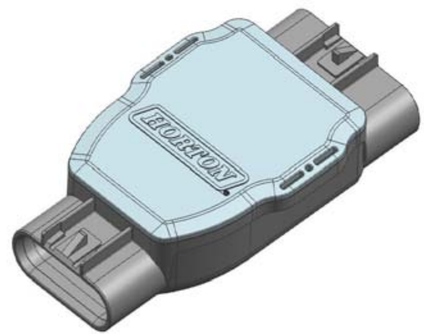
# DI+ Controller Technical Reference Manual

Version 1.1.0

# Design and Functions




The DI+ Controller is a custom tailored, ruggedized viscous fan drive controller. This controller is configured with a versatile algorithm capable of deriving the system's desired cooling fan speed from the ECU via the existing fan drive signal or by decoding CAN message(s) on the J1939 Bus. The DI+ Controller is capable of controlling a Viscous Fan Clutch by providing:

**-Discrete Fan Enable & Controls**
**-Enhanced diagnostics available on the J1939 CAN Bus**
**-Noise test functionality for EU Noise Directive Testing**
**-Fording Mode Option**
**-Clutch Protection: ensuring maximum life of the viscous fan drive**
**-Low frequency (PWM) clutch control signals and fan speed feedback monitoring**
**-Special Control Options: allowing control on Machines without a J1939 CAN bus**

## General Technical Data

| | |
|---|---|
| Weight | **0.14 kg** [0.30lb] |
| Nominal Power Supply | **12/24VDC** *(Reverse Polarity Protected)* |
| Rated Power Supply | **9 – 32VDC** (36V Absolute Maximum Limit) |
| Operating Temperature Ambient | **-40°C to 125°C** [-40°F to 257°F] |
| Storage Temperature | **-40°C to 125°C** [-40°F to 257°F] |
| Sensor Supply Voltage | **5VDC 50mA**, 4.5VDC Min, 5.5VDC Max |

**Connections**

| C1: ECU Connector<br>Mating Connector: Delphi GT280 | |
|---|---|
| Pin | Signal |
| A | Power Supply (+) |
| B | Power Ground (-) |
| C | J1939 CAN_H |
| D | J1939 CAN_L |
| E | Configurable Input 1* |
| F | Configurable Input 2* |

| C2: Clutch Connector<br>Mating Connector: Delphi GT150 | |
|---|---|
| Pin | Signal |
| A | Sensor Power Supply return ( -) |
| B | 5 VDC Sensor Power Supply (+) |
| C | ClutchFan Speed Feedback |
| D | Configurable Input 3* |
| E | Clutch Coil Output return (-) |
| F | Clutch Coil Output (+)(High side Switch) |

*Configurable Inputs are explained in section "Supported Algorithms"

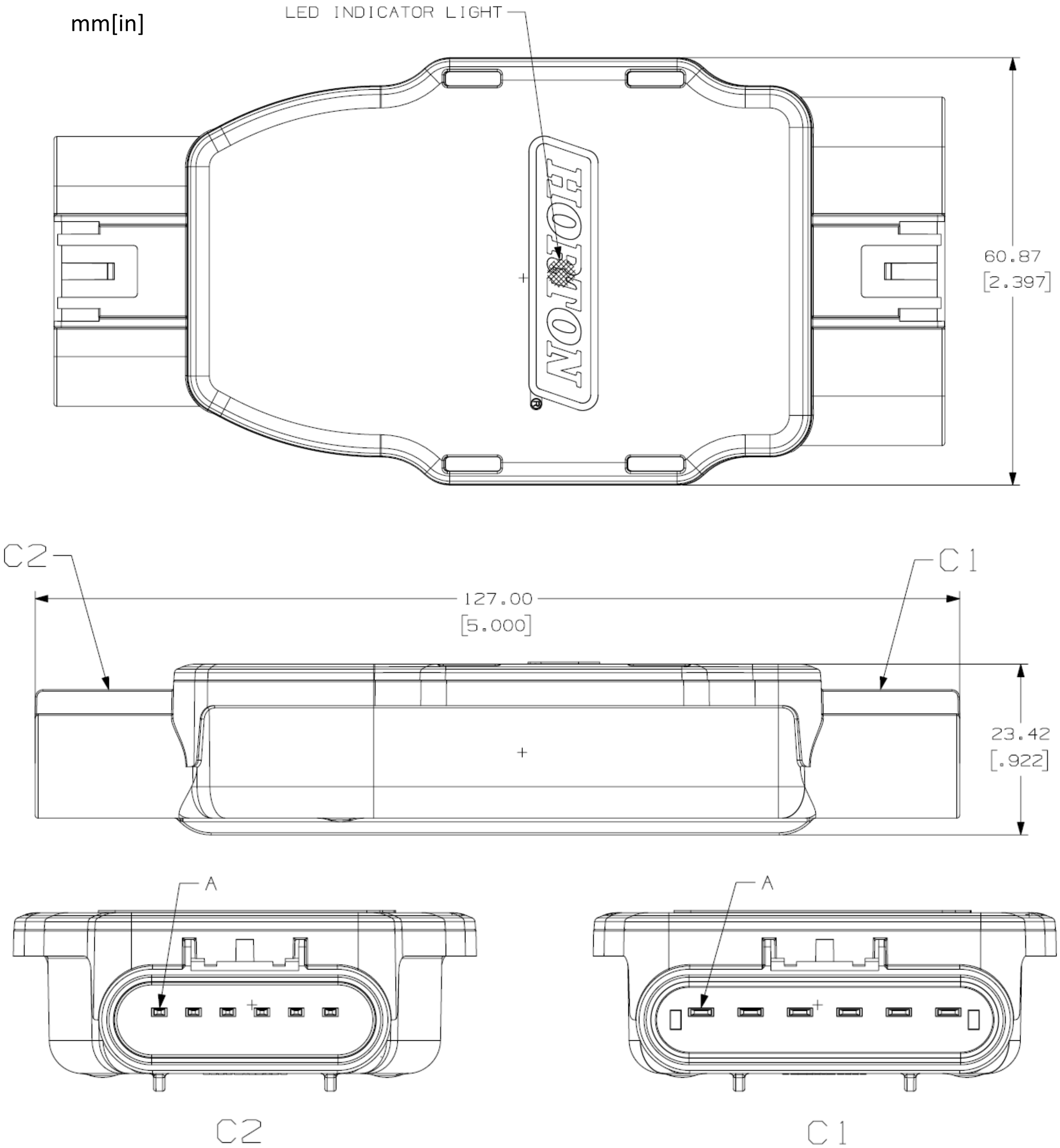



Figure 1: Controller View

# Functional Overview

The DI+ Controller is a Viscous Clutch Controller which utilizes inputs from a J1939 CAN bus and discrete signals to control a Horton Electronically Controlled Viscous Fan Clutch. The controller is programmed with two components, the control Algorithm and the Application Parameter Table (APT). The architecture utilizes a versatile powerful control algorithm with all specific requirements for an application being set in the APT.

The controller Algorithm supports 8 inputs, which can be any combination of CAN and physical inputs. Each of the CAN based inputs can be configured to any CAN Message and any Source Address. The 3 discrete inputs are mapped directly to pins C1-E, C1-F & C2-D of the controller hardware. These inputs can be used to translate temperature/ speed sensor signal to a % of Input Speed or a Fan RPM, translate a PWM signal to a % of Input Speed or a Fan RPM, translate a switch to ground to Control the Fan a specific Fan Speed or % of Input Speed or to command the Fan Speed to 0 for a Fording or measure a speed signal of a discrete speed sensor to measure the Clutch Input Speed in the event of a non CAN Based installation.

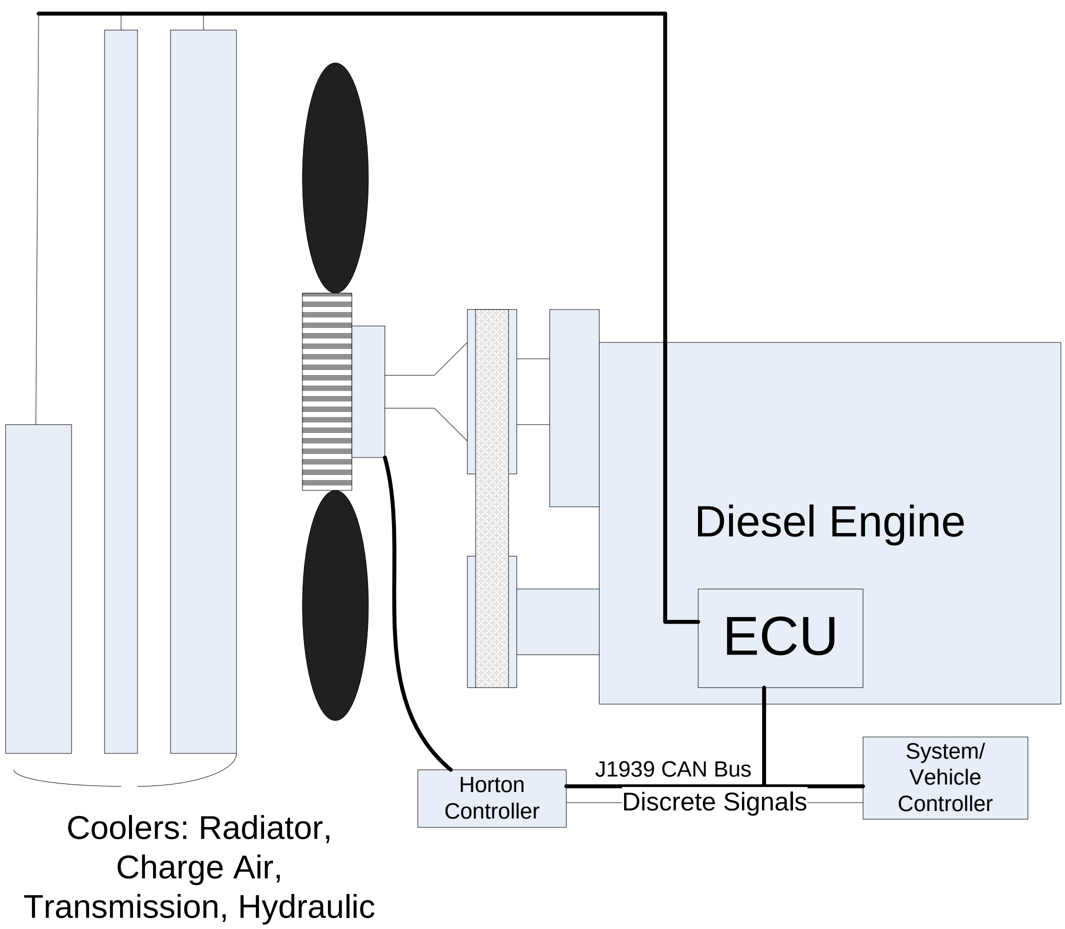



Figure 2: System Overview

# Controller Details

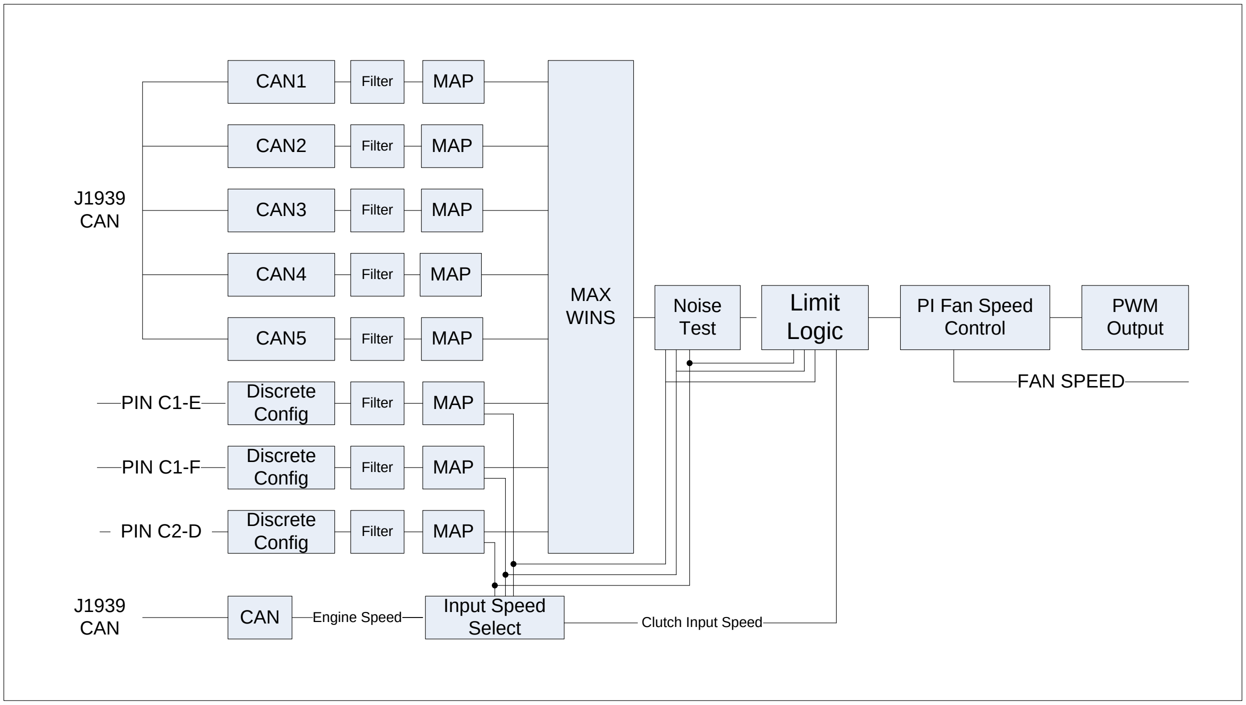



Figure 3: Example Fan Drive System

The DI+ Controller Algorithm accepts a total of 8 inputs, each input has an Exponential Filter that is customize based on the selected input, and a Fan Drive Reason for diagnostics/information use. The DI+ Controller Broadcasts the Fan Drive Message: PGN 65213 (0xFEBD) which it provides the actual Fan Speed, the Estimated Percent Fan Speed (of the greatest input) and the Reason for that particular input.

All inputs use an 8-point (x,y) map to translate the Input to a percent of input speed or an absolute rpm command for the Fan Speed.

Inputs 1-5 are CAN based inputs which have configurable PGNs, scaling formulas and Source Addresses.

Inputs 6, 7 & 8 are mapped to the controller pins C1-E, C1-F & pin C2-D respectively. Each input can be used as one of the following: CAN Based Inputs, External Fan Request (% or RPM Based), EU Noise Test, PWM Input, Discrete Pulley Speed Sensor or Ford Mode. Input 7 & 8 can also be used as Temperature Sensor Input.

-CAN based Inputs: This mode is used to request fan command using a CAN message.

-External Fan Request: This mode is used to have a Temperature or Pressure Switch map to an input. The command is enabled when respective pin is switched to ground/power, the command can be either a percent of input speed or a fan speed in RPM.

-EU Noise Test: This mode is used for either production line Audit or Random Field Audit noise testing. When the respective pin is switched to ground, the fan will command to the configured % of input speed or command fan RPM, regardless of the conditions of Input Speed or Fan Speed. This configuration is only for noise testing. For cooling purposes, always use the External Fan Request.

-PWM Input: This mode is used for another controller to request fan from the DI+ Controller without using a CAN Message. This type of input uses an 8-point (x,y) mapping scheme by specifying the PWM duty cycle that corresponds to minimum fan speed and that which corresponds to the maximum fan speed and finally the maximum output command in % of input speed or absolute fan rpm.

-Discrete Pulley Sensor: This mode is used for installations where a J1939 CAN Bus is not available to provide Engine Speed to calculate the Clutch Input Speed. Set input parameters: the pulley pulses per revolution, the minimum pulley speed and maximum pulley speed for error checking.

-Fording Mode: This mode is used for instances when regardless of the temperatures conditions, the fan needs to be slowed to 0 rpm. When the respective pin is switched to ground, the Fan Speed will be commanded to 0, regardless of the other temperature inputs.

-Temperature Sensor Input: This mode is used to request fan based on temperature from a sensor without using a CAN message. This type of inputs uses 8-point (x,y) maps to translate the temperature input to %percent of input speed or an absolute rpm command for the Fan Speed.

# Environmental Ratings

Climate Environment

| Description | Applicable standard |
|---|---|
| Ingress Protection | IP67, IP 69K<br>**IP67 and IP69K** is only valid with mating connector and all **cavities populated. Unused cavities must be filled with cavity sealing plug** |
| High Temperature | Horton test<br>Powered at 32V and 168 hours at 125 deg C |
| Low Temperature | IEC 60068-2-1, ISO 16750-4 |
| Combined Environment Cycle (temperature/humidity) | JDQ 53.3 |
| Thermal Shock (Splash) | IEC 60068-2-14, IEC 60068-2-2 |
| Temperature Cycling<br>Thermal Shock (air) | Horton test<br>-40 to 125 deg C, 900 cycles, 10-min dwell time, transition time < 10 seconds |

Chemical Environment

| Description | Applicable standard |
|---|---|
| Salt Mist | ASTM-B117-11 |

Mechanical Environment

| Description | Applicable standard |
|---|---|
| Vibration | Horton Test<br>Random Vibration per Horton Field PSD. 10-2000Hz |
| Free Fail (Transit Shock) | ISO 16750, IEC 60068-2-32 Test Ed |

Electrical/Electromagnetic Environment

| Description | Applicable standard |
|---|---|
| EMI/RFI | ISO 11452-2 (100 V/m) |
| EMC emission | CISPR 25 (2008) Class 3/COR 1 (2009) |
| EMC immunity | ISO 11452-2, ISO 11452-4, ISO 11452-8, SAE J1113-26 |
| ESD (Electrostatic Discharge) | ISO 10605 |
| Auto electrical transients | ISO 7637-2, ISO7637-3, SAE J1113-11, ISO 16750-2, SAE J1113-11, ANSI/ASAE EP455 |
| Short circuit protection | Horton test<br>All inputs and outputs will withstand continuous short to circuitry to any other leads; when the short circuit is removed, the module will return to normal function |
| Reverse Polarity Protection | Horton test<br>Modules will withstand reversed polarity at supply voltage for at least five minutes |

# Product Installation

In-line Control Module can be mounted on Side (preferred).
***Position the connector so that moisture drains away from the module. Provide drip loops in the harnesses. Provide strain relief for the mating connector wires.***

## Wiring Guidelines

1. All wires must be protected from mechanical abuse. Wires should be run in flexible metal or plastic conduits.
2. Use GXL wire or equivalent with high temperature range (125°C) and abrasion resistant insulation.
3. Use appropriate size contacts for your wire size:
   -Wire size: 16 to 18 AWG

Figure 4: Stamped Contacts: Delphi 15304719 GT 280 Series (Left), Delphi 12191819 GT 150 Series (Right)

   -Mating Connectors and Stamped Contacts:

| | |
|---|---|
| C1: ECU Connector | |
| ECU Side Mating Connector | Delphi GT280, p/n: 15326635 or 13521467 |
| ECU Side Stamped Contacts | Delphi GT280 p/n 15304719 |
| ECU Side Wire Seal | Delphi p/n: 15366066 |
| ECU Side Cavity Plug | Deutsch p/n: 114017 |
| C2: Clutch Connector | |
| Clutch Side Mating Connector | Delphi GT150, p/n: 15326829 or 15397577 |
| Clutch Side Stamped Contacts | Delphi GT 150 p/n 12191819 |
| Clutch Side Wire Seal | Delphi p/n: 15366060 |
| Clutch Side Cavity Plug | Deutsch p/n: 15305171 |

   Run wires along the inside of, or close to, metal machine surfaces where possible. This simulates a shield which will minimize the effects of EMI/RFI radiation.
4. Do not run wires near sharp metal corners. Consider running wires through a grommet when rounding a corner.
5. Do not run wires near hot machine members.

6. Provide strain relief for all wires.
7. Avoid running wires near moving or vibrating components.
8. Avoid long, unsupported wire spans.
9. All passive analog sensors interfaced to the DI+ Controller should be powered by the sensor power source from DI+ Controller (pin C2-B) and ground returned to the sensor ground (pin C2-A).
10. CAN + and CAN - wires should have 1 twist per inch.
11. It is better to use wire harness anchors that will allow wires to float with respect to the machine rather than rigid anchors.

## Grounding

Proper operation of any electronic control system requires that the DI+ Controller be connected to a dedicated ground. A dedicated ground wire of appropriate size connected to the machine battery is recommended.

## Powering

The DI+ Controller is designed to be powered by a fused power supply connected to the vehicle ignition. Powering the controller by sources that are always on may create excessive battery drain as the controller will may drive the clutch control coil. Recommended fuse size for the DI+ Controller is 5A.

## Hot Plugging

Machine power should be **OFF** when connecting the DI+ Controller mating connectors. Hot Plugging may damage the controller.

## Welding Procedures for Machines Equipped with Controller

The following procedures are recommended when welding on a machine equipped with controllers:

-Engine should be off.

-Disconnect the negative battery cable from the battery.

-Do not use electrical components to ground the welder. Clamp the ground cable for the welder to the component that will be welded as close as possible to the weld.

## Diagnostic Interface

The DI+ Controller accomplishes diagnostics (software uploads, downloads and service tool adjustments) via its bus connection. If the CAN bus that the DI+ Controller is not readily accessible for testing/diagnostics, it is recommended that a DI+ Controller diagnostic connector be installed on the machine in the operator's cabin or in the area where the machine operations are controlled and should be easily accessible. The diagnostic connector should tee into the vehicle CAN bus and have the following elements: CAN+ and CAN-.

3 pin A: CAN +
3 pin B: CAN -

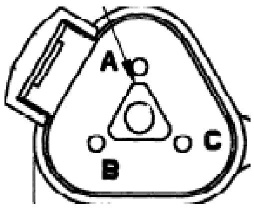



Figure 5: 3 Pin CAN

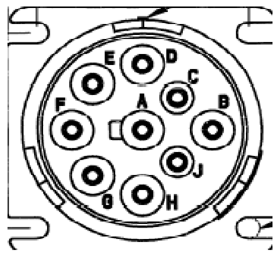



Figure 6: 9 Pin Diagnostic Connector

A: GND
B: Power
C: CAN+
D: CAN-

## USB/CAN GateWay

The DI+ Controller Field Service tool: HVDI utilizes a USB to CAN Adapter to interface a Laptop or PC to the vehicle CAN Bus. The main USB to CAN adapters is the Kvaser.

**Kvaser:** Many different types available, both single and dual channel USB to CAN interfaces.

Figure 7: Kvaser Leaf Light HS V2

## CAN Terminating Resistor

Each end of the main backbone of the CAN bus must be terminated with the appropriate resistance to provide correct termination of the CAN_H (CAN+) and CAN_L (CAN-) conductors.

| Description | Minimum | Maximum | Nominal | Comment |
|---|---|---|---|---|
| Resistance | 110Ω | 130Ω | 120Ω | 0.4 Watts Dissipation Min |
| Inductance | | 1µH | | |

For the DI+ Controller to function properly on the CAN bus, the CAN bus must be properly terminated, resistor for proper CAN communication.

# Standard Controller Inputs and Outputs

## Power Supply – Pin C1-A & C1-B

The controller itself can operate within a supply range of 9 V to 32 V DC. To ensure a correct function of the connected fan clutch, which splits in 12 V and 24 V types, the controller is monitoring the supply voltage between pin C1-A and C1-B. Minimum and maximum supply voltage thresholds can be defined in the APT.

**Input Power Fault:**
If the supply voltage is lower than the minimum threshold or over the maximum threshold, the controller will invoke an Input Fault. This fault will also command the fan clutch to **FULL FAN** and is persistent until the controller is powered off.

## Fan Speed Feedback – Pin C2-C

The Controller's Speed Feedback Pins are by default configured:

| | | |
|---|---|---|
| Input Configuration: | Pull-up/Pull-down (Input Impedance: 40±2 kΩ) | |
| Digital Level Thresholds | | |
| | Digital Low: | Measured Voltage < 2000mV |
| | Digital High: | Measured Voltage >3000mV |
| Minimum Frequency Resolution: | | 1 Hz (Range: 1 Hz to 400 Hz) |
| Measured Speed: | | 0rpm to 4000rpm with 10 rpm resolution |
| Interpreted Speed: | | 6 pulses per revolution |

**Fan Speed Pin Fault Conditions:**
If the pin voltage is between 2 V and 3V and the measured frequency is 0, or the measured Pin Voltage >= 5.175 V the controller will invoke a Fan Speed Pin Fault. This fault will force the fan clutch command to **FULL FAN**.

## Fan Speed Sensor Supply – Pin C2-A & C2-B

Output Configuration: Regulated Voltage Supply, nominal 5.0 V, max. 50mA

**Sensor Power Fault:**
If the measured Pin Voltage is > 5.5V or < 4.5V, the controller will invoke a Sensor Power Fault.

## Fan Coil Output – Pin C2-E & C2-F

The Controller Implements a High Side Push Pull Drive to drive the Clutch Coil. This design requires that the Clutch Coil return is connected Pin C2-E. The output driver has visibility of the Voltage and Current at the output pin. Minimum and Maximum coil current thresholds are programmed via the APT. Coil current is only monitored while the output is driving the coil High.
Current Measurement @ 125°C: *10mA [minimum],* *3500mA [maximum]*

**Fan Coil Fault Conditions:**
*Fan Coil Open*
If Output is being driven high and measured coil current is less than minimum coil current threshold continuously for 5s, the Fault will be latched and will not be reset without cycling power to the controller.

*Over-current Protection (Fan Coil Short)*
If the instantaneous current in each output driver exceeds the trip point, the driver is latched off. The latch will not be reset without cycling power to the controller
*The over-current trip point for the individual Controller outputs is:* ***3.5A*** *[Minimum],* ***3.8A*** *[Maximum]*

| Note: All latched Coil Faults are considered Clutch Faults and cause the Fan clutch control loop to command the fan clutch(s) to **FULL FAN**. |
|---|

# Configurable Inputs

Current Algorithm supports different input options for the three configurable pins C1-E, C1-F & C2-D. The available functions described below can be selected.

## Noise Test, Fording Mode– Pin C1-E, C1-F & C2-D

Input Configuration: Pull-up to +12/24V (Input Impedance: 6±2 / 4±1 kΩ)

**Noise Test**

If the input pin is pulled to ground, the Noise test functionality is invoked, regardless of current operating conditions. The Noise Test functionality commands the Noise Test Fan Percentage Fan command to the fan clutch speed loop. This command typically is 70% but can be adjusted in the APT.

**Fording Mode**

If enabled and invoked, Ford Mode commands the Fan Clutch Speed to 0. For clutches with Minimum Fan Speed enabled will still attempt to maintain the Minimum OFF Speed, which is configured in the APT.

Note: During the Noise Test or Fording Mode Functionality, the LED on the controller will flash green in 1Hz.

## External Fan Request (switch to GND or PWR) – Pin C1-E, C1-F & C2-D

Input Configuration: Pull-up to +12/24V (Input Impedance: 6±2 / 4±1 kΩ)

**Function**

The External Fan Request serves as non CAN based method to command Fan Speed. If the input pin is pulled to ground/power, the External Fan Request functionality is invoked. The External Fan Request functionality requests the Fan to be Commanded to 100%, but this command like other commands are subject to the Limit Logic block. If the Limit Logic allows the fan command, the fan will be commanded to Full Fan.

## External PWM Input – Pin C1-E, C1-F & C2-D

| | | |
|---|---|---|
| Input Impedance: | 40±2 / 16±2 / 11±1 kΩ [pull-up to +5/12/24V] | |
| Digital Level Thresholds | Digital Low: | Measured Voltage < 2000mV |
| | Digital High: | Measured Voltage >3000mV |
| Minimum Frequency Resolution: | | 1 Hz (Range: 1 Hz to 400 Hz) |
| Minimum Duty Cycle Resolution: | | 0.01 % Duty |

**Function**

When configured, the Controller will extract the Percent Duty Cycle of the PWM signal being fed to configured input Pin. Up to 3 PWM inputs can be configured, each can be configured as a % based or RPM Based command. When configured, the PWM input operates as an Input Command subject to Limit Logic clutch protection. Depending on the output of the PWM source (ECU), it could be necessary to add a load resistor on the PWM output to avoid driver faults in the ECU. Dimensioning of the load resistor depends on ECU specifications and ECU fault thresholds.

**Example1:** User configures input C1-E as PWM Input, % Based, Maximum Fan amount: 100%, Minimum Fan Duty at 100% and Maximum Fan Duty at 0%. When PWM input measures 75% duty cycle, the calculated command will be 25% Fan.

**Example2:** User configures input C1-E as PWM Input, RPM Based, Maximum Fan amount: 2000 rpm, Minimum Fan Duty = 25%, Maximum Fan Duty at 75%. When PWM input measures 45% duty cycle, the calculated command will be 2000 rpm *(45-25)/ (75 -25) = 800 rpm.

## External Pulley Sensor – Pin C2-D

| | | |
|---|---|---|
| Input Impedance: | 40±2 / 16±2 / 11±1 kΩ [pull-up to +5/12/24V] | |
| Digital Level Thresholds | Digital Low: | Measured Voltage < 2000mV |
| | Digital High: | Measured Voltage >3000mV |
| Minimum Frequency Resolution: | | 1 Hz (Range: 1 Hz to 400 Hz) |
| Interpreted Speed: | | 1 pulses per revolution (default, can be changed in APT) |

**Pin Fault:**

If the pin voltage is between 2 V and 3V and the measured frequency is 0,
or if the Measured Pulley Speed < Min Pulley Speed
or if the Measured Pulley Speed > Max Pulley Speed, the controller will invoke a Input Speed Fault.

## External Analog Voltage Input – Pin C1-E, C1-F & C2-D

| | |
|---|---|
| Input Configuration: | Operatinal Voltage Range 0 – 6V |
| Voltage Resolution: | 9.765625mV |

**Function**

The External Analog Voltage Input is used to request fan speed without using a CAN message. This type of inputs use 8 point (x,y) maps to translate the analog voltage input to %percent of input speed or an absolute rpm command for the Fan Speed.

## External Resistance Temperature Detectors (RTD) – Pin C1-E & C1-F

| | |
|---|---|
| Input Configuration: | max RTD 5KΩ |
| Temperature Resolution: | vary for different sensors |

**Function**

The External RTD serves is used to request fan speed without using a CAN message. This type of inputs use 8 point (x,y) maps to translate the temperature input to %percent of input speed or an absolute rpm command for the Fan Speed. For two-pin RTD, one pin of RTD is connected to controller Pin C1-E or Pin C1-F, and the other is connected to GND (Pin C1-B).

# J1939 CAN Inputs

Following messages can be used to receive data from the CAN J1939 bus. Besides several standard messages it is possible to set up a custom message that allows the controller to receive one additional standard message that is not listed below or a proprietary message that is available on the bus.

**Source Address Masking:**

To allow the controller to operate in systems with more than one ECU broadcasting the same PGN it is possible to define a source address which is used to mask the incoming messages from the CAN bus.

## PGN 61444 – Electronic Engine Controller 1 – EEC1 -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 61444 (0x00F004)

| Byte | Length | Description |
|---|---|---|
| 4-5 | 2 bytes | Engine Speed (SPN 190) (0.125rpm/bit, 0 offset) (Range 0 – 8,031.875rpm) |

## PGN 57344 – Cab Message #1 – CM1 -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 57344 (0x00E000)

| Byte | Length | Description |
|---|---|---|
| 1 | 1 byte | Requested Percent Fan Speed (SPN 986) (0.4%/bit, 0 offset) (Range 0 – 100%) |

## Custom Message – free definition (Any CAN message from CAN Bus)

Data Length: 8 bytes
Parameter Group Number: user defined (0x000000 to 0x00E000)

| Byte | Length | Description |
|---|---|---|
| 1-8 | 1/2 byte | user defined (scale, offset and range are user defined) |

## PGN 65128 – Vehicle Fluids– VF -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65128 (0x00FE68)

| Byte | Length | Description |
|---|---|---|
| 1 | 1 byte | Hydraulic Temperature (SPN 1638) (1°C/bit, -40°C offset) (Range -40 to 210 °C) |

## PGN 65129 – Engine Temperature 3– ET3 -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65129 (0x00FE69)

| Byte | Length | Description |
|---|---|---|
| 1-2 | 2 bytes | Engine Intake Manifold 1 Temperature (High Resolution) (SPN 1636) (0.03125°C/bit, -273°C offset) (Range -273 to 1735 °C) |
| 3-4 | 2 bytes | Engine Coolant Temp (High Resolution) (SPN 1637) (0.03125°C/bit, -273°C offset) (Range -273 to 1735 °C) |
| 7-8 | 2 bytes | Engine Charge Air Cooler 1 Outlet Temperature (SPN 2630) (0.03125°C/bit, -273°C offset) (Range -273 to 1735 °C) |

## PGN 65213 – Fan Drive –FD-

Transmission Repetition Rate: 1s
Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65213 (0x00FEBD)

| Byte | Bit | Length | Description |
|---|---|---|---|
| 1 | | 1 byte | Estimated Percent Fan Speed (SPN 975) (0.4 %/bit, 0 offset) (Range 0 - 100 %) |
| 2 | 1-4 | 4 bits | Fan Drive State (SPN 977) (16 states/ 4 bit) (Range 0 - 15) |

## PGN 65262 – Engine Temperature 1– ET1 -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65262 (0x00FEEE)

| Byte | Length | Description |
|---|---|---|
| 1 | 1 byte | Engine Coolant Temperature (SPN 110) (1°C/bit, -40°C offset) (Range -40 to 210°C) |
| 2 | 1 byte | Fuel Temperature (SPN 174) (1°C/bit, -40°C offset) (Range -40 – 210°C) |
| 3-4 | 2 bytes | Engine Oil Temp 1 (SPN 175) (0.03125°C/bit, -273°C offset) (Range -273 – 1735 °C) |
| 7 | 1 byte | Engine Intercooler Temperature (SPN 52) (1°C/bit, -40°C offset) (Range -40 – 210°C) |

## PGN 65269 – Ambient Conditions – AMB -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65269 (0x00FEF5)

| Byte | Length | Description |
|---|---|---|
| 4-5 | 2 bytes | Ambient Air Temperature (SPN 171)<br>(0.03125°C/bit, -273°C offset) (Range -273 – 1735 °C) |

## PGN 65270 – Inlet/Exhaust Conditions – IC -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65270 (0x00FEF6)

| Byte | Length | Description |
|---|---|---|
| 3 | 1 byte | Intake Manifold 1 Temp (SPN 105) (1°C/bit, -40°C offset) (Range -40 – 210°C) |

## PGN 65272 – Transmission Fluids – TF -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65272 (0x00FEF8)

| Byte | Length | Description |
|---|---|---|
| 5-6 | 2 bytes | Transmission Oil Temp (SPN 177) (0.03125°C/bit, -273°C offset) (Range -273 – 1735 °C) |

## Torque Calculation Inputs

DI+ controller can support fan torque calculation. If fan torque is enabled by application, following messages can be used to receive data from the CAN J1939 bus to calculate fan torque.

## PGN 65251 – Engine Configuration 1 – EC1 -

Data Length: 40 bytes
Default Priority: 6
Parameter Group Number: 65251 (0x00FEE3)

| Byte | Length | Description |
|---|---|---|
| 18-19 | 2 bytes | Engine Reference Torque (SPN 544) (1Nm/bit, 0 offset) (Range 0 to 64,255Nm) |

## PGN 65262 – Engine Temperature 1– ET1 -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65262 (0x00FEEE)

| Byte | Length | Description |
|---|---|---|
| 1 | 1 byte | Engine Coolant Temperature (SPN 110) (1°C/bit, -40°C offset) (Range -40 to 210°C) |

## PGN 65269 – Ambient Conditions – AMB -

Data Length: 8 bytes
Default Priority: 6
Parameter Group Number: 65269 (0x00FEF5)

| Byte | Length | Description |
|---|---|---|
| 1 | 1 byte | Barometric Pressure (SPN 108) (0.5kPa/bit, 0kPa offset) (Range 0 to 125kPa) |
| 4-5 | 2 bytes | Amb Air Temperature (SPN 171) (0.03125°C/bit, -273°C offset) (Range -273 – 1735 °C) |

# Controller Status Information

## A Status LED

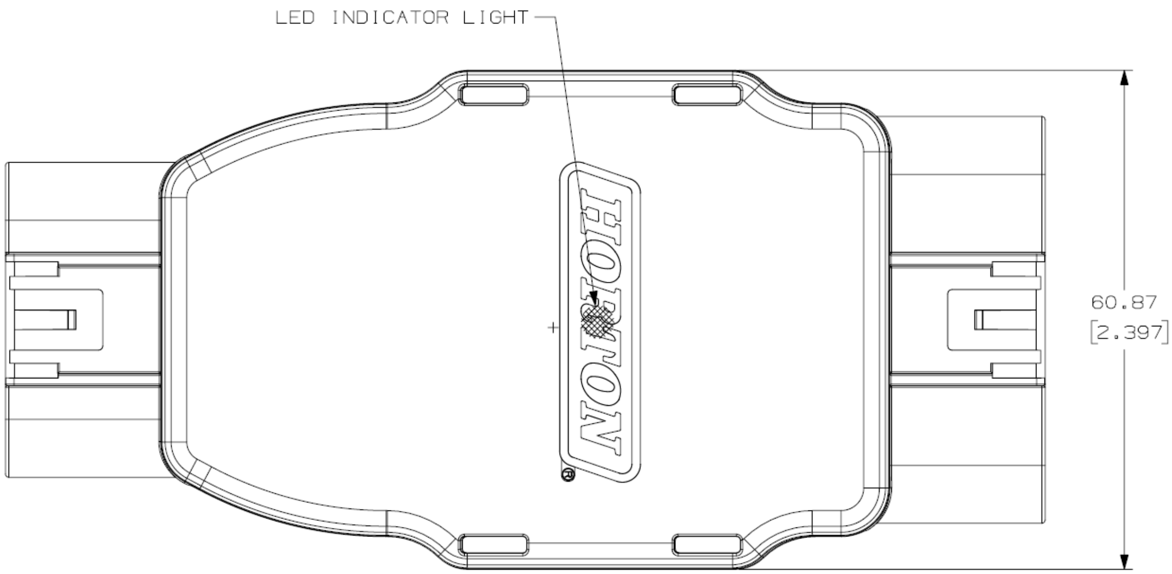
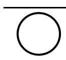
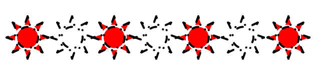
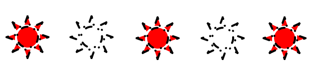
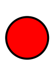
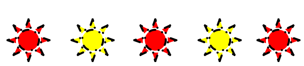
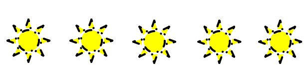
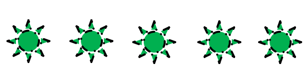
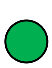



Figure 8: Controller Top View

| LED | Behavior | Description |
|---|---|---|
|  | LED OFF | Unit has no power |
|  | 5Hz Red/Off Blinking | RTOS Fault |
|  | 1Hz Red/Off Blinking | Application/APT Fault |
|  | Red ON | CAN/Cable Fault |
|  | 1 Hz Red/Yellow Blinking | Output/Clutch Fault |
|  | 1 Hz Green/Yellow Blinking | Input Fault |
|  | 1 Hz Yellow Blinking | Manual Mode Active, No fault |
|  | 1HZ Green Blinking | Override Active (Noise, Ford) |
|  | Green ON | Auto Mode, Normal, No Faults |

## J1939 Status Broadcast

The Controller is an active participant on the J1939. For applications not requiring the CAN bus for inputs, the controller CAN will provide a valuable resource for troubleshooting. For J1939 based applications (the majority), upon power up, the controller requests an address (default Horton source address 0x4E) from the system, if the system denies the first address the Controller has 3 more addresses to try. All of the preferred addresses are set in the APT. Using this newly acquired Source Address, the Controller will then broadcast 2 proprietary CAN messages and the standard parameter group "Fan Drive" to aid in troubleshooting.

## PGN 65213 – Fan Drive –FD-

Transmission Repetition Rate: 1s

Data Length: 8 bytes

Default Priority: 6

Parameter Group Number: 65213 (0x00FEBD)

| Byte | Bit | Length | Description |
|---|---|---|---|
| 1 | | 1 byte | Estimated Percent Fan Speed (SPN 975) (0.4 %/bit, 0 offset) (Range 0 - 100 %) |
| 2 | 1-4 | 4 bits | Fan Drive State (SPN 977) (16 states/ 4 bit) (Range 0 - 15) |
| 3-4 | | 2 bytes | Fan Speed (SPN 1639) (0.125 rpm/bit, 0 offset) (Range 0 - 8,031.875 rpm) |

Note: DI+ controller broadcasts SPN977 Fan Drive State as "1100 Timer" during slip heat protection mode or disengaging transition to fan off.

## PGN 65470 – Controller Status 1 –CS1-

Transmission Repetition Rate: 1s

Data Length: 8 bytes

Default Priority: 6

Parameter Group Number: 65470 (0x00FFBE)

| Byte | Length | Description |
|---|---|---|
| 1-2 | 16 bits | PWM Duty Cycle (0.01% duty/bit, 0 offset) (Range 0 - 100 %) |
| 3-4 | 16 bits | Input Speed (1 rpm/bit, 0 offset) |
| 5-6 | 16 bits | Fan Command (1 rpm/bit, 0 offset) |
| 7-8 | 16 bits | Actual Fan Speed (1 rpm/bit, 0 offset) |

## PGN 65469 – Controller Fault Status –CFS-

| | |
|---|---|
| Transmission Repetition Rate: | 1s |
| Data Length: | 8 bytes |
| Default Priority: | 6 |
| Parameter Group Number: | 65469 (0x00FFBD) |

| Byte | Bit | Length | Description |
|---|---|---|---|
| 1-4 | | | Not Used |
| 5 | 1 | 1 bit | SPN2978 Input Fault |
| 5 | 2 | 1 bit | Fan Speed Pin Fault |
| 5 | 3 | 1 bit | No Fan Speed |
| 5 | 4 | 1 bit | Excess Fan Speed |
| 5 | 5 | 1 bit | Fan Speed Error |
| 5 | 6 | 1 bit | Output Hardware Fault (**MUST REPLACE CONTROLLER**) |
| 5 | 7 | 1 bit | APT Fault |
| 5 | 8 | 1 bit | Input Speed Error |
| 6 | 1 | 1 bit | CAN BUS OFF |
| 6 | 2 | 1 bit | CAN Driver Error |
| 6 | 3 | 1 bit | CAN Fault |
| 6 | 4 | 1 bit | APP Fault |
| 6 | 5 | 1 bit | ENG_RPM Fault |
| 6 | 6 | 1 bit | Fan Clutch Output Short |
| 6 | 7 | 1 bit | Fan Clutch Output Open |
| 6 | 8 | 1 bit | Fan Clutch Output Fault |
| 7 | 1 | 1 bit | Input Power Low |
| 7 | 2 | 1 bit | Input Power High |
| 7 | 3 | 1 bit | Input Power Fault |
| 7 | 4 | 1 bit | Sensor Power Low |
| 7 | 5 | 1 bit | Sensor Power High |
| 7 | 6 | 1 bit | Sensor Power Fault |
| 7 | 7-8 | 2 bit | Not Used |
| 8 | 1 | 1 bit | Input 1 Fault |
| 8 | 2 | 1 bit | Input 2 Fault |
| 8 | 3 | 1 bit | Input 3 Fault |
| 8 | 4 | 1 bit | Input 4 Fault |
| 8 | 5 | 1 bit | Input 5 Fault |
| 8 | 6 | 1 bit | Input 6 Fault |
| 8 | 7 | 1 bit | Input 7 Fault |
| 8 | 8 | 1 bit | Input 8 Fault |

Note for Bitwise Fault Status bits, Bits are set to 1 if the Condition exists, 0 if not.

## PGN 65247 – Electronic Engine Controller 3 –EEC3-

| | |
|---|---|
| Transmission Repetition Rate: | 50ms or application defined (if fan torque is enabled by application) |
| Data Length: | 8 bytes |
| Default Priority: | 6 |
| Parameter Group Number: | 65247 (0x00FEDF) |

| Byte | Length | Description |
|---|---|---|
| 5 | 8bits | Estimated engine parasitic losses percent torque (SPN 2978) a.k.a. Percent Fan Torque (1%/bit, -125 offset) (Range -125 ~ 125 %) |

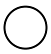
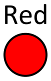
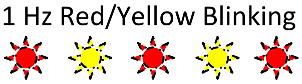
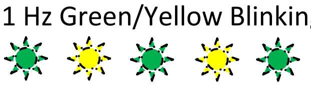
## PGN 65471 – Controller Status 2 –CS2-

| | |
|---|---|
| Transmission Repetition Rate: | 1s (if fan torque is enabled by application) |
| Data Length: | 8 bytes |
| Default Priority: | 6 |
| Parameter Group Number: | 65471 (0x00FFBF) |

| Byte | Length | Description |
|---|---|---|
| 1-2 | 16 bits | Fan Torque (1 Nm/bit, 0 offset) (Range 0 – 65535 Nm) |

# Controller Troubleshooting Advice

## Troubleshooting using ONLY LED

| Condition | Action |
|---|---|
| No LEDs ON<br> | Controller has no Power<br><br>Check that input voltage is > 9VDC referenced to GND.<br>Check Harness In-line Fuse (if applicable) |
| 5Hz Red/Off Blinking<br> | RTOS Fault<br><br>Cycle power to the controller to clear the fault<br>If error persists, contact Horton Engineering! |
| Red LED ON Solid<br> | Application/APT Fault<br><br>The controller is not programmed correctly.<br>Send controller back to Horton for further investigation. |
| Red LED ON Solid<br> | CAN/Cable Fault<br><br>The CAN Bus is in either a Driver Error (hardware, wrong CAN baudrate, etc…)<br>Or it has experienced a BUS OFF condition on the Bus. |
| 1 Hz Red/Yellow Blinking<br> | Output/Clutch Fault<br><br>Check wiring from Controller to Clutch<br>Inspect the integrity of the Anti-rotation strap (Vmaster)<br>Ensure Fan Bolts are of External Torx Type (Vmaster)<br>If Available, try swapping Clutch or Anti-rotation Strap |
| 1 Hz Green/Yellow Blinking<br> | Input Fault<br><br>If fan appears to be on Full (engaged) one of the critical inputs are missing for controls: CAN Message (Engine Speed or other CAN inputs), Valid PWM Signal, Valid Pulley Speed, etc…<br>Check System Voltage, is it within the Limits specified in the APT?<br>Double check the wiring if this is a new wiring harness. |

## Detailed Troubleshooting using CAN Broadcast Messages

| Fault | Action |
|---|---|
| Fan Speed Error | No Fan Speed or Excess Fan Speed |
| Fan Speed Pin Fault | Ensure that the Anti-rotation strap is properly connected to the clutch<br>Verify the wire from DI+ pin C2-C to the Appropriate Speed Pin on the Anti-Rotation Strap |
| No Fan Speed | No Fan Speed is being seen on from the Speed Feedback pin (pin C2-C) if fan speed < 50rpm and Input speed > 500rpm. Check to verify the Speed sensing targets: target ring (Stratis), Fan Bolts (VMaster). If using a VMaster ensure that Fan bolts are of External Torx type and are evenly tight. |
| Excess Fan Speed | Fan Speed is measuring faster than the input speed (fan speed > Input speed + 200 rpm while fan speed > 500 rpm). Verify that Pulley Ratio is set correctly in APT. Verify Fan Bolts (VMaster). Verify integrity of speed sensing ring (Stratis) |
| Fan Clutch Output Fault | Controller Clutch Output has experienced a fault, the Open or Short conditions are not latched but the Output Fault is. Cycle power to the controller to clear the fault. See below for trouble shooting. |
| Fan Clutch Output Short | Controller Clutch Output (pin C2-F) has drawn current in excess of the parameter set in the APT. Verify that the current parameter is set correctly. Cycle power to the controller to clear the fault. If the condition persists, double check the wiring to the Anti-rotation strap.<br>Verify that the voltage of the controller matches the voltage rating for the clutch coil. |
| Fan Clutch Output Open | Controller Clutch Output (pin C2-F) wasn't able to see the clutch. Cycle power to the controller to clear the fault. If the condition persists, double check the wiring, check the input resistance of the clutch coil with multi-meter. Verify that the coil resistance is within spec. |
| Output Hardware Fault | Controller Clutch Output (pin C2-F) wasn't able to send 0V as request. This fault will fail to turn the fan full on and force fan running at a very low speed. This will cause over heating issue. **MUST REPLACE THE CONTROLLER IMMEDIATELY.** |
| Sensor Power Fault | Sensor Power Voltage is too low or too high |
| Sensor Power Low | Sensor Supply +(C2-B), -(C2-A) is measuring below 4.5V, this is often indicative of a wiring issue with any sensor operating on the sensor supply voltage. Double check sensors and wiring. |
| Sensor Power High | Sensor Supply +(C2-B), -(C2-A) is measuring above 5.5V, this is often indicative of a wiring issue with any sensor operating on the sensor supply voltage. |

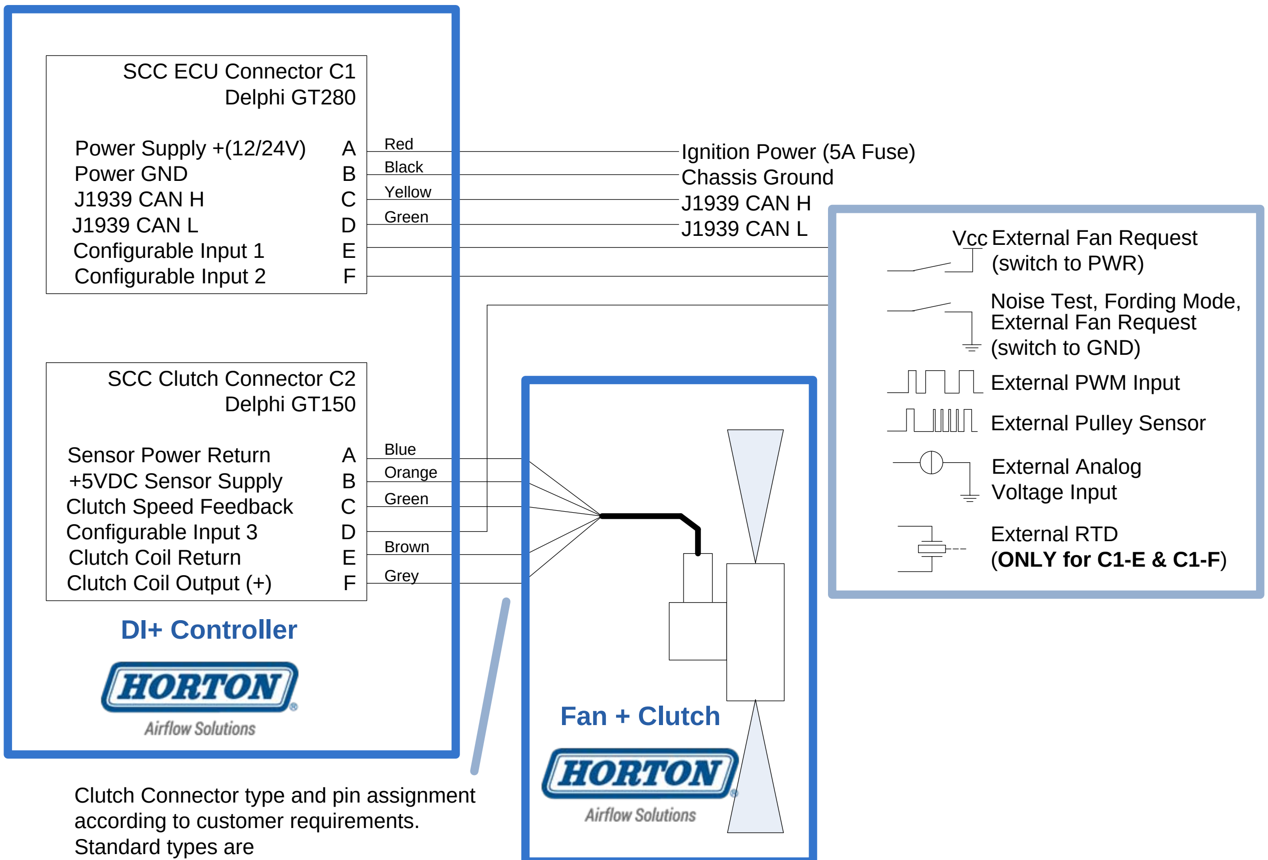
| | |
|---|---|
| CAN Fault | CAN BUS OFF or CAN Driver Error |
| CAN BUS OFF | Cycle Power on the controller to verify that Error persists<br>If the error persists, contact Horton Engineering, a critical CAN error is occurring |
| CAN Driver Error | This error is typical indicative of a hardware failure or CAN baudarate mismatch. Cycle power, if error persists, contact Horton Engineering. |

Note: Because the diagnostics are CAN Based and the Tool communicates with the Controller via the CAN interface, it is very likely that you will never see a CAN error via an actually Error bit but rather the Controller may no longer transmit its Fault status or Speed messages.

| | |
|---|---|
| Eng_RPM Fault | Engine Speed (SPN 190), Broadcast in PGN 61444 "EEC1" Message either is not being transmitted or is not valid. Verify that the message exists and is valid. If the messages are valid, verify the source address, verify that the CAN bus is properly terminated (transmit rate < 1Hz), verify CAN wiring. |
| Input Speed Fault | Pulley speed as input speed.<br>Verify that Pulley PPR is set higher than 0 in APT<br>Verify that Pulley Sensor is wired correctly and sensing the target.<br>Verify that Min/Max Pulley Speed is set appropriately. |
| Input Power Fault | Input Power Voltage is Lower or Higher than Expected. |
| Input Power Low | Controller Input Voltage is lower than the parameter set in the APT. Verify that the APT value is correct, verify the voltage input to the Controller (pin C1-A) with respect to Ground (pin C1-B). |
| Input Power High | Controller Input Voltage is higher than the parameter set in the APT. Verify that the APT value is correct, verify the voltage input to the Controller (pin C1-A) with respect to Ground (pin C1-B). |
| SPN2978 Input Fault | Inputs to calculate SPN2978 percentage fan torque are missing if fan torque is enabled. Verify that the input messages (SPN544 engine ref torque, SPN110 engine coolant temperature, SPN108 barometric pressure and SPN171 ambient air temperature if applicable) exist and are valid. If the message are available on the CAN bus, verify the input source address and other APT torque settings. |

# Controller Basic Wiring Schematic

Harness is always customer specific.




Clutch Connector type and pin assignment according to customer requirements.
Standard types are
- Delphi, Metri-Pack 150, 6-pin
- Tyco, DIN 72585 round, 7-pin
- Deutsch, DT series, 6-pin

Others available on request