]			
No sharp bends in the harness			
Tie wraps on Harness Jacketing only			
Harness not anchored to objects that are free to move			
All connectors are fully mated and latches locked			
All unused connectors or pins should be plugged			
No exposed splices or wire strands			

#### **Diagnostic Procedures**

A

**Purpose:** Document the vehicle symptoms and determine if the engine will crank.

- 1. Document the vehicle symptoms by completing the Driver Questionnaire on page 8.
- 2. Key on with engine off.
- 3. Attempt to start the engine.
  - If engine does not crank, go to Step B.
  - If engine cranks, go to Step D.

B

Purpose: Observe gear display.

- 1. Key on with engine off.
- 2. Observe gear display.
  - If "F" appears in gear display, go to Step H.
  - If "-" (1 dash) appears in gear display, go to **Step C.**
  - If "--" (2 dashes) or "\* \*" (2 stars) appears in gear display, perform the *Power-Up Sequence Test* on page 23.
  - If gear display is blank, perform the *Power-Up* Sequence Test on page 23.
  - If "N", appears in gear display perform the Start Enable Contact Test on page 397.

C

**Purpose:** Check for Active or Inactive fault codes.

- 1. Key on with engine off.
- 2. Connect ServiceRanger.
- 3. Retrieve Snapshot and VPA data by creating a Service Activity Report within ServiceRanger.
- Update transmission software to latest available level.



**Caution:** To avoid damaging the TECU, use an Eaton-approved communications adapter and ensure all satellite systems are disabled before updating software.

- **5.** Retrieve and record the transmission fault codes and FMIs, and their occurrences and timestamps.
  - If Active fault codes are present, go to Step H.
  - If no Active fault codes are present, perform the *Main Case Control Test* on page 429.

D

**Purpose:** Confirm transmission engages a gear from neutral.

- 1. Attempt to engage a gear from neutral.
  - If transmission engages a gear, go to **Step E.**
  - If transmission does not engage gear and the gear display shows a solid number, perform the Main Case Control Test on page 429.
  - If transmission does not engage gear and the gear display shows anything else, perform the Transmission Not Engaging a Gear From Neutral Test on page 437.

E

**Purpose:** Operate vehicle and attempt to recreate vehicle symptom.

- 1. Drive or operate vehicle and attempt to set a fault code or duplicate the previous complaint.
  - If a problem is duplicated, go to **Step F.**
  - If no problem is duplicated, go to Step G.

F

Purpose: Check for Active or Inactive fault codes.

- 1. Key on with engine off.
- 2. Connect ServiceRanger.
- **3.** Retrieve Snapshot and VPA data by creating a *Service Activity Report* within ServiceRanger.
- **4.** Retrieve and record the transmission fault codes and FMIs and their occurrences and timestamps.
  - If fault codes are present, go to Step H.
  - If no fault codes are present, match the vehicle symptoms from the test drive and *Driver* Questionnaire to the Symptom-Driven Diagnostics Index on page 10.

G

Purpose: Check for Active or Inactive fault codes.

- **1.** Key on with engine off.
- 2. Connect ServiceRanger.
- **3.** Retrieve Snapshot and VPA data by creating a *Service Activity Report* within ServiceRanger.
- **4.** Retrieve and record the transmission fault codes and FMIs and their occurrences and timestamps.
  - If fault codes are present, go to Step H.
  - If no fault codes are present, no problem was identified, Test Complete. If additional troubleshooting support is required, contact Eaton at (800) 826-4357.



Purpose: Prioritize fault codes for troubleshooting.

- **1.** Key on with engine off.
- 2. Connect ServiceRanger.
- **3.** Retrieve and record the transmission fault codes and FMIs, and their occurrences and timestamps.
- 4. Determine which fault code to troubleshoot first by using the priority index below (with 1 highest priority and 4 least priority).
  - Priority 1: 11, 12, 81, 84, 85, 99
  - Priority 2: 15, 16, 19, 26, 27, 33, 34, 35, 36, 37, 61, 63, 66, 67, 74
  - Priority 3: 13, 14, 17, 21, 22, 29, 43, 44, 46, 51, 52, 56, 57, 58, 64, 65, 68, 83
  - Priority 4: 41, 42, 45, 71, 72, 73
    - Troubleshoot the fault code with the highest priority level. If more than one fault code within a level applies, troubleshoot Active fault codes before Inactive fault codes.
    - If only Inactive fault codes are present, troubleshoot the fault code that has the highest occurrence count or most recent timestamp.
    - If no fault codes are found, match the vehicle symptom to the appropriate item in the *Symptom-Driven Diagnostics Index* on page 10.

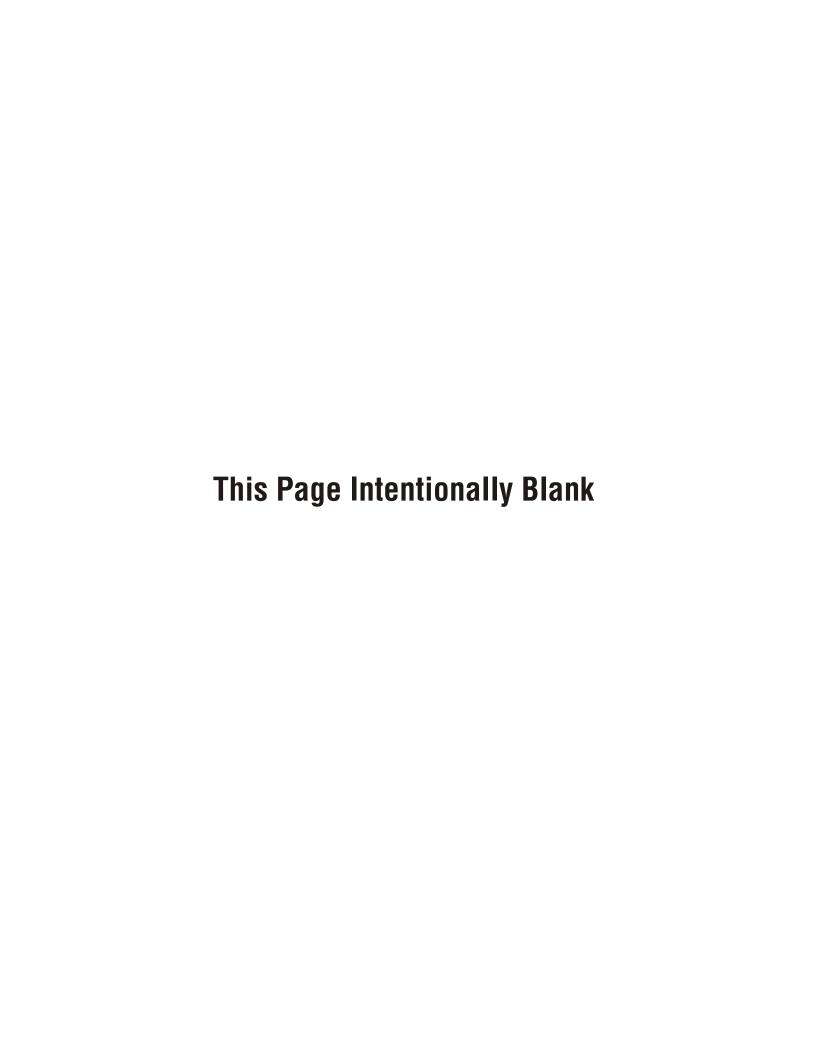
# **Torque Specifications**

Description	Torque Value lbs. ft. [Nm]	Thread size	Additional Comments
Transmission-to-Engine capscrews	Refer to OEM for s	pecification	
Clutch-to-Flywheel capscrews	40–50 lb-ft [54–68 Nm]	7/16" x 2 x 14	M.D.
1 Reverse switch	20–25 lb-ft [27–34 Nm]	9/16"-18	
1 Neutral switch/cap	20–25 lb-ft [27–34 Nm]	3/4"-16	
2 Transmission ECU 38-Way Connector Capscrews	25 +/- 3 lb-in [2.82 +/-0.33 Nm]	M5 x 0.80"	
1 Push Button Shift Controller 30-Way Connector Capscrew	10 +/- 3 lb-in [1.1 +/-0.33 Nm]		
2 Push Button Shift Controller Backing Plate nuts and lock washers	14–16 lb-in [1.58–1.8 Nm]		
3 ECA Capscrews	25 - 35 lbs. ft. [34 - 47 Nm]	3/8"-16	
1 ECA stud Nylon Lock Nut	25 - 35 lbs. ft. [34 - 47 Nm]	3/8" - 24	A 3/8"-24 nut with washer may be used in place of a nylon lock nut.
1 ECA Engine Speed Sensor Jam Nut	15 lb-ft [20 N•m]	3/4"	0.045" +/- 0.015"
1 Main Shaft Speed Sensor Capscrew	8–10 lb-ft [10.8–13.6 Nm]	1/4"-20	
1 Input Shaft Speed Sensor Capscrew	8–10 lb-ft [10.8–13.6 Nm]	1/4"-20	
1 Lubricant fill plug	60–75 lb-ft [47–61 Nm]	11⁄4-NPT	
2 Lifting Bracket Capscrews	35–45 lb-ft [47–61 Nm]	3/8"-16	Apply Loctite 242 to threads.
4 Rear Bearing Cover Capscrews	35–45 lb-ft [47–61 Nm]	3/8"-16	Apply Loctite 242 to threads.
Transmission Nodal Mount Capscrews	Refer to OEM for Specification		Apply Loctite 242 to threads.
Transmission Rear Mount Nuts/Capscrews	Refer to OEM for Specification	5/8"-11	

# Change Control Log

# **Change Control Log**

Last Revised Date	Description of Clarifications and Updates		
September 2014	1. ECA Mounting torque changes and added PV ECA Removal instructions - Pages: 15, 90 2. Changes to J1939 Start Enable Type requirements		
	2. Changes to J1939 Start Enable Type requirements - Page 40		
	3. Rewrote Grade Sensor calibration procedure for ServiceRanger 4 - Page 84		
	4. Updated Diagnostic Procedure from TRTS0940 - Pages: 87, 88, 89		



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