Scope of this Document
These Guidelines were written to assist OEMs in integrating TRCM controllers into their equipment. This technical installation package includes the diagnostic codes supported by the TRCM as well as the CAN messages supported.

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Section I TRCM Communications

Introduction

CAN (Controller Area Network) is a data communication system widely used in the automotive industry. CAN provides the means for electronic devices on the vehicle to interact with each other. Some typical functions performed are sharing of sensor data, sharing of calculated information, allowing subsystems (e.g. engine, transmission, etc.) to influence each other’s operation, and communication of subsystem operation state. The CAN network also provides a means for on and off board diagnostic work to be done. The TRCM has been designed with an onboard CAN communications port. This port provides access to both SAE J1939 and J2284 CAN networks.

SAE J1939 is a high-speed network for machines that operate at 250K baud. It is capable of supporting control, information sharing, diagnostics, multiplexing, and proprietary communications. The J1939 (physical layer) uses a differential line driver circuit and allows a maximum bus length of 40 meters. The network can have a maximum of 30 node connections at a given time.

SAE J2284 is a high-speed network for machines that operate at 500K baud. It is capable of supporting control, information sharing, diagnostics, multiplexing, and proprietary communications. The J2284 (physical layer) uses a differential line driver circuit and allows a maximum bus length of 40 meters. The network can have a maximum of 30 node connections at a given time.

About The TRCM

The TRCM is able to communicate with both standard CAN interfaces, selected through a serial interface when connected to a laptop. Diagnostic data may also be returned to the host computer via this serial RS232 interface. The TRCM is capable of performing a range of functions; such as receiving raw CAN messages and performing higher-level functions. The TRCM is "hot-pluggable" and all TRCM settings are saved in non-volatile flash memory so that the unit will resume its configured tasks following a power interruption.

About This Manual

This document is primarily a reference manual which describes the required CAN connections for the TRCM. It is assumed that the reader has some familiarity with the operation of CAN-based systems and the various communication protocols which operate over CAN. Note that the TRCM software provides an easy-to-use "front end" which will generate the required commands in order to monitor and record the parameters of interest from the CAN bus.
Applicable SAE Documents

This document, along with the SAE specifications listed below, contain the information required to apply the TRCM interface (both J1939 and J2284) to vehicle applications.

SAE 1939  Recommended Practice for a Serial Control and Communications Network (April 1997).
          Provides a list of all of the J1939-xx documents that are planned. It provides a brief tutorial about the overall set of documents and basic operation of the network.


SAE J1939-13 Off-board Diagnostic Connector (January 1997). Specifies 9-pin Deutsch that will provide a connection to J1939, J1587, a second CAN network for implements, unswitched power and ground.

SAE J1939-21 Data Link Layer (July 1998). Specifies CAN 2.0b as the message protocol to be used. Also defines an interface to the application layer of J1939.

SAE J1939-71 Vehicle Application Layer (May 1996 plus 1/97 addendum). Defines transmitted parameter value interpretation rules that allow receiving devices to determine if the sending device is able to supply all parameters associated with the parameter group, if any of the parameters has an error condition or if the signal is valid.

SAE J1939-73 Diagnostic Application Layer (October 1998)–Diagnostics. Defines capability required to perform diagnostics on J1939 strategy to identify the least repairable subsystem that failed, how it failed, read and clear diagnostics fault codes, communication of diagnostic lamp status and providing a variety of parameters for monitoring by the service tool.

SAE J1939-81 Network Management (November 1996)

Applicable Telma Documents

This document contains the information required to apply the TRCM interface to vehicle applications.

Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN</td>
<td>Controller Area Network</td>
</tr>
<tr>
<td>CRLF</td>
<td>Carriage Return, Line Feed</td>
</tr>
<tr>
<td>ECU</td>
<td>Electronic Control Unit</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>ID</td>
<td>Identifier</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
</tr>
<tr>
<td>NMEA</td>
<td>National Marine Electronics Association</td>
</tr>
<tr>
<td>OBD</td>
<td>On Board Diagnostics</td>
</tr>
<tr>
<td>PGN</td>
<td>Parameter Group Number</td>
</tr>
<tr>
<td>PID</td>
<td>Parameter Identifier</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>SPN</td>
<td>Suspect Parameter Number</td>
</tr>
<tr>
<td>DTC</td>
<td>Diagnostic Trouble Code</td>
</tr>
<tr>
<td>PDU</td>
<td>Protocol Data Unit</td>
</tr>
</tbody>
</table>
## Section II TRCM Hardware

### Connectors

The TRCM consists of a small plastic box with two Deutsch connectors on each side.

#### J1-A Port

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digital 1 input</td>
<td>ground</td>
</tr>
<tr>
<td>2</td>
<td>Digital 2 input</td>
<td>ground</td>
</tr>
<tr>
<td>3</td>
<td>Digital 3 input</td>
<td>ground</td>
</tr>
<tr>
<td>4</td>
<td>Digital 4 input</td>
<td>ground</td>
</tr>
<tr>
<td>5</td>
<td>Speed Signal input</td>
<td>pulse</td>
</tr>
<tr>
<td>6</td>
<td>Ground</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>Battery</td>
<td>12V</td>
</tr>
<tr>
<td>8</td>
<td>Battery</td>
<td>12V</td>
</tr>
<tr>
<td>9</td>
<td>Retarder-1</td>
<td>output</td>
</tr>
<tr>
<td>10</td>
<td>Retarder-2</td>
<td>output</td>
</tr>
<tr>
<td>11</td>
<td>Retarder-3</td>
<td>output</td>
</tr>
<tr>
<td>12</td>
<td>Retarder-4</td>
<td>output</td>
</tr>
</tbody>
</table>

#### J1-B Port

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAN High</td>
<td>signal</td>
</tr>
<tr>
<td>2</td>
<td>CAN Low</td>
<td>signal</td>
</tr>
<tr>
<td>3</td>
<td>not used</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Ground</td>
<td>GND</td>
</tr>
<tr>
<td>5</td>
<td>not used</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>COM RX</td>
<td>signal</td>
</tr>
<tr>
<td>7</td>
<td>COM TX</td>
<td>signal</td>
</tr>
<tr>
<td>8</td>
<td>not used</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Transducer</td>
<td>signal</td>
</tr>
<tr>
<td>10</td>
<td>DSC set input (momentary)</td>
<td>ground</td>
</tr>
<tr>
<td>11</td>
<td>ABS Control input</td>
<td>ground</td>
</tr>
<tr>
<td>12</td>
<td>Throttle Position input</td>
<td>positive</td>
</tr>
</tbody>
</table>

#### Host RS232 Port

A female DB9 is used to connect to an RS232 port on a host computer. The pin-out follows the standard DTE (Data Terminal Equipment) layout as used on a PC.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Function</th>
<th>TRCM pin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RXD</td>
<td>Receive Data input</td>
<td>B-7</td>
</tr>
<tr>
<td>3</td>
<td>TXD</td>
<td>Transmit Data output</td>
<td>B-6</td>
</tr>
<tr>
<td>4</td>
<td>not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Ground</td>
<td>B-4</td>
</tr>
<tr>
<td>6</td>
<td>not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>not used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>not used</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note that the RTS and CTS pins are not used*
LEDs

The LEDs are used to indicate activity on the various ports:

<table>
<thead>
<tr>
<th>LED</th>
<th>LED Color</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD1</td>
<td>Yellow</td>
<td>3.3V power supply</td>
</tr>
<tr>
<td>LD2</td>
<td>Red</td>
<td>5V power supply</td>
</tr>
<tr>
<td>LD3</td>
<td>Yellow</td>
<td>Heart Beat, normal operation</td>
</tr>
<tr>
<td>LD4</td>
<td>Red</td>
<td>CAN Data present</td>
</tr>
</tbody>
</table>

Connecting TRCM

Host Computer Connection

The host computer serial cable is wired as a standard cable:

![Diagram of host computer to TRCM connection with DB9 straight through cable](image)

*Host computer serial connection wiring diagram*

If the host computer does not have an RS232 port then a USB to serial adapter may be used.

**Note:** By default, the TRCM host port operates at a high baud rate (57600 baud). At this speed, the maximum cable length for the host computer or diagnostics connection is approximately 5 meters, assuming good quality shielded cable is used. If a longer cable is required, contact Telma for assistance.
Section III CAN Bus and Termination

A high speed CAN network is required to have a linear topology. There is a single twisted pair "backbone" cable which can be up to 40m long. Electronic control units (ECUs) are then connected to the bus using short stub connections (max length 0.3m). (These limits are for 1Mbps operation and can be increased somewhat for lower bit rates.) At each end of the bus, correct termination is required. This typically consists of a resistor (wired across the two bus lines) that matches the impedance of the cable (i.e. 120Ω). The termination resistance provides the correct DC load for the CAN output drivers, and minimizes signal "reflections", which can distort the CAN signals and cause errors.

J1939 Installation Information

This section provides information required by those involved in installing J1939 TRCM's on their vehicles.

1. J1939

To install J1939 datalink on a machine, it is important to understand the requirements relating to cabling and connectors. The following section provides details on both.

2. Cabling

**Backbone** - It is a linear bus with a maximum length of 40 meters (approximately 131 feet). At a given time, the maximum number of nodes (electronic controllers) that can be connected to the backbone is 30. For J1939-11 compliance, the backbone is a twisted shielded pair with a drain and requires passive termination resistors at each end of the network. The J1939-11 topology is typically used for automotive/on highway applications. Please refer to Figure 4.

**Stub** - The connection from the backbone to each node (electronic controller) is called a stub and it can be a maximum of 3-meters in length. Please refer to Table 3.

**Shield** - Electrical connection to the shield is achieved by the drain wire at bus connection points for the nodes (electronic controllers) and at the main bus interconnects. Also note that the shield should be grounded only at one point with a connection to the battery negative. Although the shield does not provide coverage in the area where connections are made to the linear bus or at the stub connector (read section below for details) locations, it is connected electrically to the next segment of the shielded cable, and provides sufficient coverage to provide the necessary electromagnetic compatibility (EMC) improvements.

**Note-No data is ever transmitted on the CAN bus at any time.**
3. Connections

**Backbone Connection** - The TRCM may be connected to the backbone by a 3-pin unshielded connector called a stub connector. This is illustrated by the manner in which ECU 1 is connected to the backbone in Figure 1. For a connection type as shown for ECU 1 in Figure 1, one of the three pins will be used to pass the drain wire through to the mating half (A MATE) of the stub connector, in order to allow the electrical continuity of the shield to be maintained. It should be noted that the connection of ECU 2 provides the best case EMC improvement (i.e. shortest possible stub).

**Diagnostic Connection** - The diagnostic connector is a 9-pin Deutsch and will provide a connection to J1939, a 2nd CAN network for implements (for Agriculture/Construction Application), unswitched power and ground. The maximum allowed distance of the diagnostic connector from the backbone is 2.66 meters. The remaining one-third of 1 meter (0.33 meter) is the maximum allowed distance between the diagnostic connector and the TRCM connected to the diagnostic connector. For the automotive/ truck industry the SAE preferred location of the connector is in the cab area on the operator’s side and should be accessible from the ground on the operator’s side. A 9-pin installation for J1939 and J1587 is suggested to use the Deutsch HD10-9-1939P connector.

**Bulkhead Connection** - The TRCM may be routed through the OEM bulkhead connector. To reduce the chance of electrical noise affecting the datalink, it is recommended that the wires not be placed adjacent to circuits with extremely high current loads or switching currents.

4. Connecting to an existing CAN Network

A typical CAN network might be wired as follows:

![Typical layout of a vehicular CAN network](image)

In this case the vehicle has four ECUs connected to the CAN bus, plus a diagnostic connector. ECUs 1 and 4 are at the ends of the main bus, so they incorporate termination resistors. ECUs 2 and 3 connect to the bus via short stub connections and do not include a termination resistor.

Notice that TRCM-1b incorporates a *weak termination* (2.6k Ω). This is required to allow the length of the stub to be extended up to 5 meters. This value is high enough so as not to significantly increase the DC load on the already terminated bus, yet low enough to provide some damping of reflections on TRCM’s stub connection to the bus. Note that some of the ECUs may also include weak termination to allow their stub connections to be extended slightly.

5. Connecting to a Single ECU

If the TRCM is connected to a single ECU (eg for laboratory testing) then a 120 ohm external termination resistor will be required on both ends of the connection.
Section IV Messages Supported by TRCM

This section details the J1939 and J2284 industry standard messages that are supported by TRCM. Parameter characteristics for messages sent on J1939 and J2284 are also listed.

The TRCM is looking for 4 separate packets of information on the CAN bus.

1. Wheel-Based Vehicle Speed
2. ABS Active
3. Accelerator Pedal Position
4. Cruise Control Active

Messages on J1939

Wheel-based vehicle speed  PGN 65265, 0xFE01  SPN 84

SPN 84  Wheel-Based Vehicle Speed

Speed of the vehicle as calculated from wheel or tail shaft speed.

Data Length: 2 bytes
Resolution: 1/256 km/h per bit, 0 offset
Data Range: 0 to 250.996 km/h
Operational Range: same as data range
Type: Measured
Supporting Information:
PGN reference: 65265

ABS Active  PGN 61441, 0xF001  SPN 563

SPN 563  Anti-Lock Braking (ABS) Active

State signal which indicates that the ABS is active. The signal is set active when wheel brake pressure actually starts to be modulated by ABS and is reset to passive when all wheels are in a stable condition for a certain time. The signal can also be set active when driven wheels are in high slip (e.g., caused by retarder). Whenever the ABS system is not fully operational (due to a defect or during off-road ABS operation), this signal is only valid for that part of the system that is still working. When ABS is switched off completely, the flag is set to passive regardless of the current wheel slip conditions.

00 - ABS passive but installed
01 - ABS active
10 - Reserved
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3
Operational Range: same as data range
Type: Status
Supporting Information:
PGN reference: 61441
Accelerator Pedal Position  PGN 61443, 0xF003  SPN 91

SPN 91 Accelerator Pedal Position 1

The ratio of actual position of the analog engine speed/torque request input device (such as an accelerator pedal or throttle lever) to the maximum position of the input device. This parameter is intended for the primary accelerator control in an application. If an application has only one accelerator control, use SPN 91.

For on-highway vehicles, this will typically be the operator's accelerator pedal. Although it is used as an input to determine powertrain demand, it also provides anticipatory information to transmission and ASR algorithms about driver actions.

Data Length: 1 byte
Resolution: 0.4 %/bit, 0 offset
Data Range: 0 to 100 %  Operational Range: same as data range
Type: Measured
Supporting Information:
PGN reference: 61443

Cruise Control Active  PGN 65265, 0xEF1  SPN 595

SPN 595 Cruise Control Active

Cruise control is switched on. It is not ensured that the engine is controlled by cruise control, as in the case of a large driver's demand the engine is controlled by the driver while cruise control is active (maximum selection of cruise control and driver's demand). The cruise control is set to 0 if a switch off condition occurs.

00 - Cruise control switched off
01 - Cruise control switched on
10 - Error
11 - Not available

Data Length: 2 bits
Resolution: 4 states/2 bit, 0 offset
Data Range: 0 to 3  Operational Range: same as data range
Type: Measured
Supporting Information:
PGN reference: 65265
Messages on J2284 Ford

Wheel-based vehicle speed
0x201   byte4 and 5
Data Length:  2 bytes
Resolution:  1/256 km/h per bit, 0 offset
Data Range:  0 to 250.996 km/h

ABS Event
0x211   byte5
Data Length:  2 bits
Resolution:  4 states/2 bit, 0 offset
Data Range:  0 to 3

Accelerator Position
0x201   byte6
Data Length:  1 byte
Resolution:  0.4 %/bit, 0 offset
Data Range:  0 to 100%

Cruise Control Active
0x165   byte5
Data Length:  2 bits
Resolution:  4 states/2 bit, 0 offset
Data Range:  0 to 3

Messages on J2284 GM

Wheel-based vehicle speed
0x3E9   byte0 and 1
Data Length:  2 bytes
Resolution:  1/256 km/h per bit, 0 offset
Data Range:  0 to 250.996 km/h

ABS Event
0x1E9   byte2
Data Length:  2 bits
Resolution:  4 states/2 bit, 0 offset
Data Range:  0 to 3

Accelerator Position
0x0C9   byte2
Data Length:  1 byte
Resolution:  0.4 %/bit, 0 offset
Data Range:  0 to 100%

Cruise Control Active
0x0C9   byte3
Data Length:  2 bits
Resolution:  4 states/2 bit, 0 offset
Data Range:  0 to 3